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LIFE HISTORY AND LIFE TABLES
OF RHIZOGLYPHUS ROBINI CLAPARÈDE
(ACARI : ASTIGMATA : ACARIDAE)

BY U. GERSON*, S. CAPUA* & D. THORENS**

ABSTRACT: Rhizoglyphus robini Claparède (Acari: Astigmata: Acaridae) was reared in the laboratory on three diets under four temperature regimens in individual plexiglass cages. Immature survival was uniformly high on garlic and peanuts at 22°C and 27°C, but rather low for mites on garlic at 35°C or on filter paper at 27°C. The calculated threshold of development was at 11.8°C, and the thermal constant was 184.8 day-degrees. The sex ration was 1:1. Adults kept at 27°C and offered peanuts or garlic deposited an average of 690 eggs/females and 400 eggs/females, respectively, during about six weeks. No eggs were usually produced by females reared at 35°C or on filter paper. Males lived almost twice as long as females. Life tables were constructed from these data. The intrinsic rates of increase ($r_m$) for mites offered peanuts or garlic at 27°C were 0.285 and 0.218, respectively. The compounded effect of various nutrition-affected factors, such as survival, body size and fecundity on changes in mite populations is discussed, as well as the importance of defining diets for polyphagous mites in similar studies.

RÉSUMÉ: Rhizoglyphus robini Claparède (Acari: Astigmata: Acaridae) a été élevé au laboratoire sur trois nourritures et sous quatre régimes de températures dans des cages de plexiglas individuelles. La survie des individus immatures était uniformément haute sur l'ail et les cacahuètes à 22°C et 27°C, mais plutôt basse pour les acariens tenus sur l'ail à 35°C ou sur du papier filtre à 27°C. Le seuil de développement calculé était de 11.8°C, et la constance thermale était de 184.8 jour-degrés. Le rapport des sexes était 1:1. Les adultes tenus à 27°C et nourris de cacahuètes ou d'ail pondaient respectivement en moyenne 690 œufs/femelle et 400 œufs/femelle durant environ six semaines. Aucun œuf n'était habituellement produit par des femelles élevées à 35°C sur du papier filtre. Les males vivaient près de deux fois plus longtemps que les femelles. Des tables de vie ont été construites pour ces données. Le taux intrinsèque d'accroissement ($r_m$) des acariens nourris de cacahuètes ou d'ail à 27°C était respectivement 0.285 et 0.218. L'effet combiné de différents facteurs modifiés par la nutrition, tels que la survie, la taille du corps et la fécondité sur les changements dans les populations d'acariens est discuté, de même que l'importance de nourriture déterminée pour les acariens polyphages dans des études semblables.

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INTRODUCTION

Bulb mites, *Rhizoglyphus* spp. (Astigmata: Acaridae) are cosmopolitan pests of various crops. They infest winter grains, onion and garlic in the field (GERSON *et al.*, 1981; RAWLINS, 1955; SOMERMAA, 1972), bulbs, corms and tubers in storage (GARMAN, 1937; MUNK, 1972; MULLER & HOLLINGER, 1980), and consume even medicinal herbs (CZAJKOWSKA, 1972). The mites also disseminate bacteria and fungi which infect bulbs, facilitating the pathogens' entry into host plants (FORSBERG, 1959; POE *et al.*, 1979).

The biology of *Rhizoglyphus* has been studied several times (GARMAN, 1937; KUZNETZOV & TKATCHUK, 1972; MICHAEL, 1903; SEKIYA, 1948; WOODRING, 1969; ZAKHVATKIN, 1959), but taxonomic and methodological problems intrude. Only recently has *Rhizoglyphus robini* Claparède been clearly separated from *R. echinopus* (Fumouze et Robin) (EYNDHOVEN, 1968, 1972). This interpretation, although not universally accepted (HUGHES, 1976) was an important first step, especially as supplemented by MANSON (1972). Diets as well as experimental conditions varied in these studies, but no effort has been made to compare results. Consequently life history data are sometimes presented in generalised terms (i.e., HUGHES, 1976, p. 122).

*R. robini* has recently become a pest of onion and garlic in Israel, and is now under intensive study (GERSON *et al.*, 1981). Within this project it became pertinent to study (or restudy) the biology of *R. robini*, assay the effects of nutrients and temperatures on its development and fecundity, and construct life tables from the resultant data.

The mite used in this study conforms to the concept of *Rhizoglyphus robini* as developed by EYNDHOVEN (1968, 1972).

EXPERIMENTAL METHODS

**Rearing of mites.** A colony of *R. robini* was collected from infested garlic and kept in the laboratory. Mites were continuously reared on water-soaked peanut seeds (var. Virginia) placed in petri dishes. Several thousand mites were thus obtained in each dish. Gravid females were individually placed overnight in small, humid containers, and the deposited eggs were transferred on the next day onto the various diets.

**Observation cages.** Plexiglass cages were constructed for observing mites individually. Plexiglass sheets (4 mm thick) were cut to rectangular pieces (7.5 × 3.5 cm), into which three holes (each 12 mm diameter) were drilled (Fig. 1, a). Bits of black filter paper (product of Eaton-Dikeman, Mt. Holly Springs, Pennsylvania, U.S.A., Grade 8613), measuring 2.0 × 1.5 cm, were placed on top of the holes. A small depression was then made in the paper on top of each hole, food was introduced and a mite placed therein (Fig. 1, b). The paper was covered by a microscopic slide and held in place by two metal clips (Fig. 1, a). Each rectangular plexiglass piece thus served as three individual observation cages. The whitish mite eggs, immatures and adults can easily be seen through the glass slide against the dark filter paper background. Such cages may conveniently be placed in controlled-humidity desiccators, or, in smaller units, within standard petri dishes.

**Diets.** Three foods, differing in the quality of their nutrients, were offered: 1. Peanut seeds (var. Virginia), representing a diet rich in protein and fat (according to GUGGENHEIM *et al.*, 1973, peanuts contain almost 27% proteins and about 44% fats). 2. Garlic cloves, representing a crop which is damaged by the mite in the field while also being a much poorer diet (containing 5% proteins and only 0.2% fats, loc. cit.). Both peanut seeds and garlic cloves also contain over 20% carbohydrates. 3. Black filter paper (Eaton Dikeman, as above), which contains only cellulose and an unidentified pigment. Observations (unpublished) have shown that *R. robini* develops (albeit rather slowly) on various types of filter paper, feeding on the cellulose. Peanut seeds and garlic were offered as very fine fragments which were replenished at least twice a week.
Experimental procedure. Each experiment (except with filter paper) was begun with 30-40 eggs of uniform age. Saturation humidity was maintained in all cages. Development on garlic was assayed at 16, 22, 27 and 35°C; on peanuts and filter paper only at 27°C. Upon eclosion individual females were isolated in cages, a single male was added, and each couple remained together throughout life. Longevity (of both sexes) and fecundity data were obtained on garlic and peanuts at 27°C, on the former diet also at 16°C. Egg hatch, immaturity and adult survival, duration of all stages and fecundity were daily recorded.

Separate mite batches, obtained either from the field or from laboratory cultures, were periodically examined to establish their sex ratio.

Computations. Survival of immatures was calculated as suggested by Varley et al. (1973). The effect of temperatures on development was
computed by using the equilateral hyperbola equation, which assumes that the product of development time and temperature above a certain threshold is a constant (the so-called “thermal constant” or $ThC$, BODENHEIMER, 1958). The parameters of the equilateral hyperbola ($ThC$ and $C$, the developmental threshold) are derived from the equation $ThC = 1/b$; $C = -a/b$, $a$ and $b$ being coefficients obtained from the regression of developmental rate on temperature. Life tables were constructed and calculated according to BIRCH (1948) and WATSON (1964); the simplified method of WYATT & WHITE (1977) was also tried. The latter was based on the observation that about 95% of the progeny of certain short-lived arthropods (aphids and tetranychid mites) were produced during the first few days of reproduction, usually in about 2d (d being number of days from birth to birth of first offspring). Number of progeny born during the 2d period ($Md$) was the product of age-specific survival, $l_d$, and age-specific fecundity, $m_d$ ($Md = \sum_{i=1}^{d} l_d m_d$). Intrinsic rate of increase may now be obtained from the expression $r_m = c (\log Md/d)$, where $c$ is a correcting factor. From their computations WYATT & WHITE (1977) concluded that $c = 0.74$ was appropriate for the arthropods noted above. They further showed that generation time, $T$, may be calculated from $d/c$, or $d/0.74$.

RESULTS

Immature stages. Development rate of $R. robini$ was accelerated from 16°C through 22°C to 27°C (Table 1), but declined at 35°C, indicating that this temperature is beyond the mite’s optimum. SEKIYA (1948) has already shown that the development of $R. echinopus$ was retarded at 33°C. Mites offered peanuts or garlic required about the same period to mature at 27°C (the former food imparting a slight advantage), but almost four times as many days on filter paper, (at the same temperature). The stages which suffered most mortality on filter paper, and on garlic at 16°C, were the larvae and protonymphs, while at 35°C these were again the larvae, and the eggs. At 22°C and 27°C, on the other hand, mortality was low and uniform during all stages, on peanuts as well as on garlic. The high, similar “adjusted survival” rates obtained under these circumstances (last column of Table 1) indicate that the latter were close to the mites’ optimal conditions.

The calculated threshold of development (obtained from the regression of developmental rate on temperature, Fig. 2) was at 11.8°C, and 184.8 day-degrees were required to reach adulthood.

Data recorded at 35°C were not used in this calculation.

<table>
<thead>
<tr>
<th>Food</th>
<th>Temperature (°C)</th>
<th>Eggs</th>
<th>Larvae</th>
<th>Proto-</th>
<th>Trito-</th>
<th>Total</th>
<th>Adjusted survival (Ls)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garlic</td>
<td>16</td>
<td>10.7</td>
<td>13.0</td>
<td>7.3</td>
<td>9.2</td>
<td>41.0</td>
<td>40.2 0.512</td>
</tr>
<tr>
<td></td>
<td>(40)</td>
<td>(32)</td>
<td>(24)</td>
<td>(21)</td>
<td>(10)</td>
<td>(9)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>5.7</td>
<td>6.5</td>
<td>4.6</td>
<td>4.4</td>
<td>21.6</td>
<td>19.2 0.794</td>
</tr>
<tr>
<td></td>
<td>(42)</td>
<td>(42)</td>
<td>(39)</td>
<td>(35)</td>
<td>(13)</td>
<td>(22)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>3.6</td>
<td>3.0</td>
<td>2.8</td>
<td>2.6</td>
<td>11.6</td>
<td>12.6 0.744</td>
</tr>
<tr>
<td></td>
<td>(38)</td>
<td>(38)</td>
<td>(38)</td>
<td>(38)</td>
<td>(21)</td>
<td>(17)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>3.4</td>
<td>3.5</td>
<td>4.2</td>
<td>4.1</td>
<td>15.2</td>
<td>15.2 0.360</td>
</tr>
<tr>
<td></td>
<td>(36)</td>
<td>(29)</td>
<td>(17)</td>
<td>(16)</td>
<td>(13)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peanuts</td>
<td>27</td>
<td>3.3</td>
<td>2.6</td>
<td>2.4</td>
<td>2.1</td>
<td>10.1</td>
<td>11.1 0.778</td>
</tr>
<tr>
<td>Filter</td>
<td>27</td>
<td>3.5</td>
<td>9.5</td>
<td>15.4</td>
<td>10.7</td>
<td>39.1</td>
<td>39.1 0.279</td>
</tr>
<tr>
<td>paper</td>
<td>(25)</td>
<td>(23)</td>
<td>(16)</td>
<td>(10)</td>
<td>(7)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Besides affecting rate of development (Table 1), the various nutrients also greatly influenced the dimensions of individuals which had fed on them.
FIG. 2: Effect of temperatures on the development rate and duration of *Rhizoglyphus robinii* reared on garlic.

\[ t(x-11.8) = 184.8 \]

\[ y = -0.0638 + 0.0054x \]

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Mites given peanuts attained, at maturity, almost twice the size of those offered filter paper; individuals on garlic were intermediate in this respect.

**Oviposition and longevity.** Mating (at 27°C) usually occurred as soon as adults had begun to feed, and often recurred (GERSON & THORENS, 1982). Females on peanuts began to oviposit one day after mating, those on garlic waited an additional day. Rate of oviposition rose very rapidly thereafter, peaking at about 40 eggs/females on the seventh day for peanut-feeding mites, at about 20 eggs/female, on the tenth day, for those offered garlic. Mean fecundity was 690 eggs/female on peanuts (range 277-935, the maximum deposited by a single female in one day being 53 eggs), close to 400 eggs/female on garlic (range 137-555, maximum for a single female in a single day, 33). Females kept on both diets oviposited during a similar period (Fig. 3). At 16°C oviposition began on the fifth day of adult life, its rate peaking during the second week (Fig. 4). Mean fecundity was 133 eggs/female, and the recorded maximum for a single female was 568. Some females, however, produced no eggs at all, and others oviposited less than a dozen. No eggs
were deposited by females which had developed on filter paper, with two exceptions. The males which had been placed with the latter females were found dead after one day, possibly killed by their mates. Each of these females subsequently deposited a single egg. This suggests that a minimal measure of fertility had been retained by these mites, notwithstanding their development under conditions of virtual starvation. Females raised and held at 35°C produced no eggs, indicating that they and/or the males were rendered infertile by the high temperature.

Total longevity of the two sexes was quite different. At 27°C, females on peanuts lived approximately 40 days, ovipositing for most of this period. The comparative males, remaining alone in the cages, survived an average of 73 days. On garlic the values were 31 and 62 days, respectively, and at 16°C some males remained alive for several months. On filter paper (27°C) and at 35°C (on garlic) adult longevity reached only 15.1 and 14.3 days, respectively.

Counts of laboratory-reared adults indicated that their sex ratio was 1 : 1; this is similar to the rate recorded for *Rhizoglyphus echinopus* (Woodring, 1969).

Life tables were constructed for mites maintained at 27°C and 16°C (Figs 3 and 4). The net reproduction rate (R$_0$), finite rate of increase ($\lambda$), intrinsic rate of increase ($r_0$) and mean generation time (T) were calculated by the conventional method; the latter two values were also computed according to the simplified procedure (Table 2).
### TABLE 2. Net reproduction rate (R$_0$), intrinsic rate of increase (r$_m$), finite rate of increase (À), mean generation time (in days) (T), number of days from birth of first birth (d) and effective number of progeny by day d (M$_d$) of Rhizoglyphus robini maintained at two temperatures on two diets. Values a-d calculated according to Birch (1948) and Watson (1964), values e-i according to Wyatt & White (1977).

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Diet</th>
<th>R$_0$</th>
<th>r$_m$</th>
<th>$\lambda$</th>
<th>T</th>
<th>d</th>
<th>M$_d$</th>
<th>T deviation</th>
<th>Percent of deviation</th>
<th>Percent of deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>16°C</td>
<td>Garlic</td>
<td>36.79</td>
<td>0.064</td>
<td>1.10</td>
<td>56</td>
<td>35.48</td>
<td>0.059</td>
<td>7.8</td>
<td>60.8</td>
<td>7.6</td>
</tr>
<tr>
<td>27°C</td>
<td>Garlic</td>
<td>134.47</td>
<td>0.218</td>
<td>1.24</td>
<td>22</td>
<td>82.26</td>
<td>0.218</td>
<td>—</td>
<td>20.3</td>
<td>9.7</td>
</tr>
<tr>
<td>27°C</td>
<td>Peanuts</td>
<td>257.63</td>
<td>0.285</td>
<td>1.33</td>
<td>19</td>
<td>125.40</td>
<td>0.298</td>
<td>4.6</td>
<td>16.2</td>
<td>16.8</td>
</tr>
</tbody>
</table>

### DISCUSSION

The threshold of development of *R. echinopus* was calculated by Kuznetsov & Tkatchuk (1972) to be 9.7°C, and an average of 180 day-degrees were therefore required to complete a generation. Our computed threshold (11.8°C) was well above the reported one, but the sum of day-degrees (184.8) was quite similar. Most authors who had studied *Rhizoglyphus* (Garmar, 1937; Kuznetsov & Tkatchuk, 1972; Sekiya, 1948; Woodring, 1969) noted that the egg stage may last for a third or even more of the entire immature period. Our results (Table 1) are in general agreement, except that larval and nymphal development became prolonged under adverse conditions, which did not affect the egg period.

Food quality had a marked effect on the development and fecundity of *R. robini* (Tables 1 and 2, Fig. 3). It also strongly affected the frequency of mating (Gerson & Thorens, 1982), as mites offered richer foods mated more frequently than those on poorer diets. The influence of food quality on changes in this mite's populations is thus made up of several components. These include survival of immatures, development time, mating frequency and thereby the length of time to first oviposition, and number of progeny produced (which may be affected by size of individuals which had grown on that diet, in addition to the latter's specific nutritive value). The compounded effect of these factors (and possibly others, such as male potency, not investigated in this context) probably causes great fluctuations in mite numbers under natural conditions. Another confusing factor could be the influence of poor nutrition. Results obtained with *R. robini* reared on filter paper suggest that were such starved mites to be offered richer foods, they could recover and produce viable progeny. However, the low immature survival rates as well as quite smaller bodies indicate that their populations would require at least another generation to recover.

Such considerations point at the need for precise definitions of diets on which polyphagous mites (such as *Rhizoglyphus*) are reared in life history studies. The rather variable development, longevity, fecundity and survival results which Czajkowska (1972) obtained upon offering 52 species of medicinal herbs to *R. echinopus* lend support to our contention. All this helps to explain the different results reported in some former life history studies (apart from taxonomic problems, as noted above). Life table parameters calculated from such variable data would also be rather variable.

The fecundity values of *R. robini* on garlic approximate those reported by Sekiya (1948), who reared *R. echinopus* on Allium bakeri (460 eggs/female at 24°C, 436 eggs/female at 27°C). They were however considerably higher than the value (109 eggs/female on gladiolus corms at 18-25°C) reported by Kuznetsov & Tkatchuck (1972, Table 6) for the same species. Woodring...
(1969), who kept *R. echinopus* on chopped fresh yellow mealworms (larvae of the beetle *Tenebrio molitor* L.), a diet presumably rich in proteins, obtained an average of 285 eggs/female, the maximum being 630. All these fecundity rates are well below the values reported herein for mites reared on peanuts, and even these values might have been higher had more than one male been placed with each female. Woodring (1969) noted that replacement of one male by another enhanced the fecundity of some (but not all) females.

The apparent sterility induced in mites reared at 35°C bears on results obtained by Gerson et al. (1981) while demonstrating control of *R. robini* in the soil by solar heating. Mites in these experiments were completely eliminated down to depths of 20 and 30 cm, where maximum temperatures reached 38°C. The data presented above indicate that mites which might have survived solar heating would probably have become infertile.

The prolonged periods of oviposition (Figs. 3 and 4) extend well over at least two, and possibly three, mite generations, thereby causing their overlapping. A single mated female may therefore raise a considerable population in its own lifetime. This could explain the large numbers of *R. robini* found on infested bulbs in the fields.

Kuznetsov & Tkatchuk (1972) reported that males lived somewhat longer than females (at 18-25°C), 38.2 days on the average as compared to 31.7 days (a difference of about 20%). In the present study males lived almost twice as long as females. As *R. robini* does not reproduce by parthenogenesis, prolonged male longevity increases the chances that virgin females, isolated in the soil, would meet their mates.

The *r*ₘ values obtained by the simplified Wyatt & White method (Table 2) for mites which had developed on peanuts and garlic at 27°C were quite similar to those calculated by conventional methods. At 16°C, and with the mean generation values, the results were too different to be acceptable. The deviation is probably due to the oviposition pattern of *R. robini*, which does not deposit 95% of its eggs during the 2d period. And yet, the good fit obtained in regard to *r*ₘ values suggests that this simplified method may have wider applicability than visualized by Wyatt & White (1977).

The present study has highlighted some attributes which facilitate the survival of *R. robini* in the soil. The mite can subsist and develop on a variety of diets, widely differing in their protein and fat contents. It may rapidly build up large populations in response to suitable foods. Males are long-lived and thereby enhance each female's chances to be fertilized. Other traits, such as response to natural foods available in the field and survival while immersed in water, will be discussed in a forthcoming paper.

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**REFERENCES**


HUGHES (A. M.), 1976. — The Mites of Stored Food and Houses. — Her Majesty's Stationery Office, 2nd Ed.


Paru en décembre 1983.