Population Demographic and Reproductive Parameters of the Cowpea Seed Beetle *Callosobruchus maculatus* Infesting Stored Lentil and Chickpea Commodities

Soumaya Haouel-Hamdi, Faten Titouhi, Emna Boushih, Laboratoire de Biotechnologie Appliquée à l'Agriculture, INRAT, Université de Carthage, Rue Hedi Karray, 2080 Ariana, Tunisia, **Mohamed Zied Dhraief,** INRAT, Université de Carthage, Rue Hedi Karray, 2080 Ariana, Tunisia, **Moez Amri**, Centre Régional de Recherche en Grandes Cultures de Béja, Laboratoire des Grandes Cultures, Université de Carthage, Route de Tunis, Km 5, 9000 Béja, Tunisia, **and Jouda Mediouni-Ben Jemâa,** Laboratoire de Biotechnologie Appliquée à l'Agriculture, INRAT, Université de Carthage, Rue Hedi Karray, 2080 Ariana, Tunisia

ABSTRACT

Haouel-Hamdi, S., Titouhi, F., Boushih, E., Dhraief, M.Z., Amri, M., and Mediouni-Ben Jemâa, J. 2017. Population demographic traits and reproductive parameters of the seed beetle *Callosobruchus maculatus* infesting stored lentil and chickpea commodities . Tunisian Journal of Plant Protection 12: 67-81.

This paper carried out first exhausted investigations on pest status of the cowpea weevil *Callosobruchus maculatus* on two food legumes namely chickpea (Amdoun 1 variety) and lentil (Ncir variety) during six months of storage. Data on populations' dynamic, demographic traits, reproductive parameters, juvenile and adult fitness, economic injury level (EIL) and damages (impact on germination and weight losses) were studied through this work. Results revealed that *C. maculatus* is a major pest on stored chickpea in Tunisia. Moreover, results indicated that reproductive parameters, the juvenile and adult fitness of *C. maculatus* exhibited great variations among hosts. In this respect, linear regression analysis demonstrated that hosts have significant effects on adult fitness. Results showed that host contributed respectively by 77% for body weight and 80% for body size. Chickpea was more suitable host compared to lentil, since the mortality rate of eggs and larvae and the generation duration means were higher in lentil. In addition, significant differences were observed in the Susceptibility Index of the two food legume hosts showing chickpea seeds as moderately susceptible to *C. maculatus* attacks while, lentil seeds were resistant. *C. maculatus* caused large reductions in seed germination (78% chickpea and 33% lentil for highest infestation level 80%) and seeds weight (45% for chickpea against 8% for lentil after 6 months of storage) of both hosts; the infestation levels and the weight losses were significantly different in the storage periods. Overall, this study provides reasons for farmers and traders to make a decision to take a control action against *C. maculatus* during storage. Moreover, this work pointed out the variability of economic injury levels with host legumes.

Keywords: Adults' and juvenile fitness, *Callosobruchus maculatus*, chickpea, demographic traits, economic injury level, lentil, reproductive parameters

Corresponding author: Jouda Mediouni-Ben Jemâa
Email address: joudamediouni@lycos.com

Accepted for publication 03 February 2017

The cowpea seed beetle *Callosobruchus maculatus* (Coleoptera: Chrysomelidae) is a cosmopolitan polyphagous pest of pulse crops under

storage conditions in the most tropics and subtropics such as Mediterranean's areas and Africa (Ajayi and Lale 2001; Bagheri 1996; Booth et al. 1990). This beetle is reported to be the most damaging pest of legume seeds and its larvae, being internal feeders, infested grains such as bean, chickpea, green gram, lentil, broad bean and green pea (Kazemi et al. 2009). It is a field-to-store pest that causes heavy yield losses in terms of both quantity and quality of stored grain legumes. The neonate larvae penetrate the grains causing serious damage such as grain weight loss, reduction in germination, seed viability and nutritional low quality (Melo et al. 2015; Oke and Akintunde 2013). Furthermore, this pest also causes secondary infestation by preparing appropriate conditions for activity of saprotrophic fungi during seed storage (Loganathan et al. 2011).

In Tunisia, few studies have examined the importance of *C. maculatus* damages on stored food legumes in relation to its population growth and reproductive parameters. Even fewer have examined whether damages depend on the host plants and storage conditions. In this respect, Jarraya (2003), Mabrouk and Belhadj (2012) reported that *C. maculatus* is among the major insect pests attacking chickpea in Tunisia. Additionally, Haouel et al. (2012; 2015) indicated that *C. maculatus* is among the most important stored grain pests commonly found in chickpea in Tunisia. Thus, this work aims to investigate population dynamics, reproductive parameters, demographic traits, juvenile and adult fitness, the Susceptibility Index (SI), damages (weight losses, germination) and the Economic Injury Level (EIL) of *C. maculatus* reared on two host legumes: chickpea and lentil.

MATERIALS AND METHODS

Insect rearing and seed material.

C. maculatus individuals were obtained from infested chickpea seeds provided by the Field Crops' Research Laboratory. The stock colonies were maintained in glass bottles of 1 liter of volume in a growth chamber at 30 ± 5ºC temperature, 65 ± 5% RH and 12:12 Light:Darkness photoperiod.

Two food legumes hosts: a chickpea (*Cicer arietinum*) Amdoun 1 variety (Pedigree Be-sel-81-48) and a lentil (*Lens culinaris*) Ncir variety (Pedigree ILL 4400) served as food substrates for the insect rearing. Flightless-form females were used for this study.

Reproductive parameters and life table study.

The reproductive parameters of *C. maculatus* laid on either chickpea or lentil seeds studied using three replicates of 100 eggs. To determine durations of eggs incubation, larval developmental time and life cycle, the eggs were transferred individually in Petri dishes and were checked daily until the emergence of adults. Moreover, adult longevity was recorded daily until death of last individual. After emergence of adults, each couple was placed in Petri dish containing 20 g of either chickpea or lentil seeds. The duration of ovipositon and post-oviposition periods as well as longevity, daily fecundity (eggs per female day), total fecundity (eggs during reproduction period), sex ratio, emergence rate and juvenile and adult fitness were determined.

Demographic traits study.

The age-stage specific fecundity (f_{xj}), the age-specific survival rate (l_x), the age-specific fecundity (m_x) and the population growth parameters namely:

the net reproduction rate (R_0), the mean generation time (*T*), the intrinsic rate of increase (*r*), the finite rate of increase (λ), and the doubling time (*DT*) were calculated according to Khanamani et al. (2013) and Win et al. (2011).

The age-specific survival rate (l_x) comprising both female and male, was calculated according to Chi and Liu (1985) as:

$lx = \sum_{j=1}^{k} Sxj$ with k: number of stages

The age-specific fecundity (m_x) was calculated as:

$$mx = \frac{\sum_{j=1}^{k} Sxjfxj}{\sum_{j=1}^{k} Sxj}$$

The net reproduction rate (R_0) was calculated according to Carey (1993) as:

$$Ro = \sum_{j=1}^{k} lx\ mx$$

The mean generation time (*T)* can be defined as the average length of time between when an individual is born and the birth of its offspring approximated by the following formula (Birch 1948)

$$T = \frac{\sum xlxmx}{\sum lxmx}$$

The intrinsic rate of increase (*r*) also called the intrinsic rate of natural increase or the innate capacity for increase was after that estimated using Carey (1993) formula as: $r = \frac{Ln\ Ro}{T}$

The doubling time (*DT*) defined as the number of days required by a population to double was as well calculated according to Carey (1993):

$$DT = \frac{Ln\ 2}{rm}$$

The finite rate of increase (λ) characterized by the number of female offspring per female per day was calculated according to Carey (1993) as: $\lambda = e^{rm}$.

The susceptibility index (SI).

The Susceptibility Index was used as the criterion to test the susceptibility of both host substrates toward insect feeding. It was calculated using the method of Dobie and Kilminster (1977) given by the formula:

$$SI = \frac{\log_e F}{D} \times 100$$

with D: the median development period, F: the total of number of F1 progeny emerged.

The SI was used to classify the two host legumes into susceptibility groups following the scales as follows: scale index of ≤ 4 was classified as resistant; scale index of 4.1-6.0 as moderately resistant; scale index of 6.1-8.0 as moderately susceptible; scale index of 8.1-10 as susceptible and scale index >10 as highly susceptible.

Seed germination.

Germination tests were carried out following the methodology of the International Seed Testing Association employing a representative sample of 50 seeds in three replications of chickpea and lentil with three infestation rates of *C. maculatus* (0, 5, and 80%).

Infestation levels and weight losses.

This trial was conducted over a storage period of six months where weight loss controls were performed each month. The experiment consists on placing five pairs of *C. maculatus* (less than 24 h old) in glass bottles containing 100 g of healthy seeds of chickpea or lentil. The test was replicated three times. The females laying their eggs were left until they died. After laying eggs, the dead adults were removed from bottles. Hatched eggs were allowed to develop until adult emergence.

Each month, infested and healthy seeds were separated, cleaned, counted,

and finally weighed after completion of adult emergence. Seed infestation and weight loss were computed by using the following formulae (Anonymous 1988):

$$A\% = \frac{Nd}{Nd + Nu} \times 100 \; B\% = \frac{WuNd - WdNu}{Wd(Nd + Nu)} \times 100$$

with A% = percent of damage, B% = percentage of weight loss, Nd = number of damaged seeds, Nu= number of undamaged seeds, Wu = weight of undamaged seeds, and Wd = weight of damaged seeds.

Economic injury levels.

C. maculatus Economic Injury Levels (EILs) were determined each month for chickpea and lentil seeds for a period of six moths' storage duration. EILs were calculated according to Pedigo et al. (1986) formula:

$$EIL = \frac{C \times N}{V \times I}$$

where C=management cost per production unit expressed with Tunisian Dinars/kg, I = percent weight loss, N = number of pests causing injury and V = market value per production unit expressed with Tunisian Dinars/kg.

Statistical analysis.

To analyze the possible effects of the rearing substrates (chickpea and lentil) on all biological parameters of *C. maculatus*, statistical analyses were performed using SPSS statistical software version 20.0. All values given were the mean of three replications and were expressed as the mean ± standard deviation ($\bar{x}$ ± SD). Significant differences between the mean values ($P \leq 0.05$) were determined by using Student test.

Adults' fitness component (weight) and number of eggs was log transformed to attain normality. Correlation analyses (Pearson's correlation coefficient) and general linear model were established between the juvenile and adults' fitness and the number of eggs.

RESULTS

Reproductive parameters.

The reproductive parameters of *C. maculatus* reared on chickpea and lentil were illustrated in Table 1. Results showed that *C. maculatus* reproductive parameters varied upon host legumes. Best performances were recorded when the insect was reared on chickpea. In this respect, the mean eggs per female, the fertility rate and the immature development period values were respectively 87.4 egg/female, 38.1% and 38.3 days for chickpea against 25.7 egg/female, 10.1% and 50 days for lentil. However, no statistical differences were detected between the two hosts regarding adult's longevity parameter (F = 4.00, P = 0.12, Table1).

Table 1. Reproductive parameters of *Callosobruchus maculatus* reared on two food legumes (mean ± SD)

Seed	Adult longevity (Days)	Oviposition period (Days)	Immature development period (Days)	Mean eggs per female	Mean progeny per female	Fertility rate (%)
Chickpea	5.3 ± 0.6 a	7.3 ± 0.6 b	38.3 ± 1.5 a	87.4 ± 10.5 b	13.9 ± 5.1 b	38.1 ± 9.9 b
Lentil	4.0 ± 0.0 a	5.3 ± 0.6 a	50.0 ± 5.0 b	25.7 ± 5.0 a	2.7 ± 0.6 a	10.1 ± 3.2 a

For each biological parameter, comparisons were made between the two legume hosts. Means followed by the same letters are not significantly different at the 5% threshold (Student Test).

Juvenile and adults' fitness assessment.

Correlation. Results revealed that the juvenile and adults' fitness of *C. maculatus* exhibited great variations among hosts (Table 2). A highly significant and negative correlation was observed between the host and the body weight and size of the beetle (r_{weight} = -0.88, $P < 0.001$ and r_{size} = -0.89, $P < 0.001$). On the other hand, results showed high significant and positive correlations between juvenile fitness, adults' fitness and number of eggs (fertility) (Table 2).

Table 2. Correlation analyses between juvenile fitness, adults' fitness and number of eggs of *Callosobruchus maculatus*

Pearson's correlation coefficient	Seeds legumes	Juvenile fitness	Adults fitness (log weight)
Juvenile fitness	-0.681**	-	-
Adults fitness (log weight)	-0.877**	0.482**	-
Adults fitness (body size)	-0.895**	0.554**	0.816**
Log number of eggs	-0.915**	0.634**	0.778**

** Highly significant at 1% level

Linear Regression Model. Linear regression analysis revealed that hosts have significant effects on adults fitness (body weight, body size) (F = 75.64, $P < 0.001$, R^2 = 0.66, Fig. 1) confirming results of correlation analysis (Table 2). The importance of the host for explaining significant portions of the independent variable for fitness of *C. maculatus* is also emphasized. The linear regression analysis allowed as investigating the host contribution into the variation of adults' fitness. Results showed that host contributed respectively by 77% for body weight and 80.1% for body size (Fig. 1). Overall, *C. maculatus* laid a larger number of eggs on chickpea than lentils. The interaction between host and body weight explain a significant amount of the variance in fecundity (F = 58.11, $P < 0.001$, R^2 = 0.60). These results pointed out the direct effect of host on fecundity and adults' fitness.

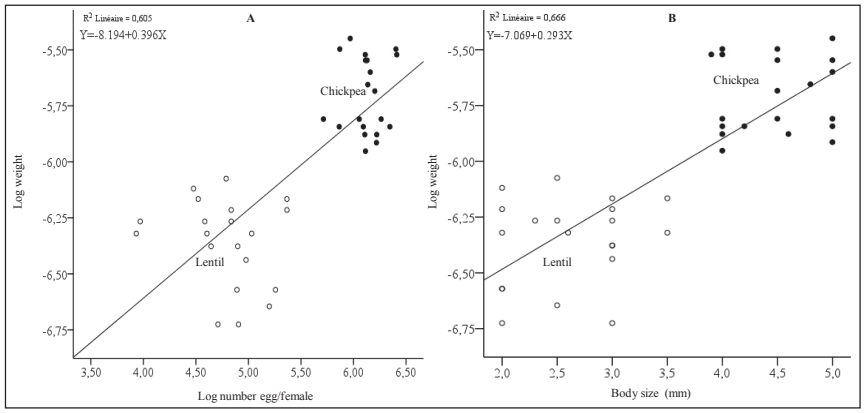

Fig. 1. Relationship between weight-number of laid eggs (A) and weight-body size (B) of *Callosobruchus maculatus*. Linear regression line plotted for significant ($P < 0.005$).

Demographic parameters traits.

Results revealed that the host legumes affect significantly all demographic parameters excepted for the sex-ratio where no differences were detected (F = 0.72, *P* = 4.44) (Table 3).

Demographic traits data revealed that *C. maculatus* performances were dependent on host legumes. Chickpea appeared as the most suitable host compared to lentil.

Table 3. Demographic traits of *Callosobruchus maculatus* reared on chickpea or lentil

Seeds	MGR*	MRE*	MRL*	ER*	SR*	Ro*	GT*	R*	DT*	λ*
Chick-pea	0.8 ± 0.1 b	60.6 ± 10.6 a	4.6 ± 0.6 a	89.8 ± 2.6 b	0.7 ± 0.2 a	11.3 ± 6.2 b	44.3 ± 1.5 a	0.051 ± 0.015 b	14.5 ± 5.2 b	1.050 ± 0.020 b
Lentil	-1.4 ± 1.1 a	89.6 ± 0.7 b	62.8 ± 14.5 b	37.1 ± 14.5 a	0.8 ± 0.3 a	0.2 ± 0.2 a	54.0 ± 5.0 b	-0.035 ± 0.02 a	-	0.960 ± 0.020 a

For each demographic parameter, comparisons were made between hosts. Means followed by the same letters are not significantly different at the 5% threshold (Student Test).
* MGR = mean growth rate, MRE = mortality rate of eggs, MRL = mortality rate of larvae, ER = emergence rate, SR = Sex-Ratio, R = net reproductive rate, T = generation time, r = intrinsic rate of increase, DT = doubling time, λ = finite rate of increase.

C. maculatus could successfully survive and reproduce both on chickpea and lentil, with a food-preference tendency to chickpea (Fig. 2).

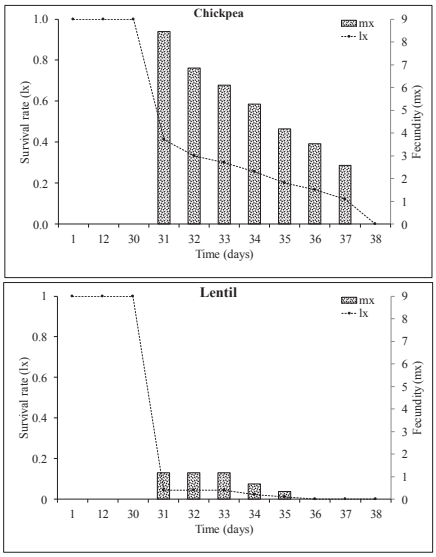

Fig. 2. Effect of time on age-specific survival rate (l_x) and fecundity (m_x) of *Callosobruchus maculatus* on two host legumes chickpea (left) and lentil (right).

The susceptibility index (SI).

Significant differences (F = 47.48, *P* = 0.02) were observed in the susceptibility index of the two food legume hosts (Table 4). The SI values were 3.54 for lentil and 6.06 for chickpea. Chickpea seeds were moderately susceptible to *C. maculatus* attacks, while lentil seeds were not.

Table 4. Susceptibility Index of chickpea and lentil seeds to *Callosobruchus maculatus* after six months of storage

Hosts	SI*	Scale index classification
Chickpea	6.06 ± 0.47 b	Moderately susceptible
Lentil	3.54 ± 0.41 a	Resistant

Comparisons were made between hosts susceptibility index. Means followed by the same letters are not significantly different at the 5% threshold (Student Test). *SI = The Susceptibility Index.

Germination.

C. maculatus caused significant reduction in seeds germination of both hosts, with the highest infestation level (80%) causing reductions of 78% and 33% for chickpea and lentil, respectively (Fig. 3).

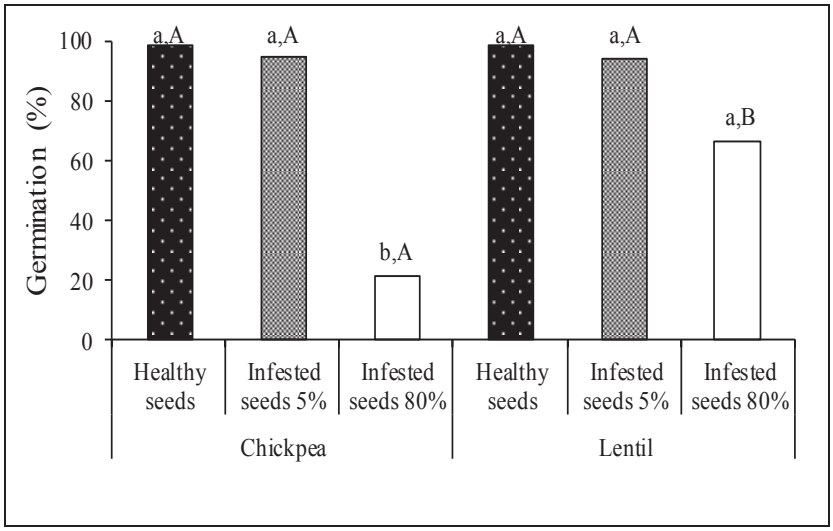

Fig. 3. Effect of infestation rate by *Callosobruchus maculatus* on germination of chickpea and lentil seeds. Bars having different letters are significantly different at 5% level of probability among infested levels for each legume seeds (lowercase letters) and among legume seeds for each infested levels (uppercase letters).

Infestation levels and weight losses.

Infestation levels and weight losses are significantly different among the two hosts and storage periods (Fig. 4). For chickpea, infestation levels ranged from 15 and 49 to 100% after 1, 3 and 6 months of storage, respectively. Similar data for lentil which had infestation levels ranging from 0.3 and 19 to 80% after 1, 3 and 6 months of storage, respectively. For chickpea, weight losses varied between 1, 19 and 45% after 1, 3 and 6 months of storage, respectively. For lentil, weight losses oscillated between 0.3, 4 and 8% after 1, 3 and 6 months of storage, respectively (Fig. 4).

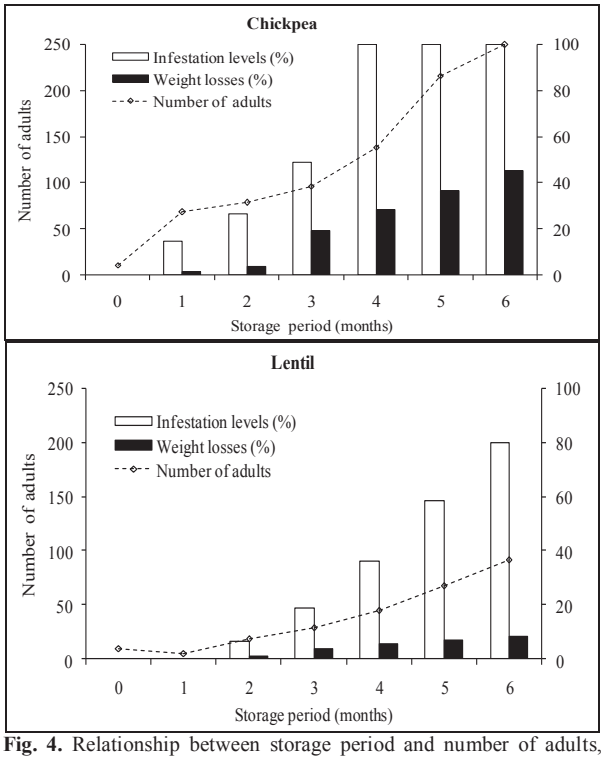

Fig. 4. Relationship between storage period and number of adults, infestation levels (%) and weight losses (%) of *Callosobruchus maculatus* reared on chickpea (left) and lentil (right).

Economic Injury Level (EIL).

EIL depended on food hosts (Fig. 5). The respective values were 63 and 83 insect/kg for chickpea and lentil. These findings further revealed that *C. maculatus* has a host-trophic preference toward chickpea.

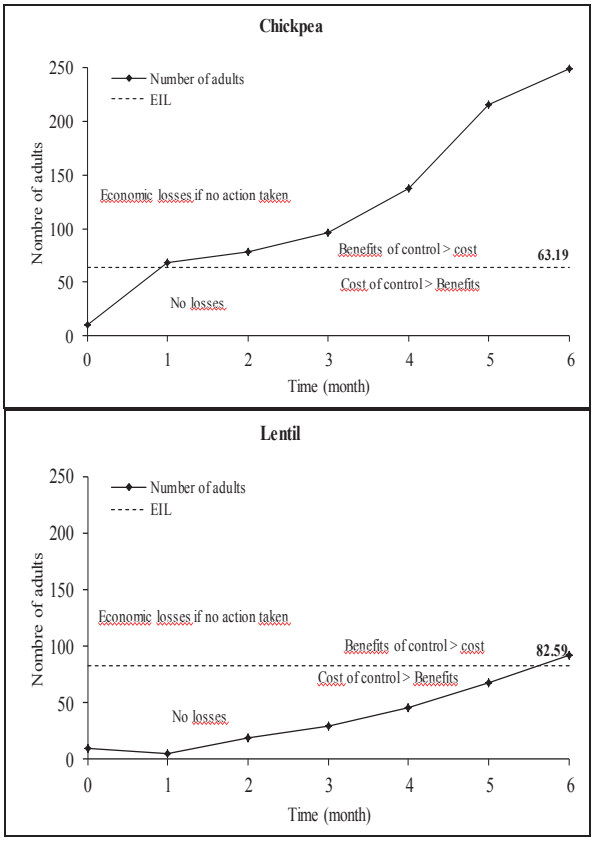

Fig. 5. Representation of the Economic-Injury Level (EIL) of *Callosobruchus maculatus* and its relationship to economic loss, benefits, and costs in chickpea (left) and lentil (right).

DISCUSSION

The cowpea seed beetle *C. maculatus* is considered as the most important pest of stored food legume worldwide. However, in Tunisia data on the pest population dynamic, the growth parameters and demographic traits, the susceptibility index, the economic injury level and its impact on germination and weight losses was poorly documented.

Our results revealed that *C. maculatus* is a major beetle pest on stored chickpea in Tunisia. These findings are consistent with those reported by Iturralde-García et al. (2016), Kedia et al. (2015), Staneva (1982), Van Huis and De Roy (1998) indicating that *C. maculatus* is the main pest of stored chickpea. Previous works reported that *C. maculatus* reproductive parameters varied according to host plants. In this respect, Gokhale (1973), Obopile et al. (2011), and Swella and Mushobozy (2009) specified that the highest mean egg counts and high percent of adult emergence were obtained on chickpea compared to other legume seeds.

Moreover, Kazemi et al. (2009) demonstrated that it was a significant difference in the immature development

period of *C. maculatus* on four legume species (cowpea, lentil, chickpea, green gram). It was the shortest on chickpea (37.43 ± 0.43 days) and the longest on lentil (42.66 ± 0.22 days). Similarly, several studies were achieved on reproduction and fecundity of *C. maculatus*. It was clearly demonstrated that egg production was significantly affected by host (Van Huis and De Roy 1998), seed size and weight (Cope and Fox 2003; Govindarajan and Balasubramanian 1981; Meyer et al. 1986), female weight at the time of mating (Credland et al. 1986; Sibly et al. 1991), male size and density (Giga and Canhao 1997; Savalli and Fox 1999), and egg and larvae density in seeds (Ofuya and Agele 1990; Wijeratne 1998).

The comparative study of the demographic traits between the two hosts legumes performed in our study revealed that a highly significant and negative correlation was observed between hosts and the adults' fitness (body weight and size) of *C. maculatus* whereas high significant and positive correlations between juvenile fitness, adults' fitness and number of eggs were obtained. Thus, we could conclude that the host legumes affect fecundity and adult emergence size. In these regards, our results are in accordance with those described by (Credland et al. 1986; Messina 1991; Smith and Lessells 1985) who point out the relationship between fecundity and the size of adults of *Callosobruchus* beetles. Additionally, Kawecki (1997) demonstrated that females emerging from *Vigna radiate* and *Vigna angularis* had different fecundities but apparently similar weights. According to William and Kirk (1991), there was a correlation between insect size and host size. Body size has many ecological implications (Peters 1983), including those relating to an insect's distribution, abundance, and population variability (Gaston and Lawton 1988).

Our results pointed out the fact that, if individual fitness adaptive traits increased, the population size and reproductive and demographic performances increased. These outcomes agree with those reported by Metz et al. (2008). Additionally, since the seed beetle *C. maculatus* is a cosmopolitan pest of legume seeds, its populations vary substantially in their host associations, and vary in a suite of life history and behavioral traits associated with these host plant differences as reported by Kawecki and Mery (2003), Fox et al. (2004), Messina (1991), Messina and Slade (1997), and Savalli et al. (2000). Similarly, Janzen (1977) specified that the different hosts provide different qualities of resource to the beetles leading to different biological parameter traits.

On the other hand, differences of hosts' susceptibility toward *C. maculatus* could be due to the differences in the ability of particular hosts to resist to *C. maculatus* attack including protein, carbohydrate, ash, tannin and saponin (Desroches et al. 1995; Janzen 1977; Mogbo et al. 2014; Onuh and Onyenekwe 2008). Lentil has the lowest weight losses, infestation levels and the highest germination rate. In fact, our results are in agreement with those described by Jackai and Asante (2003), Keba and Sori (2013), and Redden and McGuire (1983) who indicated that variables such as adult emergence, growth index, developmental period and weight loss are the most reliable indicators for resistance of cowpea to damage by *C. maculatus*.

In addition, Tadesse (1995) and Tefera et al. (2011) indicated that the extent of damage during storage depends on the number of emerging adults during each generation, the duration of each life cycle and host varieties. These authors

specified that varieties allowing more rapid and higher levels of adult emergence are more seriously damaged.

EIL is defined as the lowest population density of a pest that will cause economic damage or the amount of pest injury which will justify the cost of control. However, no economic studies were undertaken to assess the injury of *C. maculatus* on food legumes stored commodities in Tunisia. Earlier works by Mi et al. (1998), Pedigo et al. (1986), and Stern et al. (1959) reported that the EILis a basic component of decision making in pest management. Thus, this study will provide reasons for farmers and traders to make a decision to take a control action against *C. maculatus* during storage. Moreover, this work pointed out the variability of EIL with host legumes. Consequently, a complementary study on the economic threshold is required for a best postharvest management of *C. maculatus* populations.

To summarize, this study demonstrated that *C. maculatus*is a serious problem for food stored legumes in Tunisia, mainly chickpea. Therefore, an appropriate technical panel on the beetle pest status on various host legumes together with adequate control approaches is required either for farmers and traders. In addition, further studies are required to determine the extent of infestation and damage in fields.

RESUME

Haouel-Hamdi S., Titouhi F., Boushih E., Dhraief M.Z., Amri M. et Mediouni-Ben Jemâa J. 2017. Les traits démographiques et les paramètres reproductifs des populations des bruches du niébé *Callosobruchus maculatus* infestant la lentille et le pois chiche stockés .Tunisian Journal of Plant Protection 12: 67-81.

Cet article est une première étude exhaustive concernant le statut de nuisibilité du coléoptère du niébé *Callosobruchus maculatus* sur deux légumineuses alimentaires le pois chiche (Variété Amdoun 1) et la lentille (Variété Ncir) durant six mois de stockage. Les données relatives à la dynamique des populations, les traits démographiques, les paramètres reproductifs, les performances juvéniles et adultes, le niveau de nuisibilité économique et les dégâts (impact sur la germination et les pertes de poids) ont été étudiés à travers ce travail. Les résultats ont révélé que *C. maculatus* est un ravageur majeur du pois chiche stocké en Tunisie. En outre, les résultats ont montré une grande variation des paramètres biologiques ainsi que les performances juvéniles et adultes selon les hôtes. Dans ce contexte, l'analyse de la régression linéaire a démontré que les hôtes affectent significativement les performances des adultes de *C. maculatus*. Les résultats ont également prouvé que l'hôte contribue par 77% du poids corporel et 80% de la taille du corps. Les données des traits démographiques ont montré que le pois chiche apparait comme un hôte plus favorable que la lentille puisque les taux de mortalités des œufs et des larves ainsi que la durée d'une génération ont été supérieurs chez la lentille. De plus, des différences significatives ont été observées pour l'index de sensibilité aux attaques de *C. maculatus* des deux hôtes montrant ainsi que les graines du pois chiche sont modérément sensibles aux attaques tandis que les graines de lentille ne le sont pas. En outre, les résultats ont indiqué que *C. maculatus* induit des réductions significatives de la germination (pois chiche 78%, lentille 33% pour le taux d'infestation le plus élevé 80%) et le poids des graines (pois chiche 45%, lentille 8% après 6 mois de stockage) des deux hôtes et que les niveaux d'infestation et des pertes de poids diffèrent significativement selon la durée du stockage. En somme, cette étude fournit des arguments pour les agriculteurs et les commerçants pour entreprendre des décisions de lutte contre *C. maculatus* durant le stockage. En outre, ce travail révèle la variabilité des niveaux de nuisibilité économique selon les hôtes.

Mots clés: *Callosobruchus maculatus*, lentille, niveau de nuisibilité économique, paramètres reproductifs, performances juvéniles et adultes, pois chiche, traits démographiques

ملخص

حوال-حمدي، سمية وفاتن تيتوحي وآمنة بوصحيح ومحمد زياد ظريف ومعز عمري وجودة مديوني-بن جماعة. 2017. الصفات الديموغرافية والخصائص الإنجابية لمجتمعات حشرة خنفساء اللوبيا *Callosobruchus maculatus* التي تصيب العدس والحمص المخزنيْن. Tunisian Journal of Plant Protection 12: 67-81.

يقدم هذا المقال أول دراسة شاملة على وضعية أضرار خنفساء اللوبيا *Callosobruchus maculatus* على بقوليتين غذائيتين هما الحمص (الصنف عمدون 1) والعدس (الصنف نصير) خلال ستة أشهر من التخزين. تمت دراسة المعطيات المتعلقة بديناميكية مجتمعات الحشرة والصفات الديموغرافية والخصائص الإنجابية وكفاءات الطور اليرقي والطور البالغ ومستوى الضرر الاقتصادي والخسائر (تأثيرها علي الإنبات و فقدان الوزن). أثبتت النتائج أن خنفساء اللوبيا تمثل آفة حشرية مهمة على الحمص المخزن في تونس. بالإضافة إلي ذلك، أشارت النتائج إلى أن الخصائص الإنجابية وكفاءات الطور اليرقي والطور البالغ تتغير بصفة كبيرة حسب العائل. في هذا السياق، أظهرت تحاليل الانحدار الخطي أن العوائل تؤثر بطريقة معنوية علي خصائص الطور البالغ للخنفساء. بينت النتائج أن العائل يساهم بنسبة 77% في وزن الجسم وبنسبة 80% في حجم الجسم. أثبتت بيانات الصفات الديمغرافية أن الحمص يمثل العائل الأكثر ملائمة بالمقارنة مع العدس بما أن نسب وفيات طور البيض وطور اليرقة وطول مدة الجيل كانت الأعلى بالنسبة للعدس. لوحظت اختلافات معنوية بخصوص مؤشر القابلية لهجمات للخنفساء لدى العائليْن بما أن بذور الحمص أظهرت قابلية معتدلة للهجمات بينما بذور العدس لم تكن كذلك. من جهة أخرى، أشارت النتائج أن الخنفساء خفضت بشكل ملحوظ نسبة الإنبات للعائليْن (78% للحمص و33% للعدس بالنسبة إلى أعلى معدل إصابة 80%) ووزن البذور (45% للحمص و8% للعدس بعد ستة أشهر من التخزين) وأن نسبة الإصابة وفقدان الوزن يختلفان بشكل معنوي حسب مدة التخزين. في الخلاصة، وفرت هذه الدراسة الحجج للمزارعين والتجار لاتخاذ القرارات لمكافحة خنفساء اللوبيا خلال التخزين وإضافة إلى ذلك كشف هذا العمل عن الاختلاف في مستوى الضرر الاقتصادي بحسب العائل.

كلمات مفتاحية: حمص،خصائص إنجابية، صفات ديموغرافية،عدس،كفاءات الطور اليرقي والطور البالغ، مستوى الضرر الاقتصادي، *Callosobruchus maculatus*

LITERATURE CITED

Ajayi, F.A., and Lale, N.E.S. 2001. Susceptibility of unprotected seeds and seeds of local bambara groundnut cultivars protected with insecticidal essential oils to infestation by *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae). Journal of Stored Products Research 37: 47-62.

Anonymous, 1988. Conservation des grains en régions chaudes: Techniques rurales en Afrique, Centre d'Etude et d'Expérimentation du Machinisme Agricole et Tropical. Paris, France, 539 pp.

Bagheri, Z.E. 1996. Pests of stored products and their control methods (Injurious Coleopterans of Food and Industrial Products), Volume 1. Sepehre Publishing, Iraq, 309 pp.

Birch, L.C. 1948. The intrinsic rate of natural increase of an insect population. Journal of Animal Ecology 17: 15-26.

Booth, R.G., Cox, M.L., and Madge, B. 1990. IIE Guides to Insects of Importance to Man, 3 Coleoptera. CAB International Wallingford UK, Wallingford, UK, 384 pp.

Carey, J.R. 1993. Applied Demography for Biologists with special emphasis on insects. Oxford University Press, New York, USA, 206 pp.

Chi, H., and Liu, H. 1985. Two new methods for the study of insect population ecology. Bulletin of the Institute of Zoology Academia Sinica 24: 225-240.

Cope, J.M., and Fox, W.C. 2003. Oviposition decision in the seed beetle *Callosobruchus maculatus* (Coleoptera: Bruchidae): effects of seed size on superparasitism. Journal of Stored Products Research 39: 355-365.

Credland, P.F., Dick, K.M., and Wright, A.W. 1986. Relationship between larval density, adult size and egg production in the cowpea seed beetle *Callosobruchus maculatus*. Ecological Entomology 11: 41-50.

Desroches, P., El Shazly, E., Mandon, N., Duc, G., and Huignard, J. 1995. Development of *Callosobruchus chinensis* (L) and *C. maculatus* (F) (Coleoptera : Bruchidae) in seeds of *Vicia faba* L. differing in their tannin, vicine and convicine contents. Journal of Stored Products Research 31: 83-89.

Dobie, P., and Kilminster, A.M. 1977. The susceptibility of triticale to post-harvest infestation by *Sitophilus zeamais* Motschulsky, *Sitophilus oryzae* (L.) and *Sitophilus granarius* (L.). Journal of Stored Products Research 14: 87-93.

Fox, C.W., Bush, M.L., Roff, D.A., and Wallin, W.G. 2004. The evolutionary genetics of lifespan and mortality rates in two populations of the seed beetles, *Callosobruchus maculatus*. Heredity 92: 170-181.

Gaston, K.J., and Lawton, J.H. 1988. Patterns in body size, population dynamics, and regional distribution of bracken herbivores. The American Naturalist 132: 662-680.

Giga, D.P., and Canhao, J. 1997. Interspecies interference of oviposition behaviour in the cowpea weevils *Callosobruchus rhodesianus* (Pic) and *Callosobruchus maculatus* (F.). Insect Science and its Application 17: 251-255.

Gokhale, V.G. 1973. Developmental compatibility of several pulses in the bruchidae. Growth and development of *Callosobruchus maculatus* F. on host seeds. Bulletin of Grain Technology 11: 28-31.

Govindarajan, R., and Balasubramanian, M. 1981. Observations on the oviposition behavior of *Callosobruchus maculatus* (F.) and *C. chinensis* (L.) in relation to seed size. Journal of Entomological Research 5: 177-179.

Haouel, H.S., Hedjal, C.M., Kellouche, A., Khouja, M.L., Boudabous, A., and Mediouni, J.B.J. 2015. Management of three pests' population strains from Tunisia and Algeria using *Eucalyptus* essential oils. Industrial Crops and Products 74: 551-556.

Haouel, H.S., Mediouni J.B.J., Khouja M.L., and Boudabous A. 2012. Activité fumigène de trois huiles essentielles d'*Eucalyptus* contre les adultes de *Callosobruchus maculatus* Fabricius. Page 96. In: Troisième Journées Scientifique sur la Valorisation des Bioressources. May 5-6, 2012, Monastir, Tunisia.

Iturralde-García, R.D., Borboa-Flores, J., Cinco-Moroyoqui, F.J., Riudavets, J., Toro-Sánchez, C.L.D., Rueda-Puente, E.O., Martínez-Cruz, O., and Wong-Corral, F.J. 2016. Effect of controlled atmospheres on the insect *Callosobruchus maculatus* Fab. in stored chickpea. Journal of Stored Products Research 69: 78-85.

Jackai, L.E.N., and Asante, S.K. 2003. A case for the standardization of protocols used in screening cowpea, *Vigna unguiculata* for resistance to *Callosobruchus maculatus* F. (Coleoptera: Bruchidae). Journal of Stored Products Research 39: 251-263.

Janzen, D.H. 1977. How southern cowpea weevil larvae (Bruchidae *Callosobruchus maculatus*) die on non-host seeds. Ecology 58: 921-927.

Jarraya, A. 2003. Principaux nuisibles des plantes cultivées et des denrées stockées en Afrique du Nord. Leur Biologie, leurs ennemies naturels, leurs dégâts et leur contrôle. Climat PubEditions, Tunis, Tunisia, 415 pp.

Kawecki, T.J. 1997. Habitat quality ranking depends on habitat- independent environmental factors: a model and results from *Callosobruchus maculatus*. Functional Ecology 11: 247-254.

Kawecki, T.J., and Mery, F. 2003. Evolutionary conservation of geographic variation in host preference in *Callosobruchus maculatus*. Ecological Entomology 28: 449-456.

Kazemi, F., Talebi, A.A., Fathipour, Y., and Farahani, S. 2009. A comparative study on the effect of four leguminous species on biological and population growth Parameters of *Callosobruchus maculatus* (F.) (Col.: Bruchidae). Advances in Environmental Biology 3: 226-232.

Keba, T., and Sori, W. 2013. Diffential resistance of maize varieties to maize weevil (*Sitophilus zeamais* Motschulsky) (Coleoptera: Curculionidae) under laboratory conditions. Journal of Entomology 10: 1-12.

Kedia, A., Prakash, B., Mishra, P.K., Singh, P., and Dubey, N.K. 2015. Botanicals as ecofriendly biorational alternatives of synthetic pesticides against *Callosobruchus* spp. (Coleoptera: Bruchidae) a review. The Journal of Food Science and Technology 51: 2210-2215.

Khanamani, M., Fathipour, Y., and Hajiqanbar, H., 2013. Population growth response of *Tetranychus urticae* to eggplant quality: Application of female age-specific and age-stage, two-sex life tables. International Journal of Acarology 39: 638-648.

Loganathan, M., Jayas, D.S., Fields, P.G., and White, N.D.G. 2011. Low and high temperatures for the control of cowpea beetle, *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) in chickpeas. Journal of Stored Products Research 47: 244-248.

Mabrouk, Y., and Belhadj, O. 2012. Integrated pest management in chickpea. Pages 19-38. In: New perspectives in plant protection. INTECH <www.intechopen>. DOI: 10.5772/35487

Melo, B.A.D., Molina-Rugama, A.J., Haddi, K., Leite, D.T., and Oliveira, E.E.D. 2015.

Repellency and bioactivity of *Caatinga Biome* plant powders against *Callosobruchus maculatus* (Coleoptera: Chrysomelidae: Bruchidae). Florida Entomologist 98: 417-423.

Messina, F.J. 1991. Life-history variation in a seed beetle: adult egg-laying vs. larval competition ability. Oecologia 85: 447-455.

Messina, F.J., and Slade, A.F., 1997. Inheritance of host-plant choice in the seed beetle *Callosobruchus maculatus* (Coleoptera: Bruchidae). Annals of the Entomological Society of America 90: 848-855.

Metz, J.A.J., Mylius, S.D., and Diekmann, O. 2008. When does evolution optimize? Evolutionary Ecology Research 10: 629-654.

Meyer, J.S., Ingersoll, C.G., McDonald, L.L., and Boyce, M.S. 1986. Estimating uncertainly in population growth rate: Jackknife vs bootstrap techniques. Ecology 67: 1156-1166.

Mi, S., Danforth, N.P., Tugwell, N.P., and Cochran M.J. 1998. Plant-based economic injury level for assessing economic thresholds in early-season cotton. Journal of Cotton Science 2: 35-52.

Mogbo, T.C., Okeke, T.E., and Akunne, C.E. 2014. Studies on the Resistance of cowpea seeds (*Vigna unguiculata*) to weevil (*Callosobruchus maculatus*) infestations. American Journal of Zoological Research 2: 37-40.

Obopile, M., Masiapeto, K., and Gwafila, C. 2011. Variation in reproductive and developmental parameters of *Callosobruchus maculatus* (F) reared on ten Botswana cowpea landraces. African Journal of Biotechnology 10: 13924-13928.

Ofuya, T.I., and Agele, S.O. 1990. Ability of ovipositing *Callosobruchus maculatus* (Fabricius) (Coleoptera: Bruchidae) females to discriminate between seeds with differing numbers of emergence holes. Journal of Stored Products Research 26: 117-120.

Oke, O.A., and Akintunde, E.M. 2013. Reduction of the nutritional values of cowpea infested with *Callosobruchus maculatus* (Coloeptera: Bruchidae). International Journal of Agriculture Sciences 3: 30-36.

Onuh, M.O., and Onyenekwe, R.I. 2008. Assessment of inhibitory substances in the seed coat of some cowpea cultivars for resistance against *Callosobruchus maculatus*. The Scientific World Journal 3: 15-19.

Pedigo, K.P., Hutchins, S.H., and Higley, L.G. 1986. Economic injury levels in theory and practice. The Annual Review of Entomology 31: 341-368.

Peters, R.H. 1983. The Ecological Implications of Body Size. Cambridge University Press, Cambridge, UK, 329 pp.

Redden, R.J., and McGuire, J. 1983. The genetic evaluation of bruchid resistance in seeds of cowpea. The Australian Journal of Agricultural Research 34: 707-715.

Savalli, U.M., and Fox, C.W. 1999. The effect of male mating history on paternal investment fecundity and female remating in the seed beetle *Callosobruchus maculatus*. Functional Ecology 13: 169-177.

Savalli, U.M., Czesak, M.E., and Fox, C.W. 2000. Paternal investment in the seed beetle, *Callosobruchus maculatus* (Coleoptera: Bruchidae): variation among populations. Annals of The Entomological Society of America 93: 1173-1178.

Sibly, R.M., Smith, R.H., and Moller, H. 1991. Evolutionary demography of a bruchid beetle. IV. Genetic trade-off, stabilizing selection and a model of optimal body size. Functional Ecology 5: 594-601.

Smith, R.H., and Lessells, C.M. 1985. Oviposition, ovicide and larval competition in granivorous insects. Pages 423-448. In: Behavioural Ecology: Ecological consequences of adaptive behaviour, Blackwell Scientific Publications, Oxford, UK.

Staneva, E. 1982. Studies on the food plants of the cowpea weevil *Callosobruchus maculatus* (Coleoptera: Bruchidae). Rasteniev'dni Nauki 19: 111-119.

Stern, V.M., Smith, R.F., Van Den Bosch, R., and Hagen, K.S. 1959. The integrated control concept. Hilgardia 29: 81-101.

Swella, G.B., and Mushobozy, D.M.K. 2009. Comparative susceptibility of different legume seeds to infestation by cowpea bruchid *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae). Plant Protection Science 45: 19-24.

Tadesse, A. 1995. Insects and other arthropods recorded from stored maize in Western Ethiopia. African Crop Science Journal 4: 339-343.

Tefera, T.M., Mugo, S., Ikhayo, P., and Tende, R. 2011. Effects of insect population density and storage time on grain damage and weight loss in maize due to the maize weevil *Sitophilus zeamais* and the larger grainborer *Prostephanus truncatus*. African Journal of Agricultural Research 6: 2249-2254.

Van Huis, A., and De Roy, M. 1998. The effect of leguminous plant species on *Callosobruchus maculates* (Coleoptera: Bruchidae) and its egg parasitoid *Uscana lariophaga* (Hymenoptera: Trichogrammatidae). Bulletin of Entomological Research 88: 93-99.

Wijeratne, P.M. 1998. Variation in egg and adult production of *Callosobruchus maculatus* (F.)

and *Callosobruchus chinensis* (L.) and the effect of egg density and oviposition site limitation. Tropical Agricultural Research and Extension 1: 136-142.

William, D., and Kirk, J. 1991. The size relationship between insects and their hosts. Ecological Entomology 16: 351-359.

Win, S.S., Muhamad, R., Mior, A.Z.A., and Azura, N.A. 2011. Life Table and Population Parameters of *Nilaparvata lugens* Stal. (Homoptera: Delphacidae) on Rice. Tropical Life Sciences Research 22: 25-35.
