NOTE: Utilization of Sounding Methodology to Detect Infestation by *Rhynchophorus ferrugineus* on Palm Offshoots

V. Soroker,[1] Y. Nakache,[2] U. Landau,[2] A. Mizrach,[3] A. Hetzroni[3] and D. Gerling[2,*]

The use of sounding equipment for the detection of boring larvae of the red palm weevil (RPW), *Rhynchophorus ferrugineus* (Olivier) (Col., Curculionidae), in palm trunks was evaluated and found to be useful. Employment of this method would improve the detection efficiency of weevils in palm offshoots, thereby avoiding the transfer of infested material and curtailing the spread of RPW infestations. Sound recordings of RPW larval activity are being studied for the development of a sound profile that will serve as a basis for future instrumental detection of RPW infestations within tree trunks.
KEY WORDS: *Phoenix dactylifera*; red palm weevil; dates; *Rhynchophorus ferrugineus*; sound detection.

The red palm weevil (RPW), *Rhynchophorus ferrugineus* (Olivier) (Col., Curculionidae), is a severe palm pest, native to South-East Asia. It was introduced into the Middle East in the mid 1980s and reached Israel and Jordan in 1998/99 (3). Although it attacks practically all species of palms, the major commercial damage in the Middle East occurs to the date palm, *Phoenix dactylifera*, whereas in Spain most damage is to *Phoenix canariensis* (1) and in Asia and Melanesia it is a serious pest of the coconut palm (7,8). The weevils develop in the tree trunk, with the period from oviposition to pupal formation lasting 25 to 105 days (2).

Heavily infested trees may contain 80 or more larvae developing simultaneously and more than one generation may develop in the same tree. Feeding larvae sever the vascular bundles, cutting off the food supply and weakening the tree. Infested trees suffer from reduced productivity and heavy infestation often results in collapsed trees and, thus, total loss.

Local spread of the weevils occurs *via* the dispersal of adult females that may cover 1000 m or more in flight. However, long-range pest dissemination occurs mainly when offshoots from an infested plantation, in which infestation cannot be visually detected, are planted elsewhere (1). The present distribution of *R. ferrugineus* infestations around the Mediterranean Basin – encompassing Egypt, Israel, Jordan and Spain – as well as those in Saudi Arabia and the United Arab Emirates, was shaped by the transport and planting of infested offshoots (2). The danger of spreading the pest *via* the infested offshoots prompted authorities to decree quarantine measures aimed at cutting off their transfer from place to place. This has been only partially successful, because offshoot trade is a very profitable business and constitutes a substantial part of the income for many palm growers. Thus, the need for an alternative method of preventing the dissemination of infested offshoots is apparent, for example, through the reliable detection of

Received March 10, 2003; accepted June 25, 2003; http://www.phytoparasitica.org posting Dec. 1, 2003.
[1]Dept. of Entomology, and [3]Dept. of Agricultural Engineering, ARO, The Volcani Center, Bet Dagan 50250, Israel.
[2]The Peres Center for Peace, Tel Aviv 67892, Israel. *Corresponding author [e-mail: dangr@post.tau.ac.il].

infested offshoots. Because observations of the last 3 years showed that $<1\%$ of the harvested offshoots are infested, their detection and exclusion from any shipment would serve the interests of both the sellers (growers) and the consumers.

Our approach towards this goal is to utilize the fact that boring larvae continuously create audible sounds while severing the vascular bundles of the tree. These sounds can be detected by the trained and equipped ear and can serve instead of visible signs, which normally appear in the tree only following severe infestations – when it is too late to prevent the spread of the problem (1,3). We explored this possibility by infesting palm and offshoots and sugarcane segments with single larvae, listening to them, and determining that the larval sounds are indeed distinctive. We also worked in an infested plantation in Egypt, where we used the sounding technique to examine numerous trees, 20 of which were diagnosed as infested. Two of the latter were cut down to reveal RPW larvae of different stages inside. However, at times, detection by the human ear of the crunching sound indicating larval activity is hampered by extraneous sounds such as those emitted by other tree inhabitants, and by external sounds which interfere with determination of larval presence. A reliable and objective method for RPW acoustic detection is therefore warranted.

Acoustic sensing has already been employed to detect a number of hidden pest species, mainly those of granaries (6), underground roots (4) and trees (5). Work for detecting RPW infestations had also been initiated (9) but had never been followed up or put to practical use. We employed an acoustic device (Larva Lausher®, NIR, Bad Vilbel, Germany) to amplify RPW larval activity inside tree trunks. The device, which had originally been developed to detect granary pests, includes a sensitive microphone and an amplifier. The microphone was tightly attached to the lower part of the tree trunk (up to 1 m high) or offshoot, which enabled us to detect the sounds generated during RPW larval motor activity, especially feeding.

Our current work is aimed at developing a monitoring system that will identify and differentiate larval activity from among the mixture of sounds captured by the sensitive microphone attached to the palm trunk. Recordings of amplified sounds from infested and healthy palm tree trunks and offshoots were collected from the field. Likewise, we used artificially infested material in which only one larva of different ages (21 to 72 days) and weights (*ca* 0.02 to 1.4 g) had been placed. Using a sampling frequency of 44.1 kHz, the typical crunching sound was found to appear in bouts lasting each 3 to 10 ms (Hetzroni, A., Mizrach, A., Nakache, Y. and Soroker, V. (2002) Unpubl. report to Israel Palm Growers Association.). A Matlab®Software version 6 (Mathworks Inc., South Natick, MA, USA) application was developed to sample and analyze the recordings. The software enables us to select interactively regions of interest and to extract power spectral density parameters in the frequency domain such as minimal, maximal and average frequencies. A digital signature of the sound is then made of the extracted parameters in the frequency domain and it is being evaluated to determine if it can be used to distinguish between sounds generated by larvae activity and others (Hetzroni *et al.*, *op cit.*).

The knowledge accumulated in this study will be used in the development of future instrumental detection of weevil infestations. The detection of infested palm offshoots using the acoustic method will, it is hoped, help to curb the spread of the RPW and facilitate free trade of healthy offshoots.

ACKNOWLEDGMENTS

We thank Ms. Shlomit Levsky and Ms. Miriam Eliyahu for maintaining the laboratory population of the weevils. This research was supported by the Peres Center for Peace; the Israel Ministry of Agriculture Chief Scientist foundation grant No. 131-1127-01; and the Israel Palm Growers Association grant No. 463-0232.

REFERENCES

1. Cabello, T. (2002) RPW in Spain. http://www.redpalmweevil.com/RPWReport/Spain.htm.
2. Giblin-Davis, R.M. (2001) Borers of Palms. *in:* Howard, F.W., Moore, D., Giblin-Davis, R.M. and Abad, R.G. [Eds.] Insects on Palms. CABI Publishing, Wallingford, UK. pp. 267-305.

3. Kehat, M. (1999) Threat to date palms in Israel, Jordan and the Palestinian Authority by the red palm weevil, *Rhynchophorus ferrugineus*. *Phytoparasitica* 27:241-242.
4. Mankin, R.W., Brandhorst-Hubbard, J., Flanders, K.L., Zhang, M., Crocker, R.L., Lapointe, S.L. *et al.* (2000) Eavesdropping on insects hidden in soil and interior structures of plants. *J. Econ. Entomol.* 93:1173-1182.
5. Mankin, R.W., Osbrink, W.L., Oi, F.M. and Anderson, J.B. (2002) Acoustic detection of termite infestations in urban trees. *J. Econ. Entomol.* 95:981-988.
6. Mankin, R.W., Shuman, D. and Coffelt, J.A. (1997) Acoustic counting of adult insects with different rates and intensities of sound production in stored wheat. *J. Econ. Entomol.* 90:1032-1038.
7. Murphy, S.T. and Briscoe, B.R. (1999) The red palm weevil as an alien invasive: biology and prospects for biological control as a component of IPM. *Biocontrol News Inf.* 20:35-46.
8. Ramachandran, C.P. (1998) The red palm weevil *Rhynchophorus ferrugineus* F.: A review and future strategies. *Indian Coconut J.* 29(4):104-106.
9. Sivaraman, K., Moni, R.S., Sasikumar, and Ramachandran, C.P. (1989) Red palm weevil detector. *Invention Intelligence* 24:32-35.