DEVELOPMENT OF TWO BRUCHID SPECIES *BRUCHIDIUS ATROLINEATUS* (PIC) AND *CALLOSOBRUCHUS MACULATUS (F.) AND THEIR* LARVAL PARASITOIDS DURING STORAGE OF COWPEA SEEDS *VIGNA UNGUICULATA* (WALP) IN WEST AFRICA

Jean-Paul MONGE, Albert Patoin OUEDRAOGO, Jacques HUIGNARD

Institut de Biocénotique Expérimentale des Agrosystèmes, URA CNRS 1298,

Avenue Monge, Parc Grandmont, 37200 TOURS (FRANCE)

Summary

The Coleoptera Bruchidae cause important damage during the storage of the legume seeds. The multivoltine species colonize the growing crop and also the seeds in store. The ecology and the population development of two tropical species *Bruchidius atrolineatus* and *Callosobruchus maculatus* and their parasitoïds are analyzed on growing cowpeas and then in storage. The two bruchid species present two different strategies in the store but they cause important damages. Populations of parasitoïds are very dense during the all storage periods and influence the population dynamic of the bruchids. The importance of these studies in bruchid population control is examined.

Introduction

Johnson and Kistler (1987) estimate that 80 % of the species developing in wild species of Leguminosae are specialist and have 1 to 3 host plants. A limited number of species attack the cultivated Leguminosae and cause important damage.

Some species are univoltine : the *Bruchus* species living in the mid paleartic region provides a good example. In spring, the eggs are laid as soon as the pods of the host plant are initiated and the larvae develop in growing seeds. Adults in reproductive diapause emerge as the crop reach maturity and migrate to hibernation sites. Adults survive in these sites during winter and at the beginning of spring, colonize the host plant and terminates their diapause. Damage is produced in the field where dense populations are frequently observed. In the Center of France, Dupont (1990) observed that 50 to 66 % of *Vicia faba* pods had received eggs of *B. rufimanus* during the fructification period and 25 % of the seeds containe(bruchid larvae.

The multivoltine species are capable of infesting pods in the field and a high proportion of seeds contained bruchid larvae before harvesting. In the store, the emerging adults can reproduce and successive generations increase the damage. *Callosobruchus* species are particularly adaptated to storage conditions which represent a man made environment. Caswell (1961) notes that a 2 % infestation of cowpea seeds (*Vigna unguiculata*) by *Callosobruchus maculatus* causes a complete destruction of the seeds after several months of storage. The observations in cowpea storage in Sahelian zones (Huignard *et al.*, 1985 ; Alzouma, 1987) or in bean storage in Colombia (Huignard and Biemont, 1978) confirm the importance of the damage due to different species of Bruchids.

Studies of the ecology, physiology of bruchid species are necessary before attempting pest management. For multivoltine species, it is necessary to know the conditions of crop infestation in the field and then the biology of the insects in the store.

We have analyzed, in a tropical zone in Niamey region of Niger, two sympatric species, *Bruchidius atrolineatus* (Pic) and *Callosobruchus maculatus* (F.) developing on cultivated varieties of cowpea *Vigna unguiculata* Walp.

Results

COLONIZATION OF THE COWPEA PLANT BY THE TWO BRUCHID SPECIES .

In the Niamey region, the adults of the two species appeared in the field at the end of the rainy season when cowpea began to produce pods. The density of *B. atrolineatus* was important and females laid their eggs on the pods during all the fructification period (September and beginning of October). The eggs were deposited on green pods and then on mature pods. Huignard *et al.* (1985), Alzouma (1987) observed that 83 to 88 % of the pods produced by the cowpea plots received *B. atrolineatus* eggs (m = 8 eggs per pods). However the mortality was important and 20 to 30 % of laid eggs gave rise to adults. The influence of egg parasitoïds (*Uscana lariophaga*), larval parasitoïds (*Eupelmus orientalis*, *E. vuilleti*) and the action of climatic factors (rains, high temperatures), probably explained this high mortality during development (Huignard *et al.*, 1985 ; Alzouma, 1987 ; Lammers and Van Huis, 1989).

Adults of *C. maculatus* were also observed in the cowpea field but their density was lower. Females laid their eggs preferentially on maturing pods. 40 to 50 % of the pods received a limited number of eggs (1 to 3), but the mortality was high. Huignard *et al.* (1985), Lammers and Van Huis (1989) estimated that 50 to 60 % of the eggs may be parasitized by *U. lariophaga*.

The new generation of bruchids developed in the field and the first adults emerged in October and emergences continued in the store after harvesting. *B. atrolineatus* adults were sexually active. *C. maculatus* adults belonged to the flightless form described by Utida (1954) and Caswell (1956) and had functional reproductive organs.

DEVELOPMENT OF BRUCHID AND PARASITOIDS POPULATIONS IN THE STORES

Analysis of the adult populations : 7 kg of pods, collected in the experimental field were stored in a traditional mud built store equipped with a lateral opening covered by a trap. The number of insects captured in the trap and the number of insects not escaping from the store were determined from November 1987 to September 1988. Temperatures were constantly recorded inside the store.

B. atrolineatus population : 90 % of adults emerging from the seeds were collected in the trap. Two generations succeeded in the store (fig. 1). The first generation, emerging at the beginning of the study was sexually active and females laid their eggs on stored pods. 100 % of adults of the second generation developing in storage conditions were in reproductive diapause. The duration of their development was highly variable, the emergences began in January with a maximal value in March and extended until June.

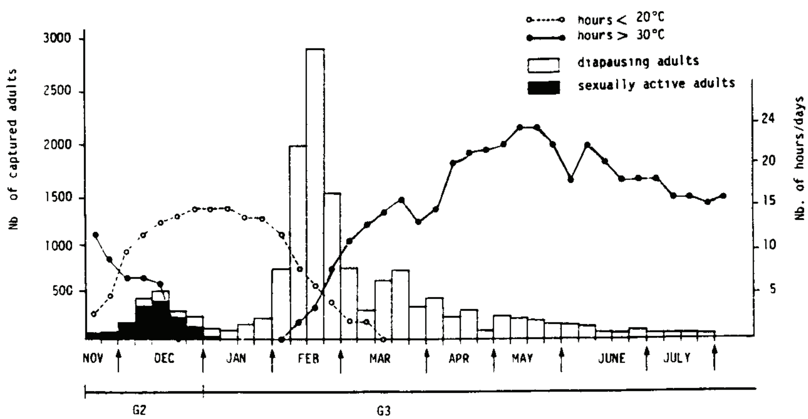

Figure 1 : Number of sexually active and diapausing adults of *B. atrolineatus* captured in the trap during the dry season and the beginning of the rainy season (November 1986 to July 1987). Analysis of the corresponding thermal variations during this period. These variations are characterized by the mean number of hours per day > 30° C or < 20° for each week.

Experimental studies showed that *B. atrolineatus* reproductive diapause was induced during the larval development of the second generation by the thermoperiodic conditions prevailing during this period (Monge *et al.*, 1989). The cold temperatures during December and January (absence of temperatures higher than 30°C and presence of temperatures lower than 20°C) induced this reproductive diapause. Insects in reproductive diapause had a long and variable post embryonic development and were very mobile. In traditional storage conditions, these beetles escape from the store and reach aestivation sites so far undiscovered (Germain, 1987).

C. maculatus population : At the beginning of storage, flightless form adults appeared and did not escape from the store. These beetles were sexually active and several generations of adults developed in the store (fig. 2). In March the density of *C. maculatus* was high but an important decrease was observed in April. The density of adults increased slowly and during the rainy season, flight form adults appeared. These beetles in reproductive quiescence (Bilal, 1987) left the store and probably represented the host plant colonization form.

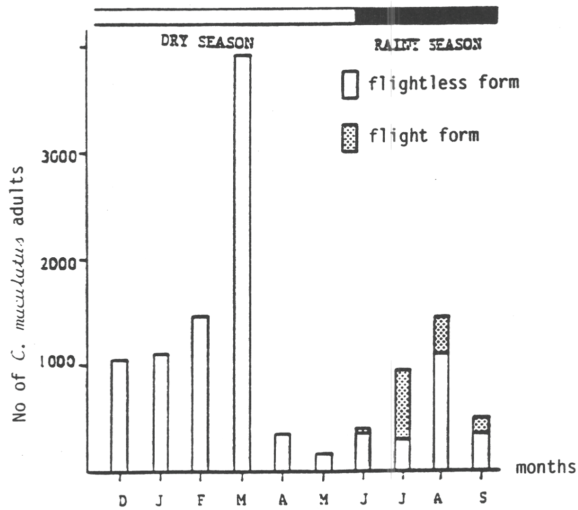

Figure 2 : Development of the *C. maculatus* population in the store.

Parasitoïds : Two species of larval ectoparasitoïds were collected in the store, *Eupelmus vuilleti* (CRW) and *Dinarmus basalis* (Rond). Among 4600 adults captured in the trap, 67 % were *E. vuilleti*. The maximum number of parasitoïds of both species occured in March and then the numbers decreased (fig. 3).

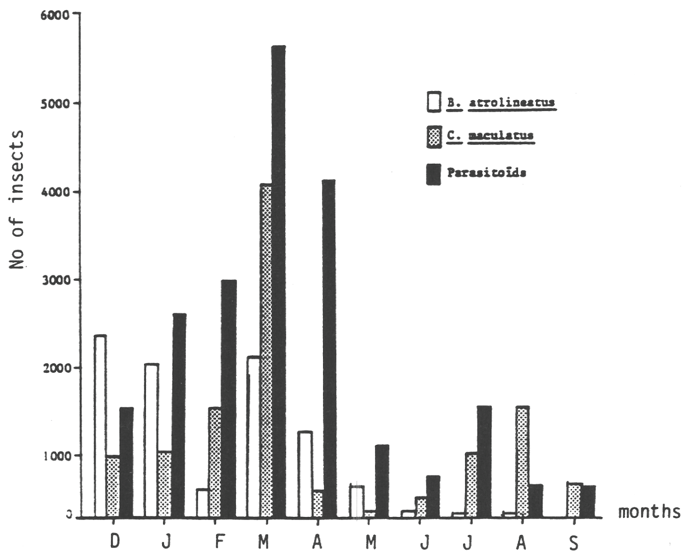

Figure 3 : Development of bruchids and their larval parasitoïds in the store.

The parasitoïds represented 50 % of the total insects emerging from the seeds during the study. They probably caused the decrease of the *C. maculatus* population from March to April. This density dependent response is fairly frequent in parasitoïd hymenoptera (Hassel, 1986).

Egg-laying on stored pods

Cowpea pods (variety TN 88-63) were stored in a traditional banco granary containing 5 wire netting drawers. 50 labelled pods (10 per drawer) were systematically checked for oviposition, egg parasitization and adult emergences (bruchids and larval parasitoïds) from November 1989 to June 1990.

The cowpea pods received *B. atrolineatus* eggs from November until January with a maximal value in December. From February where a high proportion of adults were in reproductive diapause, the number of eggs laid on pods was very reduced (fig. 4). However 64 % of the eggs hatched, and 27 % are parasitized by *Uscana lariophaga* (Trichogrammatidae). Parasitoïds were present during all the oviposition period.

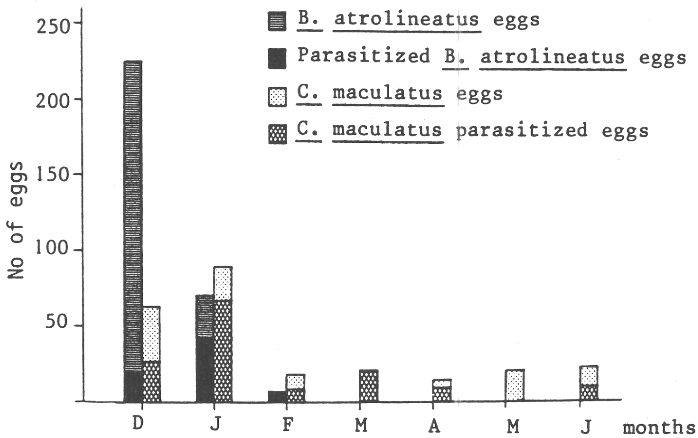

Figure 4 : Number of eggs laid by the two bruchid species on the 50 sample pods. (Dec. 1989 - June 1990).
Results obtained with the collaboration of S. Piquet.

C. maculatus oviposition began in November with maximal value in January and then decreased. However eggs were laid on pods at different periods during the dry season. 58 % of the eggs were parasitized by *U. lariophaga* during the study.

Influence of the climatic factors on the development of bruchid population

B. atrolineatus populations

When beetles were reared in the conditions of 25:20°C 12:12 11:13 LD simulating the temperatures observed in Niamey country during December and January, 76 % of the males and 77 % of the females were in reproductive diapause. The first emerging adults were sexually active, the diapausing adults emerged later and the duration of their development was highly variable (fig. 5A). In conditions of 40:25°C 12:12 h 11:13 LD, the proportion of diapausing beetles was reduced (fig. 5B) and the variability of the developmental time duration was lower than in "cold conditions".

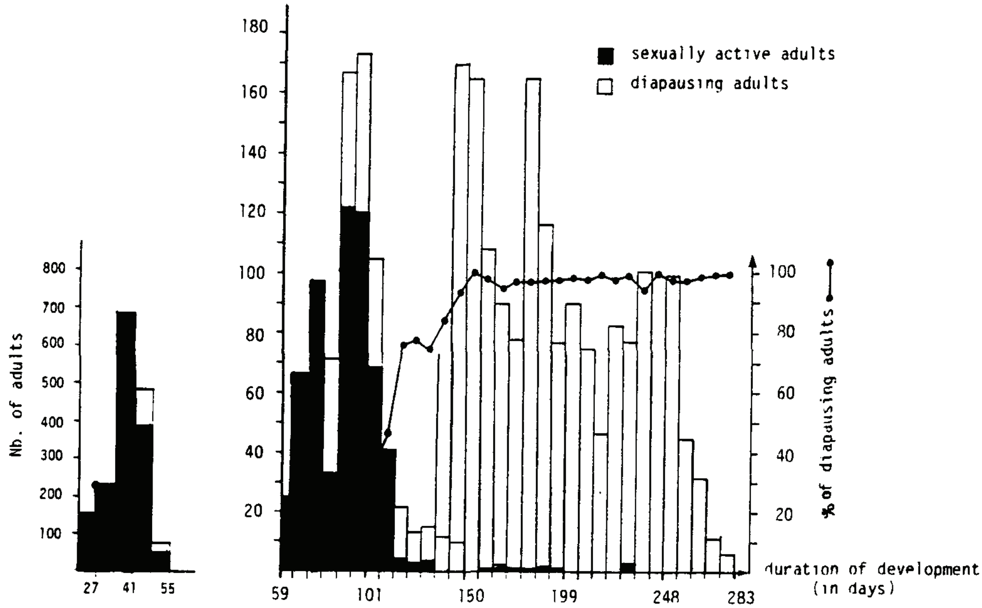

Figure 5 : Number of sexually active and diapausing adults and duration of their development (in days) in conditions of 25:20°C 12:12 h 11:13 LD (5A) and in conditions of 40:25°C 12:12 h 11:13 LD (5B).

B. atrolineatus population was analyzed in a rearing box containing 2.000 seeds with L1 larvae and 20.000 non-attacked seeds (level of contamination observed in Niamey country at the beginning of storage). The number of adults emerging from the seeds and their gonadal development were determined each week.

During 16 weeks, four generations of *B. atrolineatus* developed in the store (table I). At the end of experiment, 62.450 adults emerged. The proportions of sexually active adults were stable at each generation (27 to 35 %). In these climatic conditions, some generations could develop in the store but the experiment was stopped after 4 generations, the number of available seeds being exhausted.

Table I : Development of *B. atrolineatus* population in a rearing box in conditions of 40:25°C 12:12 h 12:12 LD.

Generations	No of adults	% of sexually active adult
1	757	33
2	4677	35,1
3	20145	30,1
4	36890	27,2
Total	62450	29,4

C. *maculatus* populations

The influence of climatic factors (particularly hygrometric factors) is predominant for induction of imaginal polymorphism (Sano Fujii, 1984 ; Ouedraogo *et al.*, 1991). The importance of the hygrometric factor was analyzed in a *C. maculatus* population developing in a rearing box containing 20.600 undommaged seeds and 500 seeds with L1 larvae (initial contamination observed at the beginning of storage in different sahelian zones). Expe-riment was carried out in conditions of 35:25°C 12:12 h and in 70 and 20 % rH. In each condition the air water content varied between 33 and 14 g/kg in 70 % rH and between 4,6 and 1,9 g/kg in 20 % rH. The number of adults and their imaginal form were determined each 15 days. In both conditions, the increase of the population was important. The proportion of flight forms depended on the hygrometric conditions (fig. 6).

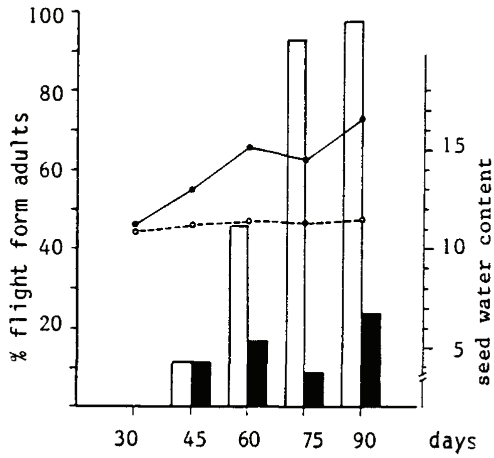

Figure 6 : Variations of the percentages of flight form *C. maculatus* adults reared in 35:25 12:12 DD in 70 % rH (white bars) and 20 % rH (black bars) and variation of the seed water content in 70% rH (—) and in 20% rH (---)

In 70 % rH, the seed water content, determined as described by Ouedraogo *et al.* (1990), was high (between 14 and 17 %) and 96 % of the beetles emerging from the seeds belonged to the flight form.

In 20 % rH, the seed water content did no change (11 %) during the experiment. The proportion of flight form beetles was lower than 25 % and a high number of flightless form adults emerged in the rearing box.

Influence of larval parasitoïds on bruchid populations

Seeds with L3, L4 or nymphs of *B. atrolineatus* or *C. maculatus* were placed during 24 hours in presence of the adults of the parasitoïds *D. basalis* or *E. vuilleti* (200 males and females in presence of 400 to 500 seeds containing bruchid larvae). In each condition, the rate of parasitism was high (table II) whatever the bruchid species. Females of *D. basalis* or *E. vuilleti* laid eggs and larvae developed in both host species. The rate of parasitism was higher on *C. maculatus* than on *B. atrolineatus*. The rearing conditions before experiments probably, explained these differences. *D. basalis* and *E. vuilleti* were reared on *C. maculatus* larvae for several generations and could preferentially parasitized the host where they had developed as observed in other hymenoptera (Smith and Cornell, 1979).

Table II : Rate of parasitism of *D. basalis* and *E. vuilleti* on the two hosts.

Parasitoïd species	Hosts	Rate of parasitism (in %)
D. basalis	*B. atrolineatus*	89.8 ± 3.1
	C. maculatus	98.8 ± 4.0
E. vuilleti	*B. atrolineatus*	78.3 ± 4.1
	C. maculatus	83.2 ± 5.9

This experiment showed the ability of the two species to influence the population dynamics of their host and that they could be used in biological control in storage.

DISCUSSION

The studies carried out in Niger show that the two bruchid species can develop in the storage conditions but their strategies are different.

B. atrolineatus adults colonize the cowpea culture at the beginning of the fructification period and the population density is high at this period. A important population of larvae develop in the maturing seeds and adults emerge in the field or in the store. The females lay eggs on dry pods and the new generation in reproductive diapause leaves the store. *B. atrolineatus* partially exploit the trophic ressources available in the store. Induction of diapause by the temperature decrease limits the population development. When the climatic factors are favourable for sexually active adult emergences and when trophic ressources are permanently available, several generations of *B. atrolineatus* can develop in the store leading to a high population density.

The density of the *C. maculatus* population is low in the field and at the beginning of the storage. However, the presence in the store of the flightless form adults with a high fecundity, allows an important colonization of the store. The increase in population is high and the seed damage due to *C. maculatus* is serious. Egg and larval parasitoïds, which are probably density dependant, limit the *C. maculatus* population development.

The control of the population of these two multivoltine bruchid species is difficult, particularly on small farms :

1) Adult populations could be controlled in the field before pods are harvesting. These control methods using insecticides are very expensive and their utilization in intercropping systems (frequent in Africa) is very difficult.

2) The development of adult population could be limited in the store by insecticides but it is necessary to protect the hymenoptera parasitizing a high percentage of eggs and larvae when the conditions for their development are favourable.

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LE DEVELOPPEMENT DE DEUX ESPECES DE BRUCHES (*BRUCHIDIUS ATROLINEATUS* PIC ET *CALLOSOBRUCHUS MACULATUS* F.) ET DE LEURS PARASITES LARVAIRES LORS DU STOCKAGE DES SEMENCES DE NIEBE (*VIGNA UNGUICULATA* WALP) EN AFRIQUE DE L'OUEST

J.P. MONGE, P.A. OUEDRAOGO, A. LENGA et J. HUIGNARD

Institut de Biocénotique Expérimentale des Agrosystèmes
URA CNRS 1298
Avenue Monge, Parc Grandmont
37200 Tours, France

RESUME

Bruchidius atrolineatus (Pic) et *Callosobruchus maculatus* (F.) sont les deux ravageurs des légumineuses alimentaires telles que le niébe (*Vigna unguiculata*) d'Afrique de l'Ouest. La contamination des cultures commence à la fin de la saison des pluies, pendant la fructification et continue dans les stocks traditionnels après la récolte des gousses. Les populations de *B. atrolineatus* sont importantes au début du stockage et deux générations d'adultes émergent dans les stocks. Les adultes de la seconde génération sont en diapause reproductive et quittent le stock. Les populations de *C. maculatus* sont réduites au début du stockage mais la densité de la forme non voilière augmente progressivement et ces coléoptères causent des dommages très importants à la fin de la saison sèche. Lorsqu'arrive la saison des pluies, les adultes de la forme voilière émergent et quittent les stocks. Les adultes voiliers représentent la phase de colonisation de ce coléoptère. Des expériences de laboratoire ont montré l'importance de la température et de la teneur en eau des graines sur l'induction de la diapause reproductive de *B. atrolineatus* et le polymorphisme imaginal de *C. maculatus*.

Pendant le stockage, deux espèces de parasitoïdess larvaires, *Eupelmus vuilleti* et *Dinarmus basalis* sont présents pendant la saison sèche et influencent la dynamique de population des deux bruches. Ces hyménoptères représentent 31 % des insectes récoltés dans les stocks au début de la saison sèche et 50 % à la fin. Dans de bonnes conditions de stockage, ces espèces pourraient être utilisées pour réduire efficacement les populations de bruches.