STRATEGY FOR BIO-INTEGRATED CONTROL OF *PROSTEPHANUS TRUNCATUS* (HORN) (COL., BOSTRICHIDAE)

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Abstract

Since the first observation of Prostephanus truncatus (Horn) (Coleoptera: Bostrichidae) in 1980 in Tanzania, this pest of stored corn and other commodities (e.g. grains, cassava) has spread deeper into Africa. Intensive activities have been started to eradicate, control or prevent the invasion of the pest. A German research project is carried out jointly by the German Agency for Technical Cooperation (GTZ) and the University of Kiel.

The objective of the present investigation during the first experimental phase (in collaboration with J.Böye, S.Burde, H.Keil and B. Leliveldt) is to detail the ecological behaviour of P. truncatus in its original habitats and to conduct a cooperative study of the situation in its new areas of distribution. It is assumed that biological aspects play an important role in population regulation and attack in this pest, and hence development of a bio-integrated control system would be valuable.

The pest is endemic to several Central American countries, where its distribution is stable but local. Populations are generally small and losses are negligible. Particular emphasis has therefore been placed on a study of the biotic environment of the pest. Samples of dead and live beetles from stored corn from the small farm scale level (troja) have been investigated for the occurrence of pathogens, parasites ad predators. A number of bacteria (not yet identified), micromycetes (Aspergillus spp., Penicillium spp., Paecilomyces sp., Metarhizium sp.), protozoa (Mattesia sp., Nosema sp., Farinocystis sp.) and arthropods (Teretriosoma nigrescens, Calliodes sp. and others) have been identified as antagonists of the pest. The first results on the efficacy of the organisms in affecting the pest have been obtained, and the applicability of possible biotherapeutics is being considered.

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Introduction

Food and feed may undergo quantitative and qualitative losses during storage. This is true both for the small farm level and the governmental storage system as well. It is assumed that for grain, losses are mainly due to insects, and are generally in the range of about 5-8 %. Losses caused by other biotic or abiotic factors must also be added resulting in an overall loss of about 15 % in weight reduction. Overall minimization of these losses by stored product protection measures must be regarded as a valuable tool for improving the world food situation.

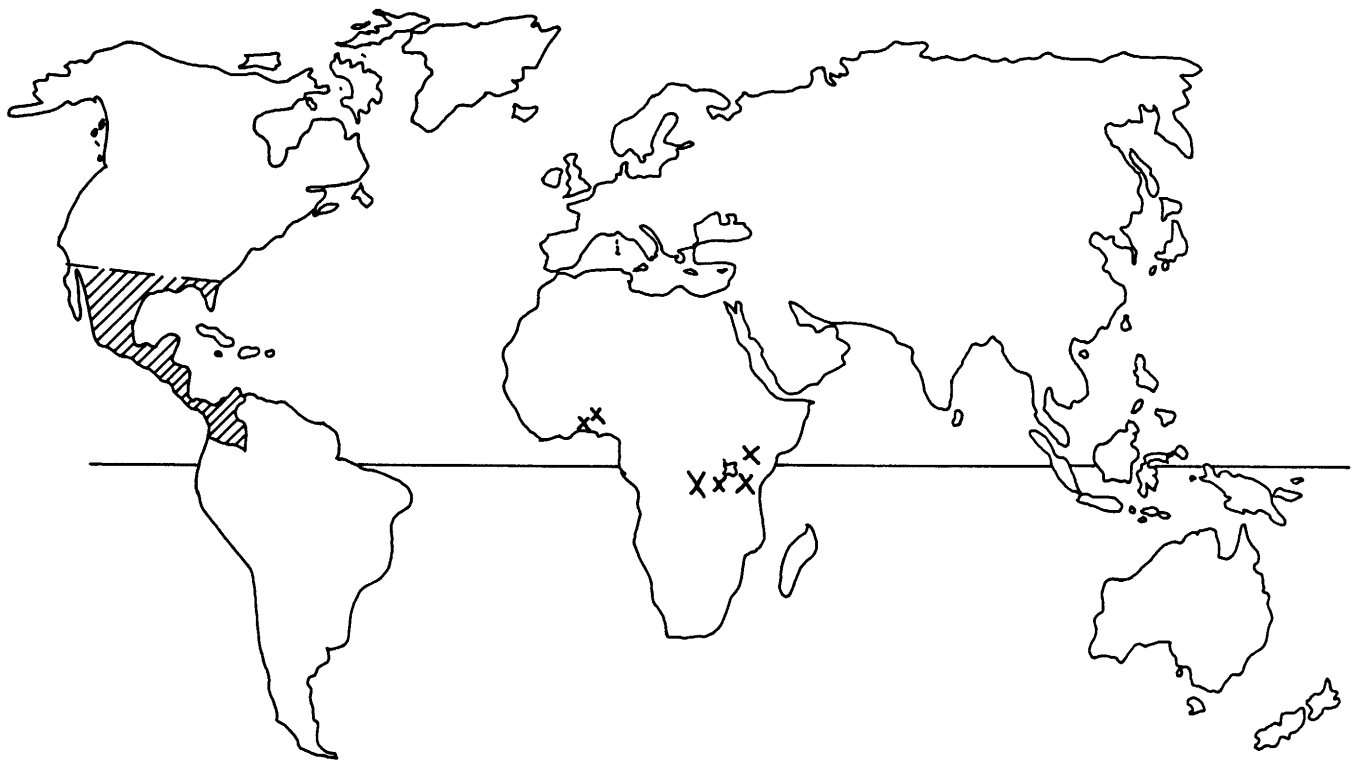
The occurrence of a new pest in a specific area, country or continent can change the agricultural situation both rapidly and dramatically. The introduction of P. truncatus to both East and West Africa is the latest known example for a storage pest in this respect. In the case of Africa this beetle was recorded for the first time in Tanzania in 1980. To date the pest has spread to other countries and including a secondary introduction it has become established so far in parts of Kenya, Tanzania, Burundi, Zaire, Togo, Benin and probably Uganda (Fig. 1). Further spread of the pest within these countries has been demonstrated for Togo (Krall, 1986) and its spread to other areas must be expected. During a 3-6 months storage period much higher losses have been observed in corn at the farm level than those due to the usual storage pests (Golob, 1984; Pantenius and Schulz, 1987). Because of these aspects, general control of the pest is urgently needed. For immediate control or possible eradication of the beetle, chemical measures are the only possible control method though various problems can arise such as development of resistance, and the danger of pesticide residues. To prevent these complications and to accomplish a longterm protection of stored products other means of control must be considered.

Research Programme

As a consequence of the GASGA-Workshop on the Larger Grain Borer held in 1983 at Slough, Great Britain, the Federal Republic of Germany decided to set up a programme for the containment and longterm control of P. truncatus in Africa. Coordinated by the German Agency of Technical Cooperation (GTZ), this organization and the Institute of Phytopathology of the University of Kiel (Working Group on Stored Product Research) have developed a research programme which gives priority to bio-integrated procedures over chemical control measures alone. Following the application for financial support to the Bonn Government in early 1984 all political decisions have been made rather rapidly so that the scientific work could be started in late 1984. Additional support for part of the project was obtained from the Commission of the European Communities.

According to the decision of the GASGA-Workshop the basic idea was to make a comparative investigation on the biology and ecology of the pest in its original habitats in Central America and in its new localities in East Africa. In the case of Central America the project was linked to the Plant Protection Service of Costa Rica at San José and the University of Costa Rica at Liberia which is in the area commonly infested by the pest (Guanacaste). Field trips for collecting biological material were made to Honduras and Mexico where the pest was originally described at the end of the last century (Chittenden, 1895).

Figure 1 Distribution map of Prostephanus truncatus showing the endemic infestation area in Central America and the recently infested countries in East and West Africa



Through the help of the National Plant Protection Service the African base of our research project was linked with the Tropical Pesticides Research Institute (TPRI) at Arusha, Tanzania, where the laboratory facilities of the Entomology Department could be used. A third group of scientists is working at 2 places in Germany (Biological Federal Research Institute, BBA, at Berlin and University of Kiel). Their work is mainly concerned with basic research on the biology and pathology of P. truncatus in contrast to those working abroad who are concentrating on ecological and more practically oriented problems of control. Altogether 6 scientists including the project supervisor are involved in the programme.

The entire programme will be realized in three phases. The objectives of the first phase in both zones under investigation are:

- monitoring of climatic conditions on an annual basis
- description of cropping systems with particular respect to maize
- evaluation of storage techniques for maize at the small farm scale level
- identification of the stored product protection procedures at the farm level including traditional measures.

The second phase to be run simultaneously is concerned with P. truncatus:

- monitoring of the occurrence of P. truncatus in the field and in the store over the whole year
- investigation of accompanying storage pests including possible interactions with P. truncatus
- studies on the population dynamics of P. truncatus in relation to environmental conditions and the local food sources.

The last but most important phase of the actual research programme is concerned with the antagonists of P. truncatus, namely:

- isolation, identification and cultivation of pathogenic viruses, bacteria, fungi, and protozoa
- isolation, identification and breeding of parasitic nematodes and arthropods
- monitoring and identification of predatory organisms.

All investigations are to be completed by testing the efficacy of the possible antagonists against P. truncatus under laboratory conditions. The results described here must still be regarded as preliminary. At the moment they only demonstrate a tendency as regards the ecological situation relating to P. truncatus in Central America. The studies must be extended to the application of biotherapeutic measures with or without synthetic pesticides applied under natural conditions. The results of the project will be published later in more detail.

Microorganisms

At the moment there are no data available about the microbial antagonists of P. truncatus. The search for pathogenic viruses has not been successful so far.

By using different media the internal and external microflora of adult P. truncatus originating from stored maize or from wooden constructions of the trojas has been studied. About 80 bacterial isolates which were macroscopically different were obtained. Following topical application of a bacterial suspension on the insect mouthparts only 2 isolates proved to be pathogenic against adult P. truncatus showing 70-90 % mortality after 3 weeks incubation. Other forms of treatment were less successful. Both of these isolates were hemolytic; one of them was a spore forming bacterial rod but not Bacillus thuringiensis. According to the results obtained so far bacteria seem to be of limited importance in regulating the population dynamics of P. truncatus. They are obviously of little interest for biocontrol.

Though the natural fungal parasitation of P. truncatus and other storage pests in Central America is generally rather low, the investigation of the fungal flora of the pest was somewhat more successful than the bacterial investigation. During the first year of work in Costa Rica several microfungi were isolated from dead adults of P. truncatus from various sources. Taxonomically all the fungal isolates belong to the deuteromycotina which rapidly reproduce asexually by proliferation of great numbers of conidia. Most of the isolates are species of Aspergillus and Penicillium including A. flavus. Pathogenicity and virulence were again tested by topical application on adult P. truncatus with spore suspensions. Table 1 gives some data for isolates obtained from P. truncatus and for 2 laboratory strains of Beauveria bassiana and Metarhizium anisopliae. Virulence differed considerably between the isolates. However, fungi inducing mortality rates of less than 70 % were considered to be of no interest. It is interesting to note that the efficacy of the fungal isolates seems to be much better than for the bacterial strains. Under laboratory conditions high rates of mortality could be obtained after 3 days of incubation. Whether these fungi have a regulating effect on the natural population dynamics of P. truncatus remains to be seen. Initial experiments indicate the importance and difficulty of the technique for applying the infectious material.

With respect to the biotherapeutic activity of the fungal isolates it must be kept in mind that some species are both pathogenic to insects and also to warm blooded animals and man, or are mycotoxigenic as is A. flavus. Clearly mycotoxins must not be involved in pathogenic activity against insects. So far the value of micromycetes also seems limited for biocontrolling P. truncatus in the field or after harvest.

Protozoa

Following microorganisms the protozoa are receiving increasing interest in insect pathology. Lipa and Wohlgemuth (1986) were the first to describe the occurrence of protozoa of the genus Mattesia in P. truncatus originating from Togoan material. The distribution and importance of protozoa in all Prostephanus populations is still

unknown. In continuing our work with the Togoan insect material it has been demonstrated that schizogregarines are worthy of inclusion in the biotherapeutic concept (Leliveldt et al., 1987). The organisms seem to have an acute lethal effect and also influence population development. The same questions as those raised for microorganisms remain to be answered in the case of protozoa namely: efficacy under natural conditions; applicability and longevity of the infective material; interaction with other pathogens or chemical control measures etc.

Other protozoa belonging to the genera of Nosema and Farinocystis and most probably representing undescribed species have also been isolated from insects collected in the countries under investigation.

Table 1 Influence of fungal isolates on mortality of Prostephanus truncatus

Isolate	% Mortality 3 days incubation	% Mortality 4 days incubation
2	13.3	13.3
9	16.7	33.3
12	66.7	73.6
15	70.0	96.7
22	0	10.0
32	73.3	1oo
33	96.7	1oo
45	16.6	23.3
Beauveria bassiana	0	13.3
Metarhizium anisopliae	6.7	56.7

Arthropods

Some information is already available about the interaction between P. truncatus and other storage pests as well as about the importance of parasitic and predatory insects of this pest (Hodges, 1986). Among other insects particular interest is being given to the histerid Teretriosoma nigrescens (Rees, 1985). The beetle lives in close connection to its prey P. truncatus . The aggregation pheromone of the pest acts as a kairomone for T. nigrescens (Boye et al., 1987). In Costa Rica considerable numbers of the predator could be attracted in corn fields. Thus it can be assumed that T. nigrescnes is involved in population regulation of P. truncatus and consequently reduced quantitative losses caused by the Larger Grain Borer. Other storage pests seem to be hardly influenced by the histerid.

Another predator of P. truncatus that was obtained, was a species of Calliodis (Het., Anthocoridae). Further investigations on the occurrence and antagonistic behaviour of this bug are in progress.

Outlook

The objective of the comprehensive research project is to reduce by biotechnological means the actual high level of P. truncatus infestations including the abnormally high losses of stored maize in Africa, to an acceptable level with a natural equilibrium as obviously exists in Central America. Later on it will be up to the farmer himself to decide whether or not the additional application of pesticides is necessary for a further reduction of P. truncatus and other common storage pests.

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