INCREASE IN ACOUSTIC DETECTABILITY OF PLODIA INTERPUNCTELLA LARVAE AFTER LOW-ENERGY MICROWAVE RADAR EXPOSURE

Author: Mankin, R. W.

Source: Florida Entomologist, 89(3) : 416-418

Published By: Florida Entomological Society

URL: https://doi.org/10.1653/0015-4040(2006)89[416:IIADOP]2.0.CO;2

INCREASE IN ACOUSTIC DETECTABILITY OF *PLODIA INTERPUNCTELLA* LARVAE AFTER LOW-ENERGY MICROWAVE RADAR EXPOSURE

R. W. MANKIN
USDA-ARS*, Center for Medical, Agricultural, and Veterinary Entomology, Gainesville, FL 32608

Although pheromone traps (Mullen & Dowdy 2001) are available for detection and targeting of adult *Plodia interpunctella* (Hübner) in warehouses and retail stores (Arbogast et al. 2000, 2002), larvae in packaged goods often escape notice and cause significant losses (Cox & Bell 1991). Acoustic methods have been developed to detect hidden larval infestations (e.g., Shuman et al. 1993), but the weak sounds produced by 3^{rd}-4^{th} instar *P. interpunctella* are difficult to detect through multiple layers of protective packaging. Heat treatments (Mankin et al. 1999) and electrical stimulation (Mankin 2002) have been shown to increase the activity and acoustic detectability of insect larvae, but such treatments currently have limited applicability. There is continued interest in identifying other stimuli that can increase the rate and amplitude of larval sounds during acoustic monitoring, thereby reducing the fraction of "false negatives," i.e., incorrect ratings of low likelihood of infestation in samples that actually contain insects.

Low-energy microwave radiation is a potential, but largely unexplored, stimulus of larval activity, although high-energy radiation has been demonstrated to be a successful, but impractical treatment for control of stored-product insects (Nelson et al. 1997; Nelson & Stetson 1974). High-energy microwaves induce thermal heating (Mitcham et al. 2004). Because heat increases larval activity, microwave radar insect detectors, e.g., the Termatrac (Protecusa, Coral Gables, FL) (Tirkel et al. 1997), may have the capability to stimulate activity in exposed larvae. To explore this possibility, a study was conducted that combined microwave radar monitoring of *P. interpunctella* larvae with acoustic detection. The larvae were monitored for 180-s intervals with a Termatrac device by methods described in Mankin (2004) and their acoustic activity was monitored simultaneously with a piezoelectric sensor by methods described in Mankin (2002). The tests were conducted in a 50- by 30- by 15-cm pan to reflect the radiation internally within the test setup and maximize the larval radiation exposure.

Larvae (5-15 mg, 3^{rd}-4^{th} instars) obtained from the Center for Medical, Agricultural, and Veterinary Entomology rearing facility were placed individually on soft dog biscuits (Ol' Roy Dinner Rounds, Wal-Mart, Inc., Bentonville, AK) 1-2 days before testing to allow time for the larvae to begin burrowing and feeding. Fifty-eight tests were completed over a 25-day period. Each biscuit was placed on a 4.5-cm diameter piezoelectric disk (MuRata Erie model PKM28-2AO, Smyrna, GA) (see Mankin et al. 2000) in a bottom corner of the reflective pan. The 5- by 6.5-cm Termatrac horn was centered adjacent to the edge of the disk, near the bottom corner of the pan, and the top of the pan above the test setup was covered with aluminum foil up to the edge of the Termatrac display. The experiment was conducted in an acoustically shielded room (Mankin 2002).

Acoustic signals were collected for 180-s intervals (1) immediately before Termatrac activation, (2) immediately after 180 s of monitoring, and (3) 10 min afterwards. The Termatrac sensitivity was set at midrange, and the magnitude and rate of change of the display indicator was monitored during the initial and final 15 s of Termatrac activation. The likelihood of infestation was rated low, medium, or high based on the scale described in Mankin (2004), with higher overall magnitudes and greater fluctuations indicating higher likelihoods that insect were present in samples.

The acoustic signal collection and analysis procedures were similar to those described in Mankin et al. (2001). Acoustic assessments were conducted to compare Termatrac and acoustic measurements, with the likelihood of infestation rated as low, medium, or high when the acoustic activity rate was, respectively, below or above a low threshold, 0.033 pulses/s, determined by the background noise levels in control tests with uninfested biscuits, or above a high threshold, 0.33 pulses/s, that had been observed in previous experiments (Mankin et al. 2001; Mankin 2002) as strongly indicative of insect presence.

All but two of the Termatrac readings were rated as low on the scale described in Mankin (2004), i.e., the movement level remained at 0 dB during the entire 15-s monitoring period. In those two tests, the reading changed from an initial level of low at the beginning of the 180-s monitoring interval to medium at the end of the interval. The acoustic activity of the larvae in those two tests changed from 0.338 to 6.03 pulses/s, and from 1.883 to 2.667 pulses/s. Both of the final rates were considerably higher than the mean initial rate, 0.60 pulses/s (Table 1). Such results suggest that only highly active *P. interpunctella* lar-

*The use of trade, firm, or corporation names in this publication does not constitute an official endorsement or approval by the United States Department of Agriculture, Agricultural Research Service of any product or service to the exclusion of others that may be suitable.

TABLE 1. COMPARISON OF MEAN ACTIVITY RATES OF *P. INTERPUNCTELLA* LARVAE BEFORE, IMMEDIATELY AFTER, AND 10 MIN AFTER TERMATRAC MONITORING.

Measurement period	Mean activity rate (pulses/s) ± standard error for	
	All larvae (n = 58)	Larvae w/ low initial activity[1] (n = 40)
Before monitoring	0.600 ± 0.184	0.115 ± 0.014
Immediately after	0.968 ± 0.205	0.576 ± 0.204 *
10 min after	0.834 ± 0.217	0.608 ± 0.208 *

Mean activity rates marked by asterisks are significantly different from the before-monitoring control in a paired, 2-tail t test ($\alpha = 0.05$).

[1]Biscuits in which the larval activity rate before treatment was below the high-infestation-likelihood threshold of 0.33 pulses/s (Mankin et al. 2001).

vae can be detected individually by the Termatrac system. Mankin (2004) found similarly that adult beetles in a box of flour or corn-meal mix could be detected reliably in numbers as small as 5-10, but not as reliably with smaller numbers per box.

A question of particular interest was whether a stimulatory treatment could increase the activity levels of a quiet larval sample sufficiently to change its infestation likelihood rating from low or medium to high, which would have the effect of changing a "false negative" assessment of infestation likelihood to a "true positive". Forty of the 58 samples had below-threshold initial activity, and these initially quiet samples were considered in a separate paired, 2-tail t-test in Table 1. Different results were obtained for the entire 58-sample experiment than for the initially quiet subset. Overall, rates increased after Termatrac monitoring, but the differences were not significant. However, significant differences were observed when analysis was restricted to the initially quiet subset. Twenty-two of these larvae increased their activity during Termatrac operation sufficiently enough to acoustically rate the sample as infested, and 24 larvae had elevated activity 10 min after the Termatrac monitoring period.

The microwave radiation effects reported here are not as pronounced as the effects of electrical stimulation demonstrated in Mankin (2002), and a considerable increase in the power output of the microwave horn or a longer exposure period would be necessary to achieve a practical increase in the acoustic detectability of *P. interpunctella* larvae or other insects hidden in protective packaging. Nevertheless, these initial results suggest that additional applications of low-power microwave radiation to insect detection and control may be feasible above and beyond the already demonstrated usage of high-power radiation.

Daniel Ortner, a summer intern in the 2004 University of Florida Student Science Training Program, conducted the tests in this study with supervision by the author and Everett Foreman.

SUMMARY

P. interpunctella larvae are difficult to detect by currently available nondestructive techniques. In this report, a Termatrac device was evaluated for utility in larval detection, and low-power microwave radiation was evaluated as a means of increasing larval activity and acoustic detectability. High levels of radiation are known to produce lethal thermal heating. The low-power radiation in this study produced a small, but statistically significant increase in the rate of sounds by larvae that initially were inactive. The results suggest that higher power radar or a longer duration of exposure might have potential as a treatment to increase the acoustic detectability of hidden infestations of *P. interpunctella* larvae and other stored product pests.

REFERENCES CITED

ARBOGAST, R. T., P. E. KENDRA, R. W. MANKIN, AND J. E. MCGOVERN. 2000. Monitoring insect pests in retail stores by trapping and spatial analysis. J. Econ. Entomol. 93: 1531-1542.

ARBOGAST, R. T., P. E. KENDRA, R. W. MANKIN, AND R. C. MCDONALD. 2002. Insect infestation of a botanicals warehouse in north-central Florida. J. Stored Prod. Res. 38: 349-363.

COX, P. D., AND C. H. BELL. 1991. Biology and ecology of moth pests of stored foods, pp. 181-193 *In* J. R. Gorham [ed.], Ecology and Management of Food Industry Pests, Association of Official Analytical Chemists, Arlington, VA.

MANKIN, R. W. 2002. Increase in acoustic detectability of *Plodia interpunctella* (Lepidoptera: Pyralidae) larvae in stored products after electrical stimulation. Florida Entomol. 85: 524-526.

MANKIN, R. W. 2004. Microwave radar detection of stored-product insects. J. Econ. Entomol. 97: 1168-1173.

MANKIN, R. W., J. BRANDHORST-HUBBARD, K. L. FLANDERS, M. ZHANG, R. L. CROCKER, S. L. LAPOINTE, C. MCCOY, J. R. FISHER, AND D. K. WEAVER. 2000. Eavesdropping on insects hidden in soil and interior structures of plants. J. Econ. Entomol. 93: 1173-1182.

MANKIN, R. W., S. L. LAPOINTE, AND R. A. FRANQUI. 2001. Acoustic surveying of subterranean insect populations in citrus groves. J. Econ. Entomol. 94: 853-859.

MANKIN, R. W., D. SHUMAN, AND D. K. WEAVER. 1999. Thermal enhancement of acoustic detectability of *Sitophilus oryzae* (Coleoptera: Curculionidae) larvae. J. Econ. Entomol. 92: 453-462.

MITCHAM, E. J., R. H. VELTMAN, X. FENG, E. DE CASTRO, J. A. JOHNSON, T. L. SIMPSON, W. V. BIASI, S. WANG, AND J. TANG. 2004. Application of radio frequency treatments to control insects in in-shell walnuts. Postharv. Biol. Tech. 33: 93-100.

MULLEN, M. A., AND A. K. DOWDY. 2001. A pheromone-baited trap for monitoring the Indian meal moth, *Plodia interpunctella* (Hübner) (Lepidoptera: Pyralidae). J. Stored Prod. Res. 37: 231-235.

NELSON, S. O., AND L. E. STETSON. 1974. Possibilities for controlling insects with microwaves and lower frequency RF energy. IEEE Trans. Microwave Theory Tech. MTT-22: 1303-1305.

NELSON, S. O., P. G. BARTLEY, AND K. C. LAWRENCE. 1997. Measuring RF and microwave permittivities of adult rice weevils. IEEE Trans. Instrum. Meas. 46: 941-946.

SHUMAN, D., J. A. COFFELT, K. W. VICK, AND R. W. MANKIN. 1993. Quantitative acoustical detection of larvae feeding inside kernels of grain. J. Econ. Entomol. 86: 933-938.

TIRKEL, A., G. J. SANDERSON, AND R. J. DAVIES. 1997. Termite detection system. International patent, no. WO9709611.