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A time-sorting pitfall trap and temperature datalogger for the sampling of surface-active arthropods ☆

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ABSTRACT

Nearly all arthropods display consistent patterns of activity according to time of day. These patterns of activity often limit the extent of animal co-occurrence in space and time. Quantifying when particular species are active and how activity varies with environmental conditions is difficult without the use of automated devices due to the need for continuous monitoring. Time-sorting pitfall traps passively collect active arthropods into containers with known beginning and end sample times. The trap described here, similar to previous designs, sorts arthropods by the time they fall into the trap using a rotating circular rack of vials. This trap represents a reduction in size, cost, and time of construction, while increasing the number of time windows sampled. The addition of temperature data collection extends functionality, while the use of store-bought components and inclusion of customizable software make the trap easy to reproduce and use.

1. Hardware description

Circadian clocks are nearly ubiquitous among life on Earth, allowing organisms to anticipate environmental changes by adjusting behavior and physiology [6,16]. Arthropods adjust activity levels in response to environmental cues, frequently limiting activity to times when the environment is suitable [5]. Activity times of arthropods can affect opportunities to gather food, find mates, or avoid predators [15]. The study of arthropod activity times and the environmental factors that affect them has been of interest to entomologists and ecologists for nearly a century, with early accounts made solely through personal observations [8]. Given the constant effort required to precisely monitor species activity times, automation of data collection is highly desirable in this field.

Pitfall traps passively collect mobile arthropods from leaf litter and the surface of the ground [7]. The basic design of a pitfall trap is simple: a steep interface, commonly a funnel or cup edge flush with the ground, causes ground-active arthropods to tumble into a deadly liquid beneath. As early as the 1950's, designs for time-sorting pitfall traps were developed to measure temporal patterns in arthropod behavior [14]. Early designs were large and required custom-built motors, housings, and clock devices [9]. The basic elements of automated pitfall trap designs have consistently included a timed rotating rack of containers beneath a funnel through which arthropods fell.

Most recently [4] proposed a design that improved upon previous iterations, allowing accumulation of arthropods for up to 3 weeks into 7 samples, with each sample assigned to a portion of the day. While this design offered substantial improvements, it required a large hole to be dug for installation ($40 \times 40 \times 38$ cm), and did not include schematics or software

☆ Source File Repository: https://data.mendeley.com/datasets/hz8zcvvhmb/1 and doi: http://dx.doi.org/10.17632/hz8zcvvhmb.1.

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allowing individuals with limited experience to reproduce the device. Recent decreases in price, size, and power requirements for electronic components allow for time-sorting pitfall traps that are cheaper, smaller, and offer additional functionalities. Finally, repositories for accompanying software, parts lists, and design schematics now allow for easier replication and modification of existing designs.

I designed a small, inexpensive, time-sorting pitfall trap that can be easily programmed to sample at a set of customized intervals. This particular design was made to collect ants, and other medium sized arthropods with body length of 15 mm or less. My goal was to make construction of the device easily reproducible and allow for the addition of external sensors within the Arduino computing platform. The trap is approximately the size of a shoebox, allowing for installation with minimal disturbance of the habitat under study.

- 24 rotating collection vials give hourly resolution of ground active arthropod abundance.
- Software allows for easily adjusted programming of the pitfall trap settings including: sample duration, frequency of temperature measurement, and a delayed start.
- The pitfall trap description includes parts lists and detailed specifications for quick and easy construction.
- The Arduino-based pitfall trap enables the addition of an array of sensors for datalogging including temperature, humidity, and light.
- The pitfall trap is small, approximately the size of a shoebox (27 cm × 25 cm × 17 cm), allowing minimal disturbance.

2. Design files

2.1. Design files summary

Design file name	File type	Open source license	Location of the file
Epitfall_24hourlySamples.ino	*Arduino script*	CC BY 4.0	Mendeley data: doi:10.17632/hz8zcvvhmb.1
Epitfall_wiringDiagram.fzz	*Fritzing wiring file*	CC BY 4.0	Mendeley data: doi:10.17632/hz8zcvvhmb.1
Epitfall_wiringDiagram.png	*image*	CC BY 4.0	Mendeley data: doi:10.17632/hz8zcvvhmb.1
Epitfall_dataPull.R	*R script*	CC BY 4.0	Mendeley data: doi:10.17632/hz8zcvvhmb.1
Epitfall_partsList.xslx	*Excel spreadsheet*	CC BY 4.0	Mendeley data: doi:10.17632/hz8zcvvhmb.1
Epitfall_sampleWheel2d.dwg	CAD	CC BY 4.0	Mendeley data: doi:10.17632/hz8zcvvhmb.1
Epitfall_sampleWheel2d.pdf	pdf	CC BY 4.0	Mendeley data: doi:10.17632/hz8zcvvhmb.1
Epitfall_sampleWheel3d.dwg	CAD	CC BY 4.0	Mendeley data: doi:10.17632/hz8zcvvhmb.1
Epitfall_sampleWheel3d.stl	3D printing shapefile	CC BY 4.0	Mendeley data: doi:10.17632/hz8zcvvhmb.1
TRAP2.TXT	text	CC BY 4.0	Mendeley data: doi:10.17632/hz8zcvvhmb.1
TRAP5.TXT	text	CC BY 4.0	Mendeley data: doi:10.17632/hz8zcvvhmb.1
community_matrix_EMPTY.csv	csv	CC BY 4.0	Mendeley data: doi:10.17632/hz8zcvvhmb.1
community_matrix_FULL.csv	csv	CC BY 4.0	Mendeley data: doi:10.17632/hz8zcvvhmb.1

2.2. File descriptions

Parts list

Epitfall_partsList.xslx – spreadsheet of parts needed for construction, prices, and vendors.

CAD

Epitfall_sampleWheel2d.dwg – 2D CAD file of sampling wheel.

Epitfall_sampleWheel2d.pdf – PDF version of 2D CAD file of sampling wheel.

Epitfall_sampleWheel3d.dwg – 3D CAD file of sampling wheel.

Epitfall_sampleWheel3d.stl – File for 3D printing of sampling wheel.

Example data

TRAP2.TXT – example data created by pitfall trap.

TRAP5.TXT – example data created by pitfall trap.

community_matrix_EMPTY.csv - empty matrix with rows of sampled time intervals with unique sample ID codes. This file is generated by "Epitfall_dataPull.R".

community_matrix_FULL.csv – same as above, but with ant identities and abundances entered.

Software

Epitfall_24hourlySamples.ino – Arduino script to delay start time by 1 day, collect 24 hourly samples, with temperature measurements every 5 min during sample collection.

Epitfall_dataPull.R – R script to read data files from trap, create summaries of each sampling interval, and create an empty spreadsheet with rows of unique sample ID's in which to enter arthropod abundance data.