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Original Research Article

Competition among bruchids (Coleoptera: Chrysomelidae): *Callosobruchus maculatus* (Fab.) and *Callosobruchus subinnotatus* (Pic) on Bambara groundnut (Fabacea)

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Abstract: Interspecific competition was investigated in bruchids (Coleoptera: Chrysomelidae) major pests of stored Bambara groundnut (BGN), during eggs laying process. Field observations carried out for 2 years revealed that 2 bruchids *Callosobruchus maculatus* (Fab.) and *Callosobruchus subinnotatus* (Pic.) are major pests of BGN; *C. maculatus* is more prolific and dominant in the Sudano Sahelian landscape whereas *C. subinnotatus* is the major pest in the Sudano Guinean area. Intraspecific competition affects the amount and the fertility of eggs laid. *C. maculatus* laid more eggs in presence of *C. subinnotatus* than it does alone. Moreover, *C. subinnotatus* added very few barren eggs on seeds upon which *C. maculatus* oviposited previously. Allelo chemicals involved in this phenomenon are to be described.
Keywords: Sudano Sahelian and Sudano Guinean Africa, Bambara groundnut, interspecific competition, *Callosobruchus subinnotatus*, *C. maculatus*.

INTRODUCTION

Competition is routinely cited as one of the primary biotic factors that shape patterns of distribution, abundance and diversity in ecological communities[1]. Competition also impacts availability and resource consumption, consequently, it structures relationship among populations[2-4]. Competitive interactions have negative effects to all or to only one of individuals involved. Precisely, there is a competition when interactions between two or more individuals have negative consequences for all participants [5].

In Sub Saharan Africa, bruchids attack and destroy Bambara groundnut (BGN) seeds during storage within smallholder granaries[6-8]. It is not sufficient to consider these insects, because they are sharing a common resource, to be in competition. This co-occurrence must have a negative impact on their survival. This negative impact can be confirmed by field observations and through laboratory bioassays. Field observations must access their spatial-temporal co-occurrence in relationship with the availability of the resource. Laboratory bioassays must point out the theoretical behavior of the competitor dependent to the presence or not of its opponent assuming that the quality of the resource is suitable for all competitors.

Each of the competing species excludes the other through aggressive behaviors or by the production of allelochemicals to repel it or to force it to avoid habitats where the first competitor is most frequent[9, 10]. Both physical or chemical exclusions are widespread in the animal kingdom, these competing mechanisms have a real impact on energy and behavioral responses of the competitors and play a central role in the structure and interactions in populations[11-15].

MATERIAL ET METHODS

Occurrence of bruchids on stored Bambara groundnut' seeds in Northern Cameroon

The Northern Cameroon (NC) is an area extending from the latitude 7°236 to 12° north and from the longitude 11° to 13°3472 East. It covers the sudano Guinean savannah in its southern part and the sudano sahelian dry lands in the north. It is made of sets of highlands culminating in the Adamawa Region at 1480 m above sea level. The Benoue valley in the North Region is the lowest part at the elevation 450m. The climate alternates between a short rainy season from May to September and a long dry season from October till April [16]. In the far North region, the dry season is the sahelian type with less than 100 rainy days per year. The 3 Regions constituting the NC are organized in 15 administrative Divisions. In each of the15 divisions 5 localities were sampled.

During 2 successive agricultural campaigns in 2013 and 2014BGN seeds were collected from smallholder granaries all around the NC, taken to the laboratory and observed. Sets of 300g of seeds of BGN were kept in glass flasks of 1200ml capacity. For each sample, 5 replications were made and kept for a period of 100 days, seeds of each sample were checked and all emerging bruchids removed identified and counted.

Dynamic of the emergence of bruchid from stored seeds during 100 days of storage

The strain BLANC CRÈME of BGN was chosen for bioassays in laboratory. 300g of seeds were introduced in a 1200ml flasks, infested with 4 couples of each species of bruchid and observed in an incubator, monitor at 30°C. A first set of experiment was made to access the chronology of the life cycle of each bruchid. The second set of experiment was checkup, made every 20 days, to access the dynamic of the bruchid population. These assays lasted for 100 days. 5 replications were made for each bruchid. Cumulative amount of emerging bruchid was computed.

Expression of competition between bruchids on Bambara groundnut seeds

Oviposition of bruchids was observed on the BGN seeds of the strain BLANC CRÈME. Each bruchid oviposition was observed during 48 hours in test-tube filled with10g of seeds, infested with 2 couples of each species of bruchid, 5 different situations were accessed:

- Oviposition of *C. maculatus* alone ;
- Oviposition of *C. subinnotatus* alone ;
- Oviposition of *C. maculatus* after previous oviposition of *C. subinnotatus*;
- Oviposition of *C. subinnotatus* after previous oviposition of *C. maculatus*;
- Simultaneous oviposition of both *C. maculatus* and *C. subinnotatus*.
- The amount of eggs laid by first bruchid introduced was counted and 3 days later, the second bruchid was introduced. It was therefore easy to determine the total number of eggs laid and that of each of the 2 bruchids species. Eggs laid were thereafter observed in an incubator monitor at 30°C till emergence of bruchids. Emerging adults were identified and counted.

RESULTS AND DISCUSSION

Bruchids feeding on Bambara groundnut in Northern Cameroon

In Sudano Sahelian and Sudano Guinean areas, Bambara groundnut (BGN) is a culture of off season regularly produced and mostly practiced by women [26]. It is consumed, sold or stored for future use as seed or lean season food by the end of the dry season when granaries are empty.

Seeds sampled during 2 years and observed in laboratory for the emergence of bruchids pointed out that during storage, 2 species of bruchids are present: *C. maculatus* and *C. subinnotatus*. Bruchid *C. maculatus* is present and dominant in the Far North region (91% of the bruchids sampled) corresponding to the Sahelian area. This pest is scarce in the Adamawa region (2%) corresponding to the Guinean zone whereas the weevil *C. subinnotatus* is present and dominant in the Sudano Guinean lands (92%) and scarce in the Sahelian zone including the North (4%) and the Far North (4%) Regions (Table 1). The presence of these two bruchids in black eyed cowpea and BGN has being recorded also by Alzouma *et al.* in West Africa[27].

In addition to being very present in the NC, *C. maculatus* is numerically the most abundant species, constituting the main bruchid emerging from stored BGN in this area. Despite of its low presence, *C. subinnotatus* is not present at the same density in all three regions explored.

Table 1: Numerical importance of *Callosobruchus maculatus* and *C. subinnotatus* on Bambara groundnut seeds in the Northern Cameroon in 2013/2014 and 2014/2015 agricultural campaigns

Regions	*C. maculatus*	*C. subinnotatus*
Adamawa	288 (2%)	**2136 (92%)**
North	880 (7%)	105 (4%)
Far North	**11176 (91%)**	97 (4%)

Life cycle and dynamic of bruchids' population on Bambara groundnut seeds

Life cycle of the bruchids parasitizing BGN

Reared on the strain BLANC CRÈME, both *C. maculatus* and *C. subinnotatus* completed their life cycle in 29 days and 33 days respectively. This observed difference is not significant. These results are similar to the one of Sanon A[28] who found that the development cycle of bruchids ranged between 22 to 32 days at 30°C. At this same condition in an incubator monitor at 30°C, in 48h time, a female laid 27.6 eggs for *C. maculatus* and 17.6 for *C. subinnotatus* (Table 2). The loss of weigh observed during the stay of this first generation is 3.8g for *C. maculatus* and 1.8g for *C. subinnotatus*.

Table 2: Characterization of life cycle and damages of *C. maculatus* and *C. subinnotatus* towards Bambara groundnuts strain BLANC CREME seeds observed in an incubator monitor at 30°C

	Life cycle (days)	Ovipo:sition	Weigh loss (g)
C. maculatus	28.91a	27.6a	3.8 a
C. subinnotatus	32.34a	17.6b	1.8b

(Within the column, values followed by the same letter do not differ significantly; Chi² = 2.893* ndl = 1).

Dynamic of the population of bruchids parasitizing BGN strain BLANC CRÈME seeds

The analysis of the emerging adults from seeds kept for 100 days in laboratory conditions pointed out difference is their population size (Figure 1). Bruchid *C. maculatus* dominates upon *C. subinnotatus* which is present in reduce number. Beginning on clean seeds without infestation at the day zero, the level of one bruchid emerging per gram of seed is reached after one month for *C. maculatus*. This level even after 100 days of rearing will not be completed in *C. subinnotatus*. The cumulated density of adults completed with *C. maculatus* after 100 days of infestation of the strain BLANC CRÈME of BGN seeds is 3.16 adults per gram of seeds.

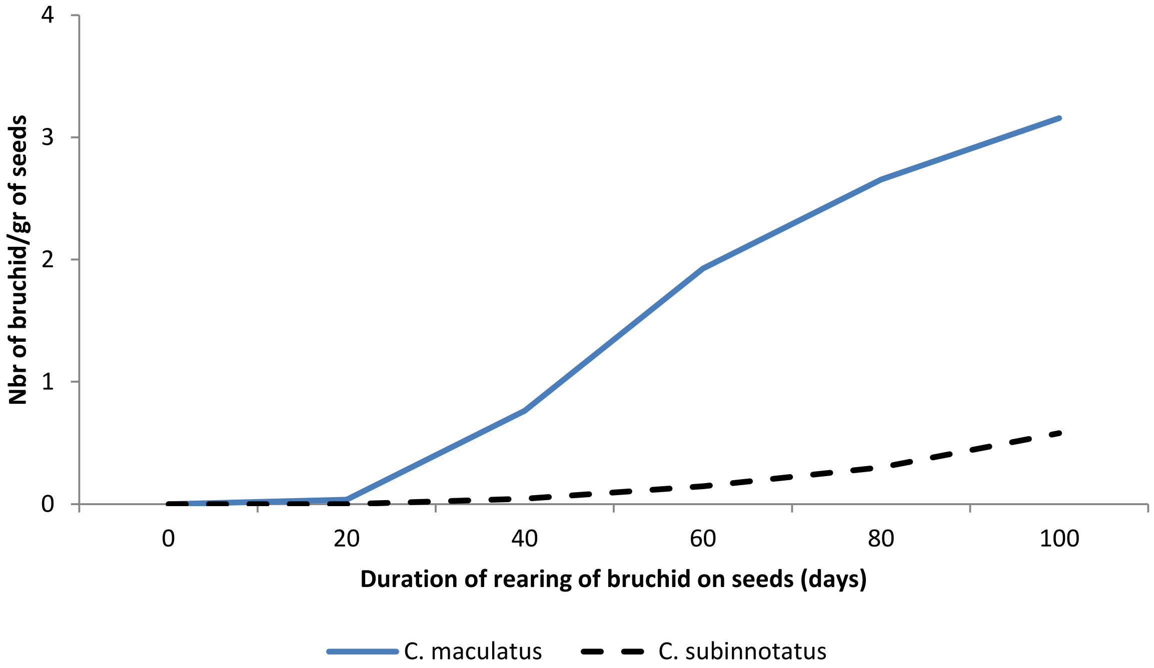

Fig-1: Cumulative density of bruchids (adult/gr of seeds) emerging from 300gr seeds of the stain BLANC CREME infested by 3 couples of bruchid, sampled every 20 days till 100 days.

The bruchid *C. subinnotatus*, most present in the Sudano Guinean area is less prolific in laboratory condition. Around one adult emerged from gram of seeds after 100 days of rearing.

Interspecific competition between bruchids on Bambara groundnut seeds

Five situations were tested to access the oviposition capacity of bruchids and to conclude on the effectiveness of intraspecific competition between them for the oviposition site. Their oviposition observed alone pointed out that *C. maculatus* (27.6) is most prolific than *C. subinnotatus* (17.6). Reared together on the same site, the total amount of eggs laid is greater than that observed when there are alone (Table 3). Moreover, this oviposition (54.5 eggs) is significantly bigger than the sum of their oviposition they perform while doing it alone (27.6 + 17.6 =45.2). There seems a synergistic factor stimulation oviposition in that situation. These results are different of those of Mbata (2000) who said that when *C. maculatus* and *C. subinnotatus* were reared together on Bambara groundnuts, *C. subinnotatus* did better than *C. maculatus* but both populations thinned down after 90 days. In the case *C. maculatus* laid eggs first on the site which is again offered to *C. subinnotatus* for oviposition, it is observed that the total amount of eggs laid is not significantly different from that observed when they are together. It is noted here the additional oviposition by *C. subinnotatus* is very low, 4.6 eggs. This additional oviposition by *C. subinnotatus* in lower than its normal oviposition observed while it is alone: 17.6 eggs.

Inversely, when *C. subinnotatus* oviposited first and *C. subinnotatus* came after, the total oviposition was higher, significantly bigger than that observed in all situation, 139.62 eggs. This may originate from the fact that additional oviposition by *C. maculatus* is stimulated by previous presence of *C. subinnotatus*. This amount of eggs is bigger than the normal oviposition of *C. maculatus*, 109.6 eggs.

Table 3: Oviposition of bruchids observed in different situation comparing amount of eggs laid in normal and in interspecific competition situations.

	Initial oviposition	Total oviposition	Added oviposition
C. maculatus alone	27.6 ±13.72 b	27.6 c	/
C. subinnotatus alone	17.6 ±15.96 c	17.6 c	/
C. maculatus and *C. subinnotatus*	54.4 ±2.8 a	54.4 b	/
C. maculatus first, *C. subinnotatus* after	46.8 ±4.0 a	52.8 b	4.6 ±2.1 b
C. subinnotatus first, *C. maculatus* after	30.02 ±1.64 b	139.62 a	109.6 ±14.67 a

To ensure a good survival to her offspring, female have the task to choose suitable and high quality oviposition sites. They may avoid installing their offspring on occupied sites as seeds already carrying eggs of a competitor [28]. This is the strategy *C. subinnotatus* used to exploit Bambara groundnut seeds in presence of its opponent *C. maculatus*.

The competitive success of some species is the result of exclusive behaviors through chemical or physical agressivity of a competitor towards its opponent. On Bamabara groundnuts, *C. maculatus* dominates *C. subinnotatus* by laying more eggs normally and moreover by lying especially more eggs on site where *C. subinnotatus* had oviposited before. Allelo chemicals associated to process of laying eggs by *C. subinnotatus* may play a role of stimulus for oviposition of *C. maculatus*. The phenomenon among competitors to exclude an opponent through allelochemicals to avoid some habitats is frequent [29-30]. Analysis of emergence of bruchids coming from the oviposition in this excluding situation released that no *C. subinnotatus* was observed (Figure 2). There is a need to identify and characterize the set of allelochemicals having the potential to stimulate oviposition of one bruchid and those allowing the other one to exclude totally the first oviposition present on the site.

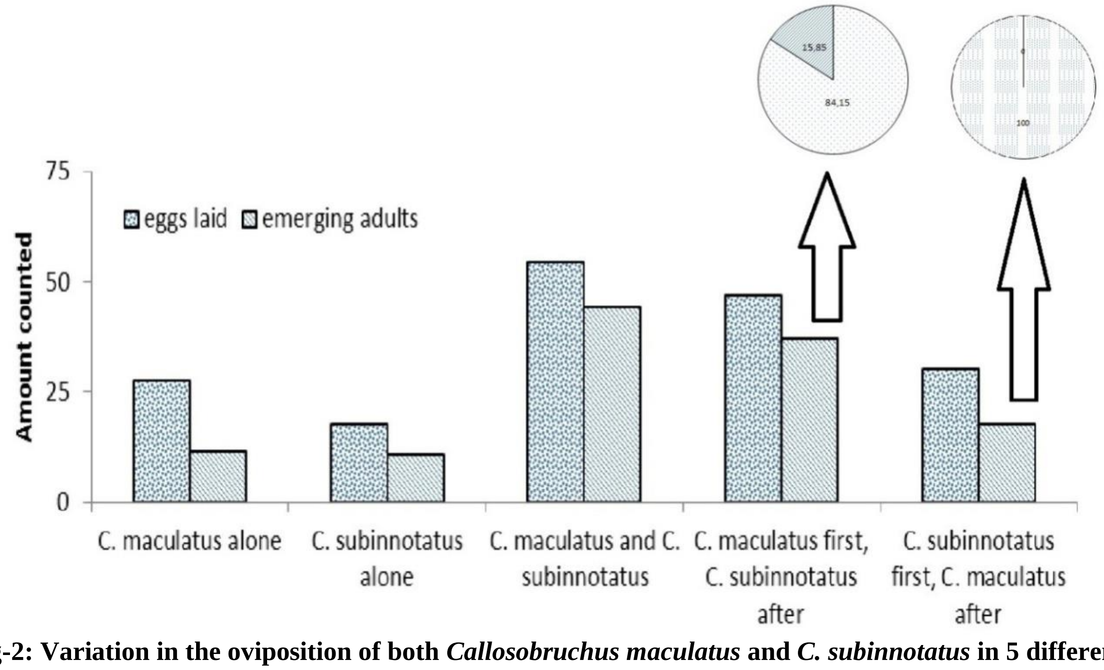

Fig-2: Variation in the oviposition of both *Callosobruchus maculatus* and *C. subinnotatus* in 5 different situations in presence or in absence of competition and of the proportion of emerging bruchids per species in the situation of successive oviposition on the same site.

CONCLUSION

The two species of weevils that attack and destroy Bambara groundnut during storage share the same resources over time and space in the NC. Bruchid *C. maculatus* which is numerically more important and *C. subinnotatus* although present very low density is competing on Bambara groundnut seeds during storage. This competition produces on both bruchids a mutual negative effect, since each one is regulated by resource and is regulating its competitor. The allelochemicals involved in this process are to be identified.

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