ATTRACTION OF LAELAPS ECHIDNINA
(ACARI: LAELAPIDAE) TO
HOST-EMITTED IR RADIATION

WILLIAM A. BRUCE

Stored-Product Insects Research and Development Laboratory
Agr. Res. Serv., USDA, Savannah, Ga. 31403

ABSTRACT

Adult females of Laelaps echidnina Berlese (so-called spiny rat mite) within 4 cm of a rat were attracted to host-emitted infrared radiation. No attraction to rat odor was observed. Mites were exposed at several distances to various combinations of natural and artificial sources of radiation and host odors, and the response was recorded.

The detection of and attraction to the visible and ultraviolet (UV) portions of the electromagnetic spectrum by insects is well-documented though poorly understood. Several reports have suggested that infrared radiation (IR) may be detected by insects (Grant 1948, Laithwaite 1960, Callahan 1967, Griffith 1968). Recently (Bruce 1971), I demonstrated that a mite, Laelaps echidnina Berlese, a bloodsucking ectoparasite of rats, can detect intermediate IR radiation but apparently only across a relatively short distance.

With the exception of a report by Evans (1966), little discussion has been presented in support of either long or short range IR detection systems in arthropods. An investigation was therefore made to determine the maximum distance that a spiny rat mite could be attracted to the IR radiation emitted by its host. During this study, it became necessary to determine the probable function of rat odor in the biology of L. echidnina and its relationship to IR attraction.

MATERIALS

Adult female mites were collected from a stock culture, partially dehydrated for 6 hr over CaSO₄, at 0% RH, and subsequently fed whole human blood diluted 1:1 with distilled water (Cross 1954). After feeding, the mites were transferred to a relative humidity of 93% for 7 days until the gut was empty (Kanungo 1964). One hour before testing they were removed from the humidity chamber and placed 1 to a vial. Approximately 1,100 mites were used in the study.

PROCEDURES AND TESTS

Tests of IR Radiation.—The test chamber for the tests of IR radiation was a 3-sided Plexiglass® chamber (25.0 x 20.0 x 11.2 cm) fitted on top with a 15.0

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§Research Entomologist.
cm diam air exhaust hose connected to a laboratory chemical hood. The IR source (white laboratory rat) was placed directly under the exhaust opening in a small wire-mesh cage. Directly in front of the cage, a test area, marked at 1-cm intervals, extended out from the open side of the chamber (Fig. 1A).

Air speed along the length of the test area at substrate level was measured with a hot wire anemometer. Also, cigarette smoke was introduced (exhaust on) into the test chamber area to determine the nature of any air turbulence and whether any backflow occurred.

Air temperatures were taken with a digital thermometer and Yellow Springs® air temperature probe No. 405. The probe shield was modified by attaching a thin rectangular piece of plexiglass to the side nearest the source of radiation. This modification allowed adequate airflow around the probe but effectively eliminated the possibility of direct measurement of radiant heat from the source.

A mite was released onto the test area at the desired distance from the source by gently tapping the side of a holding vial. Then the vial was immediately removed. No attempt was made to orient the mite either toward or away from the stimulus, but after 15 sec, the position of the mite was noted. Movement toward the stimulus was scored as a positive response; movement away was recorded as a negative response. A zero value was assigned if the mite was observed in a lateral position at the release distance. The behavioral responses were scored as an attraction index (AI):

\[
AI = \frac{\text{Total number of positive responses} - \text{negative responses}}{\text{Total number of positive, negative, and zero mites tested}} \times 100
\]

Several tests were designed to determine if the spiny rat mite is attracted by host-emitted blackbody IR radiation.

In 1 test the exhaust fan was turned off and a series of mites was released at several distances from the rat to determine the maximum distance of attraction when host odors, convected heat, and IR radiation were present. In another test the fan was engaged and a second series of mites was released in the same manner so the maximum distance of attraction to IR radiation alone could be determined (odors and convected heat presumably were being removed).

A third test was designed to determine mite attraction to host-emitted radiation at reduced intensities. Three 7.5 × 10.0-cm sheets of saran wrap were placed together and positioned along the front of the holding cage, which accomplished a 10% reduction in irradiance as measured with a calibrated Eppley® thermopile. Also, 0% transmission of radiation was achieved by replacing the saran wrap with an equal size 0.3 cm-thick piece of plexiglass. Thus, any reduction in response produced by the 10% reduction was then compared with the response that occurred when the radiation was almost completely attenuated. Since the IR radiation is almost completely attenuated by the plexiglass and its size did not interfere with air flow, any movement of the mite toward the rat would not be a response to IR radiation. Thus, the plexiglass would also provide an indication of the effectiveness of the exhaust system in removing rat odor.
Fig. 1. Olfactory chambers. A. Odor exhaust system: a—exhaust tube; b—plexiglass chamber; c—rat holding cage; d—test area. B. Odor delivery system: a—induction fan; b—rat holding cage; c—odor delivery nozzle.

A fourth test was made with an artificial source of IR, a nichrome wire enclosed in a rubber belt with lateral surface area and temperature about equal to those of the rat so as to produce similar blackbody radiation without any possibility of contamination by rat odor. Blackbody spectra of both the rat and artificial IR source were checked by using a Digilab® IR spec-
trophotometer and found to approximate each other. Belt temperature was maintained with a temperature regulator set at 38.0 ± 0.2°C.

Results of the IR radiation tests showed that the spiny rat mite was attracted to a rat at distances of 9 cm and beyond when odor, convected heat, and blackbody IR radiation were present (Fig. 2). However, when the exhaust fan was engaged, presumably leaving blackbody IR as the primary stimulus, no attraction (detection?) was observed at or beyond 4 cm. The 10% reduction in radiation (exhaust fan on) resulted in a 25% decrease in the AI at 2 of the 3 selected distances (Table 1). Complete attenuation of IR radiation by the plexiglass resulted in a negative AI at 2.5 cm.

**TABLE 1. Response of L. echidnina to IR radiation (from 0-100% transmission): 50 mites tested at each distance; exhaust fan on during each test.**

<table>
<thead>
<tr>
<th>Test</th>
<th>Distance mite released from 1R source (cm)</th>
<th>Mite response*</th>
<th>AI**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (No IR or rat odor)</td>
<td>2.5</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Saran wrap cover (Rat IR)</td>
<td>1.5</td>
<td>31</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>2.5</td>
<td>29</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>3.5</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td>Plexiglass cover (Rat IR)</td>
<td>2.5</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td>Artificial blackbody (No rat odor)</td>
<td>1.0</td>
<td>34</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
<td>33</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

*Positive response in direction of 1R source position.

**Attraction Index described in text.

The substitution of an artificial blackbody source of IR with no rat odor present resulted in an index similar to that found with a normal host at 3 of the same test distances (Table 1).

Tests of olfaction.—The tests of olfaction were made in a simple plexiglass olfactometer consisting of a holding chamber, a fan, and a delivery tube to determine the effects of rat odor on the distance at which the host was attractive to the parasite (Fig. 1B). Laboratory air was blown across a rat placed in the holding chamber and forced through the tube and out an exit nozzle. The olfactometer was cleaned with 95% alcohol after each test.

The system was designed to permit the nozzle to be introduced into either the front or back of the test area. Air speed at the nozzle was 18 m/min and appeared, in preliminary tests, to have no adverse effect on the mites. Introduction of rat odor, with and without an IR source and from both the front
and back of the test area, was possible. In these tests, 50 mites (tested individually) were introduced at 5 cm from the stimulus, and the response was noted and recorded as before. In some tests, mites were released at other distances.

In addition, the effects of previous exposure to odor on the attraction of the mite to IR was tested by introducing rat odor into the holding vial for 15 sec and then releasing the mite 10 sec later.

Results of the olfaction tests showed that when the mites were released in the presence of a rat (exhaust system off) at a distance (5 cm) beyond that essential for IR attraction, the AI was 42 (Table 2). When the exhaust system was engaged and a second series of mites was released at 5 cm, the index dropped to zero. These preliminary results suggested that the exhaust system apparently was effective in eliminating odor. When the mites were released in the presence of rat odor but without a source of IR radiation, the AI was essentially zero at the 3 release distances (Fig. 2). However, mites released midway between the source of IR radiation (exhaust on) and the rat odor (delivered via the olfactometer) showed a definite response toward the source of radiation (Table 2). Mites exposed in the holding vials to rat odor for 15 sec before release at 5 cm had a lower AI of 24.

**TABLE 2.** Response of *L. echidnina* to IR radiation and/or odor; mites released 5 cm from stimulus; 50 mites used in each test.

<table>
<thead>
<tr>
<th>Test</th>
<th>Mite response*</th>
<th>AI**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>No.</td>
</tr>
<tr>
<td>Odor present, exhaust fan off†</td>
<td>28</td>
<td>11</td>
</tr>
<tr>
<td>Odor absent, exhaust fan on</td>
<td>29</td>
<td>25</td>
</tr>
<tr>
<td>Odor introduced from direction opposite IR source; exhaust fan on</td>
<td>37</td>
<td>12</td>
</tr>
<tr>
<td>Odor introduced in vial for 10 sec before release opposite IR source; exhaust fan on</td>
<td>30</td>
<td>18</td>
</tr>
</tbody>
</table>

*Positive response in direction of IR source position.
**Attraction Index described in text.
†Forty mites tested.

**DISCUSSION**

The study demonstrated 2 important aspects of the biology of *L. echidnina*. First, host IR emissions alone are not effective in attracting the spiny rat mite beyond a distance of 4 cm; and second, host odor does not appear to
function either as directional stimulus or as an attractant. Thus, the IR
detection/attraction system of the spiny rat mite, and perhaps that of other
ectoparasitic arthropods (Kivnay 1951, Benton et al. 1959, Aboul-Nasr and
Erakley 1968), only operate at short distances. Indeed, the distance is such that
the host is close enough for directional pre-contact activity and also requires a
minimum expenditure of energy from the mite with a maximal chance of
contact.

If host odors do not function either as directional stimuli or attractants,
what possible role do they have? My observation of the responses of the rat
mite to rat odor suggests that it produces a general increased kinesis, and the
experimental data support this observation. When rat odor was released op-
posite an IR source and mites were released midway (5 cm from both), a
definite attraction toward the IR source occurred (Table 2). However, when
odor was introduced into the vials before this release, the attraction toward
the IR source decreased. Thus, in the first instance, activity of the mites may
have been increased and maintained by the odor long enough to increase the

Fig. 2. Response of *L. echidnina* under various conditions (n = 50 mites per
test): • = exhaust fan off, rat present; ● = exhaust fan on, rat present;
○ = rat odor only.
chances that the mite would move into the 4-cm range; or the odor in some way may have lowered the response threshold to IR radiation. In the second instance, the less attraction probably occurred because of the 10 sec delay before release and also because rat odor was not continuously present during testing so activity was not as vigorous; therefore, the probability that the mite would move within the critical distance was also diminished.

In the natural rat nest, rat odor—CO₂ is probably the primary stimulatory component (Bruce, unpublished data) and may function to increase general activity and cause the mites to move from within the bedding to the surface. Once on the surface and active, the mites are in a better position to be attracted by host IR emissions, which increases the possibility of host contact.

ACKNOWLEDGEMENTS

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LITERATURE CITED


SURVIVAL OF CRAWLERS OF CALIFORNIA RED SCALE, AONIDIELLA AURANTII (MASK.) (HOMOPTERA:DISPIDIDAE)—(Prepublished Abstract) The periods of survival of first instar larvae (crawlers) of California red scale were estimated in the laboratory under conditions that attempted to simulate those that the crawlers would be exposed to during dispersal by wind in the field. Since attempts to keep crawlers suspended in a stream of moving air for long periods were unsuccessful, they were placed in small cages, and air at constant temperature and humidity was passed through the cages at known rates. Following exposure, the crawlers were transferred to lemon leaf discs, and only those able to begin feeding and secrete a scale were recorded as survivors.

At 15°C crawlers survived a mean period of 17-1 hr at 70% R.H. and 14.2 hr at 35% R.H.; at 25°C, 10-1 hr at 70% R.H. and 6-8 hr at 25% R.H.; at 35°C, 7-2 hr at 70% R.H. and 5-7 hr at 25% R.H. The period survived was significantly higher at the higher humidity in each case. At 70% R.H. the period of survival decreased significantly with increased temperature. At 25% R.H. the period was significantly higher at 15°C than at 25°C, but not between 25 and 35°C. The period of survival decreased as the rate of flow of air past the crawlers increased to the terminal velocity.

The long periods of survival of crawlers, even under extreme conditions to which they would rarely be exposed in nature because of their rhythm of emergence, leaves little doubt that they could withstand transport by wind over long distances even during hot, dry summer weather. (Aust. J. Zool., 1973, 21:567-73; J. R. Willard, Univ. of Saskatchewan, Saskatoon, Canada S7N, OWO).