# INVESTIGATIONS ON THE CAPABILITY OF *PROSTEPHANUS TRUNCATUS* (HORN) (COLEOPTERA: BOSTRICHIDAE) TO DEVELOP ON DIFFERENT TYPES OF WOOD

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## Abstract

In two separately conducted trials, a total of 23 types of wood from Togo and Benin as well as maize stems and maize cob cores were tested to see if they could serve *Prostephanus truncatus* for feeding and reproduction. *P. truncatus* was able to reproduce in two different types of wood (*Manihot esculenta*, manioc, and *Poincinia regia*, flamboyant) as well as in maize stems. In comparison to maize grains, the reproduction rate in *M. esculenta* stems was considerable. The duration of the generation cycle was equivalent to that in maize. *P. regia* was less suited by way of comparison. The ability of the insect to reproduce in wood evidently depends on the wood's starch content. The test using potassium iodide solution on a cross-section surface showed a strong blue colouring in both mentioned types of wood. All other types of wood responded only weakly or not at all. The ability of *P. truncatus* to reproduce in wood is discussed against the background of the establishment of a biologically-integrated control programme.

## Introduction

Since the first occurrence of *P. truncatus* in Africa, numerous studies have been published providing data on its biology, ecology and control. Nonetheless, a number of questions still remain unanswered which need to be clarified to outline an integrated control approach. The biological significance of the wood-boring behaviour of the beetle, mentioned by Chittenden as early as 1896, is still unknown. Beetles which have bored their way into wood are better able to survive periods in which no maize is available in comparison with those which do not have this possibility (Boeye, 1988). Assumptions that the insect is capable to use wood for his nutrition or even for breeding were initially unable to be confirmed in studies with various types of wood from tropical and temperate zones (Detmers, 1990).

Observations made by Golob (1988) and Krall (1988) (pers. comm.) which have not been confirmed in experiments seemed to suggest that feeding and reproduction were possible. In our own ecological studies in Togo, strong boring activity of *P. truncatus* was established in lignified, dried manioc stems. These crop residues used for fuel contained numerous holes and a lot of dust produced by the beetles was observed. These findings were the decisive factor for commencing new trials on the above mentioned question, as exact knowledge of the pest's survival and development possibilities is urgently required if prevention and control measures are to be successful.

## Material and Methods

Tests were carried out in two locations:

1. at the Service de la Protection des Végétaux in Lomé/Togo
2. at the Federal Biological Research Centre for Agriculture and Forestry (BBA) in collaboration with the Technical University (TU) in Berlin/F.R.G.

### 1. Trials in Lomé

1.1 Insect Material: For the tests, use was made of insects from a laboratory strain of *P. truncatus*, constantly refreshed with insect material from the field.

1.2 Test Substrates: The types of wood selected are those which are commonly used by Togoan farmers to construct their maize stores. The wood was used in branches 2-4 cm in diameter, with bark. Only the stems of *Manihot esculenta* were decorticated. Maize stems without leaves and maize cob cores were used as additional media. The cob cores were taken from farms and some of them contained still small grains of maize. Loose maize was used as control medium. All substrates were predried in the sun. The moisture content of the woods varied between 11.2 % and 12.4 %. The water content of the *M. esculenta* stems was 9.2 % and that of the maize stems 13.8 %. The test substrates are listed in Table 1.

1.3 Execution of Experiments: 5-6 pieces of branch, each measuring 5-7 cm in length, were placed in ventilated jars of 1 l volume. Some of the wood pieces were split. This corresponds to the condition of wood used by farmers in practice for building stores. 50 adults of *P. truncatus* were placed into each test vessel. The test was conducted with three repetitions.

Table 1: List of types of wood tested as potential feeding and reproductive media for *Prostephanus truncatus*, Lomé and Berlin 1989/1990

| Species | Family | Origine Benin = B Togo = T | Tested in Lomé = L Berlin = B |
|---|---|---|---|
| *Zea mays* L. (reference media) | Gramineae | T | L |
| *Manihot esculenta* Crantz, manioc | Euphorbiaceae | T | L, B |
| *Mangifera indica* L. mango tree | Anacardiaceae | T | L |
| *Dialium guineense* Willd. | Leguminosae | T | L |
| *Malacantha alnifolia* (Bak.) Pierre | Sapotaceae | T | L |
| *Milletia thonningii* (Schum. & Thonn.) Bak. | Leguminosae | T | L |
| *Dichapetalum guineense* (DC.) Keay Syn.. *D. madagascariense* Poir. | Dichapetalaceae | T | L |
| *Lecaniodicus cupanioides* Planch. ex Benth. | Sapindaceae | T | L |
| *Azadirachta indica* A. Juss., neem tree | Meliaceae | T, B | L, B |
| *Poincinia regia* Boj., flamboyant Syn.: *Delonix regia* (Boj. ex Hook.) | Leguminosae | T | L, B |
| *Fagara zanthoxyloides* Lam. Syn.· *Zanthoxylum zanthoxyloides* (Lam.) Zepernick & Timler | Santalaceae | T, B | L, B |
| *Uvaria chamae* P. Beauv. | Annonaceae | B | B |
| *Uvaria* sp. | Annonaceae | T | B |
| *Holarrhena floribunda* (G. Don) Dur. & Schinz | Apocynaceae | B | B |
| *Hymenocardia acida* Tul. | Euphorbiaceae | B | B |
| *Mallotus oppositifolius* (Geisel.) Müll. Arg. | Euphorbiaceae | B | B |
| *Albizia* sp. | Leguminosae | T | B |
| *Cassia siamea* Lam. | Leguminosae | B | T |
| *Lonchocarpus* sp. | Leguminosae | T | B |
| *Antiaris africana* Engl. Syn.: *A. toxicaria* Lesch | Moraceae | T | B |
| *Eucalyptus camaldulensis* Dehnh. | Myrtaceae | B | B |
| *Elaeis guineensis* Jacq., oil-palm | Palmae | B | B |
| *Allophylus africanus* P. Beauv. Syn.: *A. cobbe* (L.) Raeusch. | Sapindaceae | T | B |
| *Tectona grandis* L., teak tree | Verbenaceae | B | B |

For the experiment on the development of larvae on the wood species *M. esculenta* and *Poincinia regia*, holes were drilled in the pieces with a 1 mm drill. First larval instars were placed in these holes. A separate setup was performed for each date of control.

1.4 Climatic Conditions: The trials were carried out in a thoroughly ventilated laboratory room without airconditioning. The tests to ascertain the time of development were performed between 23 °C and 33 °C, whilst the relative humidity varied from 65 % to 99 %.

## 2. Trials in Berlin

2.1 Insect Material: Two different strains of *P. truncatus* were used. No. 1 was a laboratory strain which had been kept exclusively on maize since 1983. No. 2 was a fresh field strain from Togo, which was given both maize and wood for breeding.

2.2 Test Substrates: A total of 17 different types of wood from Togo and Benin were included in the tests. They are listed in Table 1. Their density ranged from 0.34 $g/cm^3$ to 0.84 $g/cm^3$. The moisture content was between 9.8 % and 12.5 %.

2.3 Execution of Experiments: The examination of the feeding and reproductive ability of *P. truncatus* was performed with larvae only a few days old and adults.

Holes were drilled with a 1 mm drill in pieces of branch measuring 3-6 cm in length. The wood was then left for three weeks in the test climate in order to balance the moisture content. 5 larvae were then placed in each of the 5 holes drilled into each piece of wood. Larvae without any nutritional substance were kept in test tubes as a control.

In order to make it easier for the beetles to penetrate the wood, the pieces of wood were sawn into and had holes drilled in them with a 1 mm drill. 100 adults of various ages were placed on each of 3 pieces of wood.

All tests were conducted with three repetitions.

2.4 Climatic Conditions: The tests were carried out in three temperature ranges of 20 °C, 25 °C and 30 °C, each with a relative humidity of 70 %.

# Results

## 1. Results of the Trials in Lomé

1.1 Reproductive Ability

The suspected feeding and reproductive ability of *P. truncatus* on wood was able to be confirmed in these laboratory tests. Reproduction was, however, only seen to take place on the lignified, dried stems of *Manihot esculenta* and on *Poincinia regia*. In both cases, a relatively large amout of dust was observed (Table 2).

The quality of *M. esculenta* as medium for the reproduction of *P. truncatus* seems to be amazingly high in comparison with *P. regia*.

The first successful reproduction of *P. truncatus* on maize stems is of particular interest. The early destruction of these plant parts is thus of great importance for any integrated control approach. In contrast, reproduction in cob cores was not evidenced, but beetles are able to survive for a long time in this medium. Therefore they should also be destroyd.

1.2 Time of Development

The time of development on *M. esculenta* and *P. regia* was examined in a separate trial. First larval instars were

Table 2: Number of offspring (dead or alive) of the F1 and F2 generation of *Prostephanus truncatus* on various types of wood and an maize. Average of three repetitions, after 60 days, Lomé 1989

| Testmedium | Number of eggs | larvae | pupae | adults | Total number offspring | Quantity of dust (g) |
|---|---|---|---|---|---|---|
| *Zea mays*: grain | 239.3 | 428.0 | 44.0 | 563.3 | 1,274.7 | 42.7 |
| stem | 0 | 11.3 | 2.0 | 31.7 | 45.0 | 1.3 |
| cob core | 0 | 0 | 0 | 0 | 0 | 0.6 |
| *Manihot esculenta* | 28.7 | 159.3 | 17.7 | 439.7 | 645.3 | 34.0 |
| *Mangifera indica* | 0 | 0 | 0 | 0 | 0 | 0.9 |
| *Dialium guineense* | 0 | 0 | 0 | 0 | 0 | 0.2 |
| *Malacantha alnifolia* | 0 | 0 | 0 | 0 | 0 | 0.1 |
| *Millettia thonningii* | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dichapetalum guineense* | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lecaniodicus cupanioides* | 0 | 0 | 0 | 0 | 0 | 0 |
| *Azadirachta indica* | 0 | 0 | 0 | 0 | 0 | 0.1 |
| *Poincinia regia* | 0 | 52.7 | 11.0 | 108.0 | 171.7 | 13.6 |
| *Fagara zanthoxyloides* | 0 | 0 | 0 | 0 | 0 | 0.1 |

placed in predrilled holes. According to Haubruge (1987), the average embryonal development at a temperature of 27 °C and a relative humidity of 70 % takes 4.8 ± 0.1 days. In *M. esculenta*, the first beetles were detected after 24 days. Adding the embryonal development time of 5 days gives the shortest generation cycle of around 29 days. The maximum hatching rate was between 35 and 40 days.

For *P. regia*, the shortest time of development was 39 days. The maximum hatching rate was achieved between 55 and 60 days.

Taking into account the varying temperature and moisture conditions in the tests, the succession of generations in manioc stems is roughly the same as that in maize. The exact data are shown in Table 3.

## 2. Results of the Trials in Berlin

### 2.1 Tests with Larvae

The timing of the first control was based on the life duration of the larvae without substrate. 100 % mortality was established after one week at 30 °C, and after two weeks at 25 °C and 20 °C. The larvae of the field strem (No. 2) proved to be more resistant against shortage of food than the larvae of the laboratory strain (No. 1).

100 % mortality was determined in more than 50 % of the experimental setup at the first date of control. At the final control (30 °C and 25 °C after 8 weeks, 20 °C after 12 weeks) development of the larvae to adult insects could only be observed in one of the variants. 4 *P. truncatus* beetles were

Table 3: Time of development from first larval instars of *Prostephanus truncatus* to adult insects on *Manihot esculenta* and *Poincinia regia* wood in natural climatic conditions, Togo 1989

| days after the beginning | *Manihot esculenta*: 1st larval instars at the beginning | number of stages observed | larval instars: 1st | 2nd | 3rd | pupae | adult | *Poincinia regia*: 1st larval instars at the beginning | number of stages observed | larval instars: 1st | 2nd | 3rd | pupae | adult |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | | | | | | | | 12 | 7 | 7 | | | | |
| 6 | 12 | 9 | 8 | 1 | | | | | | | | | | |
| 8 | 12 | 12 | | 12 | | | | 14 | 8 | 7 | 1 | | | |
| 10 | 12 | 12 | | 12 | | | | 14 | 11 | 1 | 10 | | | |
| 12 | 12 | 10 | | 3 | 7 | | | 12 | 7 | 1 | 6 | | | |
| 14 | 12 | 11 | 1 | 5 | 5 | | | 14 | 8 | | 8 | | | |
| 16 | 12 | 11 | | | 11 | | | 12 | 9 | 2 | 6 | 1 | | |
| 18 | 12 | 9 | | | 9 | | | 14 | 13 | 1 | 7 | 5 | | |
| 20 | 12 | 12 | | | 8 | 4 | | 12 | 8 | 1 | 7 | | | |
| 22 | 12 | 8 | | | 7 | 1 | | 14 | 12 | 1 | 7 | 4 | | |
| 24 | 12 | 12 | | | | 10 | 2 | 12 | 9 | | 9 | | | |
| 26 | 12 | 12 | | | 4 | 6 | 2 | 14 | 8 | | 3 | 5 | | |
| 28 | 12 | 11 | | | 4 | 5 | 2 | 14 | 12 | | 5 | 7 | | |
| 30 | 12 | 12 | | | 1 | 1 | 10 | 14 | 11 | | 1 | 9 | 1 | |
| 32 | 12 | 10 | | | | | 10 | 14 | 12 | | 7 | 5 | | |
| 34 | 12 | 11 | | | 1 | | 10 | 14 | 13 | | | 10 | 1 | 2 |
| 36 | 12 | 10 | | | 1 | | 9 | 14 | 9 | | | 6 | 1 | 2 |
| 38 | 12 | 11 | | | 1 | 1 | 9 | 14 | 11 | | | 8 | 3 | |
| 40 | 12 | 12 | | | | | 12 | 12 | 11 | | | 7 | 4 | |
| 42 | | | | | | | | 14 | 11 | | 1 | 4 | 4 | 2 |
| 44 | | | | | | | | 12 | 12 | | | 1 | 4 | 7 |
| 46 | | | | | | | | 14 | 12 | | | 5 | 3 | 4 |
| 48 | | | | | | | | 12 | 8 | | | 1 | 4 | 3 |
| 50 | | | | | | | | 12 | 9 | | | 1 | 1 | 7 |
| 52 | | | | | | | | 12 | 8 | | | 1 | | 7 |
| 54 | | | | | | | | 12 | 11 | | | 2 | 1 | 8 |
| 56 | | | | | | | | 12 | 10 | | | | | 10 |

found on *M. esculenta*. In all other variants, the larvae died as first instars.

In comparison to the experiments in Lomé the larval development was thus far less successful.

## 2.2 Trials with Adults

As in Lomé the development of *P. truncatus* was only observed on *M. esculenta* and *P. regia*. Reproduction was, however, dependent on the temperature and the origin of the *P. truncatus* strain. Detailed results are shown in Table 4.

Table 4: Number of offspring of *Prostephanus truncatus* on *Manihot esculenta* and *Poincinia regia* in relationship to temperature and origin of the insect (final evaluation for 20 °C after 16 weeks, for 25 °C and 30 °C after 12 weeks), Berlin 1990

| | *P. truncatus*-strain 1 (BBA) | | | | | | *P. truncatus*-strain 2 (Togo) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *M. esculenta* | | | *P. regia* | | | *M. esculenta* | | | *P. regia* | | |
| | °C | | | °C | | | °C | | | °C | | |
| | 20 | 25 | 30 | 20 | 25 | 30 | 20 | 25 | 30 | 20 | 25 | 30 |
| 2nd larval instar | - | - | - | 1 | 2 | - | - | - | - | 6 | 9 | - |
| 3rd larval instar | - | - | - | 15 | 5 | 2 | - | - | - | 3 | 3 | - |
| pupae | - | - | - | 3 | 2 | - | - | - | - | 1 | 5 | - |
| adults | - | - | 7 | - | 28 | 14 | - | 22 | 13 | 1 | 1 | 34 |

In Berlin greater reproductive ability was observed on *P. regia* than on *M. esculenta*. This contradicts the results from Lomé, where *M. esculenta* was the better breeding medium.

It was originally assumed that for the development of *P. truncatus* on wood, digestive symbionts must be necessary in order to break down the cellulose, and that strain No. 1, which had been kept exclusively on maize for many generations would have lost these in time. This assumption was evidently not correct, as *P. truncatus* of both origins were able to develop, even if strain No. 2 did prove to have a higher vitality.

The reasons for the different nutritional suitability of the various types of wood is likely to lie in their different content of digestible constituents such as starch, sugar and protein. A quantitative test was performed in order to estimate the starch content of the different types of wood by placing a drop of potassium iodide solution on the cut surface. The results were surprisingly clear.

With *M. esculenta* and *P. regia*, the cross-section of the wood turned a deep blue colour. *Mallotus oppositifolius* and *Elaeis guineensis* turned a moderate shade. In the case of *Cassia siamea*, *Antiaris africana* and *Allophylus africanus* there was only a light shade. No reaction was seen with the other types of wood.

The result suggests that the two types of wood contain a high amount of starch which enables *P. truncatus* to develop. In the case of *M. esculenta*, only the outer xylem area was coloured, while with *P. regia*, the total xylem area was coloured. But the intensity of the blue colour decreased towards the core. The zones with the highest starch content thus correspond to the areas in which the development stages of *P. truncatus* can be found under natural conditions.

## Discussion and Conclusion

The investigations have shown that the feeding and reproduction of *P. truncatus* on wood is dependent on the proportion of digestible constituents. The original assumption of the insects having symbionts which break down the cellulose is not correct.

The differences in the success of the development of *P. truncatus* in *M. esculenta* and in *P. regia* in the tests carried out in Lomé and in Berlin is probably due to two reasons. Constituents of the wood change in terms of quality and quantity the longer it is stored. It is thus conceivable that the older *M. esculenta* stems used in Berlin contained fewer digestible constituents than those used in Lomé and were thus a poorer nutritional medium. In addition, the *P. truncatus* larvae in Berlin were placed in holes 1 mm deep, and thus in a zone low in nutrients, whereas in Lomé they were placed in the outer region of the stem. The largest proportion of starch in *M. esculenta* was detected in the outer region beneath the bark, and in *P. regia* it increased from the middle to the outer zone. The different location of starch in the two types of wood in the cross-section of branches could be the reason for the better reproduction of *P. truncatus* in *P. regia* in Berlin than in Lomé.

The analyse of starch content using potassium iodide solution is a simple means of preselection for types of wood which might possibly be nutritional media for *P. truncatus*. The changes in the constituents of the wood as a result of the seasons and the age of the wood almost certainly have an influence on the success of development. Analyses of the constituents of different types of wood, or series of tests on breeding *P. truncatus* in artificial substrates with known constituents could bring about further clarification.

The present evidence for the feeding and reproduction of *P. truncatus* in wood possibly also provides an explication for the fact that the insect is to be found in scrubland and forests far from any maize stores (Rees, 1990) and is capable of survival in such areas. Here, too, the association of *P. truncatus* with the predator *Teretriosoma nigrescens* in areas remote from maize stores suggests the presence of *P. truncatus* development stages, as the predator is largely dependent on them. This would mean that the effect of the predator is not restricted solely to the part of the *P. truncatus* population present in stored maize, but also includes the part of the population living in natural habitats. This is of great significance for a biologically-integrated control approach involving *T. nigrescens*, as the pest population living in natural habitats cannot be reached by using insecticides.

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# RECHERCHES SUR LA CAPACITE DE DEVELOPPEMENT DE *PROSTEPHANUS TRUNCATUS* (HORN) (COLEOPTERA : BOSTRICHIDAE) SUR DIFFERENTS TYPES DE BOIS

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## RESUME

On sait, par différentes publications, que la forme adulte de *P. truncatus* se fraie un passage dans la tige. Jusqu'à présent, il a été difficile de prouver quelle était l'utilisation de ces tiges dans son alimentation et sa reproduction. Ce problème a été étudié grâce à deux programmes d'examens séparés. Une augmentation certaine du nombre de coléoptères dans les bois de type *Manihot Esculenta* Crants, manioc (Euphorbiaceae) et *Poincinia* (Delonix)) *regia* Boj., flamboyant, a été trouvée. Après dépôt sur chaque tige d'une solution d'iodure de potassium, une forte coloration bleu noir est apparue, indiquant un taux élevé d'amidon. Ainsi, la possibilité que *P. truncatus* utilise le bois pour ses besoins nutritionnels et sa reproduction dépendrait du contenu en substances. La période de développement dans *M. esculenta* à 30° C et 70 % RH s'est avérée plus longue qu'elle ne l'est sur le maïs. Les examens ont porté sur un total de 23 types de bois d'Afrique de l'Ouest traditionnellement utilisés dans la construction des greniers à maïs.