Modified Ultrsonic Actograph for Monitoring Activity of Lepidopterous Larvae

Article · January 1986

Source: OAI

CITATIONS
3

READS
24

4 authors, including:

Marshall W Johnson
University of California, Riverside
256 PUBLICATIONS **6,576** CITATIONS
SEE PROFILE

Nick C Toscano
University of California, Riverside
165 PUBLICATIONS **3,152** CITATIONS
SEE PROFILE

Modified Ultrsonic Actograph for Monitoring Activity of Lepidopterous Larvae

MARSHALL W. JOHNSON,[1] NICK C. TOSCANO,[2] VINCENT P. JONES,[3] and J. BLAIR BAILEY[2]

ABSTRACT

An ultrasonic actograph was modified to detect the slow movements typical of lepidopterous larvae. A differential instrumentation amplifier increased the sensitivity of the instrument. Activity patterns of 5th instars of *Spodoptera exigua* (Hubner) (Lepidoptera: Noctuidae) and *Sabulodes aegrotata* Guenee (Lepidoptera: Geometridae) were determined using the modified actograph. *S. exigua* larvae were active ca. 339 minutes of the day with significantly greater photophase activity during 0600–1000 and 1100–1300 hrs as compared to scotophase activity during 0000–0400 and 2200–2400 hrs. *S. aegrotata* larvae were active ca. 421 minutes of the day with greater activity during the scotophase period.

Actographs record such activities and periodic behavior of living organisms as locomotion and feeding (Miller 1979). To determine periodicity of many insect behaviors, different types of actographs have been developed based on various physical principles including mechanical vibration (Edwards 1964, Leppla and Spangler 1971), light interference (Sevacherian 1975, Eaton 1980), radar (Buchan and Sattelle 1979), capacitance (Luff and Molyneux 1970), and sound (Street 1971). Each kind has its own set of advantages and disadvantages.

Ultrasonics appears particularly well suited for studies on insect behavior because the lack of response of ultrasonic devices to light and moisture variations (Holloway and Smith 1975, Treherne and Foster 1977, Luff et al. 1979) allows the experimenter more control over environmental parameters. Also, there are no known effects of ultrasonics on insect behavior except perception of bat-emitted ultrasonic signals by adult noctuids (Miller 1979, Luff eg al. 1979). Luff et al. (1979) developed an ultrasonic motion detector which recorded movements of small insects and consisted of an ultrasonic transmitter and receiver (transducers) close to one another in an enclosed chamber. A steady frequency is established by acoustic feedback and a pattern of ultrasonic standing waves results within the chamber. Moving insects within the chamber disrupt the standing wave pattern and cause fluctuations in the amplitude of the standing waves. These fluctuations are picked up by the receiving transducer, amplified, and displayed on a suitable recorder (Luff et al. 1979).

This detector works well. However, preliminary studies using a circuit constructed at the University of California, Riverside, showed it did not adequately detect the slow movements typical of lepidopterous larvae. Therefore, we modified the Luff et al. (1979) ultrasonic actograph to monitor such movements.

MATERIALS AND METHODS

Studies were conducted using early 5th instars of the beet armyworm, *Spodoptera exigua* (Hubner), and the omnivorous looper, *Sabulodes aegrotata* Guenee,

[1]Department of Entomology, University of Hawaii, Honolulu, HI 96822.
[2]Cooperative Extension, University of California, Riverside, CA 92521.
[3]Department of Biology, Utah State University, Logan, UT 84321.

reared at the Department of Entomology, University of California, Riverside. Before each experiment, late 4th instars were exposed at least 5 days to an LD 14:10 photoperiod regime within a temperature cabinet. Danilevsky et al. (1970) estimate that new rhythms may be entrained within 3 new LD cycles in most species. Photophase interval was from 0500 hrs to 1900 hrs. Temperatures and lighting regimes in the cabinet during the acclimation period were identical to those of the respective experiments. Experiments were recorded from 1200 hrs to 1200 hrs the next day. Beet armyworms and omnivorous loopers were provided with lettuce and avocado fruit, respectively, during the 24-hr period.

Observations on the beet armyworm and omnivorous looper were recorded from larvae maintained at 26±2°C and 10±2°C during photophase and scotophase, respectively. Fourteen beet armyworm and 9 omnivorous looper larvae were observed individually.

Circuit Modification. The ultrasonic actograph was constructed for use with a potentiometric recorder-as based on description of Luff et al. (1979). Efforts were made to use the same components as they listed. A schematic of the experimental set-up is presented (Fig. 1). The experimental chamber was made of acoustically 'hard' plastic (reflects sound) (5.5 cm × 16 cm × 5.5 cm). Transducers were mounted to the lengthwise ends of the chamber. Analogue output signals were recorded on an Omniscribe® Series D5000 strip chart recorder. Chart paper was run at 5 cm/hr. Initial testing of the circuit indicated that the actograph did not detect larval movements at a level which could be differentiated on the strip chart recorder. To increase sensitivity the output signal was amplified by passing it through a differential instrumentation amplifier. This type of amplifier was selected for its ability to amplify small signals masked by larger ones (Wobschall 1979). In-depth descriptions of the operating principles are provided by Wobschall (1979) and Coughlin and Driscoll (1982). The AD521JD precision instrumentation amplifier produced by Analog Devices[4] was incorporated into the circuit (Fig. 2). Positive output signals from the circuit were compared with a reference source. Based on the value of the resistor (2.6k) between pins 2 and 14, the signal is amplified ca. 36 times. Due to differences in impedance, unity gain voltage followers were added to the circuit. These consisted of AD741LH operational amplifiers (Analog Devices[4]). The addition of a 9 volt dual power supply was required to operate added components. A passive low pass filter may be required to reduce interference from temperature cabinets caused by cycling of the compressor. Only the experimental chamber was kept in the temperature cabinet during experiments. All circuitry was outside the cabinet and connected to the transducers by leads.

[4]P.O. Box 280, Norwood, Mass. 02062.

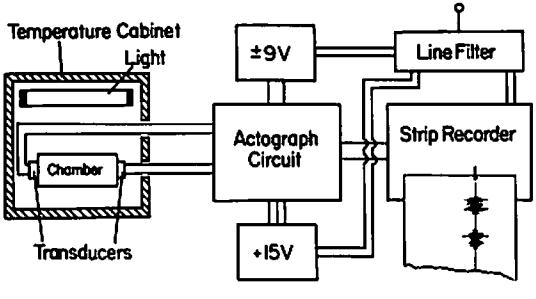

FIGURE 1. Schematic of experimental set-up and instrumentation.

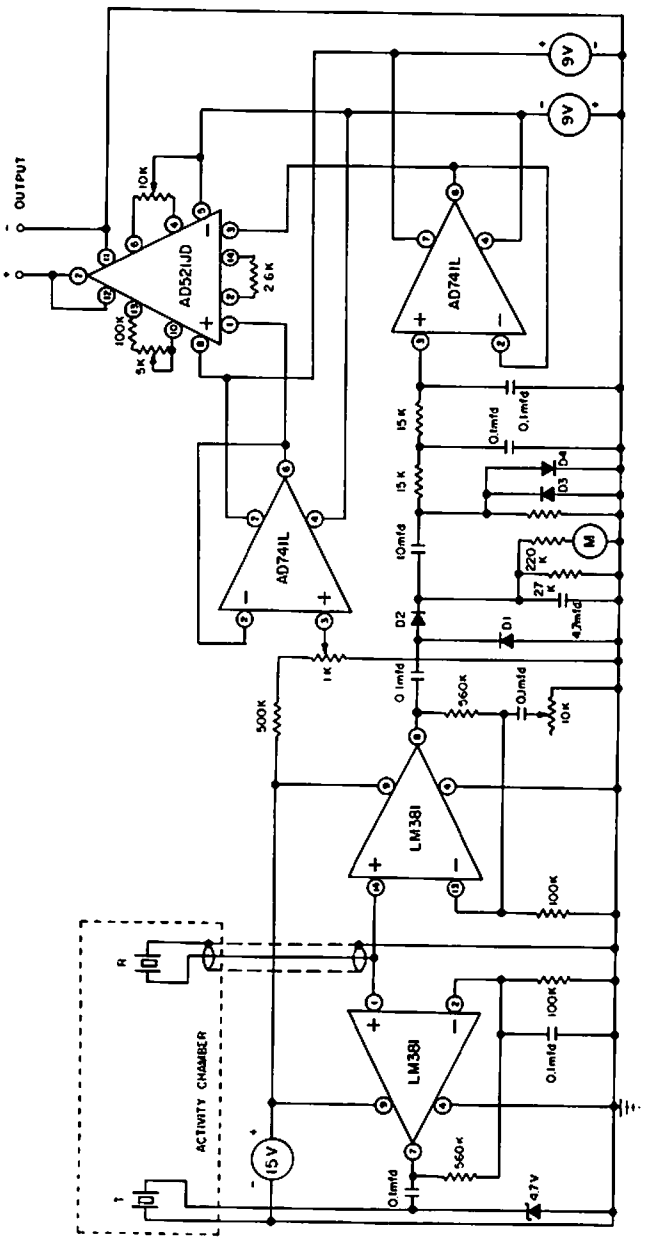

FIGURE 2. Modification of ultrasonic actograph circuit of Luff et al. (1979) which incorporates differential instrumentation amplifier AD521JD.

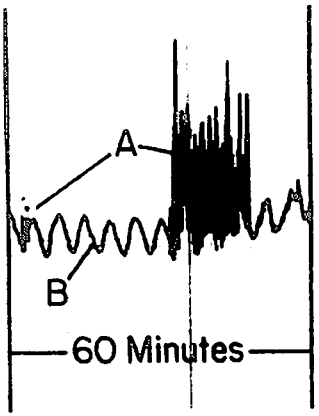

FIGURE 3. Recording pen trace showing shifts due to activity of *Sabulodes aegrotata* larva (A) versus temperature changes (B).

Laboratory data were recorded as the number of minutes per hour when movement occurred. This was summed for the 24 hour observation period to provide the total number of minutes of activity per day. Comparisons between subject species were based on percent daily activity. Data were analyzed by t tests and the ANOVA procedure and in the latter analysis means were separated using the Waller-Duncan K-ratio t test (WALLER option) ($P<0.05$) (SAS 1982).

RESULTS AND DISCUSSION

Circuit modification resulted in significant responses to larval activity. Increased amplification of the subject signal picked up small changes in the transducers over time (5 minutes) due to temperature shifts. However, these were easily distinguished from larval activity (Fig. 3).

A mean of 338.9 minutes of activity was recorded per 24 hr day with 76.8% recorded activity during the photophase for the beet armyworm. Analysis of variance indicated that significantly greater activity occurred in the "morning" hours between 0600–1300 hrs (except from 1000–1100 hrs) as compared with scotophase activity from 0000–0400 and 2200–2400 hrs. A mean of 22.6±6.4 minutes of maximum activity per hour was recorded during photophase (0600–1000, 1100–1300 hrs) as compared to 2.9±2.4 minutes of minimum activity per hour during scotophase (0000–0400, 2200–2400 hrs). Immediately after initiation of both photophase and scotophase, significantly higher levels of activity were recorded ($P<0.05$) (Fig. 4a). Increases in activity occurring at the initiation of photophase and scotophase may have been caused by abrupt changes in temperature and light levels. Lighting and temperature controls can be modified to alleviate these problems which are not related to the operation of the actograph.

A mean total of 421.3 minutes of activity was recorded for the omnivorous looper per 24 hour day. Significantly greater activity (57.1%) was concentrated in the scotophase with a mean of 24±7.3 minutes activity per hour as compared to 12.9±6.5 minutes activity per hour during photophase ($t = 3.92$ w/22 d.f., $P<0.05$) (Fig. 4b). A peak of activity was recorded between 0100 and 0600 hrs. A second peak occurred immediately following initiation of scotophase as observed with the beet armyworm.

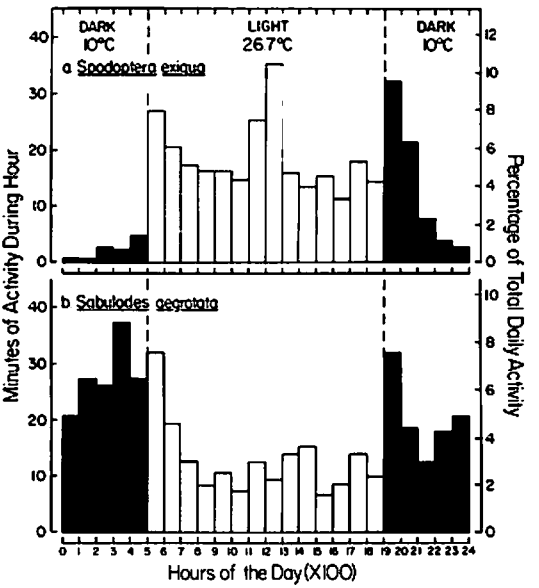

FIGURE 4. Mean activity patterns of *Spodoptera exigua* (a) and *Sabulodes aegrotata* (b) larvae held at LD 14:10 with 26.7°C and 10°C during photophase and scotophase, respectively.

The ultrasonic actograph of Luff et al. (1979) with described modifications appeared to work well in detecting activity of lepidopterous larvae and should be useful in determining their periodicity. Basic research on insect periodicity is important and may be applied to insect pest management. The spatial and temporal aspects of sampling insect populations may be influenced by an insect's daily behavior pattern or periodicity. Failure to consider periodicity may result in erroneous population estimates leading to inappropriate managment decisions. Additionally, if control measures require direct contact of the insect with pesticides, as opposed to residual contact, then applications must be made when the insect is most exposed. Applications made at times when insects are concealed will result in reduced efficacy. Hopefully, studies on behavior of lepidopterous larvae may provide some insights into this area.

ACKNOWLEDGMENTS

The authors thank T. Walsh for technical advice and assistance and C. Richardson and J. Lynch for data analysis. Appreciation is also extended to G. Platner and S. Hickson for providing larvae for studies. Comments on the studies provided by Dr. T.A. Miller were greatly appreciated. This study was supported by a grant provided by the Iceberg Lettuce Advisory Board of California.

REFERENCES CITED

Buchan, P.B., and D.B. Sattelle. 1979. A radar-Doppler autocorrelation analysis of insect activity. Physiol. Entomol. 4:103–109.

Coughlin, R.F. and F.F. Driscoll. 1982. Operational amplifiers and linear integrated circuits. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 2nd Edition. 376 pp.

Danilevsky, A.S., N.I. Goryshin, and V.P. Tyshchenko. 1970. Biological rhythms in terrestrial arthropods. Ann. Rev. Entomol. 15:201–244.

Eaton, J.L. 1980. An infrared LED-based electronic actograph for monitoring insect flight activity. Ann. Entomol. Soc. Am. 73:744–746.

Edwards, D.K. 1964. Activity rhythms of lepidopterous defoliators. I. Techniques for recording activity, eclosion, and emergence. Can. J. Zoology 42:923–937.

Holloway, R.L. and J.W. Smith. 1975. Locomotor activity of adult lesser cornstalk borer. Ann. Entomol. Soc. Am. 68:885–887.

Leppla, N.C. and H.G. Spangler. 1971. A flight-cage actograph for recording circadian periodicity of pink bollworm moths. Ann. Entomol. Soc. Am. 64:1431–1432.

Luff, M.L. and L. Molyneux. 1970. Insect movement detector using operational amplifiers. J. Physics E. 3:939–941.

Luff, M., L. Molyneux, and S. Ball. 1979. An ultrasonic insect movement detector. Physiol. Entomol. 4:147–153.

Miller, T.A. 1979. Insect neurophysiological techniques. Springer-Verlag, New York. 308 pp.

SAS. 1982. SAS user's guide: statistics, 1982 edition. p. 121–123. SAS Institute Inc., Cary, NC. 584 pp.

Sevacherian, V. 1975. Activity and probing behavior of *Lygus hesperus* in the laboratory. Ann. Entomol. Soc. Am. 68:557–558.

Street, M.W. 1971. A method for aural monitoring of in-kernal insect activity. J. Georgia Entomol. Soc. 6:72–5.

Treherne, J.E. and W.A. Foster. 1977. Diel activity of an intertidal beetle, *Dicheirotrichus gustavi* Crotch. J. Anim. Ecol. 46:127–138.

Wobschall, D. 1979. Circuit design for electronic instrumentation. McGraw-Hill Book Co., New York. 390 pp.