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# Remote Monitoring of Locomotion Using Accelerometers: A Pilot Study

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Locomotion · Biomechanics · Telemetry · Prosimian · *Eulemur mongoz* · Enrichment · Ecology

## Introduction

Knowledge of locomotor budgets is useful both for ecological studies and for the evaluation of captive conditions. The traditional method of obtaining these data involves many hours of observing the animals, which is time-consuming and not always practical (especially for nocturnal prosimians). In addition, it is often very inaccurate, due to problems with timing and with animals being hidden from view for significant periods [1].

Accelerometry is a standard locomotor analysis technique [2], but it has not been particularly popular due to problems of the cost of the equipment and the encumbrance of the sensors [3]. We have designed a new, radio-telemetered accelerometer collar that continuously monitors the acceleration of the animal. The collar uses car air-bag technology, to bring down the unit costs, requires no license in the UK and weighs just under 100 g – with most of this weight being due to batteries. Data are recorded directly onto the hard disk of a portable computer.

This pilot study was carried out on a mongoose lemur *(Eulemur mongoz)* at Bristol Zoo. Observations and acceleration recordings were made simultaneously. The behavioural observations employed a simple event recorder system linked with the same computer that was recording the accelerometer data to ensure synchronous recordings. The patterns of acceleration have been analysed with reference to the observed behaviour to assess how well particular locomotor behaviours are identified.

## Materials and Methods

Figure 1 shows a schematic diagram of the telemetry system. The transmitter uses an Analog Devices ADXL50 solid-state accelerometer interfaced to a Radiometrix TXM-418A. The receiver consists of a Radiometrix RXM-418A and associated decoding circuitry [4]. The receiver is con-

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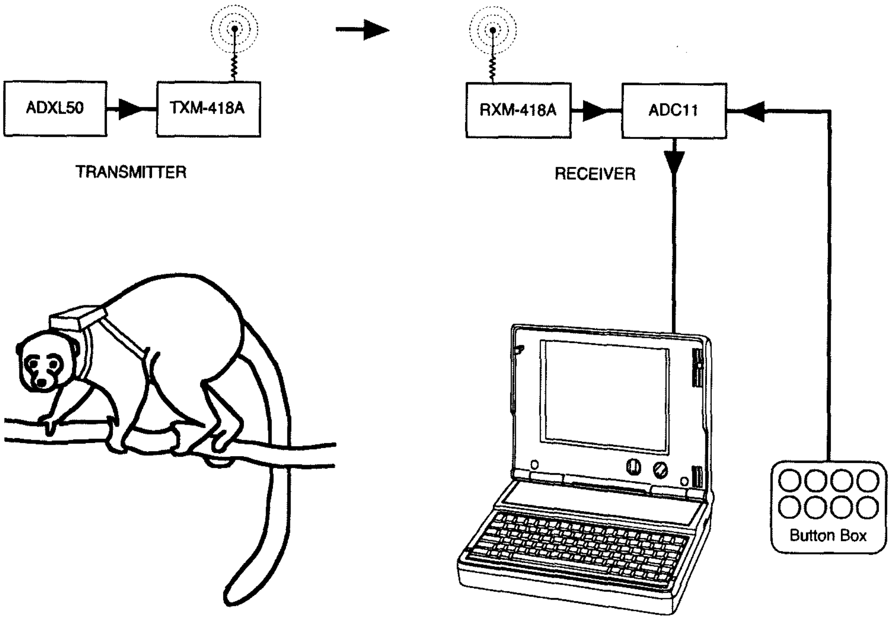


**Fig. 1.** Schematic diagram of the remote accelerometry equipment.

nected to the computer using a Pico Technologies ADC-11 analogue-to-digital converter. This is an 11-channel, 10-bit device that connects to a PC compatible laptop via the printer port. It also handles the data from the event recorder so that the data-logging software can easily guarantee synchronous recording of both the behavioural and acceleration information.

The accelerometer was attached to the mongoose lemur using a small harness, and the animal was then observed moving around its enclosure. Its locomotor behaviour was recorded using the event recorder, whilst the acceleration data were being logged at a rate of 100 samples per second. For this pilot study, broad locomotor categories were used: resting, climbing, slow quadrupedalism, fast quadrupedalism and leaping. This simplified the manual behavioural recording to ensure a high degree of accuracy and consistency.

## Results

In common with most automatic logging systems, an extremely large amount of data can be collected very quickly: in this case, approximately 3 megabytes per hour. Figure 2 shows a 50-second sample illustrating typical accelerometer recordings for a range of locomotor activities. The dotted line shows the output from the event recorder, and the solid line the accelerometer readings. The black arrows show the interpretation of the accelerometer trace. As would be expected, resting can be easily picked out since the acceleration hovers around zero. Walking produces a slowly

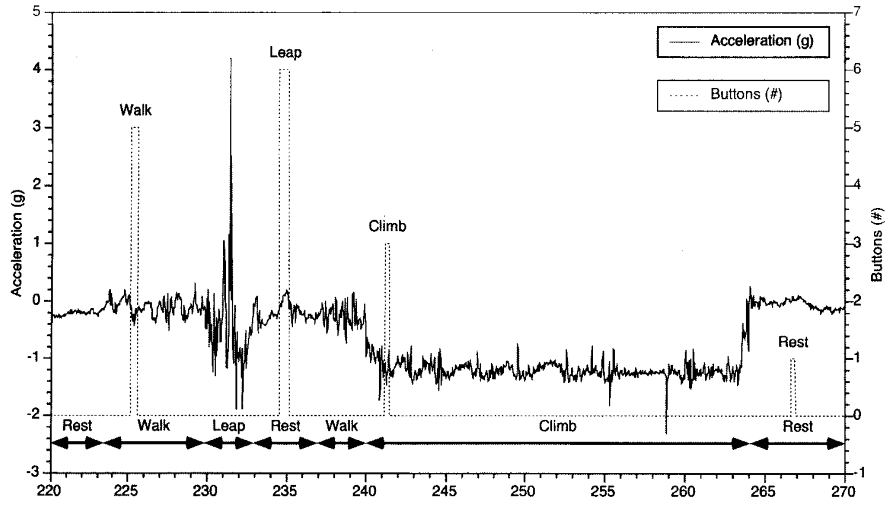


**Fig. 2.** Fifty-second extract from the accelerometer and event recorder data showing the observer interpretation and the interpretation based on the acceleration pattern.

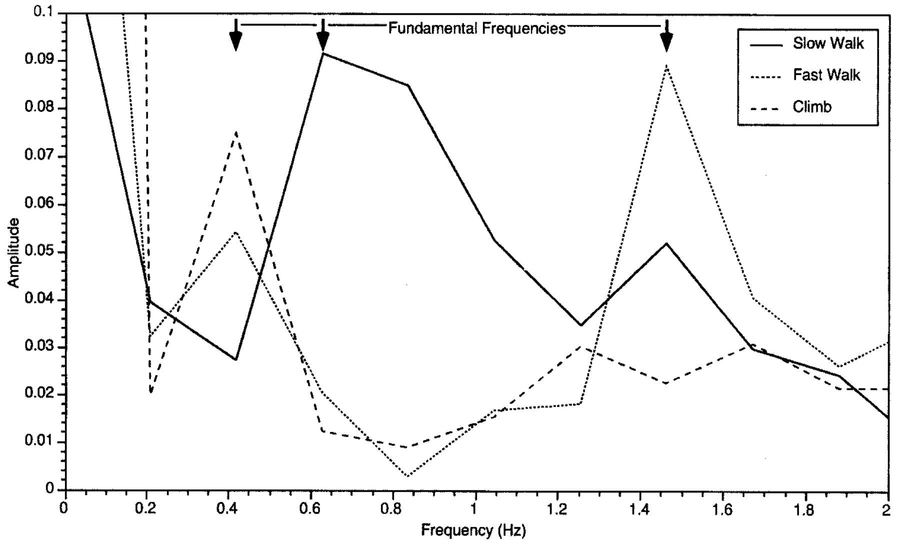


**Fig. 3.** Fast Fourier transformation (FFT) of 5-second samples of acceleration data for 3 examples of different types of cyclic locomotion.

oscillating value. Climbing is very similar to walking, but because of the orientation change (the animal was climbing vertically), the gravitational acceleration is now recorded, so the baseline shifts down to –1 g. Leaping is characterised by a large and fast acceleration peak.

As well as straightforward locomotor budgets, some other biomechanically relevant data can also be extracted from the acceleration information. Figure 3 shows the results of a fast Fourier transformation of the two sets of walking data and the climbing data from the first figure (512 samples in each case). The first amplitude peak shows the fundamental frequency of the locomotor activity and can be used to calculate the stride frequency and, hence, likely speed.

## Discussion

The goal of providing a remote means of estimating locomotor budgets has clearly been achieved. The apparatus provides patterns of data that can be recognised as indicating a particular locomotor activity. The next step is to build an expert system that can automate the currently time-consuming recognition task – perhaps using neural net technology for pattern matching. This might allow a complete record of the active period to be acquired automatically. In addition, it seems likely that a great deal of biomechanical data can also be obtained by careful analysis, widening the potential usefulness of the method. However, the transmitter needs some further development. Surface-mounted components will reduce the physical size of the unit. Converting from continuous to pulsed operation should extend the battery life, allowing the use of smaller, lighter batteries or allowing the PP3 lithium battery to last over a week. These improvements would all reduce the undesirable effects of the transmitter on the animal's locomotor behaviour [5]. The current design uses a single acceleration sensor. If three orthogonal sensors were used, more information could be obtained about the direction of the acceleration vector. This would be particularly useful for biomechanical analysis since it should allow a much more detailed analysis of locomotor and postural activity.

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