Response of *Prostephanus truncatus* and *Teretriosoma nigrescens* to pheromone-baited flight traps

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Abstract

The behaviour of *Prostephanus truncatus* (Horn) was observed in the vicinity of a source of synthetic aggregation-pheromone. These observations are discussed in relation to trap design and use. Pheromone-baited sticky traps, in various configurations, and funnel traps were evaluated for their efficiency at catching both *P. truncatus* and its predator, *Teretriosoma nigrescens* Lewis under field conditions in Mexico. The funnel trap caught most *P. truncatus* and *T. nigrescens* while delta traps caught least. However, using unfolded delta traps as flat, sticky sheets increased their catch and when two traps were deployed to make a double-sided sticky trap the number of *P. truncatus* caught was similar to that in the funnel traps.

Single-sided sticky traps were also used to investigate the effect of height of traps and of surrounding vegetation on catch. Both *P. truncatus* and *T. nigrescens* were caught in traps placed at heights of 0 m, 1 m and 2 m with a tendency towards higher catches of both species at 0 m and 1 m, which was significant when surrounding vegetation was also 0–1 m high.

Introduction

Prostephanus truncatus (Horn) (Coleoptera:Bostrichidae) is a primary pest of farm-stored maize and causes sporadic but locally important damage in Central America and Mexico (Mesoamerica) (Böye 1988; Giles and Leon 1975; Hoppe 1986). It was introduced accidentally into east and west Africa where it has become a serious pest to both stored maize and dried cassava (Golob and Hodges 1982; Hodges et al. 1985). *Teretriosoma nigrescens* Lewis (Coleoptera:Histeridae) is a predator of *P. truncatus* and occurs in close association with it in Mesoamerica and shows a kairomonal response to its aggregation pheromone (Böye et al. 1988; Rees et al. 1990). The predator has recently been released into both west and east Africa (GTZ unpublished; NRI unpublished).

Pheromone trapping is the main technique available for monitoring the distribution and relative abundance of *P. truncatus* and *T. nigrescens* but there is little information available to help interpret trap catches. The most commonly used traps are of the 'delta' type, which for convenience are normally hung between 1 and 2 m above the ground at the approximate height of maize cobs (Dendy et al. 1989a; Rees et al. 1990). Dendy et al. (1989a) concluded that *P. truncatus* flies directly to the pheromone and does not attempt to walk on the sticky surface. However, observations made while trapping *P. truncatus* in Mexico indicated that they occur on the vegetation surrounding the trap and on the outer surfaces of the trap itself. The aims of the trials reported here were to examine the relative efficiency of different trap designs and their deployment in relation to the behavioural response of insects, so that recommendations may be made for monitoring both species in the field.

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Methods and Materials

All the trials were undertaken the vicinity of the Irapuato unit of the Centro de Investigaciones y Estudios Avanzados de I.P.N. (CINVESTAV) in Guanajuata state, central Mexico. Polythene pheromone vials (supplied by the Natural Resources Institute (NRI), Chatham, U.K.) measuring 24 mm × 8 mm and impregnated with 2 mg of Trunc-call 1 and 2 in the ratio of 1:1 by weight were used throughout.

All data were analysed using the multivariate analysis of variance (ANOVA) and multiple regression analysis.

Behavioural response to pheromones

A landing target constructed from a sheet of white card (1.0 × 1.4 m) was marked with a 10 cm^2 grid and hung vertically from an external wall, 15 cm above the ground. A 5 cm^2 square marked the centre to which a pheromone vial was attached.

For three consecutive days the target was monitored at intervals from 16.20–20.17 hours, for insect arrivals. For each insect the following were noted: position of landing, the time of landing and the time to reach the centre or to take off. On 13 occasions insects were removed because too many were present to permit accurate tracking. Records of less than one minute were given a value of 0. 5 minutes. Weather conditions were uniformly warm and still during the observations.

Influence of trap design on catch

In a series of three trials the following trap types were tested.

1. Delta I. Pink bollworm delta traps, with a sticky surface of approximately 270 cm^2 (supplied by Agrisense Ltd., Pontypridd, U.K.) were suspended from a single tie at the top centre.
2. Delta II. As for delta I but suspended from additional ties at both ends to prevent rotation in the wind.
3. Single. A single-sided sticky trap made by unfolding a delta I trap, the sheet was suspended lengthways and weighted below.
4. Double. Similar to the single trap except made by fixing two unfolded delta I traps back to back.
5. Cylinder. Consisted of a delta I trap folded to form a cylinder with the sticky side facing outwards, hung vertically and secured at one side to prevent spinning.

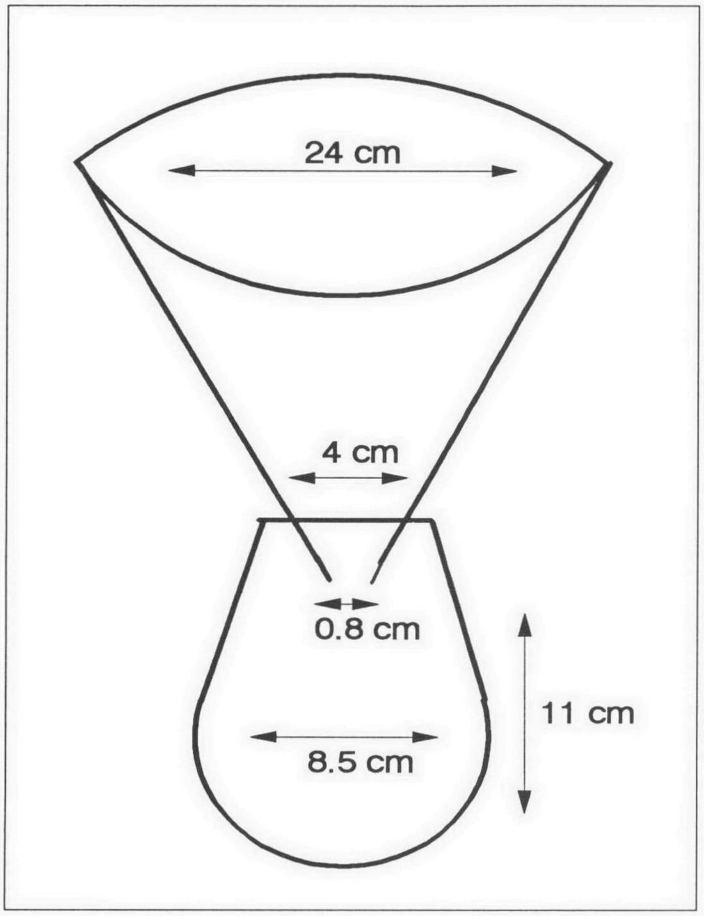

Fig. 1. Funnel trap design.

6. Funnel. Similar to that described by Dendy et al. (1989b) but having a plastic, barrel-shaped collecting vessel into which the funnel is inserted (Fig. 1). The funnel was constructed from a rolled acetate sheet, held in place with a metal rivet, with an elliptical shaped opening having the front edge lower than the back to improve access to flying beetles. A piece of tissue paper was inserted into the collecting vessel to provide a foot-hold for captured insects and to deter them from boring out of the plastic container.

Each trap was baited with a standard pheromone vial, already described; pheromones were tied to the traps to prevent loss and stuck to the centre panel of the delta I, single and double traps, or hung inside the funnel at the back.

First trial

All traps except delta II were tested in this trial. Four replicates of each design were suspended at a height of 1 m from trees and bushes, 100 m apart, around four fields some 55 km from CINVESTAV. At the time of the trial, asparagus, sorghum and maize were being cultivated at the site. Initial trap sequence was randomised and traps were rotated by one position each day. Pheromone vials were dedicated to trap position and were not rotated with the traps. This was intended to obviate any effects of position and variation in the pheromone vials. Catch was recorded daily for four consecutive days. Delta I, single and double traps were replaced by fresh traps each day, while funnel traps were emptied and re-hung with a clean piece of tissue paper.

Second trial

Similar to the first trial, but undertaken over five consecutive days in a field of immature sorghum adjoining CINVESTAV and only using delta I and delta II traps hung at a height of 1 m above the ground from cane tripods placed equidistant (100 m) around the perimeter of the field.

Third trial

Similar to the second trial but using four replicates of delta II, single and cylinder traps.

Influence of trap height on catch

Three pheromone-baited, single-sided sticky traps (see earlier) were hung from the same vertical pole with the base of the trap at 0 m, 1, or 2 m up the pole. Traps were changed daily for four or five days with the pheromone remaining at the same position throughout. Four replicates were established in fields as follows:

1. A maize field with the crop at the 'milky' stage, plants about 3 m tall and cobs occurring at 1 to 2 m. Replicates were placed 100 m apart.
2. A field of maturing sorghum with panicles at between 1 and 1.25 m. Replicates were placed 150 m apart.
3. A field of grassy turf, approximately 5–10 cm high, where the nearest tall objects, e.g. bushes, trees and walls, were at least 5 m from the traps. Replicates were placed about 60 m apart.

Results

Behavioural response to pheromones

There were 114 landings of *P. truncatus* and two of *T. nigrescens* on the landing target. *P. truncatus* reached the centre on 24 occasions but took off before reaching the centre 77 times.

Mean time to reach the centre of the target was 7.48 (±7.97) minutes ($n = 21$), with a mean of 6.57 (±1.85) squares crossed. Mean time between landing and take-off was 2.02 (±2.4) minutes ($n = 76$), with a mean of 1.58 (±2.2) squares crossed. Data was extremely variable as shown by the standard deviations.

Only 2.1% of landings on the original target occurred within 20 cm of the centre with 85% at a distance of 50 and 70 cm. Many beetles landed along one side of the board (52.1% of landings) or along the lower edge (20.8% of landings).

General observations of *P. truncatus*, responding to the pheromone lures, showed that insects approaching the card frequently dashed themselves against it. Before landing insects tended to hover close to the card surface below the level of the pheromone for several seconds and then either landed directly or with an upward swoop. Those that approached the pheromone took a more or less straight path towards it, although in some cases the approach was interspersed with periods of inactivity. This suggests that even this close to the pheromone there was a concentration gradient for them to follow. On the two occasions when *T. nigrescens* was recorded, the insects walked directly to the pheromone, arriving within one minute of the first observation.

Influence of trap design on catch

Numbers of both species caught were found to be highly significant for trap type ($F(3,139) = 6.68$, $p < 0.001$ and $F(3,139) = 23.73$, $p < 0.0001$ for *P. truncatus* and *T. nigrescens* respectively). Figures 2 and 3 show the mean numbers of *P. truncatus* and *T. nigrescens* caught, respectively. Double and funnel traps caught the most *P. truncatus* and delta I (standard delta) the least. There was no significant difference between

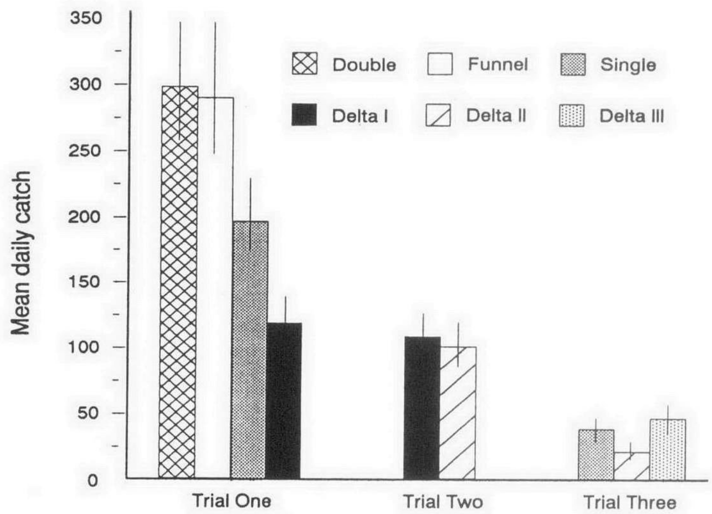

Fig. 2. Influence of trap design on catch of *Prostephanus truncatus* in three separate trials. Bars show means ±SE. For an explanation of trap design see text

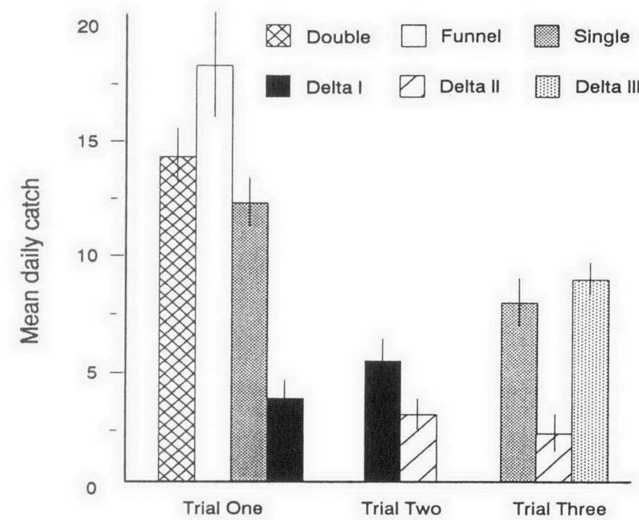

Fig. 3. Influence of trap design on catch of *Teretriosoma nigrescens* in three separate trials. Bars show means ±SE. For an explanation of trap design see text.

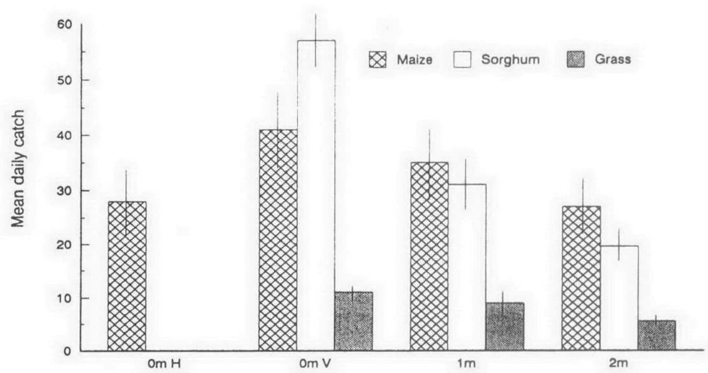

Fig. 4. Influence of trap height in various environments on catch of *Prostephanus truncatus*. Bars show means ±SE. H = horizontally and V = vertically-placed traps.

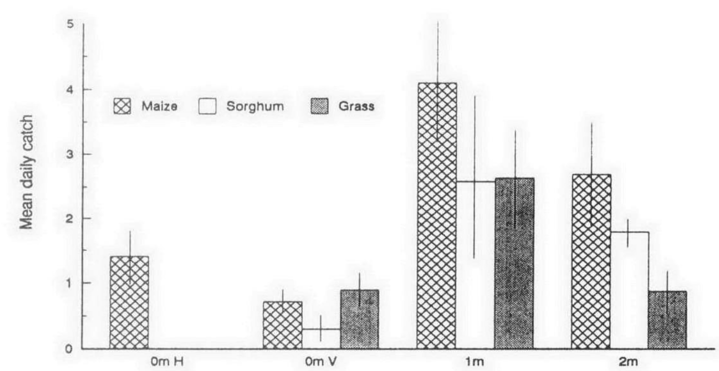

Fig. 5. Influence of trap height in various environments on catch of *Prostephanus truncatus*. Bars show means ±SE. H = horizontally and V = vertically-placed traps.

numbers of *P. truncatus* caught in delta I and delta II. Cylinder traps obtained catches similar to those of single traps.

Variation in catch was greater between than within days indicating that environmental conditions are an important factor influencing catch. In the third trial, mean numbers of both species were low in comparison to the first and second trials.

The double-sided sticky traps have a tendency to rotate and beetles may be caught on both sides, possibly influencing catch. Mean catch of *P. truncatus* was 137.9 (±133.4) from the side with a pheromone and 66.9 (±37.7) from that without a pheromone, and for *T. nigrescens* was 11.3 (±8.4) and 6.7 (±4.9) respectively.

Influence of height on catch

Figures 4 and 5 show catches of *P. truncatus* and *T. nigrescens* respectively at different heights in the three sites. A large proportion of catch variation is likely to have been caused by changes in environmental conditions throughout the experiment. Height of trap was significant for numbers of *P. truncatus* in sorghum ($F(2,45) = 22.02$, $p<0.001$) and grassland ($F(2,57) = 5.85$, $p < 0.01$) but not in maize. In both sorghum and grassland, greatest catch was achieved at 0 m and least at 2 m with a similar trend in maize.

Although far fewer *T. nigrescens* were caught than *P. truncatus,* height of trap was also significant in all three trials ($F(3,60) = 6.05$, $p < 0.01$; $F(2,45) = 8.45$, $p < 0.001$; $F(2,57) = 4.73$, $p < 0.05$ in maize, sorghum and grassland respectively). Most were caught at 1 m in all three crops. Days of high catch of *T. nigrescens* did not necessarily coincide with those of *P. truncatus.*

Discussion

Behavioural observations

Observational data differ from those of Dendy et al. (1989a), in that insects were not found to fly directly to the pheromone source. The tendency for insects to land within 1 m of the pheromone and walk towards it explains those seen on vegetation in the vicinity of traps. However, catch was found to be higher when surrounding vegetation was at trap level, suggesting that repeated landing and taking-off in the vicinity of pheromone sources occurs.

The insects caught by the delta I and II traps were usually concentrated at the two entrances of such traps, indicating that insects land on the external surface and walk into the traps, although some may alight immediately on entering. A more complex Lingren funnel was used by Leos-Martinez et al. (1986) to capture the closely related bostrichid, *Rhyzopertha dominica* (F.), and was found to be superior to various other sticky traps, including a delta trap. This type of trap presents a lot of edges for landing which may influence its success.

A white card was used to provide a good contrast and to allow easy observation of the beetles. The sticky, external surfaces of the sticky traps were also white; however, the funnel trap had a clear funnel and a yellow base and the delta traps had a bright pink external surface. It is possible that colour and search image cues influence the results for both species, and the attraction of some scolytids and platypodids may be increased by using red traps.

Trap design

In all the trials described here, funnel traps consistently caught more, and standard delta traps fewer, beetles than all other traps. This differs from a trial carried out in Tanzania where the results indicated that funnel and delta designs caught similar numbers of *P. truncatus* (Dendy et al. 1989b). This could be due to a number of factors, including trap design, placement, trapping period and behavioural differences of the separate populations. The success of funnel traps may result from attracting insects to fly directly into the acetate funnel where they hit the sides and so fall into the collecting vessel. Traps with external sticky surfaces are more likely to catch those insects which dash themselves against the surface in the vicinity of the pheromone, compared with delta traps which only catch those which either land or walk into the internal sticky surface.

Trap height

In the sorghum and grassland trials maximum catch for both species was achieved in sticky traps near ground level, between 0 and 1 m. In the maize field catch was more varied, although more insects were caught between 0 and 1 m than 2 m, suggesting that this is the preferred height regardless of surrounding vegetation. For *P. truncatus* this may be explained by the tendency of insects to land on surrounding vegetation in the vicinity of traps so that in the maize more landing surfaces were available at all trap heights.

Relation between *P. truncatus* and *T. nigrescens*

No relation in trap catch was found between numbers of *T. nigrescens* and *P. truncatus*. In the trials on trap design, days when high numbers of *T. nigrescens* were caught did not correspond to those for *P. truncatus*. It is possible that their responses to concentration and ratio of components or environmental conditions are different. Observations in the field and laboratory indicate that *T. nigrescens* is more agile and active than *P. truncatus* which may affect the speed with which each species responds. Occasional peaks in the number of *T. nigrescens* have been observed during other trials in Mexico (National Resources Institute 1990) which may last between one and three days, during which time ratios of *T. nigrescens* to *P. truncatus* ranged from 1:9 to 1:35. The former is similar to ratios found in established laboratory populations of *T. nigrescens* (1:9–11) (Leliveldt and Laborious 1990) and *T. nigrescens* caught from farm stores in Costa Rica (1:7.5) (Böye 1988).

Practical application

Observations indicated that a large, sticky surface would be a very efficient trap, but this would not be practical for a large-scale monitoring program. The delta I design used here, although less efficient, is readily available and proved easy to handle in the field with reasonable resistance to weathering. The funnel traps were custom-built and the materials from which they were constructed were readily available and made them inherently stronger than the delta traps. Once constructed they were quick to place in the field and had the advantage of catching live beetles of both species, although they tended to fill with water during rain, drowning the insects. It may be possible to improve their design by attaching a rain guard where live insects are required and by using a glass collection vessel to prevent boring. Rain did not appear to affect numbers caught by funnel traps nor did it appear to wash trapped insects off the exposed sticky surfaces of the single, double, or cylinder traps. However, the card from which these latter traps were constructed tends to disintegrate following repeated heavy rain, causing them to break and fall, particularly the single traps.

The difference in sensitivity between trap types has implications for both future experimental trials and in the monitoring of field populations. This is particularly so in Africa where monitoring for *P. truncatus* forms part of the containment and control programs of the pest, and where it is necessary to estimate the spread and abundance of *T. nigrescens* introduced into east and west Africa.

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