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Study of Some Biodemographic Parameters of *Caryedon serratus* Olivier (Coleoptera: Chrysomelidae) Insect Pest of Tamarind (*Tamarindus indica* Lin.) Fruit, in Burkina Faso

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Abstract

The lack of food security leads us to turn to the riches of the forest, namely non-timber forest products (NTFP) and timber forest products (TFP). In Burkina, these products are a source of income for families, improving their living conditions. *Tamarindus indica* L. that is a NFTP, is widely used in both rural and urban areas. Unfortunately, tamarind is subject to attack by *Caryedon serratus*. Its biological activity begins on the fruit before the harvest. The aim of our study is to evaluate some biodemographic parameters of the insect pest *C. serratus* Olivier. First100 healthy *T. indica* pods were placed in contact with ten pairs of *C. serratus* for 24 hours. 25 pods, each carrying a maximum of two eggs, were divided into five batches of 5 pods. Then a pair of *C. serratus* aged less than 24 h was placed in contact with 4 healthy pods for 24 h. Every day, the pair was removed and transferred to another box containing 4 new healthy pods. A total of 20 replicates were performed. The results showed that *C. serratus* has an average lifespan of 14 days. However, the female (16 days) lived longer and laid an average of 34 eggs during her lifetime. The egg-laying period lasted 14 days, the number of eggs increased until reaching a maximum peak on the 4th day. *C. serratus* has an embryonic development time of 3 days and an emergence rate of 66.63%. However, the weight of males and females differed significantly (p = 0.0108). We found an intrinsic rate of natural increase of 0.12 and a population doubling time was 5.68 days. These results have enabled us to gain a better understanding of its development cycle and its capacity for regeneration. This allows us to implement control strategies for better stock protection.

Keywords

Biodemographic Parameters, Stock, *Caryedon serratus*, *Tamarindus indica*

1. Introduction

Nearly 690 million people suffer from hunger worldwide with an increase of 60 million over the past five years [1] [2]. In 2021, 924 million people suffered from a lack of food security, including 322 million in Africa [3]). This difficult situation leads us to reflect on the possible contribution of NTFPs to food self-sufficiency. For example, tamarind fruits (*Tamarindus indica* L.) are non-timber forest products (NTFPs) from the Caesalpinioideae subfamily, which could be a source of food and income for people in Africa. Indeed, almost all parts of the tree are used [4]; the ripe fruit of the sweet type is usually eaten fresh, while the sour (acidic) fruits are processed into juice, jam, syrup and sweets.

However, in Burkina Faso, tamarind as many legumes [5] [6] [7] is damaged during storage. *Caryedon serratus* Olivier is one of the main pests of *T. indica*, causing huge losses to stocks [8]. The rate of seed germination could be greatly reduced as a result of insect activity [9], which could hinder the plant's natural regeneration. Control methods have been put in place to protect stocks. The methods applied in Burkina Faso by some growers, such as the use of pick bags and steaming of *T. indica* fruits [10], are not applied to large stocks. In addition to knowledge of the problem of *T. indica* seed storage in the farming environment, we also need to know something about the life cycle of this insect. [11] [12] assert that knowledge of fecundity, development time, longevity, average weight of first-generation individuals and adult sex ratio of an insect pest is more than necessary to develop effective control methods for commodity protection. Our study on the biodemographic parameters of *C. serratus* is part of the same dynamic in order to provide alternatives for better preservation of *T. indica* pods.

2. Material

2.1. Study Conditions

The study was carried out in Laboratoire d'Entomologie Fondamentale et Appliquée (LEFA) of Université Joseph KI-ZERBO (Ouagadougou, Burkina Faso). The mean temperature was 27.51˚C ± 2.34˚C and relative humidity ranged to 46.76% ± 15.27%. The duration of the experiment was 80 days.

2.2. Animal Material

The animal material used was *C. serratus* individuals from Manga's zone. This strain of *C. serratus* was isolated from naturally infested *T. indica* pods in this zone. These strains were maintained through successive rearing on tamarind from the same area in the Laboratoire d'Entomologie Fondamentale et Appliquée (LEFA) of Université Joseph KI-ZERBO Université (Ouagadougou, Burkina Faso).

2.3. Plant Material

The plant material used for this study consisted of *T. indica* pods. These tamarind pods were purchased with the women in the Manga's zone. Once transported in the laboratory, *T. indica* pods were first sorted to exclude those with holes or rotting. They were then placed in a freezer at −18˚C in the Laboratoire d'Entomologie Fondamentale et Appliquée (LEFA) of Université Joseph KI-ZERBO Université (Ouagadougou, Burkina Faso) in order to eliminate any previous infestation.

3. Methodology

3.1. Embryonic Development

100 healthy *T. indica* pods were placed in contact with ten pairs of *C. serratus* for 24 hours for oviposition. The adults were then removed and 25 pods, each carrying a maximum of two eggs, were distributed in 450 ml dishes, in five batches of 5 pods each, in 5 replicate. The batches of pods thus formed were placed in incubation until the embryo appears inside the chorion. The boxes were daily removed and the pods they contained were individually observed under a Leica binocular loupe to count the number of eggs containing an embryo. The pods carrying these eggs were then removed from the boxes. The incubation time during this study was 13 days. The embryonated egg shows a reddish spot representing the embryo's head capsule.

3.2. Reproductive Potential of *C. serratus*

As soon as the new generation of insects appeared, a pair of *C. serratus* aged less than 24 h was placed in contact with 4 healthy pods for 24 h in a 450 ml dish. Every day, the pair was removed and transferred to another box containing 4 new healthy pods until the female died. All boxes were then incubated in the laboratory at a temperature of 27.51˚C ± 2.34˚C and relative humidity of 46.76% ± 15.27%. A total of 20 replicates were carried out in order to increase the precision and validity of the significance test. After the withdrawal of each pair, the eggs laid daily by the female were counted; the number of hatched and unhatched eggs was also counted daily until the end of hatching. The hatched egg was whitish in color, while the unhatched egg remained translucent [13]. From the onset of emergence until the end, the males and females emerging each day were counted and removed from each box.

Thirty newly-emerged males and thirty newly-emerged females were weighed using a OHAUS brand sensitive scale; their size was also measured using software associated with a LEICA magnifying glass. The number of cocoons formed and the number of larvae unable to weave a cocoon were counted.

A pod can be considered healthy when it is neither damaged nor contains another form of life (eggs, larvae or insects).

At the end of monitoring, the following parameters are evaluated:

- **Development time:** This is the time between the egg-laying and its emergence as an adult. It is estimated using the following equation:

$$DD = \frac{\Sigma nixi}{\Sigma xi}$$

xi: number of insects emerging per day; *ni*: corresponding number of days.

- **Intrinsic rate of natural increase (r)**: It is the rate of population growth attributable to the natural movement of the population. It was obtained through the equation of [14].

$$r = \frac{\ln(NS)}{T + 1/2L}$$

L = female lifespan; *N* = average number of eggs laid per female; *S* = larval survival rate; *T* = development time; ln = natural logarithm.

- **Generation time (GT)**: It reflects the average time between two consecutive generations in the genealogy of a population. It is estimated by the formula of [15].

GT = T (development time) + average age of a female when all her eggs are laid.

- **Population doubling time (D.T.)**: It is the time required for the population to double in size, it was determined by using [16] formula.

$$D.T = \frac{\ln 2}{\text{r}}$$

3.3. Statistical Analysis

The data collected was entered into the Excel 2016 spreadsheet, which was used to make various graphics. Statistical processing of the data was carried out using R software, 4.1.0 version. Statistical tests were performed according to the scheme proposed by [17].

We first performed a normality test followed by a homogeneity test for all measured variables. Thus, we performed Student's t-test to compare adult lifespan, number of emerged individuals, height and weight of emerged individuals as a function of sex. The significance level was 5%.

4. Results

4.1. Average Longevity of *C. serratus* Adults

The average lifespan of *C. serratus*, all sexes combined, was 14 days. However, the average lifespan differed significantly according to sex ($t^{1;38} = 2.33$, $P = 0.025$). Females lived longer, with an average lifespan of around 16 days, compared with males, who averaged around 13 days (**Figure 1**).

4.2. Average Number of Eggs Laid, Hatching Rate

The eggs laid measure around 1 mm in length and 0.57 mm in width (**Table 1**).

These eggs were deposited on pods averaging 6.66 g and 16.59 cm thick.

The average number of eggs laid by *C. serratus's* female during her lifetime was around 34 (**Table 2**). With a hatching rate of 89.28 ± 9.76, the average number of infertile eggs is 3.85.

4.3. Daily Fecundity of *C. serratus*'s Female

C. serratus's female laid an average of two eggs on the first day. The number of eggs laid increases until it reaches a maximum peak on the 4th day, then gradually decreases until day 14, after which no more eggs were laid (**Figure 2**).

4.4. Development Time and Parameters of *Caryedon serratus*

It is estimated that 66.63% of eggs laid gave rise to adults, *i.e.* 22 individuals per female. This means that 17.12% of larvae from *C. serratus* eggs failed to reach the adult stage and thus died at the larval stage (**Table 3**). We can see that the

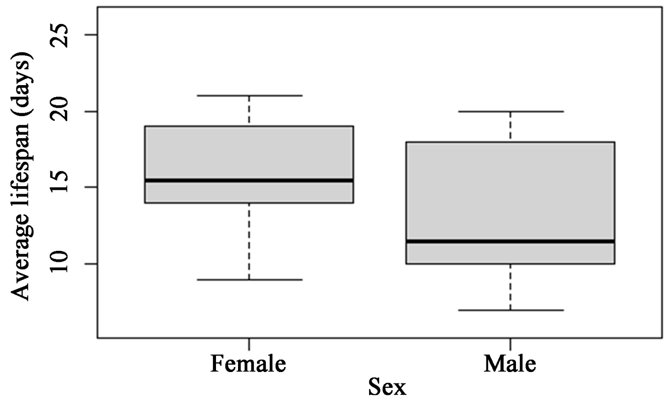

Figure 1. Average longevity of *C. serratus* males and females.

Table 1. Physical Characteristics of eggs and seeds.

	Parameters	Mean ± stand. dev.
Eggs	Length (mm)	1 ± 0.06
	Width (mm)	0.57 ± 0.04
Seeds	Thickness (mm)	165.9 ± 5.59
	Length (mm)	931.8 ± 17.56
	weight (g)	6.66 ± 1.91

Table 2. Hatching rate, number of hatched et sterile eggs.

Parameters	Mean ± stand. dev.
Number of eggs	33.65 ± 10.58
Number of hatched eggs	29.85 ± 9.01
Number of sterile eggs	3.85 ± 3.72
Hatching rate (%)	89.28 ± 9.76

embryo is established as early as the 3rd day, and the incubation time extends over 9 days. The total development of *C. serratus* in our study took around 64 days (Table 3).

4.5. Development Time, Average Percentages of Cocooned Larvae, Larvae Dead Inside the Seed and Larvae Unable to Weave a Cocoon

When larvae reached the 4th stage, they used the seed to weave a cocoon to complete their development cycle. While 83% of larvae from hatched eggs were able to weave cocoons, the remainders were unable to continue their development, *i.e.* around 8% died inside the seed and 9% outside (Table 4).

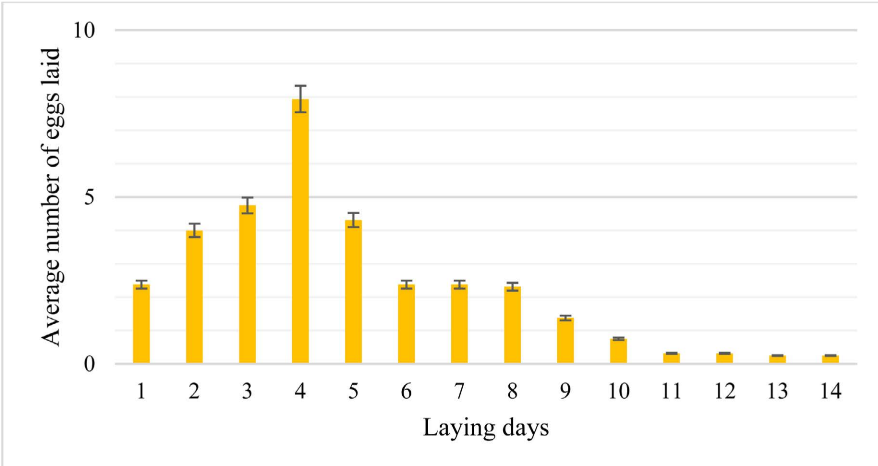

Figure 2. Evolution of the average number of eggs laid per day by a female *C. serratus* over her lifespan.

Table 3. Emergence and mortality rates.

Development parameters		Duration of development stages	
Eggs mortality rate	10.87 ± 9.61	Embryonic	3.07 ± 0.25
Larval mortality rate	17.12 ± 9.62	Incubation	9 ± 1.91
Nymphal mortality rate	10.60 ± 7.73	Larval	28.34 ± 1.23
Emergence rate	66.63 ± 16.44	Pupation	23.02 ± 1.41
		Total	63.43 ± 2.25

Table 4. Average percentages of larvae that weaved a cocoon, larvae that died inside the seed and larvae that were unable to weave a cocoon.

Parameters	Mean number (±standard deviation)	Mean percentage (±deviation standard)
Larvae able to weave a cocoon	24.75 ± 8.28	82.74 ± 9.47
Dead larvae inside the seed	2.45 ± 2.33	7.82 ± 7.71
Dead larvae outside the seed	2.65 ± 1.23	9.43 ± 5.17

4.6. Monotoring of Larvae after Cocoon Formation

88.69% of the larvae that were able to weave a cocoon were able to complete their development by emerging to give birth to adults (Figure 3). However, 11.31% were unable to reach the last phase of their development and thus died inside the cocoons. Cocoons formed by *C. serratus* larvae average 6.78 mm in length and 4.19 mm in width.

4.7. Sex Ratio, Number of Individuals of Different Sexes Emerged and Variation in Weight and Size

Analysis of Table 5 shows that there was no significant difference between the number of males and females emerged; however, there was a sex ratio of 0.96 in favor of females. However, the weight and size of the females resulting from this emergence differed significantly from those of the males.

4.8. Growth Parameters

With a generation time of around 79 days, *C. serratus* population doubles in size in 5.68 days, for an intrinsic rate of natural increase of 0.12 (Table 6).

Figure 3. Average percentage of larvae that have died in cocoons or given birth to adults.

Table 5. Sex ratio, number of emerged individuals and variation in mean weight and size.

Parameters	Male	Female	p-Value
Number of individuals emerged (mean ± stand. dev.)	10.2 ± 3.58^{A}	11.75 ± 4.96^{A}	0.264
Weight (mg) (mean ± stand. dev.)	22.03 ± 5.86^{B}	26.34 ± 6.78^{A}	0.0108
Length (mm) (mean ± stand. dev.)	6.57 ± 0.64^{B}	7.18 ± 0.47^{A}	0.000114
Sex ratio		0.96 ± 0.41	

The means followed by different alphabetic letters in the same lines are significantly different ($P < 0.05$, Student Newmann Keuls's test).

Table 6. Growth parameters

Parameters	Mean (±standard deviation)
Intrinsic rate of natural increase (Rm)	0.12 ± 0.01
Generation time (GT) (jours)	79.33 ± 4.26
Population doubling time (DT) (jours)	5.68 ± 0.34

5. Discussion

Our study shows that *C. serratus* is able to complete its development cycle on *T. indica* pods. The male's lifespan is quite shorter than the female's (around 16 days). The same trend was observed by [18] [19] on *C. serratus*. Similarly, in *Caryedon furcatus*, [20] observed a higher female longevity. *C. serratus* females laid their eggs for 14 days, with a peak on the 4th day. This oviposition period is similar to that observed by [19] [21], who also observed a peak in oviposition on the same date. Our results showed that the female laid an average of 33 eggs during her lifetime on pods averaging 6.66 g and 16.59 cm thick. The eggs laid in our experiment measured around 1 mm in length and 0.57 mm in width, and had a hatching rate of 89.28 ± 9.76. The fecundity of the female in this study is lower than that obtained by [22], who conducted their activity under a temperature of 29˚C and a relative humidity of 53% to 86%. Thus, the male *C. serratus* lived longer than the female, which laid 80 eggs on average, leading us to think, as [23] do, that egg-laying activity reduces the lifespan of females due to the energy they expend. Also, the fact that the female spends time searching for an unoccupied host would cost her a great deal of energy, leading to her death according to [24] in the case of *Callosobruchus maculatus* female. As adults do not feed, it is the reserves accumulated during the larval stage that they use throughout their lives ([25]. We can therefore assume that the females used in our study would have more reserves than the males. Our observation also revealed that 66% of eggs laid gave rise to adults, *i.e.* 22 individuals per female. Thus, 25.60% of larvae from *C. serratus* eggs died at the larval stage, as they were unable to weave cocoons. Larvae that have reached the 4th stage emerged from the seeds to weave *C. serratus* cocoons for pupation ([26], although some larvae may weave cocoons inside the seed. This low rate of emergence is due to larval mortality caused by inter-larval competition, caused by the supernumerary population of larvae in the seeds. This situation led to a shortage of food resources, as we only introduced 4 pods into each box. The same observation was made by [27] on *C. maculatus* and by [28] on *Bruchidius atrolineatus*. We found a significant difference between the height and weight of *C. serratus* males and females. This greater size and weight in females could be physiological, enabling them to perform their egg-laying function. No difference was observed between the numbers of male and female populations. However, the sex ratio favors the female. Similar results have been observed by authors such as [29] on *Rhyzopertha dominica*, [30] on *Spermophagus niger* and [31] on *C. furcatus*. It appears that the embryonic duration lasted 3 days and the total development duration was 63 days for our study, which is higher than that the fundings of [22] who obtained a duration of 52 days. [21] also found an average lifespan of 55 days under conditions of 30˚C and 65% relative humidity. Furthermore, the larval lifespan (around 28 days) was roughly similar to that obtained by [22] which was around 29 days. The average time between the birth of the parents and that of their offspring in this study is 79 days. Like the total development time, this generation time in our study is quite long. This has an impact on the population duplication time, which is 5.68 days. Hence a natural growth rate equal to 0.12.

6. Conclusion

The observations made at the end of our study show that *C. serratus* can complete its development cycle on *T. indica*. The sex ratio is in favor of the female, allowing the species to remain in the stock. After hatching, the first-instar larva starts feeding on the seeds, causing damage to the pods. When the larva reaches the fourth instar, it leaves the seed to weave a cocoon. At the end of metamorphosis, the insect thus formed pierces the cocoon to emerge. Despite the losses observed at each stage of its development, *C. serratus* manages to cause damage to the fruit, as emerged adults lay eggs on the pods, perpetuating a new cycle. In view of the damage caused by *C. serratus* to tamarind stocks, if no protective measures are taken to thwart this insect, it could gradually lead to the disappearance of this tree, and therefore of these fruits.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] FAO, FIDA, UNICEF, PAM et OMS (2020) L'état de la sécurité alimentaire et de la nutrition dans le monde 2018. Renforcer la résilience face aux changements climatiques pour la sécurité alimentaire et la nutrition. https://doi.org/10.4060/cb5409fr

[2] Laborde, D., Parent, M. et Smaller, C. (2020) Éradiquer la faim, accroître les revenus et protéger le climat: Combien cela coûterait-il aux donateurs? Ceres2030. Institut international du développement durable (IISD) et Institut international de recherche sur les politiques alimentaires (IFPRI).

[3] FAO, IFAD, UNICEF, WFP et WHO (2022) The State of Food Security and Nutrition in the World. Repurposing Food and Agricultural Policies to Make Healthy Diets More Affordable. Rome.

[4] Garba, A., Amani, A., Laouali, A. and Ali M. (2019) Perceptions et usages socioéconomiques du tamarinier dans le Sud-Ouest du Niger: Implication pour une domestication et une conservation durable. *Journal of Animal & Plant Sciences*, **40**, 6584-6602

[5] Kam, K.W. (2019) Valorisation des parasitoïdes de bruches (Coleoptera: Bruchinae, Chrysomelidae) dans la lutte contre les déprédateurs de niébé, *V. unguiculata* (L.) Walp. en stockage au Burkina Faso. Master's Thesis, Université Joseph KI-ZERBO, Ouagadougou.

[6] Kam, K.W., Ilboudo, Z., Waongo, A. and Sanon, A. (2020) Potential of Five Wild Legume Species as Alternative Rearing Substrates of *Uscana lariophaga* Stef. (Hymenoptera: Trichogrammatidae), a Promising Biocontrol Agent of Bruchids Pest of Cowpea in West Africa. *Journal of Entomology and Zoology Studies*, **8**, 741-747. https://doi.org/10.22271/j.ento.2020.v8.i3l.6837

[7] Yamkoulga, M. (2019) Entomofaune et gestion post-récolte des graines d'*Acacia*

macrostachya Eeichenb. Ex Dc. dans la province du Boulkiemdé au Burkina Faso. Master's Thesis, Université Joseph KI-ZERBO, Ouagadougou.

[8] Yusuf, S.R., Ado, R.A., Sule, H. and Wudil, B.S. (2019) Infestation and Damage by *Caryedon serratus* (Olivier) Weevil on Stored *Tamarindus indica* (Linneaus) Fruits in Kano State, Nigeria. *Asian Journal of Advanced Research and Reports*, **5**, 1-10. https://doi.org/10.9734/ajarr/2019/v5i330134

[9] Schelin, M., Mulualem, T., Ingalill, E., Sawadogo, L. and Per Christer, O. (2004) Predispersal Seed Predation in Acacia Macrostachya, Its Impact on Seed Viability, and Germination Responses to Scarification and Dry Heat Treatments. *New Forest*, **27**, 251-267. https://doi.org/10.1023/B:NEFO.0000022225.75095.41

[10] Ki, K.F.M., Kam, K.W., Kambou, S.F., Dingtoumda, O.G., Sanon, A. and Ilboudo, Z. (2023) Perception on Post-Harvest Practices and Storage Constraints of Tamarind Fruits, *Tamarindus indica* L. in the Hauts Bassins and Centre Regions of Burkina Faso. *International Journal of Innovation and Applied Studies*, **40**, 723-734.

[11] Park, S.H., Arthur, F.H., Bean, S.R. and Schober, T.J. (2008) Impact of Differing Population Levels of *Rhyzopertha dominica* (F.) on Milling and Physicochemical Properties of Sorghum Kernel and Flour. *Journal of Stored Products Research*, **44**, 322-327. https://doi.org/10.1016/j.jspr.2008.02.008

[12] Chijindu, E.N., Boateng, B.A., Ayertey, J.N., Cudjoe, A.R. and Okonkwo, N.J. (2008) The Effect of Processing Method of Cassava Chips on the Development of *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae*). African Journal of Agricultural Research*, **3**, 537-541.

[13] Delobel, A., Tran, M. and Sembène, M. (2000) Influence du choix alimentaire sur la fécondité et le développement larvaire des Caryedon des légumineuses (Coleoptera: Bruchidae) au Sénégal. *Annales de la Société entomologique de France*, **36**, 61-73.

[14] Giga, D.P. and Smith, R.H. (1983) Comparative Life History Studies of Four Callosobruchus Species Infesting Cowpeas with Special Reference to *Callosobruchus maculatus* Fab. (Coleoptera: Bruchidae). *Journal of Stored Products Research*, **19**, 189-198. https://doi.org/10.1016/0022-474X(83)90007-3

[15] Tricault, T.Y. (1995) Influence de la température et de l'hygrométrie sur l'évolution du système hôte-parasitoïde: Cas des espèces tropicales Callosobruchus maculatus et Dinarmus basalis. Rapport de D.E.A., Université François Rabelais, Tours.

[16] Ndoutoume-Ndong, A. (1996) Capacités parasitaires et plasticité comportementale de deux Hyménoptères Eupelmidae (Eupelmus orientalis et Eupelmus vuilleti) partenaires de la communauté parasitaire des stades larvaires et nymphaux de Callosobruchus maculatus (Coléoptère Bruchidae). Thèse de Doctorat, Université François Rabelais de Tours, Tours.

[17] Hervé, M. (2016) Aide-mémoire de statistique appliquée à la biologie: Construire son étude et analyser les résultats à l'aide du logiciel R. https://cran.r-project.org/doc/contrib/Herve-Aide-memoire-statistique.pdf

[18] Calderon, M., Donahaye, E. and Navarro, S.C. (1966) The Life Cycle of the Groundnut Seed Beetle, *Caryedon serratus* (OL.), in Israel. *The Israel Journal of Agricultural Research*, **17**, 145-148.

[19] Ndiaye, S. (1991) La bruche de l'arachide dans un écosystème du Centre-Ouest du Sénégal: Contribution à l'étude de la contamination en plein champ et dans les stocks de l'arachide (*Arachis hypogea* L.) par *Caryedon serratus* (01.); rôle des légumineuses hôtes sauvages dans le cycle de cette bruche. Master's Thesis, Université de Pau et des Pays de l'Adour, Pau.

[20] Yamgoulga, M., Waongo, A., Traoré, F., Ilboudo, Z. and Sanon, A. (2021) Some Bi-

ological Parameters of *Caryedon furcatus* (Anton & Delobel) (Coleoptera: Chrysomelidae), Developing on the Seeds of *Senegalia macrostachya* (Reichenb. Ex DC.) Kyal. & Boatwr. (Fabales: Mimosaceae), an Edible Wild Legume in Burkina Faso. *African Entomology*, **29**, 395-404. https://doi.org/10.4001/003.029.0395

[21] Alias, E. (1999) Technologie Post-Récolte de l'arachide: Rapport d'expérimentation 1998, ISRA/CIRAD-CA. https://agritrop.cirad.fr/6443/1/ID6443.pdf

[22] Ouedraogo, I., Hema, S.A.O., Guenda, W. and Dakouo, D. (2016) Influence of Host Plants on the Development of *Caryedon serratus* Olivier (Coleoptera: Chrysomelidae, Bruchinae), Insect Pest of Groundnut Stocks in Burkina Faso. *Advances in Entomology*, **4**, 279-292. https://doi.org/10.4236/ae.2016.45029

[23] Nguyen, D.T., Hodges, R.J. and Belmain, S.R. (2008) Do Walking Rhyzopertha Dominica (F.) Locate Cereal Hosts by Chance? *Journal of Stored Products Research*, **44**, 90-99. https://doi.org/10.1016/j.jspr.2007.06.008

[24] Davey, P.M. (1958) The Groundnut Bruchid, *Caryedon gonagra* (F.). *Bulletin of Entomological Research*, **49**, 385-404. https://doi.org/10.1017/S0007485300053694

[25] Stolk, C., Stein, A., Slumpa, S.K. and Van Huis, A. (2001) Exploring the Foraging Environment of a Natural Enemy of *Callosobruchus maculatus*: Spatial Egg Distribution in Stored Cowpea. *Entomologia Experimentalis & Applicata*, **101**, 167-181. https://doi.org/10.1046/j.1570-7458.2001.00901.x

[26] Huignard, J., Glitho, A.I. and Sembène, M. (2011) L'infestation des cultures puis des stocks de graines par les Coléoptères Bruchinae: Insectes ravageurs des graines de légumineuses; Biologie des Bruchinae et lutte raisonnée en Afrique. Editions Quae, Versailles, 33-64.

[27] Zannou, E.T. (2000) Analyse de quelques paramètres biologiques pour une meilleure connaissance des capacités reproductrices d'une souche béninoise de *Callosobruchus maculatus* F. (Coleoptera: Bruchidae): Caractérisation et importance de la diapause reproductrice chez les femelles du morphe voilier. Master's Thesis, University of Lomé, Lomé.

[28] Desroches, P. and Huignard, J. (1991) Effect of Larval Density on Development and Induction of Reproductive Diapause in *Bruchidius atrolineatus*. *Entomologia Experimentalis et Applicata*, **61**, 255-263. https://doi.org/10.1111/j.1570-7458.1991.tb01558.x

[29] Waongo, A. (2016) Insectes ravageurs des stocks de sorgho (*Sorghum bicolor* [L.] Moench) en zone Nord-soudanienne du Burkina Faso: Bioécologie et stratégies de lutte contre *Rhyzopertha dominica* F. (Coleoptera: Bostrichidae). Master's Thesis, Université Joseph KI-ZERBO du Burkina Faso, Ouagadougou.

[30] Koussoubé, J.C. (2018) Spermophagus niger Motschulsky (Coleoptera: Chrysomelidae: Bruchinae: Amblycerini), ravageur des graines d'oseille (*Hibiscus sabdariffa* L.) en stockage au Burkina Faso: Caractérisation génétique et morphologique, bioécologie et ébauche de lutte. Master's Thesis, Université Joseph KI-ZERBO du Burkina Faso, Ouagadougou.

[31] Yamkoulga, M., Waongo, A., Ilboudo, M.E., Traore, F., Dabire-Binso, C.L. and Sanon, A. (2020) Perceptions des pratiques et contraintes post-récoltes chez les producteurs des principales legumineuses cultivées en zone sud-soudanienne du Burkina Faso. https://www.researchgate.net/publication/344728552_PERCEPTIONS_DES_PRATIQUES_ET_CONTRAINTES_POST-RECOLTES_CHEZ_LES_PRODUCTEURS_DES_PRINCIPALES_LEGUMINEUSES_CULTIVEES_EN_ZONE_SUD-SOUDANIENNE_DU_BURKINA_FASO