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Orientometer for Study of Insect Behavior

Abstract. *A multidirectional treadmill for the study of insect orientation is described. The movements of an insect throughout 360° can be recorded for periods up to 12 hours. The extent of deviation from randomness serves as a quantitative measure of reaction to a given stimulus.*

Studies of insect orientation have often depended upon releasing an insect on a paper sheet and subsequently recording the direction in which it runs as a measure of reaction to a stimulus (*1*). This method has several drawbacks: (i) fast-moving insects are usually unsuitable for study; (ii) the stimulus has only a short time for effect; (iii) successive stimuli cannot be easily studied; (iv) the immediate response after release may be influenced by handling. To solve these problems, an inexpensive multidirectional treadmill (orientometer) was constructed (*2*) (Fig. 1). The orientometer consists of two portions, the platform and the translator.

The platform consists of a table-tennis ball mounted on three miniature ball bearings (ball-point pen points).

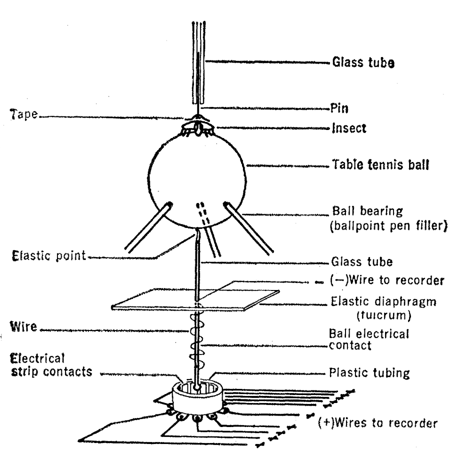

Fig. 1. Schematic diagram of the orientometer.

The insect is held in position on the platform by an insect pin inserted into a vertically mounted glass tube (5 cm by 1 mm) so that the insect can rotate freely through 360°. Attachment, in the case of a cockroach, is by a piece of masking tape pierced by the insect pin, placed on the tergite of the metathorax. The cuticle must be washed by detergent and allowed to dry for a few minutes to ensure adhesion. The ball-point pens are mounted on a ring stand with wax, clay, or glue.

The translator consists of an armature, an elastic fulcrum, and a cylindrical, multipole contact. A glass rod (8 cm by 1 mm) forms the framework for the armature. The upper end has a small piece of flexible rubber (from a rubber band) resting in contact with the bottom of the ball. The lower end has a metal contact (an insect pin with a drop of solder) inserted into it. A thin, flexible wire is soldered to the pin, wrapped around the armature, and led off near the fulcrum to the recorder. If the wire is too stiff, it will hamper the movement of the armature. A rubber diaphragm, constructed from a wide rubber band, supports the armature. The bottom of the armature fits inside a cylindrical multipole contact consisting of a section of plastic tubing with metal strips inserted around the inside. Wire connections lead from each strip contact to the recorder.

The wires from the strip contacts (+) and the lead from the armature (−) are connected to an event recorder, or more simply, to kymograph needles and a kymograph. When the insect moves, the ball rotates and moves the armature against one of the strips in the multipole contact, completing the circuit and signaling insect orientation. The greater the number of strip contacts, the smaller the angular deviation which can be measured and, of course, the greater the cost of the recording system.

A problem exists in that when contact is made there is no difference between active running in one direction and an insect resting oriented in the same direction. In practice, however, movements of the insect caused the armature contact to move on the surface of the strip contact, causing the relay to chatter due to resistance change as long as the voltage was not too great. If a more direct indication is desired, a mechanical transducer can be attached to the glass tube holding the insect since it vibrates as the insect moves.

An experiment demonstrates the use

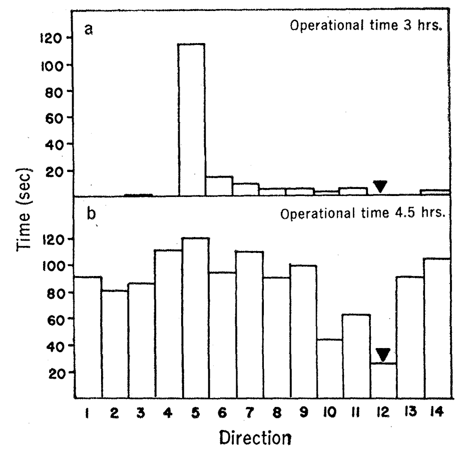

Fig. 2. The effect of light on a cockroach *Gromphodorhina portentosa* as measured by the orientometer. The total time that the cockroach spent running in different directions, distributed among 14 equal angles of about 26° each (14 contacts), is contrasted under two conditions. (a) Negative phototactic effect of a light source of about 65 lu/m² placed 3 m away and aimed at the cockroach. (b) Running orientation in a darkroom. In both cases, glue on contact 12 (triangles) resulted in a response at only one-fourth the rate on the other contacts.

of the orientometer. Theoretically, an insect will move randomly unless it is responding to a stimulus. Introduction of an appropriate stimulus will bias his direction of movement. A nymphal cockroach *Gromphodorhina portentosa* mounted on the device in a darkroom exhibited nearly random movement (Fig. 2b). The same insect displayed a negative phototactic effect in response to a light source of about 65 lu/m^2, placed 3 m away (Fig. 2a).

In addition to measuring phototactic responses, the orientometer has three outstanding general applications: (i) determination of thresholds of response to radiation (electromagnetic, atomic, magnetic); (ii) demonstration of long-term adaptation to radiation or other stimuli; and (iii) measurements of the effects of multiple stimuli, applied successively or simultaneously.

WILLIAM B. KERFOOT
Biological Laboratories, Harvard University, Cambridge, Massachusetts

References and Notes

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2. Supported by NSF predoctoral fellowship. A report of the device was released by the NSF [U.S. Dept. of Commerce, Washington, D.C., 1967 (order from Clearing House for Federal Scientific and Technical Information, Springfield, Va.)].

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