Ability of the predator *Teretriosoma nigrescens* Lewis (Col.: Histeridae) to control larger grain borer (*Prostephanus truncatus*) (Horn) (Coleoptera: Bostrichidae) under rural storage conditions in the southern region of Togo

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Abstract

The ability of the predator *Teretriosoma nigrescens* Lewis (Col.: Histeridae) to control *Prostephanus truncatus* (Horn) (Col.: Bostrichidae) in maize stores has been studied in 'on-farm' trials during two consecutive storage periods in the southern region of Togo. Eight traditional maize stores have been installed in the release area of *T. nigrescens*, and eight stores outside the release area. In addition to the naturally occurring infestation, each store has been infested artificially with 2300 adult *P. truncatus* after two months of storage. In the first and second storage seasons 1992–1993, *T. nigrescens* reduced the population of *P. truncatus* by 80% and 73%, respectively, after eight months of storage. In the release area, *T. nigrescens* followed *P. truncatus* in all stores. The prey:predator ratio after eight months settled at 1.8:1 in the first season, and at 3.7:1 in the second season. At several points of both storage seasons the population of *Sitophilus zeamais* Motschulsky (Col.: Curculionidae) was significantly increased by *T. nigrescens*. In the second storage season, *T. nigrescens* reduced losses by 34.3% after eight months of storage, whereas in the first storage season losses were too low to be influenced by the predator.

Introduction

The predator *Teretriosoma nigrescens* Lewis (Col.: Histeridae) was found to be the most effective antagonist of the larger grain borer *Prostephanus truncatus* (Horn)(Col.: Bostrichidae) in the storage system in Costa Rica (Böye 1988). Both insect species are common in Central America. *T. nigrescens* is supposed to suppress the population of *P. truncatus* and thus to limit postharvest losses caused by the larger grain borer. Between 1971 and 1980, this pest has been introduced accidentally into Tanzania. In West Africa, *P. truncatus* was discovered in Togo first in 1984 (Krall 1984), where it became widespread (Richter and Biliwa 1991). Favoured by good climatic conditions, the absence of natural enemies, and the maize trade within and between countries, *P. truncatus* is currently found in other countries in East Africa such as Kenya, Zaire and Burundi, and in countries such as Bénin, Ghana and Burkina Faso in West Africa.

P. truncatus has increased storage losses in maize and dried cassava to an extent that was unknown in Africa before (Hodges et al. 1983; Pantenius 1987). In January 1991, *T. nigrescens* was released in Africa for the first time in the 'Région des Plateaux' in Togo with the objectives of controlling *P. truncatus* and reducing storage losses of maize and cassava. Other releases followed in the 'Région Maritime' in May 1992. However, not much is known about the behaviour of the predator in this completely new ecosystem.

The research reported here was carried out as part of the GTZ Project 'Integrated Biological Control of the Larger Grain Borer *P. truncatus*' in collaboration with the University of Hohenheim, Germany. Its objective is to survey the integration of the predator in the new environment, its impact on *P. truncatus* and on other storage pests, as well as its loss reduction potential under rural storage conditions.

Materials and methods

Installation of 'on–farm' trials

In July 1992, four villages were selected in the coastal region of Togo (Région Maritime) to set up the 'on–farm' trials. Two villages were situated in the eastern part where *T. nigrescens* has been released (release area) and two villages in the western part of the region, where *T. nigrescens* was not yet present (control area) (Figure 1). Criteria for the choice of the villages were:

- the number of *P. truncatus* found in Delta pheromone traps installed at three points of 20 preselected villages in order to make sure that initial infestation of the chosen villages is comparable.
- the location of the villages: to avoid an accidental introduction of the predator in the control area, villages had to be at a secure distance from the main maize transport streams.
- accessibility during the whole year to ensure sampling.

A first trial was conducted during the first storage season from August 1992 to March 1993, a second trial during the second storage season from January to September 1993. For both trials four farmers were chosen randomly in each of the four villages. Each farmer was asked to construct a traditional maize store with local materials (type 'Ebli-va' or 'Kédélin'). The store was placed in the usual position for maize stores, either in the farm yard or in the maize fields.

In order to assure uniform quality and uniform infestation with insects, the project purchased maize of a local variety, grown on a single field in the control region. Each farmer received 350 kg which was stored traditionally, i.e. on the cob with husks.

Artificial infestation of stores with *P. truncatus*

To secure similar infestation conditions, all stores were infested artificially with *P. truncatus* in addition to the natural occuring infestation. Following the natural infestation pattern, 2300 adult *P. truncatus* were introduced into each store after two months of storage. By means of a plastic tube, 2100 adults were introduced into the centre of the store, and 200 adults were distributed on 10 cobs (20/cob) and placed in the outer layer of the maize store.

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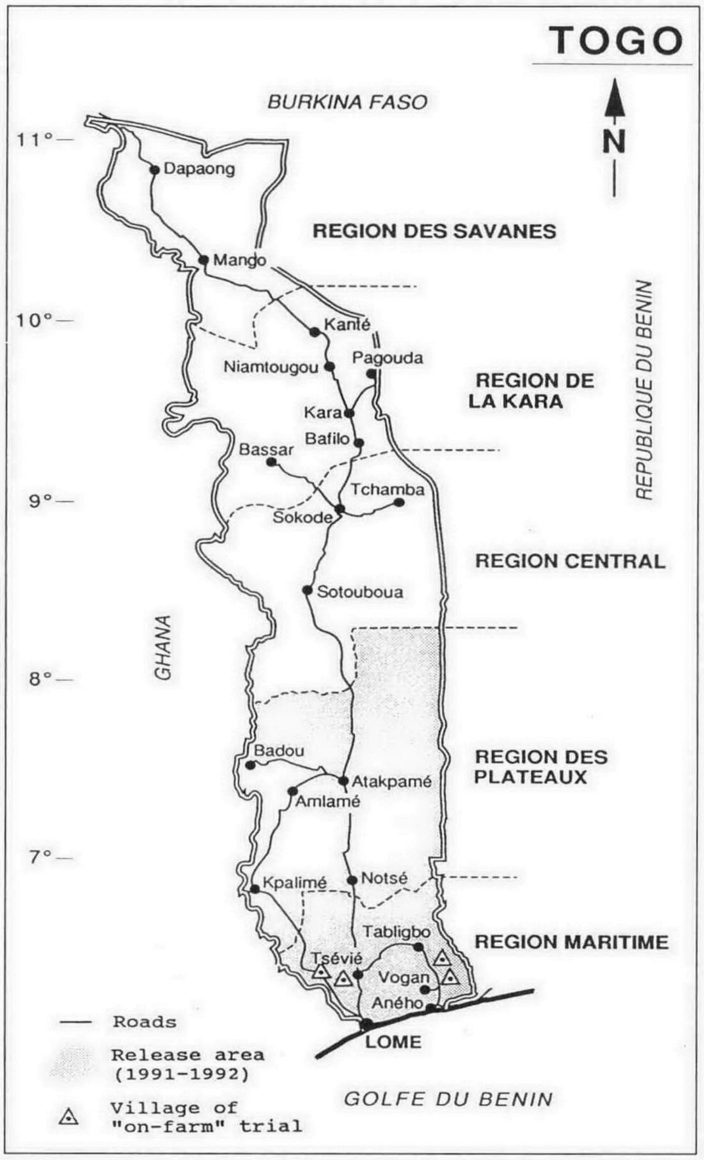

Fig. 1. Release area of *T. nigrescens* in Togo (1991-1992) and villages of 'on-farm' trials.

Sampling and evaluation methods

From the beginning of the storage, every month 100 cobs were collected on the surface of each store, using the method described by Pantenius (1987). The sampled cobs were transported in flour bags to the laboratory for evaluation. The experiment was completed after eight months of storage.

To faciliate counting of insects, cobs were fumigated with phostoxin for three days. In the laboratory every single cob was shelled carefully and stripped off. Damaged grains were counted and separated from undamaged. Both samples were sieved with two sieves (3.15 and 0.4 mm width of mesh). Damaged and undamaged grains did not pass the 3.15 mm sieve, whereas insects passed it and were counted. The fraction which passed the 0.4 mm sieve was the flour of boring activity of insects, particularly of the larger grain borer. After evaluating the 100 cobs, the three fractions (undamaged, damaged grains and flour of boring activity) were weighed. Undamaged grains were counted by a grain counting machine (Numigral). Primary pests, such as *P. truncatus* and *Sitophilus zeamais* Motschulsky(Col.: Curculionidae) were counted separately, secondary pests like *Tribolium* spp., *Catharthus* sp., *Cryptolestes* sp. and various species of Lepidoptera were counted collectively. Losses of dry matter and damage were calculated by the count and weigh method.

damage (%) $=(B/A) \times 100$

losses (% dry matter) $=((E \times B) - (C \times D))/(E \times A) \times 100$

A = total number of grains

B = number of damaged grains

C = number of undamaged grains

D = weight of damaged grains (g)

E = weight of undamaged grains (g)

Results

All insect populations were transformed to lg10, percentage of dry matter losses and damage to arcsines. The resultant data were subjected to a t-test concerning the difference between the two means. Differences were not regarded as significant unless $p < 0.05$.

Effect of *T. nigrescens* on the population development of *P. truncatus* in maize stores

First storage season 1992

The population of *P. truncatus* hardly increased over the first four months of storage (Fig. 2). After the fifth month of storage, the number of adult *P. truncatus* in stores without the predator increased more rapidly than with the predator. In the following months there was a strong increase of the population of *P. truncatus* without *T. nigrescens*. After eight months of storage 1012 adult *P. truncatus* were found in 100 cobs.

In the stores with *T. nigrescens* the increase of the number of adult *P. truncatus* was very slow. After eight months of storage there were only 202 adult *P. truncatus* found in 100 cobs, which corresponds to a reduction of 80 % of the population of *P. truncatus* in the presence of *T. nigrescens*. After seven and eight months of storage, the mean number of adult *P. truncatus* found in stores with *T. nigrescens* was significantly lower than in stores without the predator.

Second storage season

There was almost no increase in the population of *P. truncatus* until the third month of storage (Fig. 2). In the fourth month of storage, the population started to increase. Without the predator, the number of adult *P. truncatus* increased more rapidly than with the predator. After eight months of storage there were 3160 adult *P. truncatus* found in 100 cobs in the stores without *T. nigrescens*, i.e. about three times as many as in the first storage season.

In the stores with *T. nigrescens* the increase in the number of *P. truncatus* was slower (Fig. 2). After eight months of storage there were 849 adult *P. truncatus* found in 100 cobs, i.e. about four times as many as in the first storage season. This corresponds to a reduction of 73% of the population of *P. truncatus* in the presence of *T. nigrescens*. After the fourth month of storage, the mean number of adult *P. truncatus* found in stores with *T. nigrescens* was significantly lower than in stores without the predator.

Population development of *T. nigrescens* in maize stores

The population of *T. nigrescens* grew during the whole storage period, reaching 202 adult insects after eight months in the first storage season, 849 in the second. (Tables 1 and 2). The predator followed its prey in all stores. There was no store infested by *P. truncatus* in which *T. nigrescens* was not present. In the first storage season, *P. truncatus* was found in

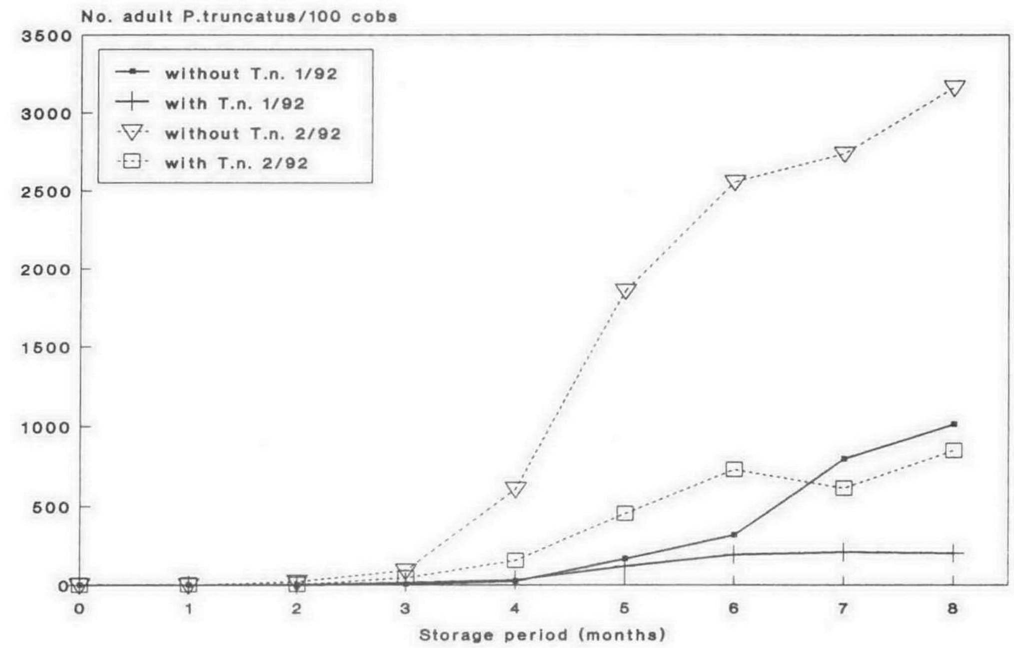

Fig. 2. Effect of *T. nigrescens* (T.n.) on the number of adult *P. truncatus* in maize stores during the first and second storage season in the southern region of Togo. Data are means of eight replicates.

the stores after two months of storage, *T. nigrescens* after three months. In the second storage season, *P. truncatus* occured after one month of storage, followed by *T. nigrescens* one month later. The prey:predator ratio settled at 1.8:1 after eight months of storage in the first storage season 1992, in the second at 3.7:1.

Effect of *T. nigrescens* on the population development of *S. zeamais* in maize stores

First storage season

The population of *S. zeamais* increased in both treatments after one month of storage (Fig. 3). Until the third month of storage there was no difference in the increase of the population. From the fourth month of storage onwards, the increase of the population of *S. zeamais* in the stores with *T. nigrescens* was higher than in the stores without *T. nigrescens*. Only at one point of the storage period, after six months of storage, was the number of adult *S. zeamais* found in the stores with *T. nigrescens* significantly higher than the number of adult insects found in stores without *T. nigrescens*. In the stores with *T. nigrescens* the maximum insect density was found after seven months of storage with 1401 adult *S. zeamais* per 100 cobs, whereas the maximum insect density in the stores without *T. nigrescens* was reached after eight months of storage with 854 adult *S. zeamais* per 100 cobs.

Table 1. Number of adult insects and and development of the prey:predator ratio during the first storage season in the release area of *T. nigrescens* in the southern region of Togo. Data are means of eight replicates ± SE.

	Storage period (months)							
	1	2	3	4	5	6	7	8
P. truncatus	0	2.6	18.1	31.8	119.6	190.6	207.6	202.3
SE		±1.8	±6.4	±8.6	±31.0	±63.9	±52.3	±52.2
T. nigrescens	0	0	1.4	6.3	42.9	73.1	115.1	110.1
SE			±0.7	±2.2	±13.9	±29.8	±36.7	±43.2
Prey:predator ratio			12.9:1	5.0:1	2.8:1	2.6:1	1.8:1	1.8:1

Table 2. Number of adult insects and development of the prey:predator ratio during the second storage season in the release area of *T. nigrescens* in the southern region of Togo. Data are means of eight replicates ± SE.

	Storage period (months)							
	1	2	3	4	5	6	7	8
P. truncatus	2.0	3.6	45.3	154.9	454.0	729.9	612.8	848.8
SE	±0.5	±1.2	±15.4	±36.6	±123.5	±150.4	±134.1	±260.6
T. nigrescens	0	0.8	6.3	37.0	68.9	144.3	185.0	230.4
SE		±0.4	±1.2	±9.7	±12.1	±25.7	±28.8	±49.1
Prey: predator ratio		4.5:1	7.2:1	4.2:1	6.6:1	5.1:1	3.3:1	3.7:1

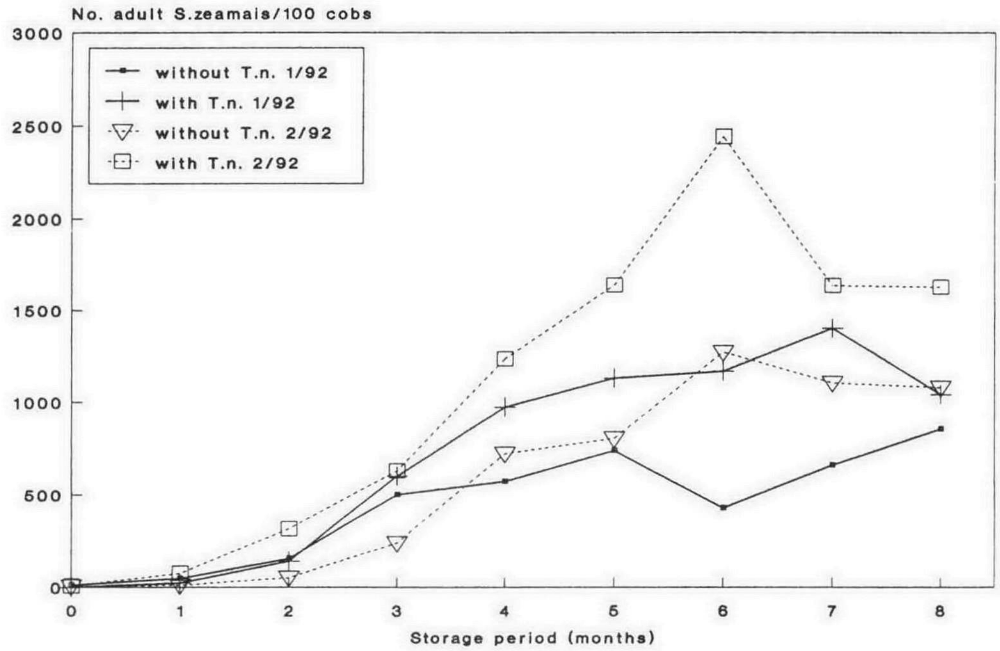

Fig. 3. Effect of *T. nigrescens* (T.n.) on the number of adult *S. zeamais* in maize stores during the first and second storage season in the southern region of Togo. Data are means of eight replicates.

Second storage season

The population of *S. zeamais* started to increase in both treatments after one month of storage (Fig. 3). From the the second month of storage onwards, the increase of the population of *S. zeamais* in the stores with *T. nigrescens* was higher than in the stores without *T. nigrescens*. After two, three, four and six months of storage, the number of adult *S. zeamais* found in the stores with *T. nigrescens* was significantly higher than the number of adult insects found in stores without *T. nigrescens*. In both treatments the maximum insect density was found after six months of storage, in the stores with *T. nigrescens* 2440 adult *S. zeamais* per 100 cobs, in the stores without *T. nigrescens* 1270 adult *S. zeamais* per 100 cobs.

Effect of *T. nigrescens* on the development of the postharvest losses in maize stores

First storage season

In both treatments the increase of losses during the storage period was very slow. Starting with less than 1% of losses at the beginning of the storage period, about 2% were recorded after three months and 7–8% after six months of storage. After eight months of storage, there are 11.6% of losses in the stores without *T. nigrescens*, 8.4% in the stores with *T. nigrescens* (Fig. 4). At no point of the storage period, was there a significant difference between the losses assessed in stores with and without *T. nigrescens*.

Second storage season

In both treatments dry matter losses increased approximately at the same rate till the sixth month of storage. After three months of storage, losses reached about 2%, after six months about 16% (Fig. 4). In the seventh and eighth month of storage, dry matter losses continued to increase in stores without *T. nigrescens*, whereas there was almost no further increase in those stores with *T. nigrescens*. After eight months of storage, dry matter losses reached 24.1% in the stores without *T. nigrescens*, compared to 15.9% in the stores with *T. nigrescens*. This corresponds to a significant reduction of dry matter losses of 34.3% in the stores with *T. nigrescens*.

Effect of *T. nigrescens* on the development of postharvest damage in maize stores

First storage season

In both treatments damage increased at approximately the same rate during the whole storage period. Starting out with about 1% of damage at the beginning of the storage period, about 9% were recorded after three months and 20–23% after six months of storage. After eight months of storage, there were 25.6% of damage in the stores without *T. nigrescens*, 20.2% in the stores with *T. nigrescens* (Fig. 5). At no point of the storage period, was there a significant difference between the damage assessed in stores with and without *T. nigrescens*.

Second storage season

In both treatments damage increased approximately at the same rate till the sixth month of storage. After three months of storage, it reached 9–14%, after six months about 32–34% (Fig. 5). In the seventh and eighth month of storage, damage continued to increase in stores without *T. nigrescens*, whereas there was no futher increase in those stores with *T. nigrescens*. After eight months of storage, damage reached 42.7% in the stores without *T. nigrescens*, 32.7% in the stores with *T. nigrescens*. This means that damage had been reduced by 23% in the stores with *T. nigrescens* but this reduction was not significant.

Discussion and Conclusions

During the two observation periods, the first and second maize storage period 1992, the population of *P. truncatus* has been efficiently suppressed by the presence of the predator *T.*

nigrescens under rural storage conditions. After eight months of storage the insect population was reduced by 80% and 73% respectively. These results conform with those obtained by Rees (1987), Böye (1988) and Leliveldt (1990) in laboratory trials. In a cage trial under semi-practical conditions in the southern region of Togo, Helbig (1993) found a reduction of the population of *P. truncatus* of 80% after nine months of storage. On the contrary, Rios Ibarra et al. (1992) found in Mexico under typical rural storage conditions no evidence at all that *T. nigrescens* could contain *P. truncatus* populations or that pest and predator reach an equilibrium.

One possible explanation of the high suppression of *P. truncatus* by *T. nigrescens* could be the close prey:predator ratio. During the first storage season suppression became evident after five months of storage at a prey:predator ratio of 2.8:1 which became even closer after eight months of storage (1.8:1). In the second storage season suppression started after four months of storage at a prey:predator ratio of 4.2:1 which settled at 3.7:1 after eight months of storage. These prey:predator ratios are very close in comparison to the rates found by Böye (1988) under field conditions in Costa Rica, which settled at a mean of 7.5:1 after eight months of storage.

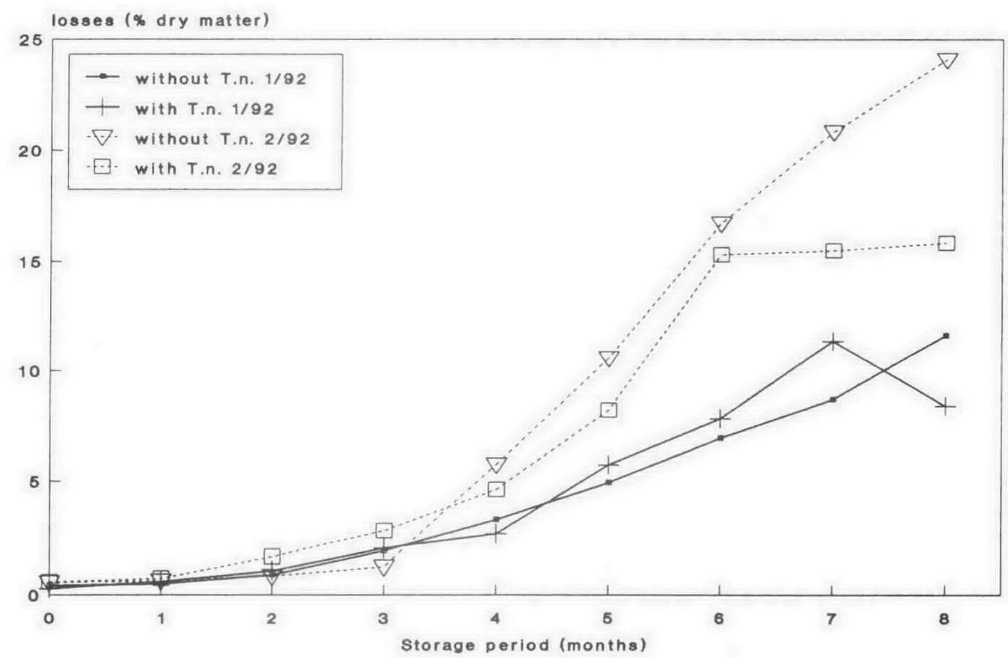

Fig. 4. Effect of *T. nigrescens* (T.n.) on the postharvest losses (percent dry matter) in maize stores during the first and second storage season in the southern region of Togo. Data are means of eight replicates.

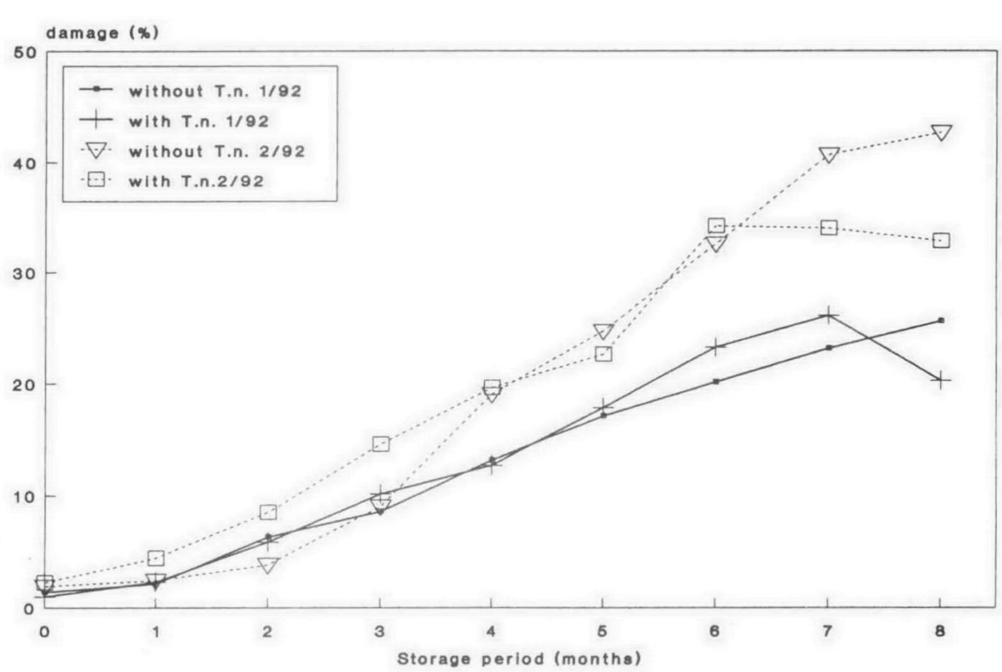

Fig. 5 Effect of *T. nigrescens* (T.n.) on the postharvest damage (%) in maize stores during the first and second storage season in the southern region of Togo. Data are means of eight replicates.

Apparently climatic conditions are favourable to the development of *T. nigrescens* in the south of Togo. Since the investigations started only three months after the release of *T. nigrescens* in the trial villages, the close prey:predator ratio might be due to the high concentration of the predator in the environment (release of 8000 adult *T. nigrescens* per village).

S. zeamais is the other major pest in Togo, which influences the loss development in stored maize. Since there is a competition between the population of *P. truncatus* and *S. zeamais*, the presence of *T. nigrescens* might also have a side effect on the population of *S. zeamais*.

At several points in the two storage seasons, the population of adult *S. zeamais* was significantly higher in the stores with *T. nigrescens*. This might be due to the sharp reduction of *P. truncatus* in these stores. Böye (1988) reported that the population growth of *S. zeamais* was negatively influenced by the presence of *P. truncatus* on corn cobs. Consequently, the reduction of *P. truncatus* in traditional maize stores might favour the development of *S. zeamais*. This result contradicts the findings of Helbig (1993) in cage trials in Togo and other laboratory studies (Leliveldt 1990; Pöschko et al. 1992). They could not find any influence of *T. nigrescens* on the population of *S. zeamais*.

Postharvest losses found during the first storage season did not exceed 12% after eight months of storage which was very low compared with the losses found by other authors in the same region (Pantenius 1987; Helbig 1993). At this low level, loss reduction by *T. nigrescens* was not very evident. During this trial, the maximum number of *P. truncatus* found in the stores without *T. nigrescens* was 10 adult *P. truncatus*/cob. Apparently this density is not high enough to cause serious losses and a further reduction of *P. truncatus* does not reduce losses. During the second storage season the population of both primary pests is much higher, which caused dry matter losses of 24.1% after eight months of storage. The maximum number of *P. truncatus* found was 32 adult/cob. At this higher density level a reduction of *P. truncatus* resulted in a reduction of losses by 34.3% after eight months of storage. Pantenius (1987) refered to a much higher field infestation with insects and bad storing conditions to explain higher postharvest losses during the second storage season.

In both storage seasons, the damage found in stores with *T. nigrescens* after eight months of storage was slightly reduced in comparison with the stores without *T. nigrescens*, but this reduction was not significant. The positive effect of *T. nigrescens* on the visual aspect of maize was seen in the reduced amount of the flour produced by the boring activity of *P. truncatus*. Cobs severely attacked by *P. truncatus* tend to be very mealy with almost all grains completely destroyed.

In conclusion one can say that after the release of *T. nigrescens* in Togo no major constraints have been observed so far for its integration in the new environment. *T. nigrescens* follows *P. truncatus* in all stores and reduces its population considerably. By this sharp reduction of *P. truncatus* the presence of *T. nigrescens* might favour the population of *S. zeamais* in traditional maize stores. *T. nigrescens* can diminish postharvest losses, particularly in those stores which suffer from a severe attack of *P. truncatus*. The infestation of maize stores with *P. truncatus* depends on populations arriving from outside the maize production and storage system. This means that in the longer term the most important impact of *T. nigrescens* on *P. truncatus* might be the reduction of its population in the environment and thus the reduction of the immigration potential of this pest in maize and cassava stores.

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