The bioacoustic detection of the Red Palm Weevil

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Introduction

The Red Palm Weevil (Rhynchophorus ferrugineus) is a difficult pest for palms. The hidden kind of living make an early detection with traditional methods very difficult. Only in the last phase of infestation this weevil can be recognized. A further problem is the absolute high reproduction rate of the RPW.
An answer to this problem could be the bioacoustic detection of the RPW. Every action produce vibrations in the trunk and the task was to proof whether this could be detected.

The developed detector

The developed detector is a handheld device with a special sensor. The device is designed to detect smallest sound vibrations, which are caused by activity of the RPW. It has to be prooved whether it is possible to detect such low signals. This tests were done with Germany beetle species which are living also in wood. Different sensor constructions and methods were built. The question about the possible in case of palms could only be tested in Saudi Arabia, because the special structure of palms was the last and highest risk.

The field test of the detector

The task of my visit was to test the developed detector for the Red Palm Weevil (RPW) detection in laboratory and field and to become a detailed overview about the actual situation of the spreading of this weevil. This optimal preparation gave us the possibility for the successfull work in a relative short time.

The questions I worked on, were:
Is there a possibility of acoustic detection of the RPW and how could it be included in a monitoring program? Further, in case of success, how could look like a monitoring program of the RPW.
For the field test and work in lab were different samples of infested palms available. In all cases, I tested all possibilities, to find the best equipment for the task. We were confirmed in our theory.

Description of used equipment

The first step was the right definition of the measuring equipment. So I wanted to get a complete overview about frequencies from low frequencies up to ultrasound frequencies. The equipment I used, was a Laar Ultrasoundgate harddisk recording system. With this system we were able to measure sound activities from 50 Hz up to 250 kHz. Further a Laar TCE 1 detector with different sensor types were used. The recorded datas were stored in three ways. The datas collected with the Ultrasoundgate were stored on a harddisk. The sound, recorded with the Laar TCE 1 unit was stored in two ways. First they were digitized with a soundcard of a computer.

Second the same datas were also recorded with a Sony DAT recorder. The Laar TCE 1 detector was a special development for this field and laboratory test in Saudi Arabia. The now available serias product is called Laar WD 60.
Further different sensors were available. Six different sensors were used. The tests were made with the following sensor classes: Contact microphone, airsound ultrasound microphone, contact acceleration sensor and a combined contact airsound probe sensor.
The sound analysis was made with Laar/Avisoft SASLab Pro.

Laar WD 60 : high end amplifying system with special probe sensor

Results of measurement and analysis

Different palm trunk samples were available. I could prove the Red Palm Weevil in a good number of palms in lab and especially in field. From all samples were two trunks large. One of this trunks was burned. This was the attempt of a farmer to rescue the palm. In lab it could be demonstrated that the burning of a palm trunk has no effect to the larvae. The external surface of the palm protect the internal structure of the palm and also then the RPW.
Further I got other fresh samples from a farm. This trunk was seperated into small blocks. So I was able to isolate different steps of the weevil development. We were able to watch the acitivities of the larvae and could also make recordings. So it was possible to transfer the knowledge about the different sounds to not seen activities in a close trunk. Also the hidden living of the RPW produce problem in case of early detection with traditional methods. But one fact of the RPW cycle give a good base for acoustic detection. The RPW don´t appear with only some animals If he is in a trunk then you have many animals, which produce a high noise level. This noise level is easier to detect as if only some larvae would be in the trunk. The reason is based on the high reproduction rate of the RPW. The best results with a sensor was possible with a insertion sensor. The use of such type of sensors give the possibility to bring the sensor nearest to the origin of the sound. During the measuring is no contact from the person who do the measurement. So external interferences caused from the person, who measure, are excluded.
The detected signals are clear and easy to identify. Every sound which is heared is caused by activities in the trunk.

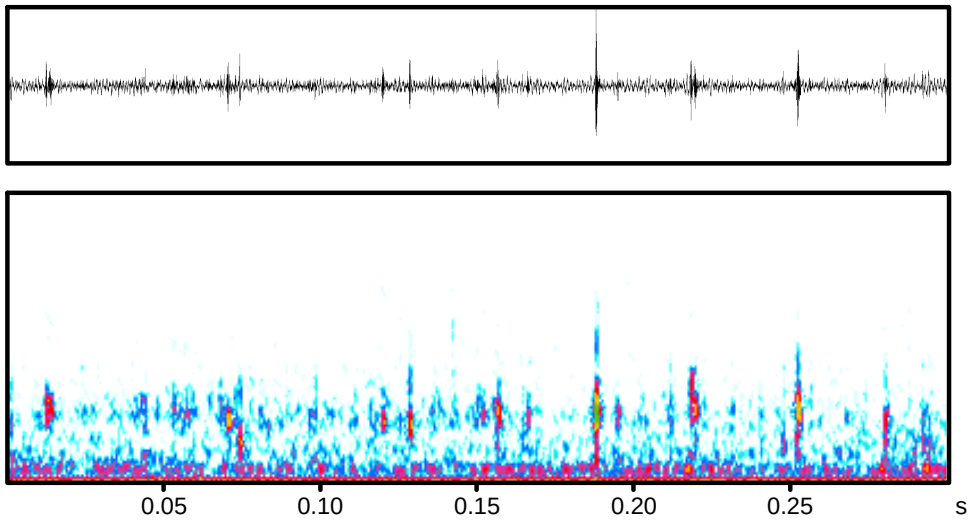
Several different sounds of the RPW could be isolated. These sounds represent different steps of the weevil development.
We could record the following typical sounds caused by the RPW:

1. eating sounds from larvae
2. moving sounds from larvae
3. larvae spinning a kokon
4. moving of a pupa
5. sounds of digestion from larvae

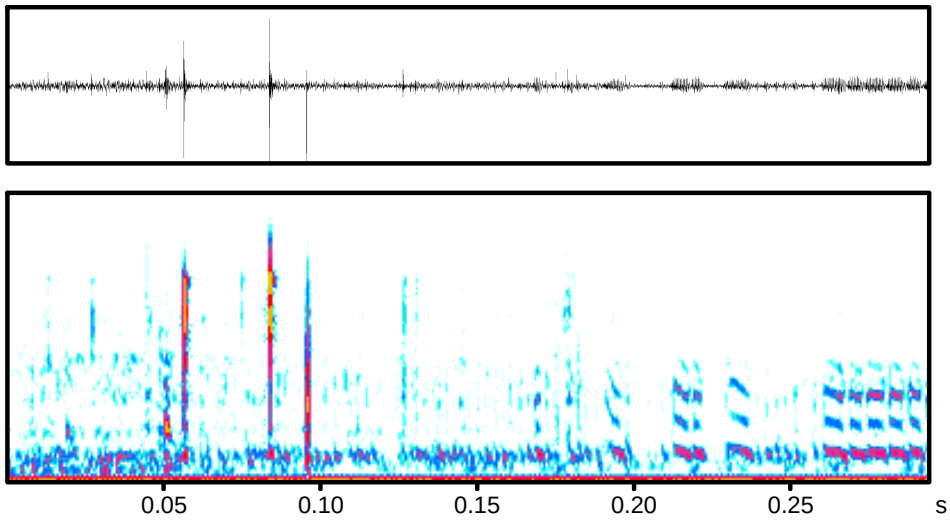
Further typical sounds of the stem borer could be recorded. The sounds of RPW can be described as following. The maximum frequencies are up to 40 kHz. This signals are not useful for detection, because they are not very often. The quality of the signals are mostly based on frequency modulation as a collection of short clicks. Sometimes could also be recorded signals with a great constant frequency part.

The results give a deep view into the problem and the ways for the solution. The first result I got, is the detailed base information about bioacoustic and the RPW. The recordings are the first worldwide in this case. I never expected the clearness and typical of the sound and the possibility to separate the different larvae steps by bioacoustic.

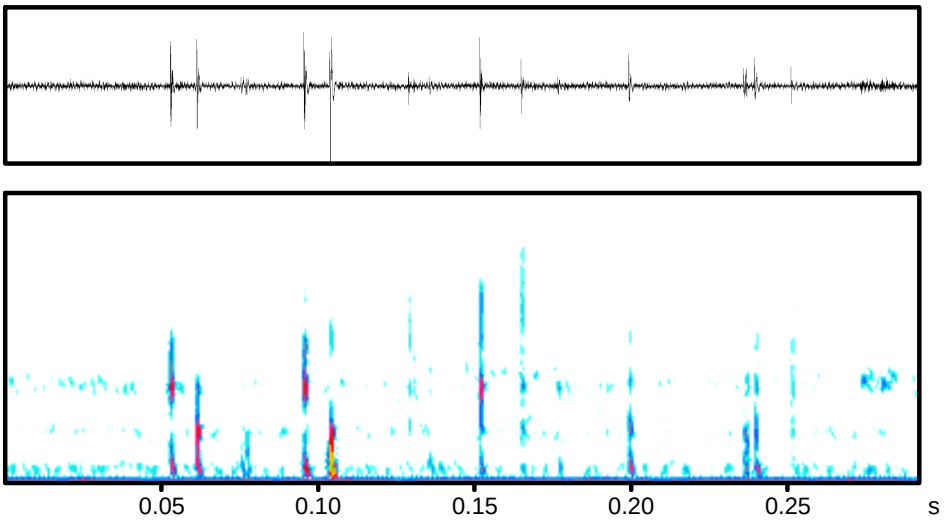
The smallest size of recorded larvae had a length of 5 mm. But for the practice it isn´t important because the power of this produced sound is very low. Better results are possible with greater larvae. The comparison of all recordings show us that the bioacoustic detection of the weevil a useful way is for recognizing the RPW in an earlier phase of infestion. The insertion sensor give the best results.



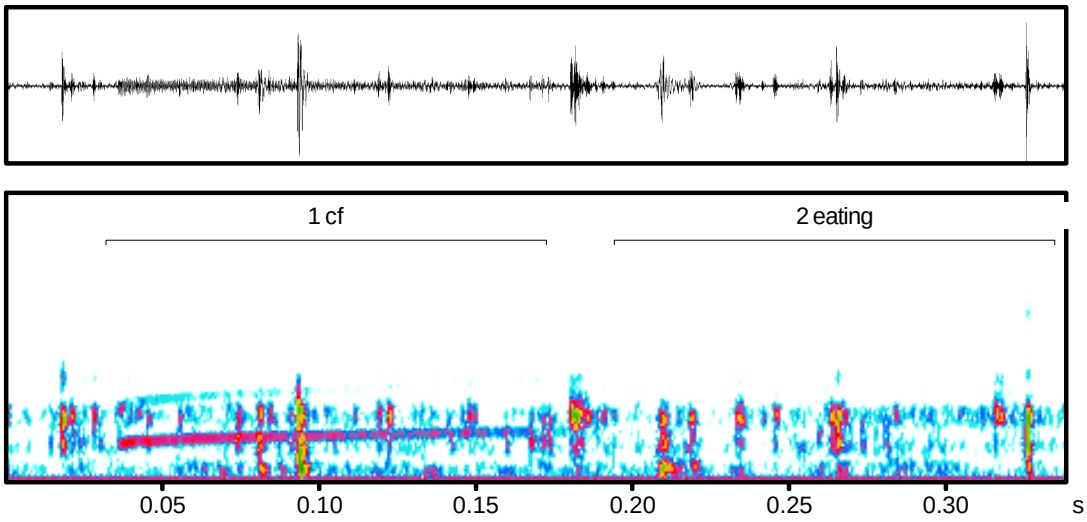
Spectrogram 1: Spinning larvae (RPW)



Spectrogram 2: Eating and digestion sound of a larvae from RPW

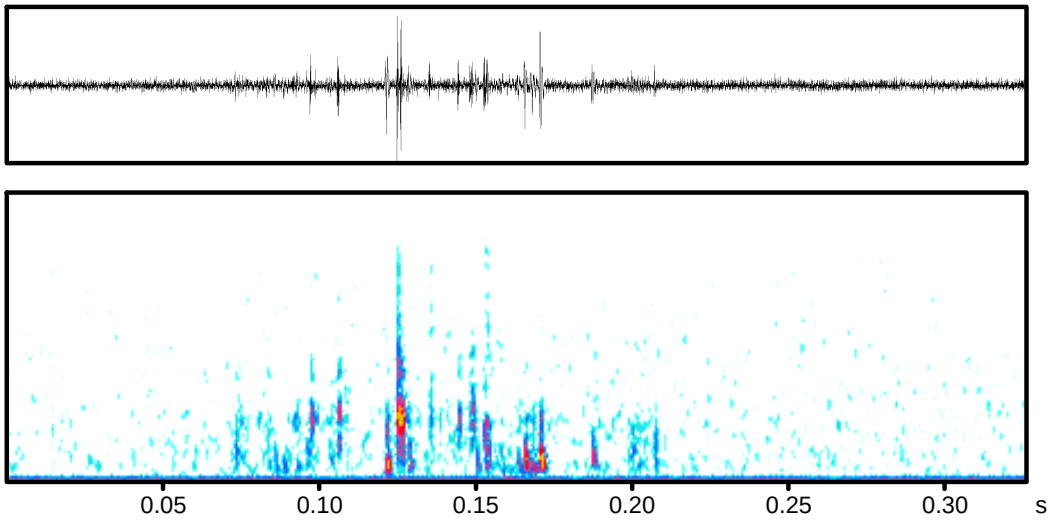


Spectrogram 3: Eating sound from larvae of stem borer



Spectrogram 4: Eating sound of RPW and undefined sound (label 1) with high constant frequency part.

The greatest different between Red Palm Weevil and other possible beetle species is that the activities of RPW seems very agressive. All kinds of produced sounds are collection of many pulses. If the RPW spectrogram is compared with spectrogram No. 4 of the stem borer then can be seen easy the differents between the activities. By the RPW it is difficult to seperate single pulses.



Spectrogram 5: Eating pulse presumable from stalk borer

The spectrogram No. 5 show another very interest sound sequence. This record have a great difference to all other recordings. It was made in a region where palms

only infested with stem borer and stalk borer. The spectrogram shows only one action of eating. The follows a break for up to seven seconds and then a further action follows. By hearing the sound you feel that there works a great larvae so there is a great possibility that this recording could be typical for the stalk borer. Perhaps it could prooved by the next field research.

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