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CONTROL OF STORED GROUNDNUT INSECT PESTS IN AFRICAN SUBSISTENCE FARMING

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Abstract

Groundnut pods are subject to insect attack prior to harvest as well as during the drying process and in the store. Infestation by primary pests occurs in the soil (termites, myriapods) and after pods are lifted (C. serratus). These pests open the way to secondary pests, among which the Lepidoptera Corcyra cephalonica and E. cautella. The groundnut seed-beetle, C. serratus, normally infests pods of leguminous trees and shrubs, and has become adapted to groundnut in Western Africa in the early XXth century. It has recently been recognized as a pest in Central Africa and India, possibly as the result of the spread of more susceptible varieties or other modifications of the agrosystems. Groundnut infestation by beetles breeding on wild hosts does occur in some areas, and efforts must aim at breaking this part of the infestation cycle. On the other hand, store hygiene (including the use of insecticides) and proper stock management should help solving the problem of infestation by local residual populations of the bruchid. The relative importance of the different primary pests varies according to ecological situation in various parts of Africa. This must also be taken into account when setting up local control strategies.

Introduction

The reasons for the high level of damage inflicted by insects to groundnut stocks in Africa are known: deficient collecting networks, inadequate basic road equipment, lack of economic incentives for a better grain quality, inadequate storage structures and management, etc.. Groundnuts reach the central stores with high infestation levels and are often left without care to further insect attack. This situation originates in an almost complete lack of hygiene and insect control measures at farm level. In Ivory Coast, Pollet (1984b) found that 88% of the groundnut producers, although fully aware of the insect problem, never take any control measure in their stores. In Congo, only 40% of the farmers in the groundnut producing

Bouenza region, in the southern part of the country, make use of specific control methods. The efficacy of these methods, consisting mainly in the admixture of various plant materials and ashes, is however quite low (Delobel and Malonga, 1987). Similar situations prevail all over the continent. As a result, severe damage is experienced at all levels. Losses have increased during the last ten years or so in Africa (Matokot et al., 1987; Koyabay, 1988), as well as in India (Dick, 1987). This increase is due in greater part to the recent extension of areas where the groundnut seed-beetle, *Caryedon serratus* Ol., attacks groundnuts. The relative importance of various insect pests of groundnuts in the different situations prevailing in Africa will be reviewed. The question of store protection against primary and secondary pests will be redefined, lying stress on the groundnut seed beetle, which distinguishes itself by the high level of losses inflicted and by its ecological and behavioural characteristics.

Materials and methods

Experiments were conducted in 1987 in the Mouyondzi district, Bouenza region in Southern Congo. The district is located in a shrub savanna with the herb layer dominated by Graminae (*Hypparhenia spp.*) and the woody elements by *Hymenocardia*. Remnants of the Chaillu rain forest occur on favorable soils. "Rouge de Loudima", a groundnut variety with high oil content permitting two crops a year, was introduced in the early 1970's and became rapidly popular among the farmers, replacing all traditional varieties. Two villages in the district, which has experienced for more than ten years heavy infestations by *C. serratus*, were selected. One of them, Bikouka, is located in a savanna area where a wild leguminous host of *C. serratus*, *Piliostigma thonningii*, is abundant. The village comprises 50 granaries. The second village, Kingoye, is located in a forested area where no wild host has been reported. It comprises 20 granaries. All 70 granaries were spread with a solution of the pyrethrinoïd insecticide cyfluthrin (50 mg a.i. per l. water) at a rate of 5l. per granary one month before harvest. Old groundnut stocks were destroyed. No chemical treatment was applied to the new harvest. A few days after it was taken to the granaries, samples consisting each of approximately 3kg of pods were collected in the two villages. Samples placed in woven polypropylene bags (28 x 40cm) were maintained in the laboratory at 25°C and 75-90% R.H. Eggs of the seed-beetle were searched for by examining groundnut pods under binocular microscope. After 3 months, larvae, pupae and adults of *C. serratus* and other insects were recorded and identified. A similar sampling procedure was performed on pods collected from the same 70 granaries 8 months after harvest. The development of *C. serratus* infestation was also studied by samplings in two villages which were not protected by insecticide, one in the savanna area, the second in the forest.

Results

Table I indicates the proportion of stores which were infested by *C. serratus* and secondary pests. *T. confusum* was the commonest species, being present in almost half of the stores.

Table I. - Insects found in 70 groundnut stores 3 months after harvest. Mouyondzi district (Congo), 1987.

	Percentage of infested stores	Status [1]
Caryedon serratus	5.7%	I
Tribolium confusum	47.7%	II
Oryzaephilus mercator	39.8%	II
Carpophilus dimidiatus	32.9%	II
Cryptolestes pusillus	29.5%	II
Ahasverus advena	21.6%	M
Tribolium castaneum	14.8%	II
Corcyra cephalonica	10.2%	II
Araecerus fasciculatus	3.4%	II
Exkorynetes analis	2.3%	P
Trogoderma granarium	2.3%	II
Other species	1.1%	M/II

[1] I: primary pest; II: secondary pest; M: mycophagous; P: predator

C. serratus was present in 6% of the granaries. Only one Lepidoptera, *Ephestia cautella*, was found in the 70 samples, but *Corcyra cephalonica* was also common on groundnuts in the area. The level of infestation by *C. serratus* in the two villages which were protected by insecticide (Table II) indicated that:

- in the village where no wild host existed, either in the village itself or in nearby fields, spraying insecticide on walls and roofs and destroying old stocks prevented the development of *C. serratus* for at least eight months in all 20 granaries.

- in the village where the wild host *P. thonningii* was present, in the village itself and in nearby fields, the same treatment did not protect granaries against seed-beetle infestation. At the time harvest was taken to the stores, four of them (out of 50) were already infested. After 8 months storage, granaries were infested, but in two of them, infestation disappeared spontaneously, possibly as a result of the presence of high population levels of the predatory mite *Pyemotes tritici*. In control villages, all granaries were infested by *C. serratus* after 8 months storage. The presence or absence of *P. thonningii* had no apparent effect on *C. serratus* infestation.

Table II. - Effect of the presence of *P. thonningii* on groundnut infestation by *Caryedon serratus* in two villages of the Mouyondzi district, Congo (1987). Stores treated with insecticide.

	Nber of stores	Infested stores: At harvest	Infested stores: 8 months a.h.
Wild host absent	20	0 n.s.	0 *
Wild host present	50	4 n.s.	12 *

n.s. No significant difference; * difference significant at the 5% level (Yates chi-square test)

Discussion

Different categories of groundnut pests

Maturing groundnut pods are bored by several species of Diplopods (Myriapods) belonging mainly to the genus *Peridontopyge* and by termites (*Microtermes spp.* and *Odontotermes spp.*)(Gillon and Gillon, 1976; Pollet, 1984a). After harvest, female *C. serratus* lay their eggs on the pods; after completing their development, larvae bite their way through the shell and pupate on the ground or in the soil; some larvae pupate in the pod, and the adults at emergence also bore a hole in the shell. The Lepidoptera *Corcyra cephalonica* and *Ephestia cautella* are often considered as primary pests of groundnut pods in Africa (e.g. Roubaud, 1916; Risbec, 1948). However, the shell normally protects nuts from attack by Lepidopterous larvae. Their development, as well as that of other secondary pests, chiefly depends on the existence of entry holes. The relative importance of these different pests depends on the geographical and ecological area. In Ivory Coast, according to Pollet (1984b), Lepidoptera infest 1.4% of groundnut pods after two months of storage, and 4.6% after 4 months.These relatively high figures must be ascribed to the fact that 2.4% of the pods are pierced before harvest by Diplopods, and 13.2% by termites. *C. serratus* attacks groundnuts only in the Niakaramandougou district, in Central Ivory Coast. Infestation rates there are so high that farmers stocks are often completely destroyed within months. In Northern Nigeria (Johnson et al., 1981), termites pierce 30 to 4O% of the pods, and up to 80% in specially dry conditions. In Senegal, termites are especially active in dry sandy soils. As for Diplopods, work by Masses (1981) has shown that they are specially abundant and noxious to maturing groundnut pods in regions with 700 to 1000mm annual rainfall. In these areas, 15 to 30% of the pods are attacked by several species of Diplopods, the commonest being *Peridontopyge subrubescens* Attems. *C. serratus* is very common in Senegal and Gambia (Appert, 1956; Green, 1959; Pointel et al., 1979), where it causes heavy losses in the absence of chemical protection. In Congo, where annual rainfall exceeds everywhere 1200mm, termites and Diplopods rarely attack groundnuts in the soil. The presence of secondary pests (Table I) in about half of the granaries (after insecticide treatment) at the beginning of the storage period may be explained by the fact that numerous shells are broken at harvest and when pods are plucked off the haulm. The origin of infestation by secondary pests must probably be traced back to residues of various products such as maize, beans, or cassava chips (Delobel, 1991). *C. serratus* adults are hardly seen in the stores at that early stage. It is only after three generations that their populations reach high levels, and that their presence becomes readily noticeable. The large number of exit holes promotes in turn a rapid increase of secondary pest populations (Matokot et al., 1987).

Development of C. serratus infestations

The groundnut seed-beetle is an African species (Decelle, 1981) which was first described in 1790 from specimens collected in Senegal. Its hosts belong to the family Caesalpiniaceae. The commonest in Africa are *Piliostigma thonningii* and *P. reticulatum*, *Bauhinia rufescens* and *Tamaridus indica*. The species is now widespread in most ofthe warm regions of the world, including Oceania and South America. Groundnut was introduced to Africa by Portuguese colonizers in the 17th century. In 1912, the quality of groundnuts in Senegal experienced a sudden and rapid decline (Azémard, 1914). In 1913, *C. serratus* was recognized as responsible for part of the observed damage (Roubaud, 1916). Since then, areas where *C. serratus* attacks groundnuts have slowly spread to the greater part of Western Africa. It may be noted that infestation does not gain ground, as is usually the case for introduced pests, along a more or less uninterrupted front, but on the contrary as isolated foci. This is not only the case of the already mentioned Bouenza focus in Congo and Niakaramandougou focus in Ivory Coast, but also of the more recent Ouham-Pendé focus in North-eastern Central african Republic (Koyabay, 1988). Starting from a new focus, infestation progresses to other villages, sometimes far apart, leaving wide areas uninfested. In these areas, if wild hosts are present, they may be infested by *C. serratus*, while local groundnut stores are not. Even within a single village, large differences in infestation levels are commonly detected between granaries. These differences may be attributed partly to field location and partly to differences in population dynamics of the bruchid, with the predaceous spider-mite *Pyemotes tritici* playing a major role in some stores (Matokot et al., 1987). In India, *C. serratus* attacks in groundnut stores were first detected in the early 1980's (Dick, 1987). Until then, local strains of *C. serratus* had been reared on groundnuts only in the laboratory and the seed-beetle was considered simply as a potential pest of groundnuts (Mital, 1969). Elsewhere in the world, *C. serratus* is a pest of tamarind seeds and does not attack groundnuts.

Hypotheses concerning C. serratus infestations

Two main hypotheses may explain the emergence of *C. serratus* as a pest of groundnuts:

(1) appearance in Senegal, towards the beginning ofthe century, of a population with physiological, ecological and comportmental characteristics such that it adopts groundnut as new host-plant. The shift was facilitated by the rapid extension of groundnut cultivation which occurred in Senegal after 1830 (Grisard and Vanden-Berghe, 1891). This population (or at most limited number of similar populations) is at the origin of all present foci. Its permanence and extension to new geograpical areas attest of an important genetical isolation from populations developing on wild hosts and tamarind. Such a population may be identified as a "biotype" in the wide sense (Maxwell and Jennings, 1980) or a "sympatric host strain" (Janzen, 1980).

(2) continuous shifting from wild hosts to groundnuts all over the distribution area of the beetle. There is no genetical isolation, but rather a high degree of compormental and trophic variability. Geographical isolation of biotypes remains a possibility, as shown in *C. serratus palaestinicus* Southgate, considered as a true species by Pfaffenberger (1984). Due probably to local cultural practices (different planting dates, use of more susceptible varieties, storage of grain with a higher moisture content, increased storage periods...), to climatic and ecological differences and to still poorly understood phenomena such as adult or larval conditioning (Robert, 1985), populations developing on groundnut reach epidemic size only in certain areas of Western and Central Africa and in India. The control strategy which should be developed against the groundnut seed-beetle depends largely upon the choice between these two hypotheses. If the former (i.e. genetically isolated populations) is verified, infestation of a granary must originate in the granary itself or in neighbouring granaries. If the latter hypothesis is verified (i.e. populations not isolated), beetles may either come from already infested stocks or from wild hosts; in this case, a simple chemical treatment of the granaries cannot be sufficient to prevent infestation. A study of *C. serratus* population genetics and behaviour and of the fitness of different hosts should allow us to decide between the two hypotheses. In particular, the knowledge of genetic distances between populations should be of great help. However, results of the experiment involving the chemical treatment of all granaries in two villages of Southern Congo (Table II) provide indirect evidence that infestation of granaries by populations developing on wild hosts does occur. Proving the existence of cross-infestation is uneasy because of extremely low population levels in the first generation of the bruchid: in the case of the 70 granaries studied in 1987, eggs were observed on 13 pods out of the 129450 which were examined. Similar difficulties exist in the genus *Callosobruchus*, where field populations are often very low (Southgate, 1979). The slow progress of *C. serratus* in reaching areas hitherto preserved has probably to do with the heterogeneity of wild host distribution. In Central Africa, *P. thonningii* grows only in certain types of savannas (Schnell, 1976). Also, a low level of coincidence between the time of groundnut harvest and the time of emergence of *C. serratus* from wild host pods may strongly reduce the probability of a shift to groundnuts. According to Conway (1983), the succession of maturing dates of pods of different wild hosts in the Gambia allows low population levels to persist the year round and thus to infest groundnut soon after harvest, when pods are drying in the field. Similar observations have been made in Niger (Pierre and Huignard, 1990). On the other hand, in Ivory Coast, where stored groundnuts are almost entirely spared by the seed-beetle, Gagnepain and Rasplus (1989) consider that savanna burning considerably reduces the number of *Piliostigma* pods available to *C. serratus* females. In Congo, where savanna is hardly burnt in the dry season and where *P. thonningii* mature pods may remain several months on the tree, an active population of *C. serratus* persists in the field all year round (Mapangou-Divassa, 1985). The emergence of a groundnut seed bettle problem seems however to have coincided in Congo with the adoption of a variety selected for its high oil content, but which proved to be more susceptible to *C. serratus* than traditionally grown varieties (Mapangou-Divassa, 1985).

Conclusion

A rational control strategy against stored groundnut pests is a global one: it must take into account the different categories of pests mentioned earlier. It should be based upon the following considerations:

(1) in areas where groundnut is prone to termite and myriapod attack (roughly in areas with less than 1000 mm annual rainfall), heavy infestation by secondary pests seems unavoidable without a chemical protection of the stock; any progress in termite and myriapod control in groundnut fields will greatly improve groundnut keeping quality;

(2) elsewhere, the shell (as long as it is perfectly sound and undamaged) protects nuts against all insects except the groundnut seed-beetle;

(3) the seed-beetle is a pest of groundnut only in certain geographic areas, which should be precisely defined. There, priority should be given to the interruption of the infestation cycle which passes through wild hosts and/or the tamarind tree. This could be achieved by eliminating the pods of these hosts; the solution is however unpracticable except in situations where infestation stems from a small number of well localized trees. Anywhere else, groundnut pods will escape field infestation if drying and pod-plucking are performed far away from wild host plants in order to avoid invading beetles. Shelling is sometimes advocated as a way to avoid *C. serratus* infestation. In fact, usual storage conditions in subsistence farming are such in Africa that unprotected nuts will immediately become the target of various secondary pests;

(4) in all cases, primary infestation originating from *C. serratus*-infested groundnut residues or from various other food products infested by secondary pests must be avoided thanks to a thorough cleaning-up of stores and houses. Granaries and bags must be treated before the new crop is taken home;

(5) preliminary investigations (Mital, 1969; Mapangou-Divassa, 1985) indicating that resistance mechanisms exist in some groundnut varieties should be continued. Research programmes aiming at the selection of new varieties resistant to *C. serratus* should be included in groundnut selection programmes.

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