Interpreting the Acoustic Characteristics of Rpw Towards Its Detection- A Review

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Interpreting the Acoustic Characteristics of Rpw Towards Its Detection- A Review

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Abstract: Red palm weevil (*Rhynchophorus ferrugineus*) is also known as Asian palm weevil or Sago weevil. This is a lethal pest of palms which can attack about 17 varieties of palm trees. The growth rate of the weevil depends upon the type of palm tree it feeds on. It attacks the palm trees which is less than 20 years. The presence of the weevil in the palm tree is not evident when seen by the naked eye. Hence palm tree cultivation is affected very badly by the red palm weevil larvae. The larva bores the trunk of the palm trees by feeding on the soft tissues which is present at the centre. The chewing activity produces a kind of sound. Other movements like crawling, emission also produces very feeble sound. The sound produced by the larvae lies between specific ranges of frequency and has its own spectral features. The spectral features extracted from the acoustic movement of the RPW larvae helps the early detection and protect the palm tree from further infestation. Here a survey on acoustic detection and development of instrument or sensors based on acoustic characteristic of RPW larvae is conducted**.**

Index Term: *Red Pam Weevil, Acoustic Activity, Sensor*

1. INTRODUCTION

Most of the cultivation has been affected by the hidden insects which attacks the crop either during cultivation process or while storing the cultivated product. These insects stay within the plant and is concealed from our naked eye. To detect the presence of these kinds of insects many methods are in existence. Among which one of the most used means to identify the pest in the early stage of the infestation is by acoustic method. This method helps in early detection of the presence of the insect.

A. Red palm weevil origin:

Red palm weevil is considered to be the native pest of South Asia and Malensia. During 80's the weevil started spreading all over the world and turned as a major economic pest of the palms. The weevil is present in Asia, Europe and Mediterranean regions [1].

B. Biology of Rhynchophorus ferrugineus:

Life cycle of the weevil is of five different stages namely egg, larvae, pupal, cocoon and adult. The adult RPW lays whitish yellow colour eggs which is 1mm in width and 3mm in length. It takes 2 to 5 days to hatch and larvae come out. Larvae is said to be the most destructive stage of the palms. It is creamy in colour with a reddish head and 13 segments are found on its body. The last stage of the larvae is the pupa. It stops feeding on the tissues of the palms and starts building the cocoon with the fibre of the tree. It takes 1 to 3 days for building the cocoon. The pupal stays inside the cocoon for almost 20 days and comes out as an adult weevil. The adult weevil is reddish brown in colour and of 42mm in length and 16mm in width. Figure 1 represents the different stages of red palm weevil

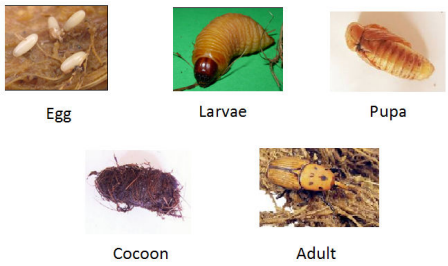

Figure 1. Different stages of Life cycle of Red Palm Weevil Courtesy: www.google.com

The appearance of the red palm weevil differs based on the concentration of colour. The concentration of the red might be more than the black colour or vice versa. The figure 2 gives a clear idea of the appearance of the red palm weevil present in the fields

Figure 2. Appearance of Red Palm Weevil.
Courtesy: Centre for Invasive Species Research, University of California, Riverside

The male weevil has a tuff of soft reddish brown hairs along the dorsal facet of the snout which is absent in the female weevil. This helps to identify the gender of the weevil as shown in figure 3.

Figure 3: (a) Male Red Palm Weevil (b) Female Red Palm Weevil
Courtesy: http://www.novagrica.com/red-palm-weevil/

2. VARIOUS TECHNIQUES FOR DETECTION OF PEST EXISTENCE:

The Presence of Red Palm Weevil can be identified using different methods namely Visual Inspection, Chemical Inspection, Acoustic Detection and Visual/Thermal Imaging Detection to prevent the tree from infestation and dying. Each method is described below.

2.1) Visual inspection depends on the stage of infestation caused by the movement of RPW. Oozing of thick brown liquid, fermenting odour, weevil waste are the few symptoms of the infestation that can be identified by visual inspection. This inspection can be laborious and is not possible for detection in large scale infestation.

2.2) Chemical detection is based on the volatile clues emitted by the infested palm trees. Sniffing dogs were used to sense the infestation and then treat the tree from dying which is not possible for large scale. In that case automated olfactory detection can be applied to detect.

2.3) Acoustic detection is based on the distinct sound produced by the weevil larvae present inside the palm trees. The limitations present in the detection process are the ambient interference produced by the low energy emitted by young larvae is difficult to acquire in the open environment.

2.4) Visual/Thermal Imaging Detection is a system where the temperature of the tree is sensed using an infrared camera. Also the water status of the field or the palm tree can be studied easily. As the number of larvae inside the trunk of the tree increases the temperature of the tree also increases.

3. STUDY OF ACOUSTICAL ACTIVITIES OF RPW WITH OTHER SOURCES

Before developing any system, the study of the particular insect's acoustic activity at different stage of its biological cycle is important. An acoustic method was applied to detect the presence of R. ferrugineus [6]. The sounds were recorded for 50 days in 7 days' interval and the sounds were recorded for 120s. The sound is classified using automated spectral analysis and found the larvae sound impulses to be 0.3 – 3ms. It is found that the entire large Rhynchophorus weevil can be detected using acoustic methods in both hosts and fronds in exposed and enclosed environments. To develop an acoustic instrument for detecting the hidden insects by the acoustic signals generated we need to follow few steps to make the device efficient in fulfilling the task. The Fig.4 explains in detail how an instrument has to be developed and also tells the important facts to be considered to develop an efficient acoustic device or sensor [12].

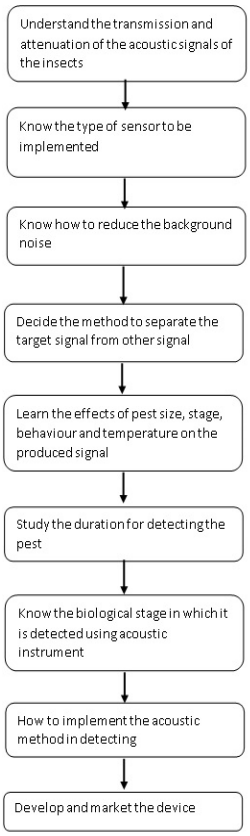

Fig 4 Steps to be followed to develop an acoustic device

3.1. Study of acoustical differences between the R. ferrugineus with environment sounds and other insects:

The acoustic sound produced by insects has its own acoustical characteristics which help in differentiating it from the other species and also from the environmental sounds. The strength and the period of acoustic signal depend upon the population of the species inside its habitat. A study was conducted to know the different attributes of the generated acoustics.

In [17], the sound of the Red Palm Weevil collected in the field is compared with the recordings from the laboratory. The obtained result is validated using few methods like acoustic pattern and frequency spectra of RPW. Finally, the presence of the weevil is confirmed by dissecting the palm tree. It was also studied that RPW will not permit other palm tree species to stay in the trunk it is available.

It was found that RPW had a mean number of impulses per burst (>30) and for O. elegans it was found to be only 18. Also the mean total rate of impulses for RPW which occurred within the bursts was >10s and for O. elegans was 2.51s. The larvae present in the offshoot were easy to identify than the larvae present inside the trunk. More automated methods can be developed with the obtained results and can help in identifying the RPW infected tree and offshoots and prevent transporting the infested trees.

The sound produced by different movements of RPW larvae is been compared with the same RPW larvae like chewing and biting sound [19]. It was observed that the spectrum is different for larvae movement and for chewing, biting activities. Also the research proved that

larvae movement produces more sound than the sound generated during chewing and biting. The sound pattern remained constant for the sound signal during chewing and biting but differs for the sound signal generated by the movement of the larvae.

The presence of the RPW larvae was identified using the speech recognition technique in a non-destructive manner. The features of the recorded sound were extracted using MFCC, feature extract technique and compared using VQ, feature matching technique to identify the RPW noise from the background noise. Validation of the result was done on the dissection of the tree. Accuracy increases if the number of samples increases [18].

Acoustic signals of the red palm weevil boring the palm trees can be recorded by a device. From the recording background sounds including human whispers get recorded. The human whisper can cause wrong prediction for the weevil sound. Using the speech recognition technique MFCC and Vector Quantisation (VQ) combination the human whispers can be separated from the recorded sound. Based on Euclidean distance concept the weevil sound is differentiated and identified. This procedure can be used to discriminate and recognize the sound of the hidden pest [10]. Similarly, using the available tools and software the presence of the larvae locomotory and feeding activities tests were conducted. The patterns of the weevil activities were also identified. MFCC extracted the features of the sound obtained and then was matched with the code books stored. VQ proved to be a useful coding method as it uses statistical occurrence. This research proved that the text independent sound identification can be performed using Cepstral Coefficients and Vector Quantization. It also proved that the resulting information will be a key characteristic in detecting the presence of the particular pest [4].

In this study the sounds of the weevil were compared using clustering and Euclidean techniques. Using MFCC the features of the recorded sound were extracted and analysed using clustering technique based on Euclidean distance. The similarities between the signals and the least Euclidean distanced is measured from the output is compared with data's available in the database to confirm the presence of the weevil. This study proved that using the above mentioned techniques the presence of weevil in the early stage can be identified [13]

A review was done to apply acoustical technology to know the population rate, geographical distributions and the species diversities. Study was conducted on all type of insects to understand their acoustical nature which would help in developing an attractive trap depending on the species they belong and their behaviour. [15].

The bioacoustics features of the RPW are extracted using signal processing technology and analysed using different window functions [3]. 980 RPW feeding sound recording were used out of which the temporal and spectral features of 765 recordings were extracted. Window function selection was studied along with extraction of specific 10 frequency domain features which proved to have efficiency more than 98%. **T**ime frequency analysis was used to analyse the recorded acoustic signals of Red Date Palm Weevil (RDPW). The collected data were analysed using three methods namely time domain, power spectral density and time frequency distribution using hamming window out of which the last one proved to be efficient in detecting the presence of RDPW. TFD was applied to study the unique signature of RDPW and distinguish it from the environmental noise [7]

3.2. Study of Acoustic Device and bioacoustic sensors based on its acoustical characteristics:

A new acoustic instrument was developed [12] based on the study conducted on unique spectral pattern and temporal pattern of the sound produced by the weevil. Using speech recognition techniques like Vector Quantization and Gaussian Mixture the recorded sound can

be analysed and identify the weevil sound from the background sound. Larven Lauker sensor was used to record the weevil sound. The sound generated by the weevil lasts for about 3ms to 5ms and has a peak frequency between 1 kHz to 3.8 kHz. Based on the analysis made on the sound pattern, acoustic instrument with suitable sensor can be invented to detect the presence of RPW.The presence of the red palm weevil is detected [16] by their acoustic characteristics with the help of wireless sensor network in coconut trees. Here a set of 8 trees is considered as an array and the sensors are placed in different heights of the trees in such a way that infestation at any part of the tree can be identified. The sound of the weevil is recorded along with the background noise and analysed using a signal processing tool to separate the weevil sound indicating the presence of the weevil.

A bioacoustics sensor was designed [14] to capture the sound of the weevil in the early infestation stage and the result is sent to the control station using wireless communication. This protype has achieved over 90% of detection rates with respect to environmental noise. It follows a periodic monitoring which is followed by a user defined schedule and works with a solar-based power unit for a long period of time. Also it does not need any maintance after installation. It proposes a future work of accessing the control station through internet allowing the supervisor to check the palm trees anytime and anywhere through a nice and initiative graphical user interface.

A new bioacoustics sensor was developed based on the acoustic signal generated by the RPW during the feeding activity in a controlled environment. The developed sensor can detect or sense the acoustic activity of 2 week old larvae with the sound intensity of about 2250 Hz in a controlled environment. The recorded acoustic of the weevil was tested using a band pass filter between 0.2 kHz and 12 kHz to eliminate the background noise and Fast Fourier transform with hamming window to analyse the sound impulse of the weevil. It was analysed that this sensor is capable of sensing the acoustic activity especially during feeding activity

A new acoustic device was developed with a sensor, main unit and a head set [11]. The accuracy was tested by conducting two different studies at three different conditions. The first study was conducted on 549 palms to determine in which position the sensor has to be placed for acquiring the sounds of the RPW larvae. Second study was conducted on 159 palms and tested to identify the symptoms of the infestation present in the palm. In this study a technique named Time Frequency Wavelet analysis was done to identify the unique acoustic signature of RPW larvae from the back ground noise.

A prototype for automatic bioacoustics detection of RPW was designed in [2] based on piezo electric sensors which is used to sense the locomotion and feeding vibration of the insect. The recorded sound is parametrised and the vector feature is extracted. The result is given to Red Palm Weevil (RPW) and BNW model where BNW model was trained based on the sound collected from the non – infected tree which was about 3 mins' duration. The results from both the models were compared to the predefined threshold and tabulated. Three different wavelet functions were used out of which 32 wavelet function was found appropriate for discrete wavelet packet features. Finally, the overall performance observed for LFCC parameter was proved to be greater than one of the DWPFs. Also, when the results were compared, variable length segmentation proved to be give accurate RPW recognition than the traditionally fixed frame size approach. Finally, it was proved that the developed prototype is portable and accurate in detecting the presence of RPW in large number of palm trees in less time. A mathematical model was developed [8] based on the speech recognition technique like vector Quantization (VQ) or Gaussian Mixture Model (GMM). Detection rate of 98% was successfully achieved

when the test was conducted under laboratory condition. It was proved that human analysis is unreliable and emphasize that automatic acoustic tool is important in detection of RPW.

4. FUTURE SCOPE

The main purpose of this study is to understand the nature of the hidden insects of the palm trees and study their acoustical features. Also to know the possible methods used to detect the hidden insects. Based on this study a proposal of an integrated system to be developed that could identify the infestation in the palm tree caused by the hidden insect in a very early stage. The proposed system will be developed in such a way that it will help the cultivator of the palm tree to take necessary steps in protecting the palm tree from further infestation.

V. CONCLUSION

The insects that are hidden inside the tree exhibit its own acoustical characteristics. Every activity of the insect produces some kind of acoustic trait and can be sensed using sensor. Many sensors are developed specially based on the type of insect which is to be identified. To confirm the presence of the insect different scientific methods were used. These methods can be further improved or modified to detect the presence of the hidden insect as early as possible before it causes severe infestation. It is also necessary to develop a device which is user friendly.

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Ms. Leena Nangai. V is a research scholar at Sathyabama University, Chennai, Tamil Nadu, India. She has a working experience for about 4 years and 9 months of teaching experience. She has also worked as trainee software developer for about 1 year and 6 months. Now she is conducting a research in developing an instrument based on acoustical characteristics which would be cost efficient and user friendly for the farmers and also detect the red palm weevil in a very early stage before it could affect the tree completely. She has done a survey on how the hidden insects are been detected using different methods. Also how instruments and sensors have been developed based on the frequency of the insects. She has published two papers using image processing which is related to medical treatment which is based on segmentation and classification of computed tomography (CT) images using Image Processing technique along with neural networks which would help in analysing the brain tumour.

Dr. Betty Martin works for Sathyabama University as an Associate Professor for more than a decade. She was awarded her bachelor of Engineering in ECE from Amravati University, Shegaon Maharashtra and her PG in Electronics and Control, Sathyabama University. She obtained her Ph.D in Sathyabama University under the title `Studies on Design and Development of a Novel Sensor to Detect Red Palm Weevil in Palms'. She has a patent filed for the above same title. As a resource personality, she has travelled to Trivandrum, Kerala later to Madanapalee Chitoor district Andrapradesh for a quest talk in workshops. She has attended various FDP`s, seminars, symposium and workshops. She has also presented paper`s in youth Congress. She has in her acclaim a number of peer reviewed national and international journal publications which are Scopus and Web of Science indexed with good citation index with 4 national journals 13 international journals 6 articles in national conference and 12 in international journals.