AUTECOLOGICAL STUDIES OF RHYNACUS BREITLOWI
DAVIS, (ACARINA: ERIOPHYIDAE)\(^1\)

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Ecological observations of various eriophyd species usually have been incidental to taxonomic and distribution studies (Hassan 1938; Baker 1939; Keifer 1942; Bailey and Keifer 1943; Smith and Stafford 1948; Kido and Stafford 1955; Breakley and Batchelor 1957; Welton and Swenson 1962; and Rice and Strong 1962), and little is known about this mite family. The effects of physical limiting factors, such as temperature, moisture, and light, are essentially unknown. Means of dispersal and host specificity, often presumed to be limiting, have neither been critically studied nor subjected to experimentation. This paper describes some field and laboratory studies of the autecology of Rhynacus breitlowi Davis (1964). R. breitlowi inhabits the undersurface of the leaves of the evergreen magnolia, Magnolia grandiflora L., its only known host.

METHODS AND MATERIALS

**Temperature Limitation on Activity:** The range of temperature within which R. breitlowi remains active was determined as follows: Each group of mites to be tested was placed on a 15 mm magnolia leaf disc. The leaf disc was then placed in a perforated 25 mm square plastic container which was suspended from the lid of a larger plastic container 50 mm deep and 75 mm in diameter. The larger container was submerged to its lip in a water bath. An iron-constantan thermocouple was inserted through the lid of the larger container and the side of the smaller and brought to rest on the leaf disc. A dissecting microscope used for making observations was placed over the water bath. A Barber Coleman portable potentiometer (Series 311) was used to measure the temperature at the thermocouple (Fig. 1).

At the start of an experiment a minimum air temperature of 12.5°C on the leaf disc’s surface was obtained by placing ice in the water bath. Hot tap water was then run into the water bath to melt the ice and slowly raise the temperature. The maximum air temperature of 45°C was reached after 25 to 30 minutes and maintained for 5 minutes. A relative humidity over the leaf disc of 100% was rapidly obtained in each test. To facilitate observation during the period of raising temperature, fogging was prevented by wiping a thin film of petrolatum on the underside of the lid. Ten adult mites were used in each of three tests and ten immatures in a fourth test.

In another set of experiments designed to determine the temperature and time required to kill the mite, containers with leaf discs, each with ten mites, were held in the water bath at 37, 40, 43, and 45°C for 5, 10, 15,

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20, and 60 minutes at each temperature. The leaf discs were examined for mite survival immediately after removal from the water bath and again after holding for 24 hours at 25°C.

Figure 1. Microscope, water bath, thermocouple, portable potentiometer, and plastic container with mites and leaf disc for temperature treatment.

Effects of Temperature and SVPD on Length of Life Cycle: These effects were investigated on magnolia leaf sections by using the microcell method of Rice and Strong (1962) for rearing eriophyids. Saturation vapor pressure deficits (hereafter referred to as SVPD) were provided by mixtures of H₂SO₄ and distilled water as determined from the International Critical Tables. The H₂SO₄ solutions were placed in quart fruit jars with metal screw-on lids. The rearing units were supported over the solutions by standing them on stender dishes and by a piece of string held by the lid.

The SVPD chambers were held in incubators to maintain the desired temperatures. Control of light was not possible as an electric light bulb provided the heat in all incubators. The temperatures inside the incubators had a maximum fluctuation of ± 1°C. The experimental setups were arranged to provide three temperatures, 20, 25, and 30°C, at each of three SVPD, 4, 8, and 12 mm of Hg.

To initiate a test, about 20 adults were placed in each microcell. These microcells were examined every two hours until an egg was observed. The adults were then removed and the time recorded. Since the adults were field collected, it was assumed that both males and females were present in each microcell and the egg was fertile. Each individual from these eggs was observed until it matured, and if female, until she produced an egg. Examination of the microcells was made at 8-hour intervals and the time
required for development of each stage recorded. When a change of form occurred between the 8-hour observations, the midpoint in the period was taken as the endpoint for the stage and the beginning of the next stage. A total of eight eggs was started at each of the nine combinations of temperature and SVPD, but not all mites completed their life cycle.

**Dispersal:** The role of wind in dispersal was examined both in the laboratory and in the field. The laboratory experiment involved the use of a large electric fan to blow air through mite-infested magnolia branches. Behind the branches was placed a lattice board on which were placed glass microscope slides. The slides had previously been painted with a dilute solution of petroleum ether and "Stickum," a commercial tanglefoot manufactured by Michel and Pelton, Oakland, Calif. The evaporation of the ether left a sticky surface that would trap mites. The air velocities were measured with a "Flo-Rite" air velocity meter (Model MRF) held immediately in front of the branches. The air speed was varied by adjusting the distance between the fan and the branches.

During the months of August, September, and October 1962, attempts were made to demonstrate wind transport of mites in the field. Each month for about two weeks, 32 free-swinging sticky slides were tied in each of two infested magnolia trees to try to recover airborne mites.

The role of other arthropod species in dispersal of the mite was examined by two methods. The sticky slides used in the wind transport study trapped many arthropods which were examined for phoretic eriophyids. The second approach involved taking sweep samples with an insect net from five infested magnolia trees once a month from July through October 1962. Arthropods collected in these samples were examined for phoretic eriophyids. All sweep samples were taken between 12:00 noon and 2:00 PM and only from the lower 8 feet of each tree. Each tree was swept by continuously walking around the tree and sweeping until no more arthropods were caught.

To observe the reaction of the mites to air currents, infested leaves were taped to the stage of a dissecting microscope and the mites subjected to various air movement intensities. The volume of air per second was measured by a "Precision" wet gas test meter. The air was led to the edge of the leaf's surface by a length of rubber tubing.

**Response to Gravity, Light, and Chemicals:** Two experiments were conducted to study the effects of gravity and/or light. In the first experiment ten adults each were placed on the center of 15-mm leaf discs. One leaf disc was pinned on each of a vertical, a horizontal and a 45° surface of a small styrofoam block. Three replicates of the experiment were conducted in continuous light and three in continuous darkness. The leaf discs were examined for any change in dispersion of the eriophyids at ½, 1, 4, and 24 hours.

The second experiment used entire leaves held in the positions mentioned for the leaf discs, each infested with approximately 50 mites. Each leaf was maintained in a small vial filled with water. The leaves were examined at ½, 1, 4, and 24 hours for any change of the population's dispersion. Three replicates were carried out for each condition.

To test for response to wave lengths of light, a modified Abbot's light board (1919) was employed. This light board provides a black surface on
which an organism can be exposed to unidirectional light. A red bulb with its maximum intensity in the red with cut off's in the yellow and infra-red, and an ultra-violet bulb with its maximum in the blue with cut off's in the green and ultra-violet were used as light sources. There was very little overlap in the colors produced by the two bulbs as observed visually with a Bausch & Lomb Littrow type spectrograph. No other light was available to the mites in the experiment.

A magnolia leaf infested with 50 to 100 mites was taped to the surface of the light board and placed in a dark room with one of the bulbs as the only light source. The position of the mites was noted at the start of each trial and again at the end of 1 and 8 hours. Three replicates were conducted using each bulb.

Two experiments were conducted to observe the reactions of the mite to chemical stimuli. The first experiment used the T-tube (see Camin 1953) constructed of 15-mm glass tubing, which had a filter paper floor added to provide mite footing. A known volume of air was drawn through a bottle of distilled water (to prevent the dessication of the mites in the tube) and then over the material to be tested before being passed over the mites. The volume of air flow was regulated by the "Precision" wet gas test meter. Materials tested as stimuli were paradichlorobenzene, magnolia leaf discs, and other eriophyds of the same species. Blanks were utilized in one side of the T-tube in all tests as controls.

The second experiment utilized a 15-mm leaf disc placed in the center of a 90-mm circular filter paper. Fifteen eriophyds were placed one at a time on the filter paper 2 mm from the cut edge of the leaf disc and their paths traced for 10 minutes. Throughout the experiment the light was from above, and the room temperature was 25°C with a relative humidity of 80±5%.

**Host Specificity:** The detached leaf method (see Rodriguez 1953) was used to examine host specificity on Magnolia grandiflora L., M. soulangeana (Soul.), and M. fraseri Walt. Six 15-mm leaf discs from each magnolia species were maintained in separate petri dishes on a substrate of cellucotton saturated with a 2% sucrose solution. This method provided a means of maintaining the leaf discs for more than two weeks with very little deterioration. On each leaf disc, 10 mites were placed, and their survival success checked and recorded every 12 hours. Temperature throughout the experiment was 25±3°C.

In an attempt to support the host specificity data, tests were carried out to determine how long the mite could survive without food. These replicates of 15 mites each were held at 25±2°C on moist filter paper in a closed stender dish provided with a charcoal-plaster of Paris substrate.

**Results and Discussion**

**Temperature Limitations on Activity:** The observations on the leaf discs held in the water bath indicate that both immature and adult mites exhibit normal activity at temperatures between 22 and 30°C. First signs of movement usually appeared at about 16°C. At temperatures above 31°C the mites were continuously moving and did not stop as they frequently did at temperatures between 22 and 30°C. The results of the experiments are presented in Table 1.
TABLE 1.—Activity of *R. breitlowi* as Temperature Was Increased from 12.5 to 45°C. Ten Mites Were Used in Each Test.

<table>
<thead>
<tr>
<th>Test</th>
<th>First signs of activity °C</th>
<th>Walked about °C</th>
<th>Range of normal activity °C</th>
<th>Marked increase in activity °C</th>
<th>Begin to leave the leaf disc °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult</td>
<td>16</td>
<td>19</td>
<td>22-30</td>
<td>31</td>
<td>38</td>
</tr>
<tr>
<td>Adult</td>
<td>17</td>
<td>19</td>
<td>22-30</td>
<td>31</td>
<td>38</td>
</tr>
<tr>
<td>Adult</td>
<td>16</td>
<td>19</td>
<td>23-30</td>
<td>31</td>
<td>38</td>
</tr>
<tr>
<td>Immature</td>
<td>16</td>
<td>19</td>
<td>22-29</td>
<td>30</td>
<td>38</td>
</tr>
</tbody>
</table>

* Normal activity was assumed to exist when the mites frequently stopped and appeared to feed.

TABLE 2.—Mean Hours Required for Completion of Life Stages of *R. breitlowi* Surviving Nine Combinations of Temperature and Saturation Vapor Pressure Deficits.

<table>
<thead>
<tr>
<th>Temp. °C</th>
<th>SVPD (mm Hg)</th>
<th>Life Stages</th>
<th>Adult preoviposition time</th>
<th>Total development time</th>
</tr>
</thead>
<tbody>
<tr>
<td>20±1</td>
<td>8±</td>
<td>12±</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>116</td>
<td>(1)**</td>
<td>44</td>
<td>124</td>
</tr>
<tr>
<td>25±1</td>
<td>8</td>
<td>92</td>
<td>(5)</td>
<td>44</td>
</tr>
<tr>
<td>30±1</td>
<td>8</td>
<td>36</td>
<td>(8)</td>
<td>20</td>
</tr>
</tbody>
</table>

*No oviposition at this combination.

**Figures in parentheses represent the number of individuals surviving each life stage.
The mites subjected to temperatures above normal activity range survived at 43 and 45°C for 10 minutes, but longer exposure were fatal. All mites survived the maximum exposure time of 60 minutes at 37 and 40°C. There was no additional mortality noted after the 24-hour holding period. Apparently about 40°C is the highest temperature the mites can survive at 100% relative humidity.

**EFFECTS OF TEMPERATURES AND SVPD ON LENGTH OF LIFE CYCLE**: The results of the experiment indicate that the mite requires a low SVPD (4 mm) and a high temperature (30°C) for its most rapid development (128 hours) (Table 2). At 20°C development occurred only at 4 mm SVPD, and no eggs were laid by the new adult. It is apparent that at the lower temperatures, the eggs were unable to withstand the desiccating effects of the greater SVPD.

Statistical treatments of the life cycle data by analysis of variance showed significantly (P<0.01) faster development at the highest temperatures, lower SVPD, and combinations of both conditions. The only exception to this level of significance (P<0.05) was for the adult pre-oviposition period at 25°C when 4 mm was compared with 8 mm SVPD.

Bailey and Keifer (1943) found that *Vasates lycopersici* (Massee), the tomato russet mite, at 70°F (21.1°C) required seven days for completion of an adult to adult cycle. They suggest that the life cycle might be shorter under hot summer field conditions. They provided no data on the effects of moisture. Sloan (1938) and Planes (1942) both stated that the mite seemed to prefer hot humid conditions in Australia and Spain. Conversely, Anderson (1954) reported that the same mite may build up heavy populations during the drier seasons. Slykhuys (1955) observed that *Aceria tulipae* (K.), the criophydiid vector of wheat streak mosaic, required seven days under greenhouse conditions at about 25°C to complete the egg to egg life cycle.

Rice and Strong (1962) reared the tomato russet mite through its life cycle at temperatures of 70, 80 and 90°F (21.1, 26.7, 32.2°C respectively) at relative humidities of 20, 60, and 90% for each temperature. They found that high humidity retarded development at high temperatures, but favored it at low temperatures. The shortest life cycle observed was completed in six days at 80°F and 30% relative humidity. Their work indicated that a high SVPD (18.3 mm) rather than the low deficit (4 mm) found in this work for *R. breitlowi* was most favorable for the russet mite’s development.

**DISPERAL**: In the experiment using the electric fan to produce air currents of 0 to 32.18 kilometers per hour through infested magnolia branches, mites were recovered on the sticky slides in all tests using air velocities of 11.20 to 19.51 kilometers per hour and above. In the field studies mites were recovered on some sticky slides during August and September. The slides for October failed to yield eriophyds, possible due to the reduced population size with the beginning of colder weather.

In the observations of the mites on the infested leaves subjected to air currents, it was noted that orientation to the air flow was a critical factor. Mites facing the air currents were most readily blown from the leaf. In all instances the mites would cease all activity and stand up on their anal suckers and move their legs rapidly about before becoming airborne.
The mites facing away from the air current seldom became airborne with the maximum air flow used (0.02832 cu. m. per sec.) unless their hold was lost by moving about. The air volumes per second necessary to cause the mite to become airborne are presented in Table 3.

**TABLE 3.—Air Flow Necessary to Blow R. breitlowi from a Surface When Facing in Various Directions in Relation to Air Flow.**

<table>
<thead>
<tr>
<th>Air flow (cu.m./sec.)</th>
<th>Facing</th>
<th>Facing away from air flow</th>
<th>Facing other directions</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00283</td>
<td>+</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>0.00566</td>
<td>+</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>0.00850</td>
<td>+</td>
<td>—</td>
<td>sometimes</td>
</tr>
<tr>
<td>0.01416</td>
<td>+</td>
<td>—</td>
<td>+</td>
</tr>
<tr>
<td>0.02832</td>
<td>+</td>
<td>sometimes</td>
<td>+</td>
</tr>
</tbody>
</table>

In the laboratory it was observed that the pubescence on the undersurface of the magnolia leaves matted down when the relative humidity appeared 100%, but if the temperature was raised and the relative humidity was lowered even a few percentage points, the pubescence would spring erect. Any eriophyd crawling over a hair when it sprang erect became airborne. Under the above circumstances, several mites were observed to be catapulted about 100 mm in horizontal distance. This may provide an important means for the movement of the mite from one leaf to another on a single host or, if accompanied by a breeze, could also play an important role in the movement of the mite from one host to another.

No arthropod vectors were recovered from any of the monthly sweep samples. The examination of the sticky slides also failed to disclose any arthropods carrying phoretic eriophyds. Eriophyds were found on some slides, but none was close enough to another arthropod that it might have crawled off the arthropod.

Slykhuis and Andrews (1953) and Slykhuis (1955) state that wind is the primary means of dispersal for *Aceria tulipae*. Gibson and Painter (1957) state that aphids can also transmit this eriophyd. This work indicates that other arthropods may not be as important as wind in the dispersal of *R. breitlowi*.

**RESPONSE TO GRAVITY, LIGHT, AND CHEMICALS:** There was no response noted to gravity on either the entire leaves or the leaf discs as the mites failed to change their dispersion in the absence of light. The mites were found to possess a weak positive photokinesis in the leaf disc tests after 1, 4, and 24 hours. No response was noted to light when entire leaves were used.

The experiment using the modified Abbot's light board showed no change in the mite dispersion when the ultraviolet bulb provided the light. A slight change in dispersion towards the light was observed at the end of 8 hours with the red bulb.

No responses were noted in the experiment using the T-tube. The lack
of response was due to the cessation of all activity by the mites when the air was passed over them.

On the filter paper four mites moved towards the leaf disc, three pathways were roughly equidistant at all times from the edge of the disc and the remaining eight pathways moved away from the disc. All pathways showed a large amount of wandering. It is apparent that under the conditions of the experiment, odors are of little value to the species in the finding of the host.

Host Specificity: The tests were arbitrarily discontinued at 336 hours, at which time some mites on Magnolia grandiflora were still alive. All mites on M. soulangeana had died before 72 hours and those on M. frazeri before 24 hours. The starvation tests showed that the mite could not live more than 72 hours without food. It is not known whether the shorter survival time on M. frazeri can be attributed to some toxic effect of the plant or if the mites died sooner because they were unable to obtain moisture from the leaf.

Summary

R. breitlowi, exhibited normal activity at temperatures between 22 and 30°C. Below this range, activity became sluggish and ceased at 16°C, while above 30°C movement was continuous. The maximum temperature that could be tolerated for 60 minutes, without apparent ill effects in the 24 hours following the exposure, was 40°C.

Comparison of developmental times at nine combinations of temperature (20, 25, and 30°C) and saturation vapor pressure deficits (SVPD) (4, 8, and 12 mm of Hg) indicated that low deficits and high temperatures were most favorable. Life cycles were completed at 25 and 30°C, but not at 20°C. The shortest time for completion of an egg-to-egg life cycle was 128 hours at 30°C and 4 mm SVPD.

The mite is apparently adapted to wind dispersal. Other arthropods collected from magnolia trees did not possess phoretic eriophyids. At high humidity the pubescence on the underside of the magnolia leaf matted down. Decreasing humidity caused this pubescence to spring erect and catapult any eriophyid off the pubescence thus providing it an opportunity to become airborne. At velocities above 11.26 to 19.31 kilometers per hour mites facing into the air flow were more readily swept off the leaves than those facing away from the air flow stream. Under the conditions of this study odors were of little use to the mite in food finding. Host specificity was examined using Magnolia grandiflora, its native host, M. frazeri, and M. soulangeana. Survival times on each host were examined for 336 hours at which time mites on M. grandiflora were still alive. Mites on M. soulangeana died before 72 hours and on M. frazeri before 24 hours.

Literature Cited


