ECOLOGY AND PREDATORY ABILITY OF *TERETRIOSOMA NIGRESCENS* LEWIS (COL.: HISTERIDAE), A POTENTIAL BIO-CONTROL AGENT FOR *PROSTEPHANUS TRUNCATUS* (HORN) (COL.: BOSTRICHIDAE).

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Abstract

In the late 1970s *Prostephanus truncatus* (Col.: Bostrichidae), a pest of erratic importance on farm-stored maize in Mexico and Central America, was accidentally introduced into Tanzania and later to Togo. It has since spread to neighbouring countries and is now a major threat to stored maize and dried cassava in Africa.

Teretriosoma nigrescens (Col.: Histeridae), found associated with *P. truncatus* in Central America but not Africa, can reduce the rate of increase of *P. truncatus* on maize cobs and dried cassava by a factor of ten. It can also prey on *Dinoderus minutus* and *Rhyzopertha dominica* (Col.: Bostrichidae), but has little effect on *Sitophilus zeamais* (Col.: Curculionidae) and *Tribolium castaneum* (Col.: Tenebrionidae).

In farm-stored maize in Yucatan, Mexico, *T. nigrescens* was found to be closely associated with *P. truncatus* and was strongly attracted to the pest's aggregation pheromones. Its presence there may account for the lower pest status of *P. truncatus* than that observed in Africa.

T. nigrescens is being considered for introduction into Africa as a bio-control agent for *P. truncatus*. Subsistence producers, used to insects in stored grain, may not be hostile to its presence. They are often reluctant to shell maize and treat with insecticides, and dried cassava is almost never treated.

T. nigrescens does not appear to be able to breed in the absence of live prey. However, it is attracted to cereal grains, and especially to maize previously infested with *P truncatus*. Adult predators were observed, in the absence of live prey, to feed on grains of wheat and maize. Compared to the damage caused by *P. truncatus*, that caused by the predator was very slight. The implications of these observations for the safe release of this predator in Africa to control *P. truncatus* are discussed.

Introduction

The genus *Teretriosoma* (Col.: Histeridae) comprises 46 species, 29 of which have been recorded from the Americas (Mazur 1984). Several species of *Teretiosoma,* as well as members of the closely related genus *Teretrius,* have been found as predators of immature stages of wood-boring bostrichid beetles (Arriagada 1985; Desbordes 1930). *Teretriosoma nigrescens* Lewis, initially described from Guanajuato in Mexico (Lewis 1891), has been found in association with *Prostephanus truncatus* (Horn) (Col.: Bostrichidae) infesting farm-stored maize in Mexico (Haines 1981), Costa Rica (Boye *et al.* 1988) and Honduras (Hoppe 1986). To date *T. nigrescens* has not been found in Africa.

Adult *T. nigrescens* lay, singly, eggs 1 mm long which hatch after 7 days at 27°C. The campodeiform larvae, 2-3 mm long at eclosion, pass through two instars and complete their development in about 20 days, when they are 10-12 mm in length. To pupate they fashion a cell in a crevice. The pupal stage lasts approximately three weeks. Development from egg to adult takes about eight weeks (Rees 1985).

Table I. Growth in populations of *P. truncatus, T. castaneum, S. zeamais* and *T. nigrescens* on maize cobs at 27°C and 70% r.h. (from Rees 1987).

Insects added at (weeks)			Mean number of adults after 14 weeks		
0	3	6	P.truncatus	T.castaneum	T.nigrescens
PT			725a	-	-
PT	TN		76b	-	17a
PT	TN	TC	67b	7b	12a
	TC	TN	-	32a	5b
	TC		-	46a	-
			P.truncatus	S.zeamais	T.nigrescens
PT/SZ			303a	42a	-
PT/SZ	TN		64b	60a	12

Notes

Initial numbers added to an individual maize cob: - *P. truncatus* (PT), *S. zeamais* (SZ), *T. castaneum* (TC), three pairs; *T. nigrescens* (TN) four individuals. Within each species, values with the same letter are not significantly different at $P<0.05$ (Newman-Keuls test performed on transformed ($\log_e$) numbers).

Immature stages of *Prostephanus truncatus* are eaten by larval and adult *T. nigrescens.* To complete development, *T. nigrescens* larvae each need to consume about 60 medium to full-grown prey larvae (Rees 1985). When searching for food, the predator can move rapidly along tunnels bored by its prey. Indeed, the larva appears so well adapted to life in a tunnel that it has difficulty walking on a flat surface.

T. nigrescens can reduce the population growth of *P. truncatus* infesting shelled maize as dry as 8.5% moisture content (Rees 1985). On maize cobs with intact sheathing leaves (Rees 1987), the rate of increase of *P. truncatus* was reduced by about 90% by the addition of *T. nigrescens* (Table I). In contrast the predator had little effect on *Sitophilus zeamais* (Col.: Curculionidae). *Tribolium castaneum,* a known facultative predator (LeCato 1975), had a significant effect

on *T. nigrescens*. Indeed, *T. nigrescens* appeared in some replicates to have bred whilst feeding on *T. castaneum*. In further laboratory studies, *T. nigrescens* was able to reduce rates of increase of *Rhyzopertha dominica* and *Dinoderus minutus* (Col.: Bostrichidae) populations infesting shelled maize by about 50% and 90% respectively (Rees 1990).

Table II. Parasites and predators of stored-product pests found in farm-stored maize in Yucatan, Mexico (from Rees *et al.* 1990).

Family	Genus	Species	Frequency	Abundance
		Hemiptera		
Reduviidae	*Peregrinator*	*biannulipes*	11%	*
Anthocoridae	*Xylocoris*	sp.	14%	*
		Coleoptera		
Histeridae	*Teretriosoma*	*nigrescens*	24%	**(P)
"	*Teretrius*	sp.	7%	*
		Hymenoptera		
Bethylidae	*Cephalonomia*	sp.	4%	*
"	indet.		4%	*
Braconidae	*Bracon*	sp.	4%	*
Chalcididae	indet.		4%	*
Ichneumonidae?	indet.		4%	*
Pteromalidae	*Anisopteromalus*	*calandrae*	7%	*
"	*Choetospila*	*elegans*	7%	*

Key:-
Frequency - Percentage of farms (38) at which this species was found.
Abundance - **: several specimens (<10) found in store.
*: individual specimens only.
(P): insects detected using traps baited with *P. truncatus* aggregation pheromone.

In a survey (Rees *et al.* 1990) of traditional on-farm storage of maize cobs in Yucatan, Mexico, *P. truncatus* formed only a small part of the pest complex present; this was dominated by *S. zeamais, T. castaneum* and *Cathartus quadricollis* (Col.: Silvanidae). *T. nigrescens* was the natural enemy most frequently found in stores: invariably in association with *P. truncatus*. It was also captured in crevice and flight traps baited with the synthetic aggregation pheromone of *P. truncatus*. Apart from *T. nigrescens* (and possibly the *Teretrius* sp.) all other parasites and predators present (Table II), known or suspected to attack stored-product insects, appeared to be cosmopolitan species also recorded from Africa (Haines 1981).

P. truncatus and *T. nigrescens* were captured together in abandoned fields containing maize crop residues, in areas of rain-fed maize and in maize being grown under irrigation. They were also caught in primary and secondary forests, scrubland, rough ground in a housing estate, and henequen plantations: areas in which maize or cassava was not present (Rees *et al.* 1990).

Other studies (Rees, unpublished data) show that *T. nigrescens* is attracted to grain previously infested with *P. truncatus*. This response remains even after the material has been washed in acetone or heated for four hours at 90°C: procedures that remove or denature most pheromones. The predator may locate infested grain from a distance with prey aggregation pheromone but once amongst cobs etc. they may follow concentration gradients of less volatile compounds present in damaged grain and prey frass.

From field and laboratory observations, *T. nigrescens* appears to date the most promising candidate for use as a biological control agent against *P. truncatus* in Africa. Prior to its introduction, tests are needed to ensure that it does not cause significant damage to stored products that are important as staple foods or cash-crops.

Comparison of the ability of *P. truncatus* and *T. nigrescens* to damage and breed on a range of stored grains.

Method

Tests were carried out to see if *T. nigrescens* could damage or breed, in the absence of prey, on a range of stored products. Results obtained were compared with the damage caused by, and breeding success of, *P. truncatus* on the same commodities. To 500ml glass jars were added 50g of undamaged whole grain: maize, wheat, kidney beans, cocoa or coffee. Ten replicates of each were set up, plus two containing grain for moisture content determination. Filled jars were equilibrated for one week at 27°C and 70% r.h. The grain was accurately weighed prior to the addition of 20 adults of either *P. truncatus* or *T. nigrescens* (five replicates per species on each commodity). After eight weeks at 27°C and 70% r.h., grain was weighed, having first been sieved to remove dust and small fragments. The numbers of live insects present were also recorded. Weight loss was calculated on a dry weight basis, moisture contents having first been determined by ISO methods.

Results

Table III Final number of insects, and percentage weight loss caused by *T. nigrescens* or *P. truncatus*, on a range of commodities after eight weeks at 27°C and 70% r.h.

	T. nigrescens		*P. truncatus*	
Commodity	number[1]	% wt loss[2]	number[1]	% wt loss[2]
Maize	11.8	0*	105.3	17.2
Wheat	4.8	0.4	17.8**	3.3
Kidney beans	0.2	0	0	0
Cocoa	0.2	0	0.7	1.1
Coffee	0	0	0	0

Key:-[1] - mean number of live adults after 8 weeks at 27°C and 70% r.h. Initial number per replicate = 20. Five replicates per treatment.

[2] - calculated on a dry weight basis

* - some evidence of insect damage observed

**- mature larvae also present

T. nigrescens was unable to breed on any of the commodities tested. However, in feeding, predator adults excavated holes in a few grains of maize and wheat (Table III). In some replicates, almost all the *T. nigrescens* present were found within one or two damaged grains. In contrast, *P. truncatus* bred on maize, and very slowly on wheat, causing a greater percentage weight-loss to commodities than the predator. Burrowing and probable feeding by adult *P. truncatus* also caused weight loss in cocoa beans.

Experiment to examine if *T. nigrescens* is attracted to a range of stored grains

Method

Under field conditions, *T. nigrescens* adults usually have a choice of commodities on which they can feed or look for prey. Some commodities may be more attractive than others. While *T. nigrescens* may attack a given commodity in laboratory tests it may only do so in the field if this material is more attractive than the others present.

T. nigrescens adults were exposed to a number of combinations of stored products to see to which they were most attracted. Polythene boxes (30 X 21 X 13 cm) were filled with 1.5 l of "Hortag"[1]. This inert material, of particle size 5 mm, provided a grain-like matrix through which the insects could move rapidly. Buried at opposite ends of the box were two pyramid-shaped bags, 6cm high, made from plastic mesh with a hole size of 2mm. Bags were filled with 40g of either Hortag or a commodity (Table IV). Three replicates of each combination were set up. Thirty adult *T. nigrescens* were added to each box. After 24hrs at 27°C and 70% r.h., the number of insects present in each bag was recorded (Table IV).

Table IV. Choice chamber test: mean number* of *T. nigrescens* in each bag after 24hrs at 27°C and 70% r.h.

Bag 1		Bag 2	
Maize	21.6	Blank	0.3
Wheat	14.7	Blank	0.3
Cassava	22.7	Blank	0
Cocoa	0.7	Blank	0
Kidney beans	1.0	Blank	0
Maize	10.3	Wheat	1.0
Maize	12.0	Cassava	9.3
Maize	22.7	Cocoa	0
Maize	24.3	Coffee	3.3
Maize	3.6	Maize**	24.7

* Mean of three replicates; number of adult *T. nigrescens* per replicate = 30

** Disinfested maize taken from a culture of *P. truncatus*.

1 - A chemically inert lightweight aggregate, *ex* Croxden Horticultural Products Ltd.

Results

In the absence of other commodities *T. nigrescens* appeared strongly attracted to maize and cassava and, to a lesser extent, wheat. They appeared especially attracted to damaged and holed grains in which the soft endosperm was accessible. The predator was not attracted to either cocoa or kidney beans. When given a choice between maize and another commodity, more insects were found in the bag containing maize. Disinfested maize, previously infested with *P. truncatus*, was found to be more attractive than uninfested maize.

Discussion

Under the conditions used in these investigations *T. nigrescens* was unable to breed in the absence of live prey. The damage caused, by adult feeding, to some grains was very slight in comparison to that produced by *P. truncatus*. In feeding, predator adults appear to be most attracted to damaged grains. Such grain, previously damaged by other insects, is almost invariably present under conditions of farm-storage. When such material is available intact grain may be at very low risk of attack. Subsistence farmers usually regard the presence of insects as inevitable. The slight damage *T. nigrescens* may cause is likely to be far outweighed by the reduction in weight loss of stored grain as a result of its predation of *P. truncatus*. When live food is present, *T. nigrescens* may be even less inclined to feed on grain material. However, the ability of a predator to survive periods when prey is unavailable could be an important factor to ensure the long-term success of any introductions of *T. nigrescens*.

T. nigrescens appears to be attracted to cereal grains, especially to those on which *P. truncatus* can breed and in particular to grain infested with the pest. This, and its ability to locate sources of prey aggregation pheromone, suggests that *T. nigrescens* has a close association with *P. truncatus*. *T. nigrescens* is therefore most likely to be found on commodities and in areas where *P. truncatus* is also present. Not being able to increase in numbers in the absence of live prey, the potential damage a few individual predators could cause is negligible.

On the basis of these results the risk that *T. nigrescens* can cause significant damage to stored food and beverage crops is minimal. The potential benefits from it reducing the impact of *P. truncatus* may be considerable. *T. nigrescens* remains the most promising candidate as a bio-control agent against *P. truncatus* in Africa.

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ECO-PHYSIOLOGIE ET EFFICACITE PREDATRICE DE *TERETRIOSOMA NIGRESCENS* (COL. : HISTERIDAE): UN POSSIBLE AGENT DE LUTTE BIOLOGIQUE CONTRE *PROSTEPHANUS TRUNCATUS* (HORN) (COL. : BOSTRICHIDAE)

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RESUME

A la fin des années 1970, *Prostephanus truncatus* (Col. : Bostrichidae), un déprédateur des stocks de maïs d'importance variable dans les fermes du Mexique et d'Amérique centrale, a été accidentellement introduit en Tanzanie et au Togo. Sa présence s'est étendue aux pays voisins et il est devenu, à l'heure actuelle, une des principales menaces pour les stocks de maïs et de cassave séchée en Afrique.

Teretriosoma nigrescens (Col. : Histeridae) trouvé associé à *P. truncatus* en Amérique centrale mais non en Afrique, peut réduire d'un facteur dix le taux d'accroissement de *P. truncatus* sur les épis de maïs et la cassave séchée. C'est également un prédateur des bostrychides, *Dinoderus minutus* et *Rhyzopertha dominica*, mais il a peu d'effets sur *Sitophilus zeamais* et sur *Tribolium castaneum*.

Dans le maïs stocké au Yucatan, Mexique, on a découvert l'association étroite entre *T. nigrescens* et *P. truncatus* et celui-ci s'est montré fortement attiré par les phéromones d'aggrégation du ravageur. Peut-être sa présence est-elle responsable de la faible extension de *P. truncatus* au Mexique par rapport aux observations faites en Afrique. La présence de ces deux espèces a aussi été découverte dans des habitats éloignés des cultures et des stocks de maïs et de cassave.

On commence à penser à introduire *T. nigrescens* en Afrique pour en faire un agent de la lutte contre *P. truncatus*. Les producteurs de denrées agro-alimentaires, habitués à trouver des insectes dans leurs stocks de grains, ne seraient peut-être pas hostiles à sa présence. Ceux-ci sont souvent peu disposés à égrener leur maïs ou à le traiter aux insecticides. La cassave séchée n'est presque jamais traitée. L'introduction sous surveillance de ce prédateur en Afrique, pourrait réduite les pertes occasionnées par les ravageurs tout en ayant une incidence minime sur les pratiques et les coutumes agricoles traditionnelles.