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AN AUTOMATIC MONITORING SYSTEM FOR RECORDING BAT ACTIVITY

by

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ABSTRACT

A simple, low-cost, automatic bat detection system is described. The system involves putting a Batbox III bat detector, a small voice activated tape recorder, a talking clock and an optional long-life battery into a waterproof container which is placed out in the field all night. When a long-tailed bat *(Chalinolobus tuberculatus)* flies within 50 metres of the detector the "clicking" noise activates the recorder and the sounds are recorded on tape. The clock speaks the time once an hour and this too is recorded on tape. An index of bat activity (bat passes/hour) can be recorded by listening to the tape.

The system was developed and calibrated for use with long-tailed bats. Preliminary trials indicate that short-tailed bat *(Mystacina tuberculata)* activity can also be monitored, although further assessment is required.

1. INTRODUCTION

Two species of endemic bat still occur in New Zealand, the vulnerable long-tailed bat *(Chalinolobus tuberculatus)* and the endangered short-tailed bat *(Mystacina tuberculata).* They are the only terrestrial native mammals occurring in New Zealand. Both species have declined significantly since humans arrived in New Zealand, but there is very little known about the current status, long-term stability and ecology of bat populations. It is not known whether populations are still declining or indeed what the causes of decline were.

One of the primary aims of the Draft New Zealand Bat Recovery Plan over the next five years will be to define the distribution and population trends of our threatened bats. The Department of Conservation needs an up-to-date database for bats, to identify where declines are still occurring and to monitor rates of population change, before any effective management can be undertaken.

The recent aquisition of hand-held ultrasonic bat detectors from overseas has meant that extensive, systematic bat survey work is now possible in New Zealand. Bats navigate by echolocation. They emit high frequency (ultrasonic) sounds, usually through their mouths, in rapid pulses at frequencies which are usually undetectable by humans. These sounds are reflected back to bats in flight as echoes, enabling them to discern the texture of the environment and the location of flying insects in the dark. Bat detectors convert these high frequency pulses to audible "clicks" through the detector's speaker.

Bat detectors have now been used for many years to locate bats, assist in identifying species, and to describe echolocation calls (e.g., Fenton 1970, Fenton et al. 1987). Increasingly, they are being used to study habitat use patterns (e.g., Fenton et al. 1977, Bell 1980, Barclay 1991, Walsh and Mayle 1991). Each bat species has a distinctive echolocation signature and often a specific frequency at which the signal strength is loudest. In countries where there are large numbers of species there can be considerable overlap in the frequencies of echolocation calls (e.g., Ahlen 1981, Fenton and Bell 1981, Fenton 1982, Thomas and West 1984). In New Zealand, the two extant species have very different call structures. The strongest in long-tailed bats occur at c.40 kHz (S. Parsons pers. comm.) and in short-tailed bats at c.27 kHz (B. Lloyd pers. comm.). Thus bat detectors provide a good, species-specific tool for monitoring bat activity.

Bat detectors are usually used while being held by a walking or stationary observer, which is very labour intensive (e.g., Fullard 1989, Walsh and Mayle 1991), or by using tape recorders which run continuously or are turned on for brief sampling periods using a timing switch (G. Hoye, L. Lumsden, H. Parnaby pers. comm.). Standard cassette recorders are limited by the length of the tape and, at most, an unattended recorder can sample 45-90 minutes of bat activity in a night. We developed a simple detection system using voice activated recorders which can record activity continuously throughout the night.

2. DESCRIPTION OF SYSTEM

2.1 Summary

The system involves putting a bat detector with a small voice activated tape recorder, a talking clock and an optional long-life battery in a waterproof container which is placed out in the field all night (Figure 1). When a long-tailed bat flies within 50 metres of the detector the "clicking" noise activates the recorder and the sounds are recorded on tape. The clock speaks the time once an hour and this too is recorded on tape. An index of bat activity (bat passes/hour) can be recorded by listening to the tape.

2.2 Bat detector

The BATBOX III bat detector is being used so that observations of bat activity can be standardised throughout the country. The Batbox appears to be twice as sensitive as most other bat detectors on the market (A. Walsh, Bristol University, pers. comm.). Preliminary trials with both long-tailed and short-tailed bats confirm this observation. The Batbox I I I costs less than similar detectors and the speaker has a crisper sound with less static.

The best recordings are made if the frequency dial on the detector is set at 40 kHz for long-tailed bats and 27 kHz for short-tailed bats. The volume dial should be set on half volume. If a higher volume setting is used, then static amplified inside the water-proof container can turn the voice activated tape recorder on when no bats are present.

2.3 Voice-activated (VOR) tape recorder

SONY TCM-82V or 85V tape recorders are currently being used in an effort to standardise results. They are one of the cheapest recorders available commercially. New models, such as the Sony TCM-S64V and TCM-38V (which has a built-in talking clock), are now being used by some workers. Other tape recorders will work but some calibration with the standard Sony will be required if results are to be compared between areas. If other recorders are used, make sure they have a calibrated volume control so that the VOR setting is always the same. When using an untried model of recorder an observer should sit with a detector beside an automatic set-up in a place where bats are common to determine if the new tape recorder has the same sensitivity. Record number of bat passes over set time periods and compare results with the automatic system.

The tape recorder is placed back-to-back with the detector in a container (Figure 1). Switch the record and VOR buttons ON. Set the volume control on a TCM-82V to "4", the lowest VOR setting. You can hear if the recorder is switching on and off by making a noise and listening to the taperecorder motor running then switching off. If a higher VOR setting is used the tape recorder will switch on and off more frequently in response to environmental noise.

2.4 Talking clock

Any talking clock which chimes and announces the time every hour is suitable for use. We are using the cheapest and smallest clock available, the VOICER TALKING KEY CHAIN. This unit emits a high pitch chime which activates the tape recorder, then announces the time, which is then recorded.

Long-tailed bats begin to leave their roost sites half an hour before dusk, but short-tailed bats leave their roosts when it is fully dark. The standard sunset times for the nearest major town or city (given in the New Zealand Nautical Almanac published annually by

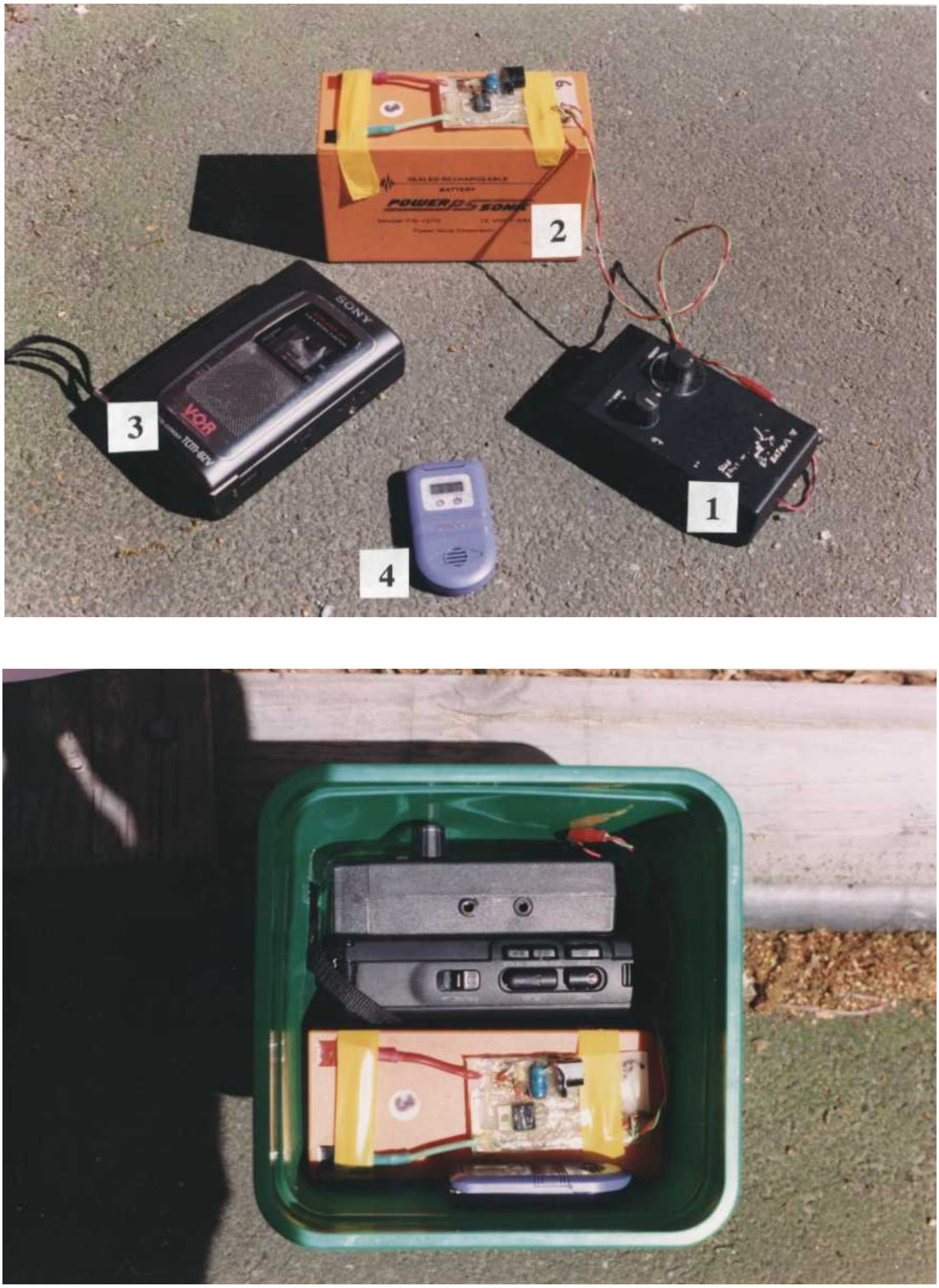

Figure 1. (A). Components of the bat detector system: 1, bat detector; 2, gel battery with voltage reduction circuit; 3, voice activated tape recorder; 4, talking clock. (B). Components fit into a four litre plastic container.

the Ministry of Transport) provide a good guide to when to commence an evening bat count and talking clocks can be calibrated on these times. We set the time so that it records hours after sunset, 12.00 being sunset, 1.00 being one hour after sunset, and so on.

2.5 Batteries

The bat detector works using a standard small alkaline 9V battery. However, these batteries only last for about 20 hours (two nights) and the bat recording rate drops steadily with battery voltage. Therefore we attached the detector to a large 12V (7.OAH) sealed gel rechargable battery via a voltage regulator (Appendix 1). This gives 10-15 days life and keeps the bat recording rate constant.

2.6 Waterproof container

The system is installed in a plastic waterproof container. A hole the size of the detector's microphone is cut in the container and the hole is covered with mesh to stop interference by birds (e.g., robins). A square 2 litre ice-cream container is suitable if a large rechargeable battery is not used. Otherwise a 4 litre liver pail is suitable (Figure 1).

2.7 Thermometer

A basic mercury maximum/minimum thermometer is required to measure temperatures on sampling nights.

2.8 Costs

The system is relatively cheap and low in technology. The total cost is less than $500, comprising the detector ($300), tape recorder ($110), talking clock ($15), battery and circuit ($50), thermometer ($20) and plastic container (<$2). Details of models and suppliers are given in Appendix 2.

2.9 Operating the system

The system can be placed in a wide range of locations and habitat types, and both formal and casual sampling regimes can be employed. We generally place the containers 1-1.5 m off the ground on logs, boxes or trees when sampling long-tailed bat activity. Sets can be placed on the ground when recording short-tailed bats, because they frequently fly very low (0.5-2 m, B. Lloyd pers. comm.).

The system works best on calm, quiet nights. Interference from ultrasonic noise produced by rain, sea or excessive wind causes the system to turn on and off more frequently or even run continuously. Consequently, the tape can run out well before the night is over. Covering the container with moss or some absorbant material will minimise noise interference from rain. How long the tape will last depends on how many bat passes activate the tape recorder. Under ideal conditions, a whole night's sampling may only use 5-10 minutes of tape. We have recorded up to 636 bat passes on one side of a C90 cassette tape.

2.10 Sampling area and efficiency

Long-tailed bats were watched at dusk and the range at which they could be detected measured. They could be detected at an average of 54 m (SD=11.4, range=40-70 m, n=20) when directly in front of the detector.

A frequency generator which emitted signals at 40 kHz was then used to construct a diagram of the detector's sampling area, using 50 m as the standard signal range

(Appendix 3). The results indicated that, on average, the detector would turn on the tape recorder when a bat was c.50 m away when in front of the detector, c.20 m if it flew in from behind the detector, and c.26 m if it flew in at right angles to the detector. We tested this by having an observer record bats using a hand-held detector and comparing the results with an automatic system one metre away. Bat passes/hr were compared on nine nights during the first hour after sunset. There was no difference between the rate of recording using the two techniques. The observer recorded an average of 8.7 passes/hr (SD=3.46, range 5-13) while the automatic system recorded 8.8 passes/hr (SD=3.52, range 3-14).

The range at which short-tailed bats can be detected appears to be less, because of their different call structure. We measured the range at which signals could be heard when releasing hand-held short-tailed bats on Codfish Island. Echolocation calls could be heard clearly at 19-20 m away, with signals being lost 22-25 m away (n=7 bats) when the detector was set at full volume.

2.11 Recording environmental variables

Several environmental variables influence the degree of bat activity on a particular night. Bats become temporarily inactive when temperatures are too low for them to obtain enough food to survive. Therefore, several temperatures should be taken during the night (sunset temperature, temperature one or two hours after sunset, and minimum overnight temperature).

As well as temperature, factors such as rain, cloud cover, moon and wind all influence the activity and detectability of bats. Long-tailed bats do fly in all manner of weather (e.g., heavy rain, strong wind), but activity (and thus the chance of recording bats) is considerably reduced in these more extreme conditions.

Bat activity is also likely to vary considerably between different habitat types. Therefore habitat descriptions should be recorded in detail. Information on composition of vegetation at a sampling site, rather than, for example, simply "forest", is necessary.

2.12 Recording and interpreting results

Following a night's sampling the tape is reviewed. The number of bat passes per hour can be recorded. A bat pass is defined as a sequence of greater than two echolocation calls as a single bat flew past the microphone (Furlonger et al. 1987). Generally, a sequence of audible clicks followed by a pause, the sound of the tape recorder turning off, and a brief gap on the tape, clearly delineate each bat pass. A distinctive sound indicating a feeding attempt (a "terminal" or "feeding buzz") can also be heard. A feeding buzz occurs when the time between echolocation pulses shortens dramatically as the bat homes in on an insect. As the train of pulses increases and the sounds almost run together, the feeding buzz sounds much like a person blowing a "raspberry". All results should be recorded on a standardised form (example in Appendix 4).

The results provide an index of bat activity, rather than absolute numbers of bats in an area. There is currently no information on how number of bat passes relates to numbers of individual bats, but this is not critical when indexing and monitoring bat activity. A series of passes in an hour could equally be produced by one bat or many bats.

A large number of factors influence whether or not bats will be active on a particular night. People should be aware of these influences when deciding whether to carry out a survey and then when interpreting results.

There is a strong correlation between bat activity, temperature and the abundance of flying invertebrates. The amount of bat activity probably depends on the average nightly temperatures, and because these vary with latitude, altitude and geographic location, timing will vary throughout the country. In the Eglinton Valley, Fiordland, there is some long-tailed bat activity at temperatures at least as low as -1.5°C. However, activity in Fiordland is much reduced between April and October (7 months). More data are needed to clarify activity patterns, but in many parts of New Zealand surveyors are much less likely to record bats in winter and most likely to record bats in mid-summer. Surveys undertaken in temperatures below 5°C are much less likely to record long-tailed bats (at least in the South Island). Daniel (1990) suggested that short-tailed bats could be more active than long-tailed bats at lower temperatures. However, recent research on Codfish Island indicated that short-tailed bat activity also declines with temperature (pers. obs.).

If a survey is being undertaken to determine whether bats are present in an area, then the survey should avoid times and temperatures when the chance of finding bats is much reduced.

2.13 Calibration of detectors

Bat detectors should be calibrated with an ultrasonic frequency generator, before being used in the field, to check that they are functioning correctly. We have tested 24 new sets and all but two operated as per specifications. On one unit the frequency dial was reset so that the dial settings and true frequencies matched. In the second unit bat calls were not being amplified and thus were not turning on the tape recorder.

3. APPLICATION TO LONG-TAILED BATS

Long-tailed bat echolocation calls are clearly recorded using bat detectors. Calls are usually distinct, loud and unmistakable. Calls usually resemble a moderately quick slapping or clicking sound when the detector is set on 40 kHz.

The automatic system has a wide range of applications, including basic survey work (Do bats occur in a certain area?), and following up bat reports, particularly in remote locations or where staff are not available for more intensive follow-up work. The system can also be used to monitor roost sites and bat activity patterns. We used the system in Fiordland over summer 1992-93 to sample habitat use and activity patterns at different times of the night, and under different environmental conditions. Four habitat types were surveyed concurrently each night and 15 random replicates made in each habitat type. An example of the results is shown in Figure 2.

4. APPLICATION TO SHORT-TAILED BATS

Short-tailed bat calls are of a more rapid crackling sound and softer to listen to than long-tailed bats on the detector when set on 27 kHz. Short-tailed bats usually emit twice as many calls per second as long-tailed bats (S. Parsons pers. comm.).

Preliminary trials on Codfish Island in April 1993 indicated that the system also works with short-tailed bats, with a maximum of 16/hr recorded in a location where bats were common. In October 1993, up to 260 bat passes per night were recorded 100 m from a roost of several hundred bats. Trials indicated that 27 kHz was better than higher frequencies for detecting the bats and that the QMC Mini detector, used with previous bat work, was not as effective as the Batbox III (fable 1). Further trials are required to document variability in detection rates more accurately. The detector system appears not to be as sensitive for use with short-tailed bats. However, even with a more limited sampling area, the detection system will still be useful for indexing bat activity or monitoring activity at specific sites (e.g., food sources like *Dactylanthus* plants or roost sites), particularly in remote locations.

Table 1 Results of sampling using the automatic bat detection system with short-tailed bats on Codfish Island, April 1993 (Paired trials using different combinations of frequencies and detectors over eight nights).

	BATBOX III DETECTOR			QMC MINI II
	27 kHz	40 kHz	60 kHz	27 kHz
Average passes/hr	3.09	0.12	0	0.55
Range (passes/hr)	0-16	0-1	–	0-4
No. hrs	67	17	27	20
No. nights	9	2	2	2

Wilcoxen signed rank tests comparing Batbox III settings: 27 vs 40 kHz ($p < 0.0015$); 27 vs 60 ($p < 0.0000$) Batbox vs QMC on 27 kHz ($p<0.0005$).

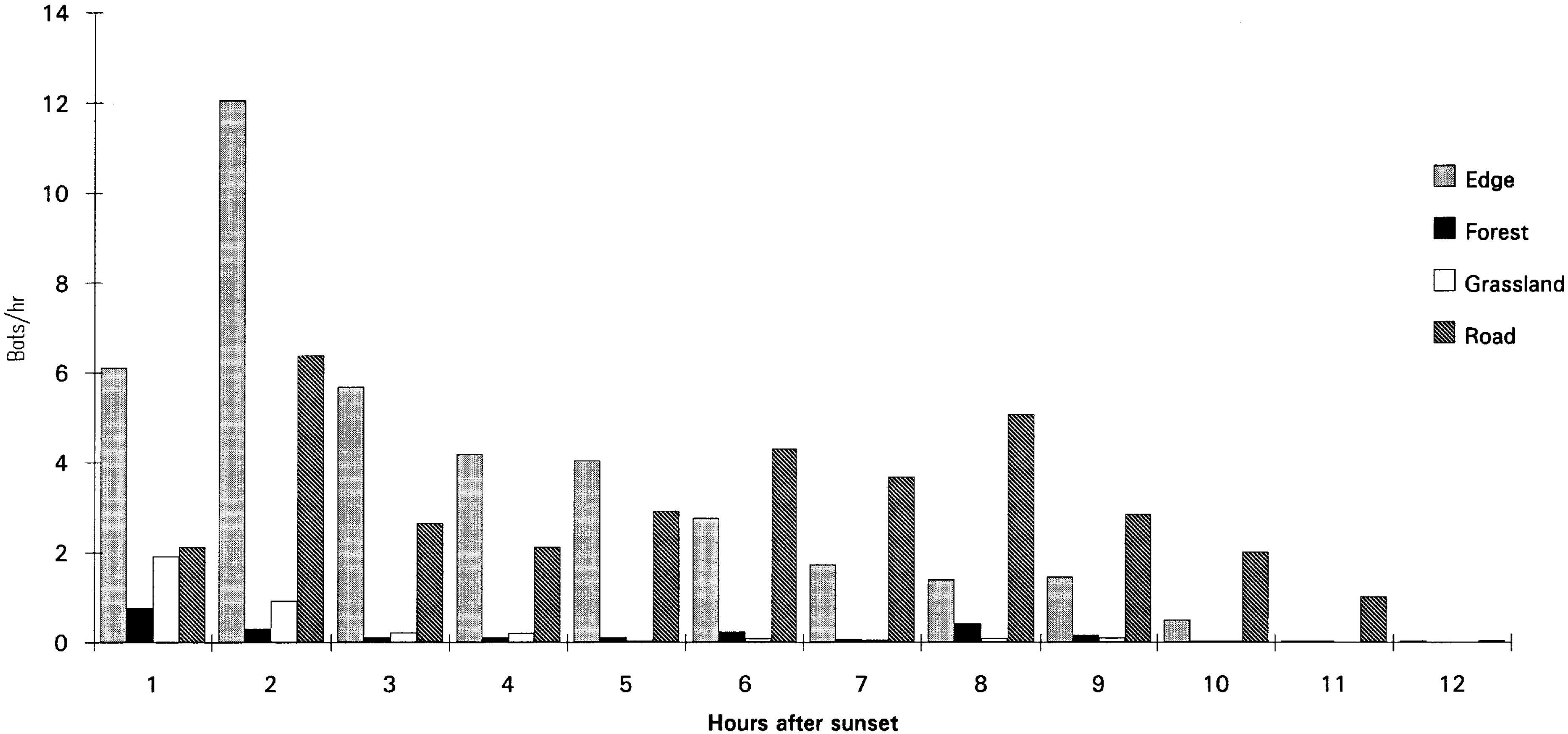

Figure 2. Long-tailed bat activity (passes/hr) in four habitat types, Eglinton Valley, Fiordland, November 1992-May 1993 (n=75 nights/habitat type).

5. FURTHER DEVELOPMENTS AND OTHER APPLICATIONS

The effectiveness of using bat detectors for survey work may vary between species and location and their use will depend on the objectives of the study. Further calibration and field trials are needed before using the system with short-tailed bats. Additional calibration may also be required if using the system for studying factors other than distribution and habitat use of long-tailed bats. Trials using a broad-band detector system (ie. one that scans all frequencies at once and could record both bat species on the one machine) are warranted. Refinements such as light or rain sensors which switch the detector on and off could also improve the system. Although more sophisticated data-loggers could be used with the detector, the additional costs would be great.

Similar approaches using voice-activated tape recorders for monitoring other nocturnal species or animals in remote locations could be developed. For example, we have recorded swamp birds (marsh crake *Porzana affinis* and Australasian bittern *Botaurus poiciloptilus*), brown kiwi (*Apteryx australis*) and frogs (*Litoria raniformis*) using the system. Voice-activated tape recorders were used to monitor kakapo (*Strigops habroptilus*) breeding activity in 1989 (B. Lloyd pers. comm.). Voice-activated tape recorders, talking clocks and radio receivers are now also being used to identify radio-tagged kakapo at feeding stations on Codfish Island (B. Lloyd pers. comm.).

6. ACKNOWLEDGEMENTS

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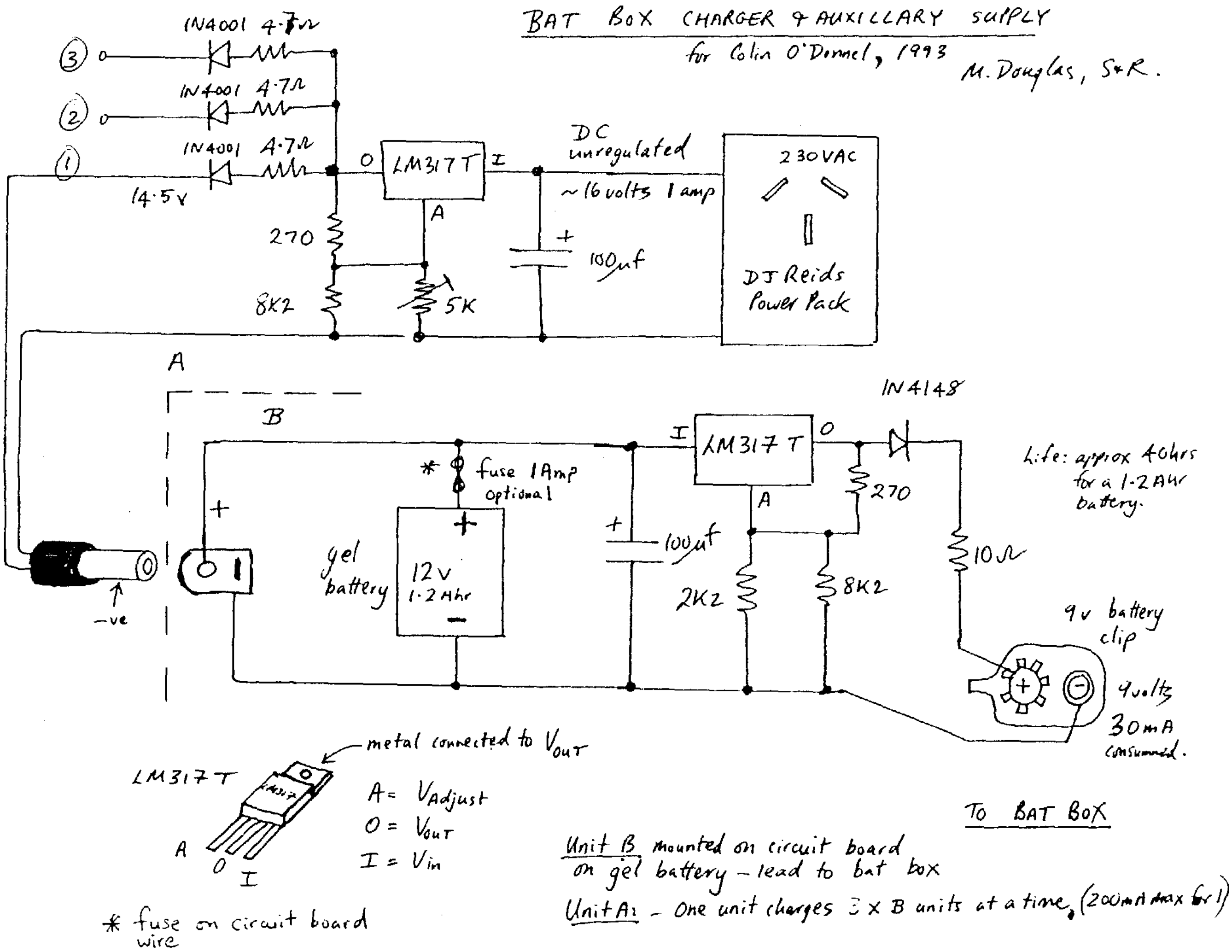
APPENDIX 1 Batbox battery charger (unit A) and voltage regulation circuit with charger socket (unit B)



APPENDIX 2 Suppliers of bat detection equipment

Batbox III bat detector

Stag Electronics
1 Rosemundy
St Agnes
Cornwall TR5 OUF
England

Phone (0044) 87255 3441
Fax (0044) 87255 2856

Sony TCM-82V Voice activated tape recorder

Sony NZ Ltd
Bush Rd
Albany
Auckland

Phone (09) 415 7777

or any Sony agent

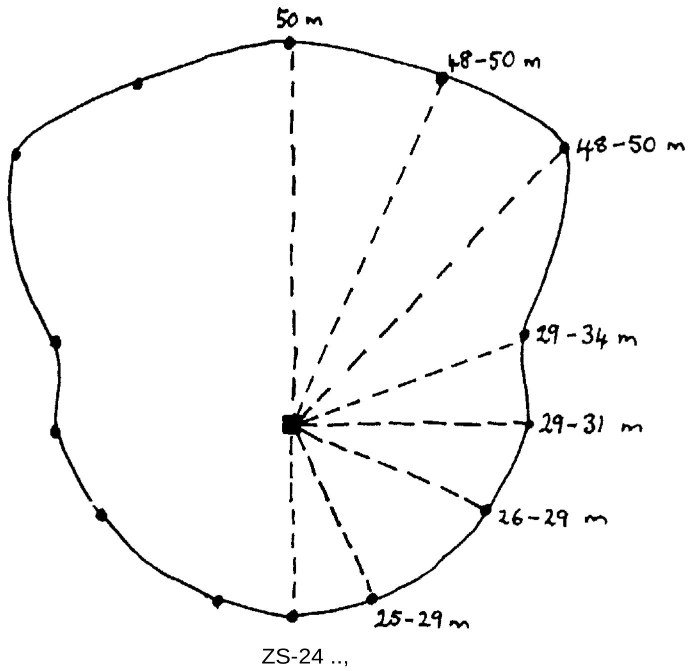
Voicer talking key chain

David Reid Electronics or Dick Smith Electronics (Throughout New Zealand)

APPENDIX 3 Diagram of standardised Batbox III sampling area for long-tailed bats, calibrated using a 40 khz frequency generator.

Methods: The gain on the frequency generator was set so that the first audible clicks could be heard on the bat detector when it was 50 m away from and in front of the detector's microphone. The batteries in the frequency generator and detector were new. The detector was stationary and 1 m off the ground. One observer moved around the detector while a second observer listened to the detector and recorded when the first observer went into and out of range of the detector (ie when the audible clicks from the frequency generator could no longer be heard). Observers swapped roles and repeated the exercise using 8 detectors.

The polar diagram (below) is only intended to give a schematic view of the detector's receiving area under optimum conditions. In reality, the strength of a bat's echolocation calls may vary depending on the behaviour of the bat.



(A) Schematic of sampling area
(.=sampling points)

APPENDIX 4 Standard data recording sheet

NEW ZEALAND BAT RECORD SCHEME
DEPARTMENT OF CONSERVATION

AUTOMATIC SAMPLING RECORD SHEET

LOCATION:			ALTITUDE(m):
MAP SERIES:	MAP NO:	GRID REF:	DATE:
OBSERVER: ADDRESS:			
WEATHER:			
DUSK TEMPERATURE:		MINIMUM TEMPERATURE:	
SUNSET TIME:		SUNRISE TIME:	
BAT DETECTOR:		TAPE RECORDER:	VOR SETTING:
HABITAT DESCRIPTION:			

HOUR AFTER SUNSET:	No. BAT PASSES:	No. FEEDING BUZZES:
TIME START:		
HOUR 0–1		
HOUR 1–2		
HOUR 2–3		
HOUR 3–4		
HOUR 4–5		
HOUR 5–6		
HOUR 6–7		
HOUR 7–8		
HOUR 8–9		
HOUR 9–10		
HOUR 10–11		
HOUR 11–12		
HOUR 12–13		
HOUR 13–14		
HOUR 14–15		
NOTES:		