

Inventory, Geographical Distribution of *Caryedon* Species in Burkina Faso, and Evaluation of Their Impact on Stored Groundnut

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Abstract

To understand the mechanism of infestation of stored groundnut in farming areas, studies on the inventory and geographical distribution of *Caryedon* species were carried out in the tree savannah and in producers' storage structures. The incidence of *C. serratus* in stored groundnut was evaluated. Inventory and geographical distribution of insects belonging to *Caryedon* genus was achieved through a sampling in the savannah and producers' granaries. The inventory and geographical distribution of insects was made throughout Burkina Faso whereas the evaluation of the perforations of groundnut pods was made in the western zone of the country. The results of the inventory showed the presence of two species belonging to *Caryedon* genus which are *C. serratus* and *C. crampelii*. These species are found on the agro-ecological zones of the country. The survival and maintenance of *Caryedon* species genus are ensured by the presence of plants belonging to various families such as *Caesalpinaceae* and *Mimosaceae*. The evaluation of the losses caused by *C. serratus* in producer's stored groundnut revealed that the pods perforation rate varied according to the locality. In Toussiana, the rate of perforated pods ranged from 53.72% to 100% in five months while in Karangasso Sembla, for the same conservation time, the rate was in the range from 2.8% to 35%. However it is *C. serratus* which is responsible for the losses observed in the stored groundnut. Indeed, in the western area of Burkina Faso where more than 25% of the production is realized, 70% of groundnut stocked without treatment is destroyed by this insect after only four months of storage.

Keywords

Groundnut, Inventory, Sahelian Zone, *Caryedon* sp., Burkina Faso

1. Introduction

The genus *Caryedon* to which the *serratus* species belongs was already described under about several names [1]. The genus *Caryedon* contains species which is morphologically very similar and its presence is reported in all parts of the world [2]. The genus *Caryedon* was reported by several authors in several tropical regions of Africa, Asia, Mexico and in Australia [2] [3] [4] [5] [6]. Recent phylogenetic studies place beetles in the Chrysomelidae family and subfamily of Bruchidae [7] [8] [9]. This family is composed of 1700 species described divided into 60 genera, subdivided into five subfamilies [2] [10]. In Burkina Faso, the presence of *C. serratus* was reported by several authors [1] [11]. The presence of this insect in stored groundnut can involve its total destruction within a few months. The importance of the losses caused by this insect pest during storage justifies the scientific research work which is devoted to it [12] [13] [14]. However, in Burkina Faso where the production of groundnut is important with 325,000 tons of groundnuts produced in 2014 [15], very little work exists on this important insect pest of stored groundnut [11]. However, the modes of infestation of stored groundnut are not well-known. This is the same about the origin of the beetles which infest stored groundnut in producer's zones. The aim of the present work is to make a geographical inventory and distribution of the insects of the genus *Caryedon* in the agro-ecological zones of the country and to evaluate the impact of this insect on the groundnut stocks in order to situate the level of losses due to these insects.

2. Materials and Methods

2.1. Inventory and Geographical Distribution of *Caryedon* sp. in Burkina Faso

Inventory and geographical distribution of insects of the genus *Caryedon* was carried out in the three agro-ecological areas of Burkina Faso during three consecutive years [16]. Each sampling zone was geo-referenced (Figure 1). In the Sahelian zone, the sampling was carried out in the locality of Dori. In the northern Sudanian zone, sampling related to the sites of Saria, Gonse, Boussé, Sapone, Boassa, Leo, Fada N'gourma, Tapoa, Gassan, Di, Solenzo, Dandé, Déougou and Nouna. In the southern Sudanian zone, the collection of the samples was carried out on the sites of Vallée du Kou, Banfora, Yendéré, Farako-Bâ, Toussiana, Karangasso sembla, Darsalamy and Niangoloko.

The fruits of the wild host plants found in the different zones were collected. For the plants with pods, 30 fruits were collected on the host plants found in each area. Date and area of sampling were recorded.

Once in the laboratory, the fruits were isolated by plant species and locality in aerated bottles at room temperature until the emergence of adults.

2.2. Inventory of *Caryedon* sp. in Stored Groundnut in Farming Areas

On each sampled site and place where groundnuts are produced, the collection

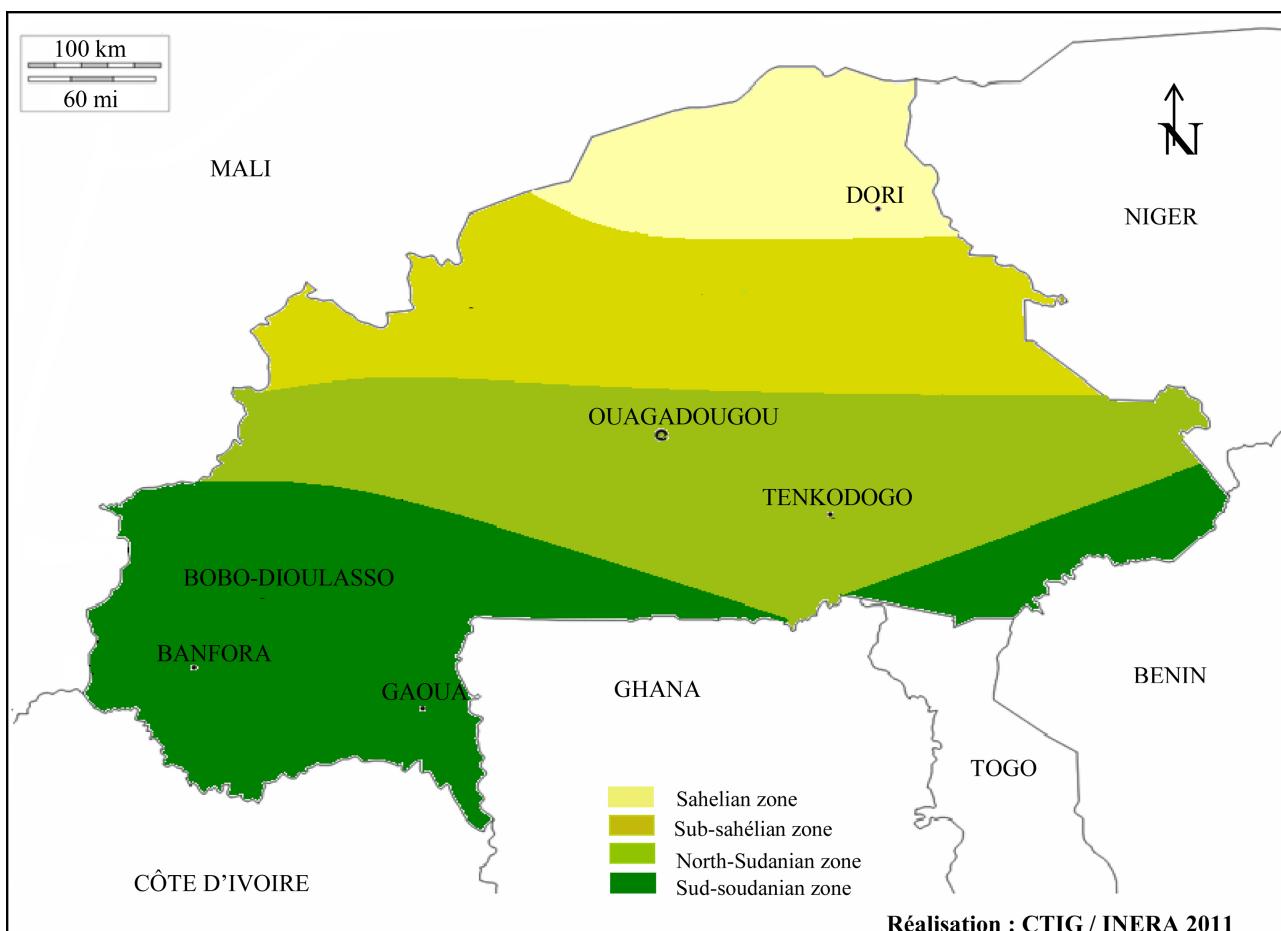


Figure 1. Inventory zones of insects of the genus *Caryedon*.

of groundnut was carried out in the producers' storage according to stocks availability. The sampling quantities per producer was 1 kg on average.

2.3. Identification of the Collected Insects

The samples of groundnut varieties (SH 470P; RMP12; RMP91; TS 32-1) collected in producer zones were isolated by locality in bottles and observed in the laboratory until the potential emergence of insects. The same procedure was followed for the fruits of the wild plants. At the emergence, the adult insects were identified by the male genitalia method according to Prevett's determination key (4) for the species of beetles of the genus *Caryedon*. The identification of plant species was made according to the Sahel trees and shrubs description [17]. Some plant species were identified by researchers from the forest production department of INERA.

2.4. Incidence of *C. serratus* on Stored Groundnut at Groundnut Producers'

The impact of *C. serratus* on groundnut storage was evaluated in the localities of Toussiana and Karangasso Sambla. The choice of these localities is justified by the importance of groundnut production and the strong pressure exerted by in-

sects on groundnut stocks. Five producers were selected in each of the two localities and five kilograms of unshelled groundnut, untreated and non-infested-groundnut was given to each producer. The varieties used are those cultivated in the area. Each month, samples were taken to track the level of infestation of groundnut stocks and identify the insects which are present. The samples were returned to the laboratory, the pods were observed to count those which are perforated and those which still contain larvae. To determine the rate of infested pods, the latter were shelled and observed to check those which really contain larvae. The parameters studied were:

- the rate of perforated pods = $(\text{Nbr of perforated pods}/\text{Nbr of total pods}) \times 100$
- Insects species found in groundnut stocks

2.5. Statistical Analysis of the Data

The analysis of variance on observed parameters were carried out by the means of XLSTAT software version 6.1.9. When the analysis of variance reveals significant differences, the test of Fisher (LSD) was applied for the comparison of averages at the probability threshold set at 5%. The formula of Abbott [18] was used to take into account natural mortality in the batches of groundnut.

3. Results

3.1. Inventory and Geographical Distribution of Insects of the Genus *Caryedon* in Burkina Faso

The sampling of fruits of plant species revealed 2172 adults which were compared with 1193 adults collected from the northern Sudanese zone. In total two species of the genus *Caryedon* namely *C. serratus* Olivier and *Caryedon crampeli* have been identified among the specimens which emerged.

The presence of species of the genus *Caryedon* was established on all the different zones where the samples were collected (Figure 1). The two species *C. serratus* and *C. crampeli* species were present in the sites of northern and southern Sudanese zones (Figure 2). As for the Sahelian zone, only *C. serratus* species was found. In the southern Sudanese zone, *C. serratus* was found on all the prospected sites showing that this species is well established in the area. As for the *C. crampeli* species, it was found on the pods of *P. africana* and *C. sieberiana*. Its presence seems to follow the distribution of its host plants because *C. crampeli* was found only on five of the 32 sites of this study.

3.2. Identification of Insects in Groundnut Stocks

Results (Table 1) show that several species of insects belonging to different orders have been observed in groundnut stocks collected in producer's environments. Among these species, *C. serratus* was found in the majority of samples, except for those coming from Saria, Boassa, Fada Ngourma and Farako-Bâ. As for the other species found, we can list *Tribolium castaneum* (Herbest), *Oryzaephilus surinamensis* (L.) and *Plodia interpunctella* (Hübner). Groundnut

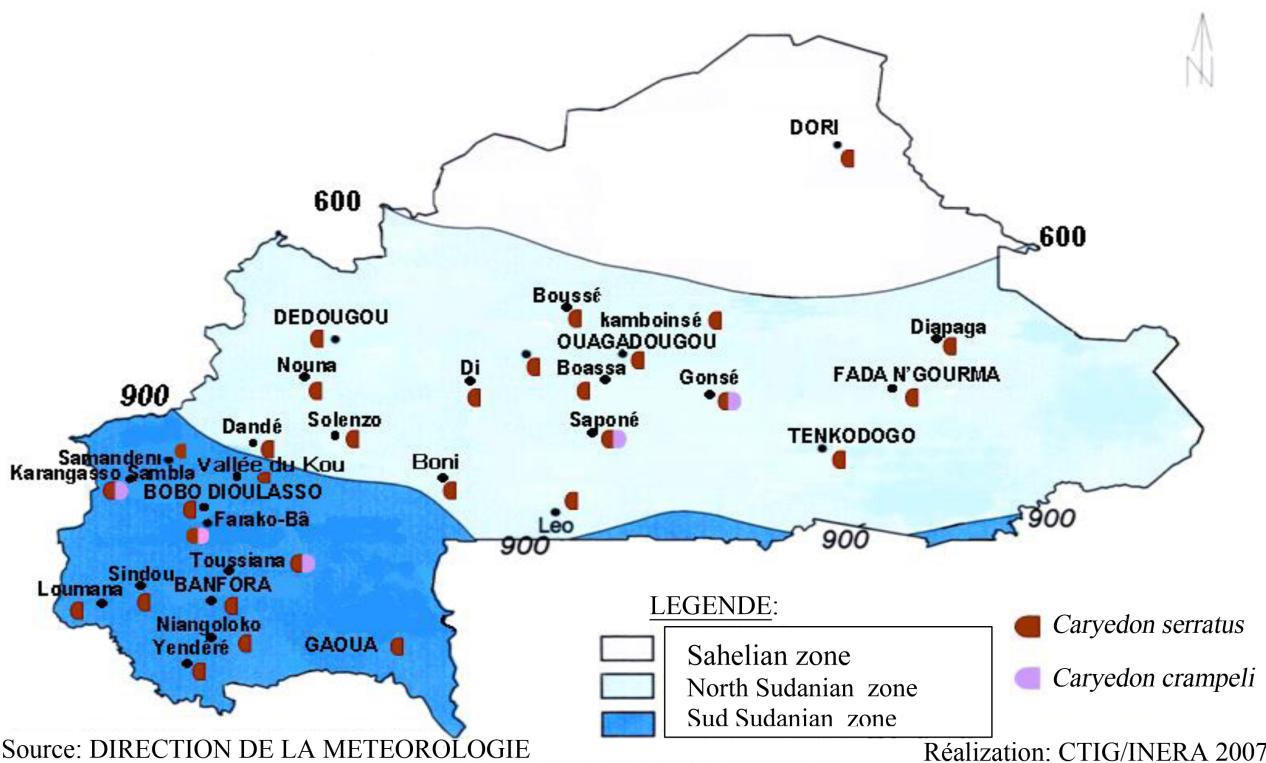


Figure 2. Map of the main species of *Caryedon* sp. inventoried in Burkina Faso.

Table 1. Main families of insects found in groundnut stocks in producers.

Order	Family	Species/genus	Status
Coleoptera	Bruchidae	<i>Caryedon serratus</i>	I
	Tenebrionidae	<i>Tribolium castaneum</i>	II
	Sylvanidae	<i>Oryzaephilus surinamensis</i>	II
Lepidoptera	Phycitidae	<i>Plodia interpunctella</i>	II

during storage was infested by four families of insects namely Bruchidae, Tenebrionidae and Sylvanidae which belong to the order of Coleoptera. The fourth family found is Phycitidae which belongs to the order of Lepidoptera.

3.3. Distribution of Host Plants of the Genus *Caryedon* sp. in Different Areas of Burkina Faso

The main host plants of *C. serratus* are listed on **Table 2**. Fifteen plant species belonging to five botanical families that are Mimosaceae, Caesalpiniaceae, Papilionaceae, Meliaceae and Fabaceae. Among each host plants family, five plant species belonging to the family of Caesalpiniaceae were listed, namely *Bauhinia rufescens*, *Cassia sieberiana*, of *Piliostigma reticulatum*, *Piliostigma thonningii*, and *Tamarindus indica* (**Figure 3**). All these plant species were collected in the northern and southern Sudanese zones except for *P. thonningii* that dominated in collected samples in the southern Sudanese zone. Two collected and identified species belong to the family of Fabaceae, namely *Albizia lebbeck* which was collected in the two zones and *S. siamea* found solely in the southern Sudanese

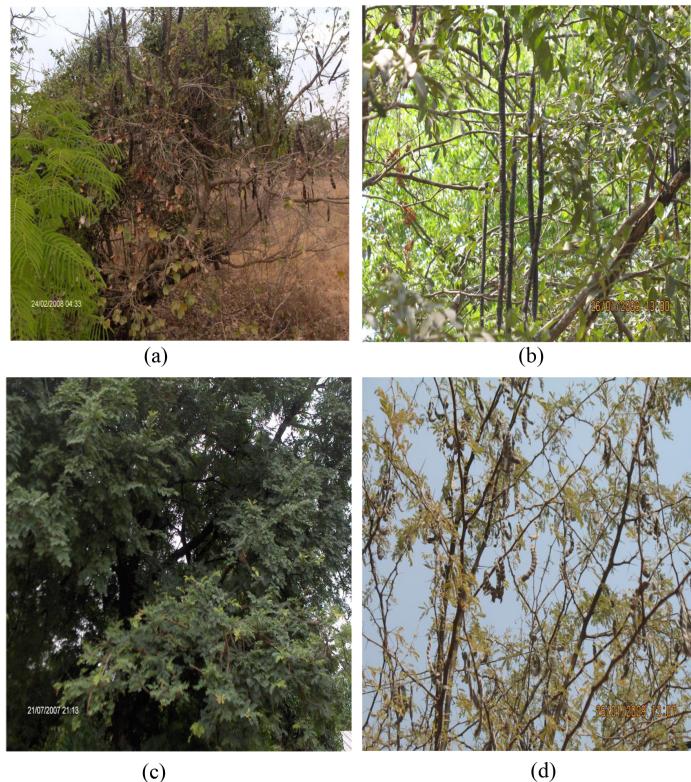


Figure 3. Some host plants of *Caryedon serratus* in Burkina Faso (Photo: Ouédraogo issoufou). (a) *Piliostigma thonningii*; (b) *Acacia sieberiana*; (c) *Tamarindus indica*; (d) *Acacia nilotica* var. *adansonii*.

Table 2. Main plants listed during inventory of *Caryedon* sp.

Host plants	Family	Northern Sudanese Zone	Southern Sudanese Zone
<i>Bauhinia rufescens</i> (Lam.)	Caesalpiniaceae	+	+
<i>Cassia sieberiana</i> (D.C)	Caesalpiniaceae	+	+
<i>Piliostigma reticulatum</i> (DC.) Hochst	Caesalpiniaceae	+	+
<i>Piliostigma thonningii</i> (Schum.) Miln-Redh	Caesalpiniaceae		+
<i>Tamarindus indica</i> (L.)	Caesalpiniaceae	+	+
<i>Albizia lebbeck</i> (L.) Benth	Fabaceae	+	+
<i>Senna siamea</i> (ex <i>cassiasiamea</i>)	Fabaceae		+
<i>Daniella oliveri</i> (R.) Hutch & Dalz	Meliaceae		+
<i>Acacia nilotica</i> (L.) Wildvar. <i>Adansonii</i> (L.)	Mimosaceae	+	+
<i>Acacia sieberiana</i> (D.C)	Mimosaceae	+	+
<i>Dichrostachys cinerea</i> (L.) Wight et Arn.	Mimosaceae	+	+
<i>Prosopis juliflora</i> (Sw.) DC.,	Mimosaceae	+	+
<i>Faidherbia albida</i> (Chev.)	Mimosaceae;		+
<i>Prosopis africana</i> (G. & Perr.)	Mimosaceae;	+	+
<i>Arachis hypogaea</i> (L.)	Papilionaceae	+	+

+: Present in the zone.

zone. In the family of Mimosaceae, six plant species were collected: *Acacia nilotica* var. *adansonii* (**Figure 3**), *Cassia Sieberiana* (**Figure 3**), *Dichrostachys cinerea*, *Prosopis juliflora* (**Figure 3**), *Prosopis africana* and *Faidherbia albida*. In the other plant families, *Arachis hypogea* of the family of Papilionaceae and *Daniella oliveri* of the family of Meliaceae were the only plant species collected in their respective families.

3.4. Influence of Host Plants on the Geographical Distribution of *Caryedon* sp.

The fruits collected in the different geographical areas of the country and under observation allowed to obtain adults (**Figure 4** and **Figure 5**). In the northern Sudanian zone, adult emergence rates of *Caryedon* were observed on five plants belonging to two plant families' species (**Figure 4**). Among the 1193 adults that emerged, in the fruits of *P. reticulatum* showed the most important rate of emergence (69.15% emergence). 23.55% adults emerged from the pods of *T. indica* collected in the northern Sudanese zone, versus 5.28% of emergences of adults from the fruits of *B. rufescens*. As for the other plant species, the rates of emergences varied from 0% to 0.67% depending on the host plants.

In the southern Sudanese zone (**Figure 4**), the highest rate of emergence was observed from the pods of *P. thonningii* (59.34% emergence) followed by the pods of *T. indica* (35.49% emergence), *C. sieberiana* (4%). As for the plant species *S. siamea* and *P. africana*, the rate of emergence of the adults of the genus *Caryedon* was respectively 0.59% and 0.55% (**Figure 5**).

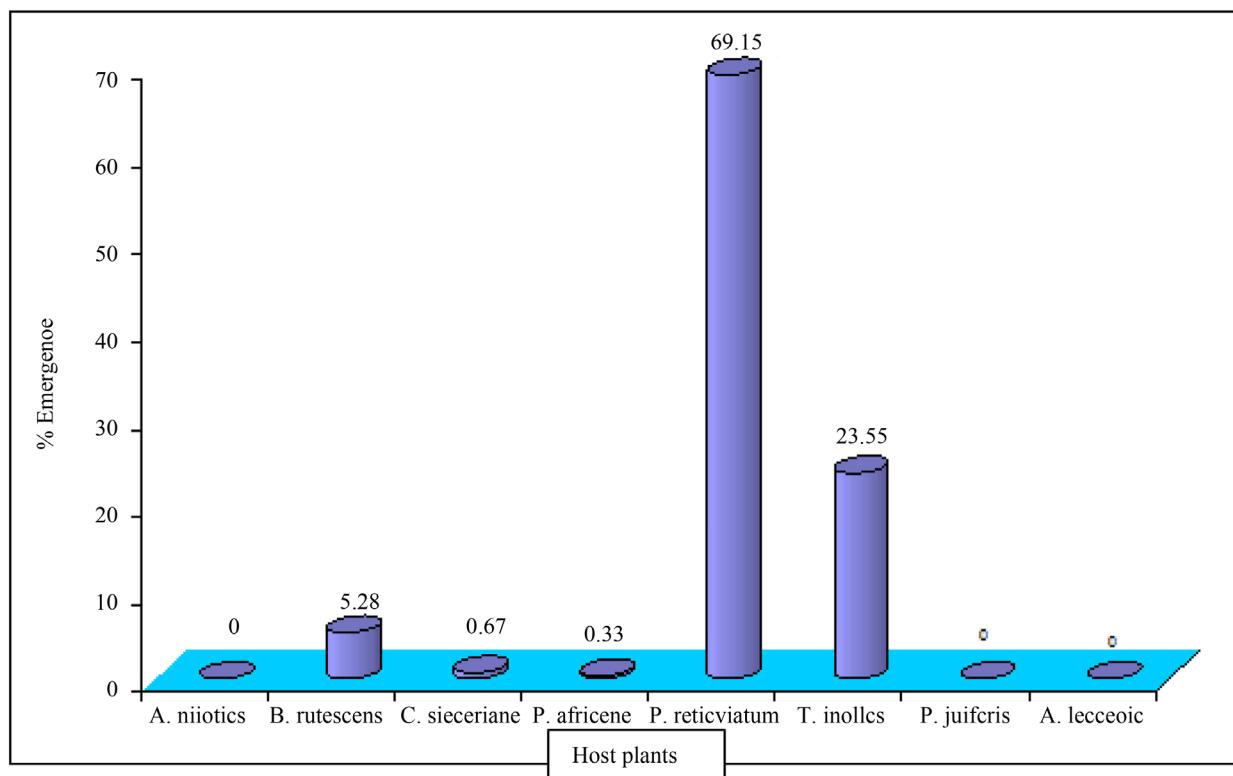


Figure 4. Percentage of emergence of the adults of *Caryedon* on different wild plants collected in the northern Sudanian zone.

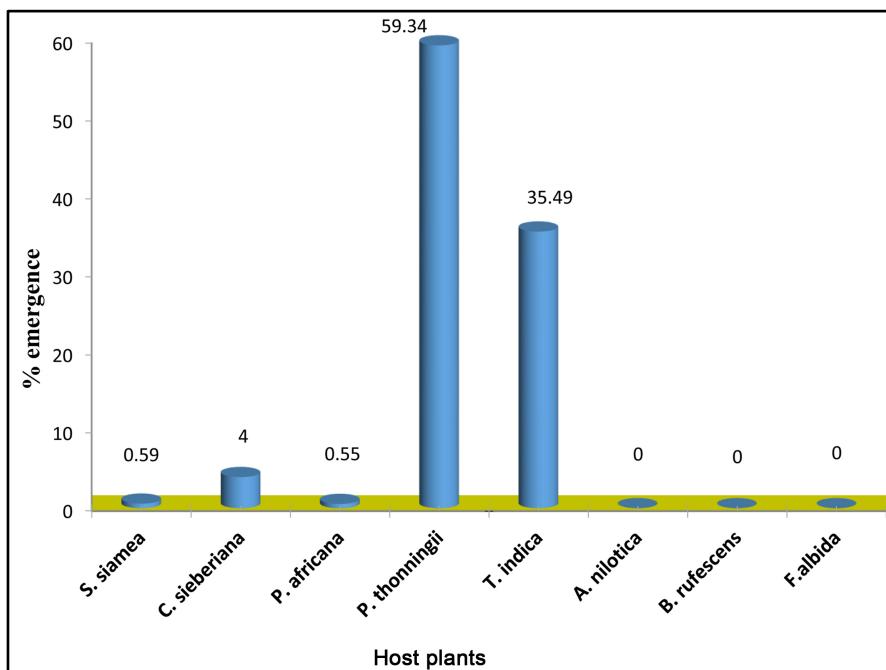


Figure 5. Percentage of emergence of the adults of *Caryedon* on different wild plants collected in the sudSudanian zone.

3.5. Incidence of Insects of the Genus *Caryedon* on Groundnut Stocks in Farming Areas

Analysis of the results (**Figure 6**) showed that the percentage of perforated pods was greater at Toussiana. Indeed, two months after the beginning of samplings, the average percentage of perforated pods was of 53.72%. This rate moved to 81.18% at the third month of sampling to 89.78% at the fourth month. From the fifth month, all the groundnut pods independently of producers carried at least one opening.

In Karangasso Sambla (**Figure 7**), the analysis of results emphasized the same tendency as the one observed in Toussiana. In this locality, the average percentage of perforated pods increased progressively, moving from 0% at the first month to 2.8% at the second, 10.8% at the third, 21.40% at the fourth and 35% at the sixth month. In the two zones the rate of performed pods by insects varied significantly depending on the duration of storage.

4. Discussion

The inventory of *Caryedon* carried out in the different agro-ecological zones showed that only two species was identified and our results confirm the presence of two species of *Caryedon* distributed throughout the Burkina Faso. These species were found in the whole of the agro-systems of Burkina Faso with a clear prevalence for *C. serratus* species. Its presence in all the prospected sites is explained by a homogeneous distribution of its host plants. In fact, on the faunistic inventory carried out, six host plants are well-distributed on the whole country allowing the development of the populations of *C. serratus*. Thus in the Sahelian

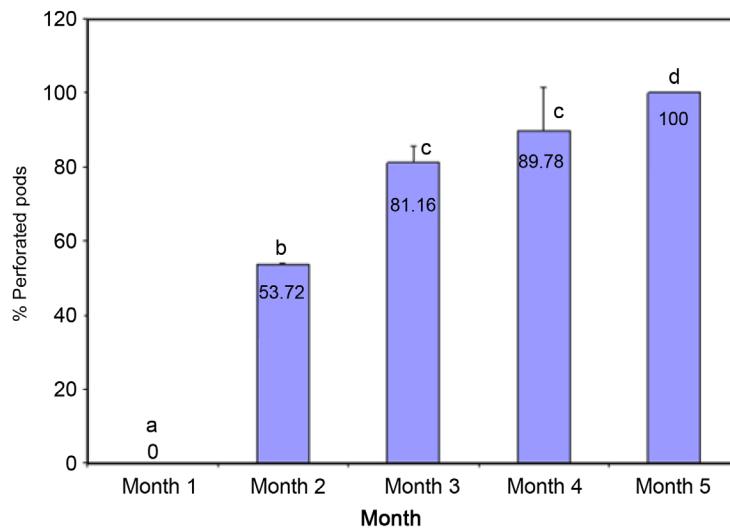


Figure 6. Average monthly evolution of perforated pods with producers of Toussiana (\pm ES).

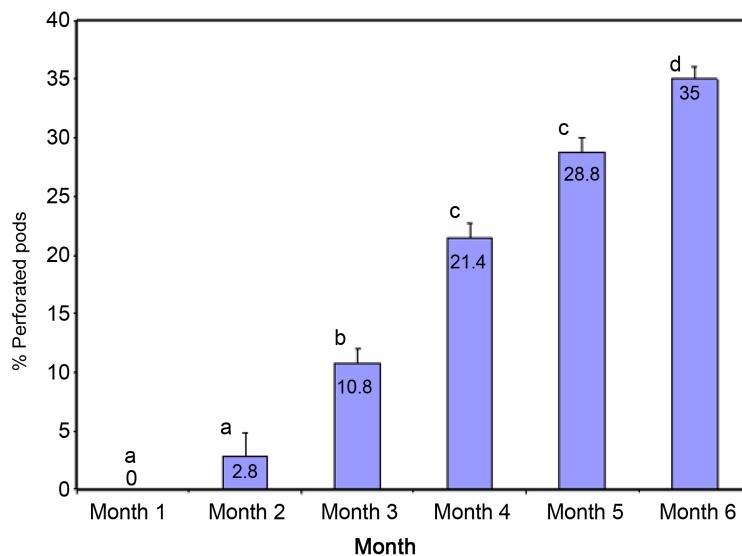


Figure 7. Average monthly evolution of perforated pods with producers of Karangasso Sambla (\pm ES).

zone of Dori, *C. serratus* was found on *B. rufescens*, a perennial plant that can live and develop in arid regions where the pluviometry is below 600 mm. This situation represents an adaptation of this plant species which was also found in wet zones as in Congo Brazaville [19]. The geographical distribution of *C. serratus* beetle is not related to climatic conditions but to the presence of host plants which are likely to allow its development and keeping alive. This explains why the species was indexed in several zones of the world [2] [7].

During groundnut storage, several groups of insects associated to this crop during were found that confirms the observations which report that groundnut is attacked by several groups of insects at the time of storage among which *C. serratus*, *E. cautella*, *P. interpunctella* and *T. castaneum* [20]. In some areas of

Asia and Africa, *Trogoderma granarium* Eversts and *Elasmolomus sordicus* (Fabricus) were also found at the beginning of storage of groundnut [21]. Among the insects found in groundnut stocks, only the *C. serratus* species is able to attack the intact groundnut pods [9]. Thus no matter the zone considered, the *C. serratus* beetle seems to be the most harmful insect of groundnut stocks [22] [23] [24]. In the northern Sudanese zone where the density and diversity of host plants is relatively important, *C. serratus* is predominant confirming the observations of several authors [2] [7].

The low number of *C. crampelli* species is related to the reduced number of its host plants whose geographical distribution is not always homogeneous. It is the case of *P. africana* main host plant of *C. crampelii*. The important use of the pods of this plant in animal feed led to the scarcity of its pods and thus of *C. crampelii* in some areas. The identified species of *Caryedon* differ from those identified by other authors [25]. In fact these authors reported the presence of *Caryedon nongoniermai* (ex *Caryedon sahelicus* Decelle), species which was collected in 1967 on *Acacia tomentosa* in the area of Ouagadougou. The second species identified by these authors, *Caryedon furcatus* (ex *C. mauritanicus* Decelle), the specimens were collected in 1969 in the area of Fada Ngourma. The degradation of the ecology of insects and the destruction of their host plants can explain this situation.

The plants play an important role in the development of the beetle like the species *Caryedon*. Indeed, the presence of *P. thonningii* and *T. indica* constitute sources of infestation in groundnut in Congo and Senegal [13] [26].

The host plants which ensure the survival and distribution of bruchidae in Burkina Faso are favorable to the evolution of these insects. The absence of secondary substances in these plants unfavorable to the evolution of the larvae of these insects that explain the preference of these plants by these insects [27].

As for groundnut, very little research work on the losses caused by *C. serratus* in farming areas on this leguminous plant is available apart from those reported in Congo Brazaville [26]. In Burkina Faso, the evaluation of farmers' losses has permitted to quantify the damage caused by this insect. Thus in the western zone *C. serratus* causes important perforations on groundnut pods during conservation. The presence of an important population of beetle in old infested groundnut stocks, just as the presence of host plants which support their development and keeping explains the level of damage observed.

In fact, in Congo Brazaville, *P. thonningii* is one of the sources of infestation of groundnut stocks [26]; while in Senegal 2% of the adults of *C. Serratus* which infest groundnut originate in the wild host plants [10]. This last point seems the most important in the infestations of groundnut stocks. Indeed, the pods of *T. indica* which carry eggs and sometimes the larvae of *C. serratus* are gathered, preserved and used gradually according to needs (culinary, commercial or medical). It is the same case for the pods of *P. thonningii* and *P. reticulatum* which are gathered and preserved for feeding animals during the dry season. Thus parts of the insects which infest groundnut stocks come from these host plants.

5. Conclusion

The inventory work carried out in the agro-ecological zones of the country has permitted to identify the presence of two species of *Caryedon* which are *C. serratus* and *C. crampelii*. Studies on the geographical distribution of these species indicate that they are present in various agricultural zones of Burkina Faso. *C. serratus* is the widely spread species; it was found in all the agro-ecological zones of the country. In the western zone of Burkina Faso, the checking of groundnut stocks showed that only *C. serratus* infests groundnut stocks. The laying and nutrition activities of the larvae of *C. serratus* in groundnut stocks are at the basis of the perforation of groundnut pods which can reach 70% without any protection methods. The importance of the damage observed in groundnut stocks is explained by the presence of old stocks of groundnut “infested with beetles” but also by the gathering and conservation of some wild fruits such as the pods of *T. indica* and *P. thonningii* which generally are infested by *C. serratus* and which constitute sources of infestation of groundnut stocks. The results showed us the mode of infestation of groundnut stocks in the rural areas of Burkina Faso and this study can foster ways and means for the reduction of the perforations of groundnut pods related to the presence of *C. serratus*.

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Competing Interest

Authors have declared that no competing interests exist.

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