

A Sound-Based System for Locating Wasp Nests

SCIENCE FOR CONSERVATION: 14

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Published by
Department of Conservation
P.O. Box 10-420
Wellington, New Zealand

Science for Conservation presents the results of investigations contracted to science providers outside the Department of Conservation. Reports are subject to peer review within the Department and, in some instances, to a review from outside both the Department and the science providers.

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ISSN 1173-2946

ISBN 0-478-01687-5

This publication originated from work done under Department of Conservation contract No. 1447, carried out by: Richard Harris, Weeds and Pests, Manaaki Whenua—Landcare Research, P.O. Box 69, Lincoln; and Rod McDonald and Peter Calvert, Engineering Development Group, Horticulture and Food Research Institute, Private Bag 3123, Hamilton. It was approved for publication by the Director, Science and Research Division, Department of Conservation, Wellington.

Cataloguing-in-Publication data

Harris, Richard J.

A sound based system for locating wasp nests / Richard Harris, Rod McDonald and Peter Calvert. Wellington, N.Z. : Dept. of Conservation, 1995

1 v. ; 30 cm. (Science for conservation, 1173-2946 ; 14.)

ISBN 0478016875

I. Wasps--Control--New Zealand. I. McDonald, Rod. II. Calvert, Peter,
III. Title. IV. Series: Science for conservation ; 14.

595.7980993 20

zbn95-017202

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1. Introduction

The potential of a sound-based system for aiding location of wasp nests was investigated by Weeds and Pests Division, Manaaki Whenua - Landcare Research, Hamilton, in conjunction with Engineering Development Group, Hort Research, Hamilton, for Science and Research, Department of Conservation, Wellington in July-June 1992-93.

2. Background

DOC staff are called upon in the wasp season to reduce wasp numbers in areas of high public use such as picnic spots and camping grounds. To do this they have a choice of two techniques; luring wasps to bait poisoned with 1080, or killing nests directly. Though the 1080 method can be effective when wasp numbers are high, it carries considerable hazards to humans and non-target organisms and requires several days of prefeeding and baiting. Direct poisoning of nests is more effective and less time consuming. The main problem is finding the nests.

Wasp nests are currently found by watching flight lines or walking along tracks or transects. This requires some time and skill. Wasps congregate at a nest entrance, and their flying activity produces sounds at a specific range of frequencies. This frequency could be the basis of an acoustic locator for nests. That concept was the basis of the investigation reported here.

3. Objectives

- To characterise sound emissions from the nest entrance of German and common wasps.
- To compare sound emissions from other social insects and from other large insects such as blowflies, hoverflies, and cicadas to determine which peak(s) is/are unique to wasps.
- To construct a filter to eliminate frequencies other than those of interest and combine it with an amplifier and microphone.
- To determine the equipment's range and the usefulness of the technique in the field.

4. Methods

Fourier analysis was used to characterise sound emissions from nests of the German and common wasp, from bee hives, and from background sources in the field.

After initial development of ideas a prototype pre-amplifier/filter/visual display unit was constructed using standard electronic techniques (Appendix 10.1).

The prototype pre-amplifier/filter/visual display unit was used to evaluate three microphone types. In a laboratory test a dummy wasp was created using a signal generator and speaker emitting 190Hz at a volume level judged by ear to be similar to that from a single wasp. Each microphone was placed in turn at a distance of 10 cm from the dummy signal and the detector system sensitivity was adjusted to give a low background noise level (9db) with no speaker output. The microphone response to its wasp-level input was then measured.

When the most effective of the three microphones was determined it was combined with the pre-amplifier/filter/visual display unit and tested at the entrance of a wasp nest to determine its range and usefulness.

5. Results

5.1 SOUND EMISSIONS

German and common wasps produced a peak at 170Hz, with a harmonic at 340Hz (Appendix 10.2). Honeybees leaving a hive produced sounds around 240Hz (Appendix 10.3). Recordings of background noise levels at the time of German and common wasp recordings showed these were low in volume and spread over a range of frequencies, with the main components being outside the frequency of interest (Appendix 10.4).

5.2 MICROPHONE EVALUATION

After subtracting the residual noise from the microphones, results of the laboratory test were as follows:

AKG	Shotgun type	21 db
Proline	Boundary type	21 db
AKG	Lavalier type	15 db

Tests with the Lavalier microphone were therefore not continued.

In outdoor qualitative evaluations the AKG Shotgun microphone was clearly superior to the Proline Boundary microphone for insensitivity to wind noise, most likely because of its factory-supplied windshield. Its sensitivity was high and intrinsic noise low. At the frequency of interest (170Hz) its directional properties gave an arc of greatest sensitivity of about 120 degrees solid angle.

Air turbulence around the angular shape of the boundary microphone produced much larger signal levels than that of a distant wasp. Without custom windshielding it would be unsuitable for field use.

5.3 FILTER SYSTEM TEST

The prototype filter unit constructed had peak sensitivity at a frequency of about 170Hz and a rapid reduction in sensitivity moving away from this frequency (Appendix 10.5).

5.4 FIELD TEST OF SHOTGUN MICROPHONE AND SOUND-FILTERING UNIT

The range of the sound-filtering unit in conjunction with the shotgun microphone was tested at the entrance to a large overwintering German wasp nest (traffic rate of >500 wasps entering per minute). The signal resulting from the traffic noise of the wasps was clearly distinguishable from background wind noise on the LED display only when wind gusts died down and only up to a distance of 5 m.

The low detection range was not due to the sensitivity of the equipment. The pre-amplifier had a sensitivity adjustment so that the background noise could be adjusted off scale to prevent it lighting up the LED display. When wind gusts were absent the wasps were detected with the amplifier at minimal sensitivity.

6. Discussion

Even though background noise levels were low at the frequency of interest they remained constant with distance from the nest, but wasp noise decreased with distance at the rate of $1/d^2$. At a distance greater than 5 m, the background noise and that emanating from the wasp nest were indistinguishable on the LED display.

Wasps are very quiet insects compared to bees and to general environmental noise. Therefore the required environmental conditions conducive to successful wasp location are:

- Distance of >1000 m from any traffic-carrying road.
- Light wind conditions (<10 km/h or <3 m/sec).

- No human voices, particularly adult male voices.
- The detecting microphone should be stand-mounted and not hand-held.

These constraints, together with the short detection range, even at the entrance of a large overwintered nest, combine to severely restrict the usefulness of a sound-based locator.

An operator wearing headphones may be able to separate regular wasp signals from random wind gusts. However, to do this the frequency of the sound would have to be altered to eliminate the feedback loop created, and wearing headphones reduces the ears' own discriminating power as they only receive signals of a very narrow frequency range. The ideal situation is one which makes use of the operator's own discriminating power and improves it.

To improve the range of the shotgun microphone and retain the directional powers a parabolic reflector could be used. It is estimated that this would give a 10-fold improvement in maximum detectable noise levels. With a sound level decreasing at the rate of $1/d^2$ from the source, this would only give approximately another 3 m of detection range. The parabolic reflector would need to be 2 m in diameter, severely reducing the portability of the device.

A series of microphones in line-array format would add useful directional discrimination, without the need for a parabolic reflector, especially if a signal-averaging method (auto-correlation) were employed to average out turbulence and road noise. A minimum of four microphones along a pole would be needed, with a minimum spacing of 0.5 m apart (because of the half wave length of the signal). To reduce background noise the system would need to be mounted on a stand. Computing power, perhaps in the form of a single-chip microprocessor, would be needed to combine the input from this array and perform the auto-correlation. Such a system would increase the detection range, but only by a factor of two or three, and would give a maximum detection range of only 10-15 m.

Such computer-based processing to recognise and eliminate background noise would increase detection capabilities but dramatically increase costs by between \$10,000 and \$20,000.

7. Conclusions

The sound-based system tested here will not help in finding wasp nests because of the environmental conditions required to maximise sensitivity and the low sound output from wasps. The detection range of 5 m is too short to be useful but it could be improved to 10-15 m, by adding an array of microphones and computer-based signal discrimination. Such enhancements would limit the portability of the locator and add greatly to costs. The effective range would still be too small to result in significant improvements in ability to locate nests in the field.

8. Recommendations

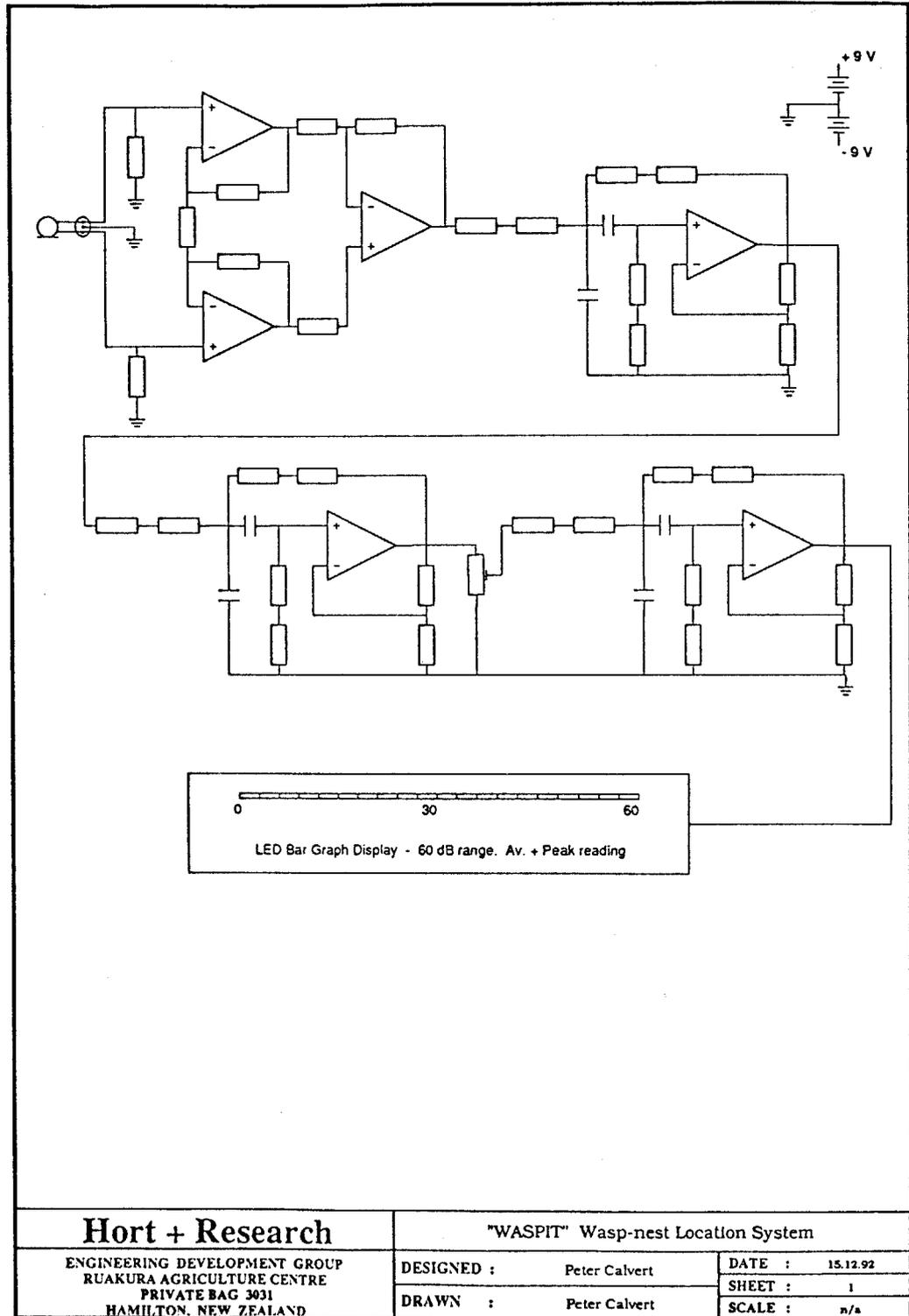
Further development of this technique would require large inputs of capital, which are not justified at this time.

9. Acknowledgments

Craig Eustace helped with Maclab recording and sound characterisations. The Lotteries Commission provided financial assistance for microphones and filter purchase and construction.

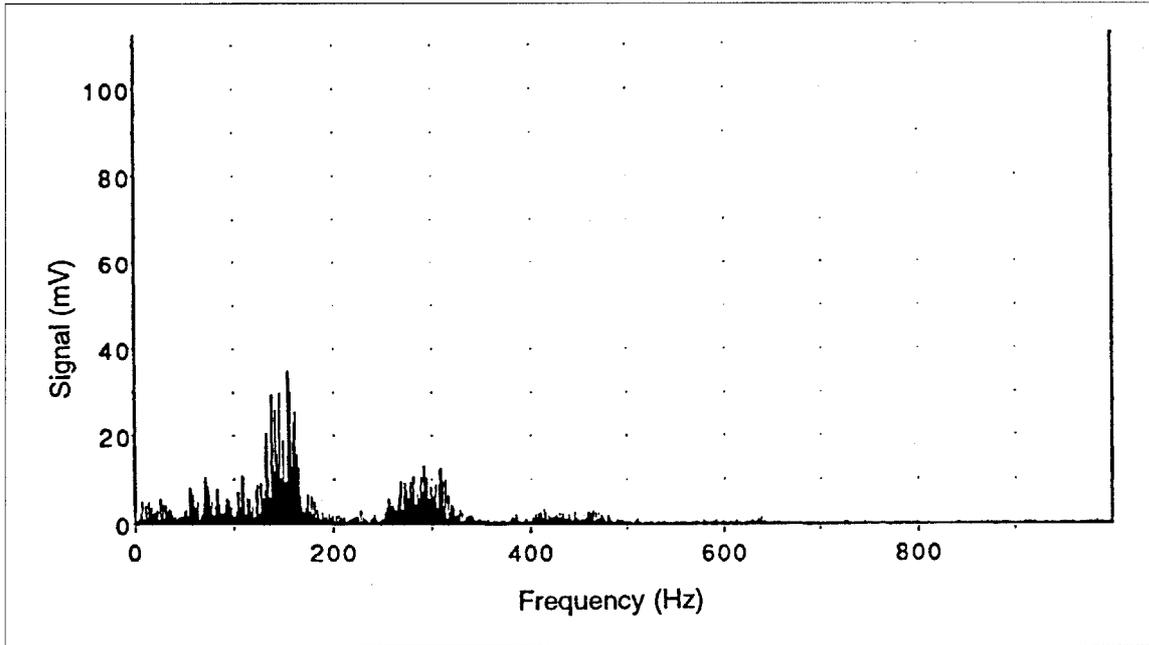
10. Appendices

10.1 PROTOTYPE WASP NEST LOCATION SYSTEM

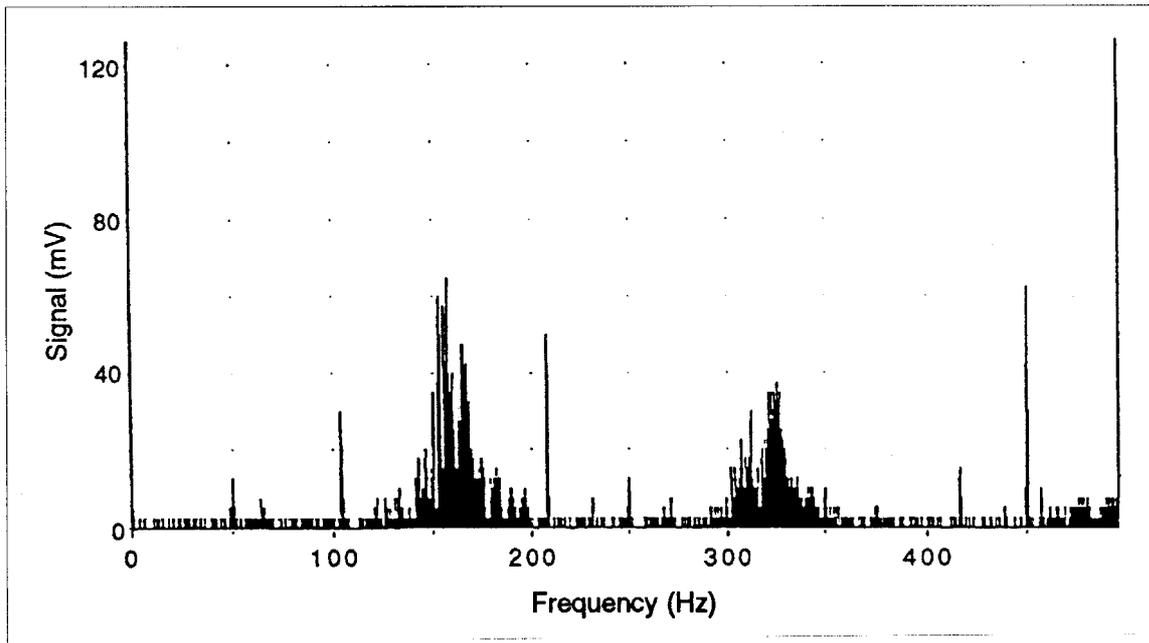


10.2 CHARACTERISTIC RECORDING FROM GERMAN
(A) AND COMMON WASP (B) COLONIES

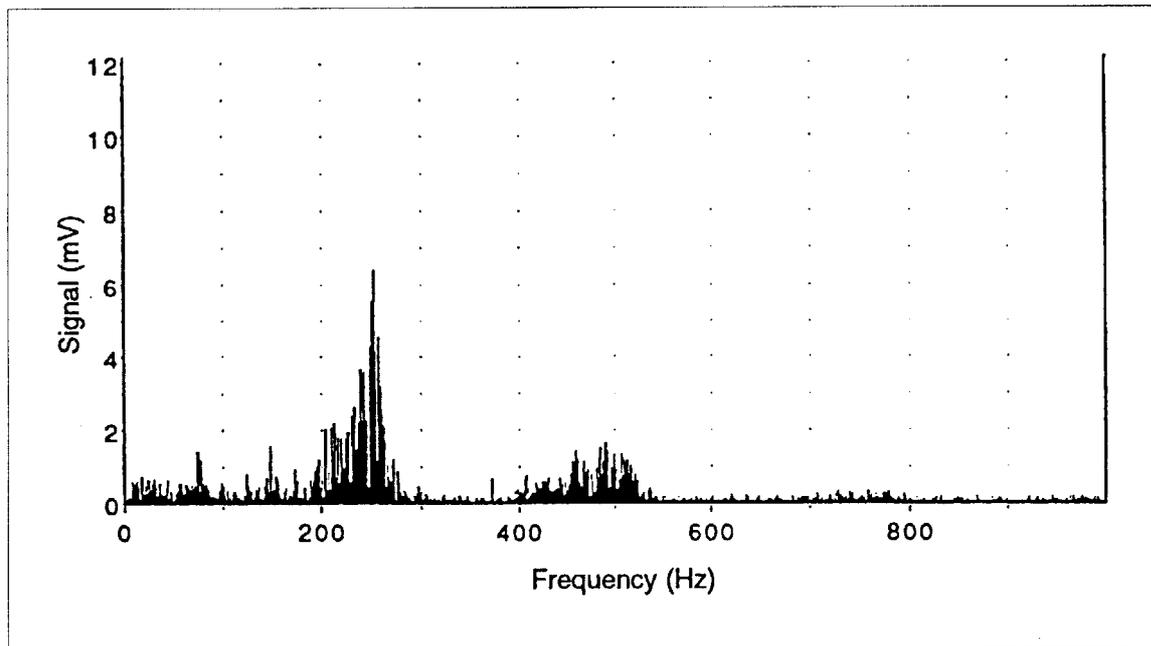
(A)



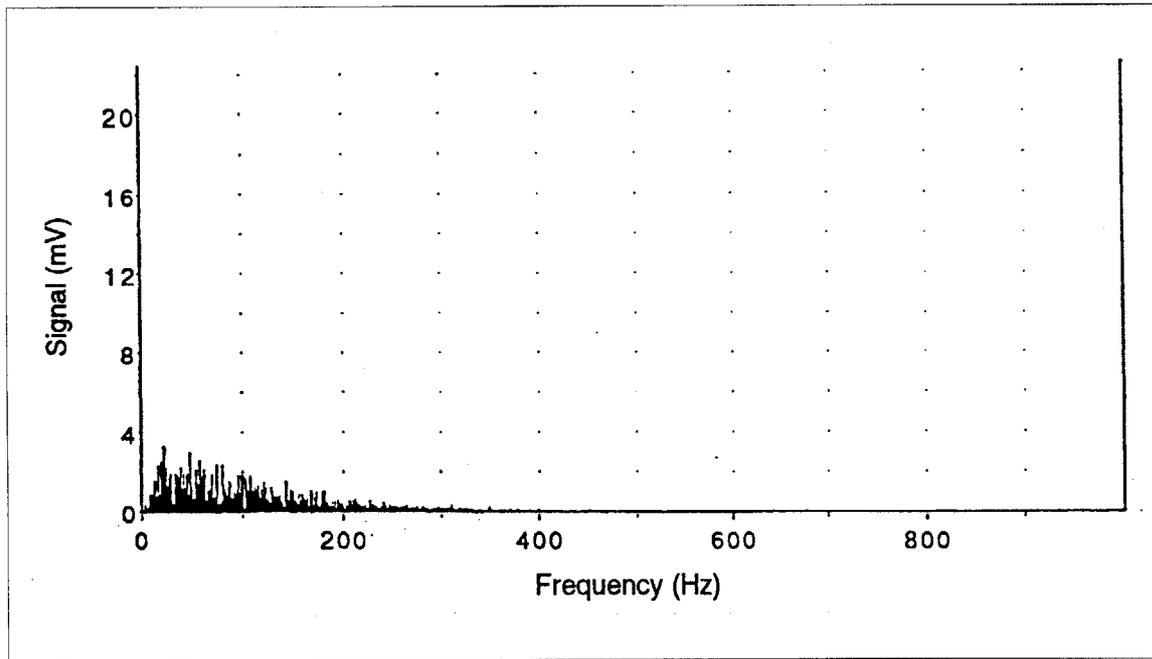
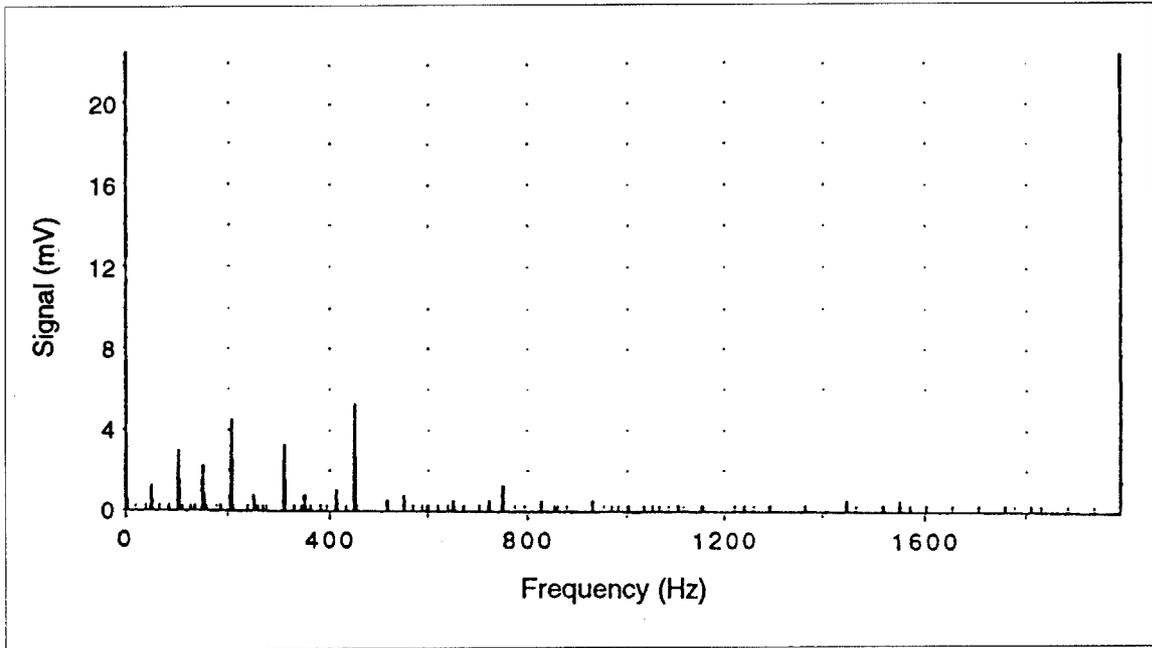
(B)



10.3 CHARACTERISTIC RECORDING FROM THE ENTRANCE TO A BEE HIVE



10.4 BACKGROUND NOISE LEVELS RECORDED AT NESTS



10.5 SOUND-DETECTION PROFILE FOR SOUND-FILTERING PROTOTYPE

FILTER FREQUENCY/AMPLITUDE
RESPONSE

