

Automatic data recording of circadian rhythms

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This paper illustrates a method for automatic data recording using the printer port of personal computer and software designed *ad hoc*. The system was tested by measuring circadian rhythms of activity in the subterranean rodent *Ctenomys talarum*. Data is recorded in a text-only comma-delimited file, and displayed on screen.

Key words: Automatic data recording, Circadian rhythm, *Ctenomys talarum*.

introduction

Automatic data recording in behavioural studies is highly advantageous. Obtaining a continuous data record of animal behaviour in a direct way can be a problem due to experimental design, difficulty in obtaining specimens, and equipment cost. However, personal computers are now very common and accessible, and can be used to measure animal behaviour for school projects.

A PC parallel port is an extremely versatile input/output (I/O) channel which can be used for a number of different sensing and control applications. It comprises of three I/O ports, called data, status, and control. Their status can be read by relatively simple software codes. The continuous monitoring of the lines on these ports allows for the chronological recording of the activity of the different switches.

The system was tested in the laboratory using subterranean rodents. Although ecological and genetic population information is available for various subterranean rodent species, behavioural information is rather fragmented due to their secretive habits (Reig *et al.*, 1990; Patton and Smith, 1990; Nevo, 1995). These animals are extremely territorial and aggressive, together with the peculiarities of the subterranean habits, this has severely restricted behavioural studies in the laboratory (Zenuto *et al.*, 1996).



Figure 1 The subterranean rodent *Ctenomys talarum*

The South American octodontid, genus *Ctenomys* (tucutuco), is the most diverse of all subterranean rodents (Reig *et al.*, 1990). *Ctenomys talarum* is a long-lived herbivore (Figure 1) that inhabits a secure, permanently sealed, and closed burrow system (Zenuto *et al.*, 1996; Antinuchi and Busch, 1992). It is possible to register individual activity in the laboratory using a semi-natural enclosure containing microswitches connected to the parallel printer port of a PC.

Here we discuss a method for automatic data recording of circadian rhythms of activity under laboratory conditions, of a small mammal species, using a PC parallel port and software that can read the port input.

Materials and methods

The animals

Animals of both sexes were collected using live traps. Four individuals of *Ctenomys talarum* (two females and two males) were captured at Mar de Cobo, Buenos Aires Province, Argentina.

Laboratory conditions

The rodents were housed individually in artificial burrow system, in the laboratory. Wood shavings for nesting were placed on the nest box floors connected to the burrow. The animals were maintained under a natural photoperiod (12 h light:12 h dark). The temperature ranged from 18 to 25 °C, and relative humidity ranged from 50 to 80 per cent. They were fed with carrots, sweet potato, alfalfa, and sunflower seed. Activity was recorded individually over 24 h periods.

The burrow system

- Burrows were built in the laboratory with black PVC tubes. The artificial burrows comprised of 4 m of tunnel (80 mm in diameter), a resource cage, and a nest box resembling the structural complexity described for natural burrows (Figure 2; Zenuto *et al.*, 1996).
- Activity was detected using the interconnection of the pins of the parallel port (four inputs and four outputs; Figure 3) and

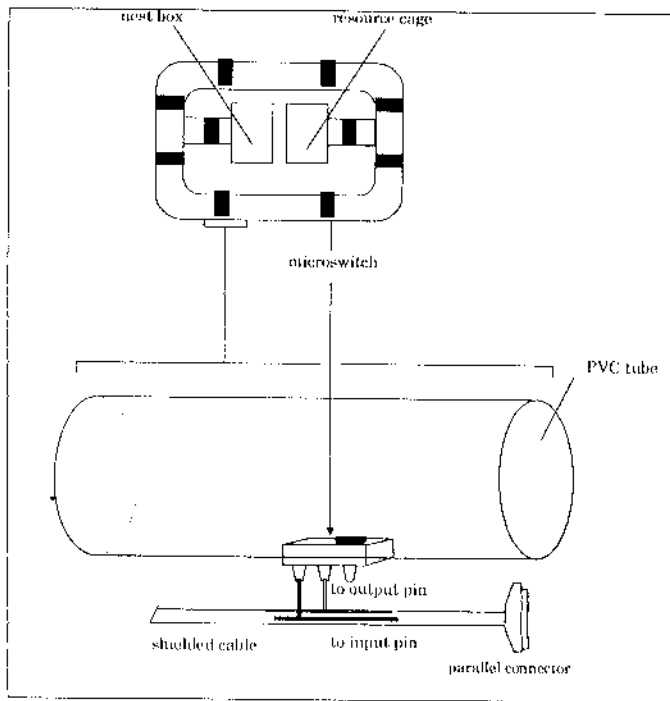


Figure 2 Schematic design of a burrow system showing microswitch location and connection.

adapted software (see Appendix A, adapted from Anonymous, 1992).

- Ten numbered, normally open, microswitches (supplied by Allied, see Appendix B) were placed in the burrow floor (Figure 2). The switches were arranged so that the weight of an animal closed the electrical contacts, allowing the flow of a sensing signal through the switch. The switches were wired with shielded cable to a 25-pin connector (type DB25, see Appendix B), and information was feed to a (386/486) PC via the parallel printer port.
- When the program is executed it asks for the file name, date, and start time in order to label all of the input data. When an animal walks over a switch, the circuit between two pins is closed, and the activated switch number and time are shown on the screen (Figure 3). File data is registered in a text-only comma-delimited format.

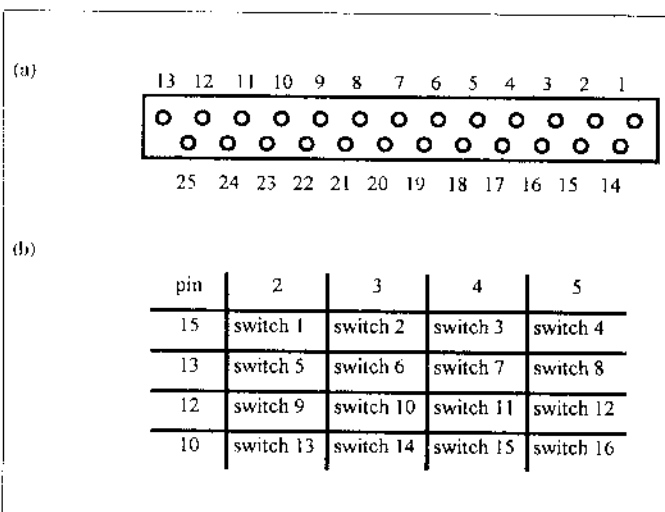


Figure 3 (a) Schematic view of a parallel port connector showing numbered pins. Pins 2, 3, 4, and 5 are outputs and 15,13,12, and 10 are inputs. (b) Arrangement of four output and four input pins, to allow for 16 individual data inputs.

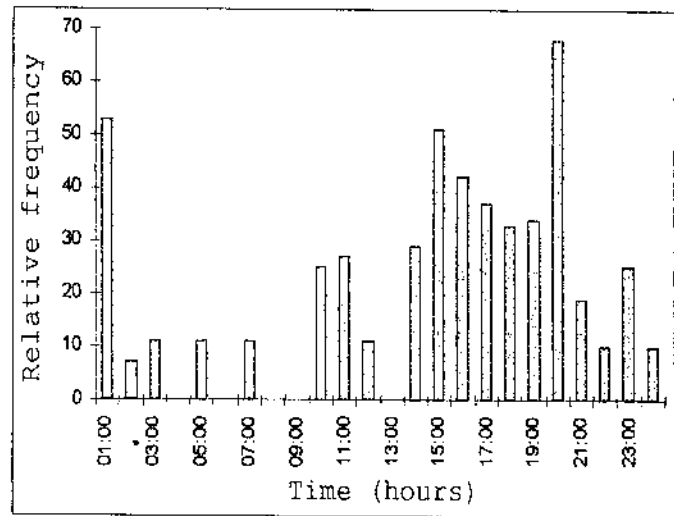


Figure 4 Daily activity of a solitary mature female of *Ctenomys talarum*.

Results and conclusions

Initially, when the system was assembled erroneous data recordings were obtained due to electric noise. This error was corrected by connecting the PC unit to a good ground.

Male and female activity patterns between dark (1800–0700h) and light (0700–1800h) periods were uniform (Mann-Whitney $U = 2.0000$; $n = 4$; d.f. = 1, $P = 0.0833$). Variations in activity were observed at different hours, although there was no statistical difference between dark and light periods (Figure 4).

Appendix A

```

100 DEFINT AZ
110 CLS
120 bse = &H3BC
130 DIM p$(4, 4)
140 p$(1, 1) = "1": p$(1, 2) = "2": p$(1, 3) = "3": p$(1, 4) = "4"
150 p$(2, 1) = "5": p$(2, 2) = "6": p$(2, 3) = "7": p$(2, 4) = "8"
160 p$(3, 1) = "9": p$(3, 2) = "10": p$(3, 3) = "11": p$(3, 4) = "12"
170 p$(4, 1) = "13": p$(4, 2) = "14": p$(4, 3) = "15": p$(4, 4) = "16"
180 INPUT "data record file name": AS$
190 CLS
200 INPUT "write comments: ", BS$
210 CLS
220 INPUT "type date as: --/--/--": FS
230 CLS
240 INPUT "type time as: hh:mm=" : TS$
250 CLS
260 DATES = FS
270 TIMES = TS$
280 OPEN AS$ FOR OUTPUT AS #1
290 PRINT #1, BS$
300 WRITE #1, "date: " + DATES$
310 WRITE #1, "time: " + TIMES$
320 WRITE #1, "switch, time"
330 ini# = TIMER
340 GOSUB 1000
350 IF ctcto = 0 THEN 340
370 PRINT "switch number: "; p$(F, C); " time: "; TIMES$
380 PRINT #1, p$(F, C); " "; TIMES$
390
400 GOSUB 1000
410 IF ctcto THEN 400
420 GOTO 340
430 CLOSE
440
1000 F = 1
1010 OUT bse, &HFE
1020 GOSUB 2000
1030 IF ctcto THEN RETURN
1100 F = 2
1110 OUT bse, &HFD
1120 GOSUB 2000
1130 IF ctcto THEN RETURN
1200 F = 3
1210 OUT bse, &HFB
1220 GOSUB 2000
1230 IF ctcto THEN RETURN
1300 F = 4
1310 OUT bse, &HF7
1320 GOSUB 2000
1330 RETURN
2000 inputs = INP(bse + 1)
2010 IF inputs AND &H8 THEN 2110
2020 ctcto = 1
2030 C = 1
2040 RETURN
2110 IF inputs AND &H10 THEN 2210
2210 ctcto = 1
2130 C = 2
2140 RETURN
2210 IF inputs AND &H20 THEN 2310
2310 ctcto = 1
2220 ctcto = 1
2230 C = 3
2240 RETURN
2310 IF inputs AND &H40 THEN 2410
2410 ctcto = 1
2330 C = 4
2340 RETURN
2410 ctcto = 0
2420 RETURN
    
```

Program for parallel port reading, and data recording to a file. In line 120, 'bse' could be either '&H3BC' or '&H378' depending on the PC parallel port address.

Appendix B

Supplier details: AlliedSignal Inc., 101 Columbia Road, Morristown, NJ 07862; Tel. 00 1 973 455 2000; fax. 00 1 973 455 4807; <http://www.allied.com>

Maplin Electronics, Maplin House, 274-288 London Road, Hadleigh, Benfleet, Essex, SS7 2DE; Tel. 00 44 (0) 1702 554000; <http://maplin.co.uk>

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