Morphologico-anatomical structure of leaves and demographic parameters of the hawthorn spider mite, *Tetranychus viennensis* Zacher and the two-spotted spider mite, *Tetranychus urticae* (Koch) (Acarina, Tetranychidae) on selected scab-resistant apple varieties

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**Abstract:** Among scab-resistant apple cultivars, good hosts for the hawthorn spider mite, *Tetranychus viennensis* Zacher, and for the two-spotted spider mite, *Tetranychus urticae* Koch (Acarina, Tetranychidae), were Novamac and Freedom, on the leaves of which the net reproduction rate (*R*ₙ) ranged between 20 and 26, while the worst hosts were the cvs. Primula, Pionier, and Lodel, on the leaves of which the *R*ₙ index ranged from 8.91 to 15.92.

1 Introduction


Studies on these species of spider mites were concentrated chiefly on their biology and occurrence on various host plants. Comparatively little attention was paid to the influence of apple or plum varieties on the biology of the mentioned species. Data on this subject can be found in papers by (Bielak, 1979; Skorupska and Boczek, 1984; Skorupska, 1993). In view of the fact that in breeding work, more and more attention is given now to resistant apple varieties, particularly to those resistant to the apple scab, it would be of interest to learn how spider mites multiply on these varieties.

The purpose of the present work was to examine the development rate of the hawthorn spider mite, *T. viennensis* Zacher, and two-spotted spider mite, *T. urticae* (Koch), on selected scab-resistant apple varieties, as well as to make attempts in determining whether the leaf anatomy and morphology of these apple varieties can influence the development of the spider mite species mentioned above.

2 Materials and methods

Five out of many scab-resistant apple varieties were selected as a result of preliminary tests. The selected varieties showed the traits of resistance or susceptibility to damage caused by the hawthorn spider mite, *T. viennensis*, and two-spotted spider mite, *T. urticae*.

The cvs. Primula, Pionier, and Lodel are Polish, while the cv. Novamac is French and the cv. Freedom is Canadian. In the studies on the influence of these apple varieties on the life longevity, fecundity and development of spider mites we applied the method of mite rearing on 1.5 cm² leaf discs which were placed on wet cotton in Petri dishes. The experiments were carried out on the laboratory at room temperature. The life longevity tests were performed on 1-day-old males and females, placed in pairs (10) on the leaf discs, whereas tests on the development of spider mites were conducted on 1-day-old eggs, the initial number of eggs being different. The tests were checked every day and the leaves exchanged each 7 days. All the experiments were performed in three replications during one season. The following demographic parameters were determined: life longevity of males and females; net reproduction rate (*R*ₙ); mean time of a generation development (*T*); rate of population increase (*rₘ*); finite rate of increase (*λ*).

These calculations were made according to the method of Andrewartha and Birch (1954). Then, analysis of variance was performed for these indices as well as the Student’s *t*-test. The mean leaf area of the studied apple varieties was obtained using the weight method by measuring 100 leaves of each variety. The number of stomata was calculated by imprinting the bottom leaf side in plastic and then counting them per cm² area (10 replications). The number of hairs was counted on the 4 mm² area under a microscope and recalculated per cm². The thickness of spongy and palisade parenchyma, as well as that of the entire leaf, was obtained by making 15 μm paraffin
cuttings (according to Gerlach, 1969), using microscopic slides to measure their thickness.

The results were subjected to analysis of variance and to the Student’s t-test.

3 Results
3.1 Demographic parameters
All the leaves of the studied apple varieties appeared to be good hosts for the hawthorn spider mite and two-spotted spider mite.

The life length of males of the mentioned spider mite species on these apple varieties showed no significant differences. Males of both species lived the longest on Novamac (31.7 and 31.5 days), respectively (tables 1, 2). The lifetime of females of the hawthorn spider mite on the selected apple varieties showed no significant differences either. Females of the hawthorn spider mite lived longest on Freedom (41.9 days) and shortest on Primula (38.1 days) (table 1). Longevity of life of the two-spotted spider mite females on the same apple varieties showed significant differences, particularly between Primula (35.2 days), Novamac (45.8 days), and Freedom (45.2 days) (table 2).

The best host variety for the hawthorn spider mite and for the two-spotted spider mite appeared to be Novamac, on the leaves of which these spider mites multiplied their population 26- and 22.7-fold, respectively, during 27.4 days. The least suitable apple varieties for the hawthorn spider mite appeared to be Primula, where this mite multiplied its population 11-fold during 26.4 days, and Pionier (11.4-fold during 27 days). The worst varieties for the two-spotted spider mite also appeared to be Primula, where this mite multiplied its population 10.2-fold during 26.5 days, (on Pionier, this was 8–9-fold during 26.4 days).

The rate of population increase (rm) for both spider mite species showed significant differences (the lowest were on Primula and Pionier, and the highest on Novamac).

Significant differences for both species of spider mites were found in the finite rate of increase (λ) (the lowest values were on Primula, and the highest on Novamac) (tables 1 and 2).

A comparison of demographic indices on each apple variety separately for the hawthorn spider mite and the two-spotted spider mite showed that such indices do not differ significantly for either species of spider mites, except for the length of life of females on Novamac and the index of net reproduction rate (R0) on Lodel.

On the basis of the performed studies it may be inferred that the best host apple varieties for the hawthorn spider mite and the two-spotted spider mite were Novamac and Freedom, while the worst ones were Primula and Pionier.

3.2 Comparison of anatomico-morphological structures of leaves of studied apple varieties
Trying to find an answer to the question why certain varieties and not others were the best or the worst hosts for spider mites, we compared anatomico-morphological structure of leaves of the studied apple varieties and found significant differences in all the components of this structure.

The average leaf area was the largest in Freedom (40.2 cm²) the smallest in Lodel (15.5 cm²) and Pionier (20.9 cm²), while Primula and Novamac had similar leaf areas and did not differ significantly.

The number of stomata cm⁻² of the bottom side of leaf may have an influence on the susceptibility of apple varieties to both species of spider mites. Novamac and

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### Table 1. Demographic parameters for the hawthorn spider mite, T. viennensis on five scab-resistant apple varieties

<table>
<thead>
<tr>
<th>Apple varieties</th>
<th>Longevity</th>
<th>( R_0 )</th>
<th>( T )</th>
<th>( rm )</th>
<th>( \lambda )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primula</td>
<td>Males</td>
<td>Females</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28.5 a</td>
<td>38.1 a</td>
<td>11.1 a</td>
<td>26.4 a</td>
<td>0.0932 a</td>
<td>1.0978 a</td>
</tr>
<tr>
<td>Pionier</td>
<td>29.5 a</td>
<td>40.1 a</td>
<td>11.4 a</td>
<td>27.1 a</td>
<td>0.0877 a</td>
</tr>
<tr>
<td>Lodel</td>
<td>31.3 a</td>
<td>40.1 a</td>
<td>15.9 a</td>
<td>26.3 a</td>
<td>0.1056 a</td>
</tr>
<tr>
<td>Novamac</td>
<td>31.7 a</td>
<td>40.6 a</td>
<td>26.0 c</td>
<td>27.5 a</td>
<td>0.1195 b</td>
</tr>
<tr>
<td>Freedom</td>
<td>31.1 a</td>
<td>41.9 a</td>
<td>20.6 bc</td>
<td>27.3 a</td>
<td>0.1127 ab</td>
</tr>
</tbody>
</table>

The same letters in columns indicate no statistical difference between the varieties.

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### Table 2. Demographic parameters for the two-spotted spider mite, T. urticae, on five scab-resistant apple varieties

<table>
<thead>
<tr>
<th>Apple varieties</th>
<th>Longevity</th>
<th>( R_0 )</th>
<th>( T )</th>
<th>( rm )</th>
<th>( \lambda )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primula</td>
<td>Males</td>
<td>Females</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24.8 a</td>
<td>35.2 a</td>
<td>10.2 a</td>
<td>26.5 a</td>
<td>0.0842 a</td>
<td>1.0879 a</td>
</tr>
<tr>
<td>Pionier</td>
<td>29.7 a</td>
<td>38.3 ab</td>
<td>8.9 a</td>
<td>26.3 a</td>
<td>0.0788 a</td>
</tr>
<tr>
<td>Lodel</td>
<td>29.9 a</td>
<td>42.4 ab</td>
<td>12.4 ab</td>
<td>27.2 a</td>
<td>0.0884 ab</td>
</tr>
<tr>
<td>Novamac</td>
<td>31.5 a</td>
<td>45.8 b</td>
<td>22.6 c</td>
<td>27.4 a</td>
<td>0.1138 c</td>
</tr>
<tr>
<td>Freedom</td>
<td>30.7 a</td>
<td>45.2b</td>
<td>20.3 bc</td>
<td>27.9 a</td>
<td>0.1085 bc</td>
</tr>
</tbody>
</table>

The same letters in columns indicate no statistical difference between the varieties.
Freedom have the largest number of stomata (over 50,000) and are simultaneously the best plant hosts for both mite species.

The number of hairs · cm⁻² of the bottom leaf side for these varieties differed significantly, but did not correlate with the demographic parameters of the mentioned spider mites.

The thickness of spongy parenchyma was smallest in Primula (63.8 μm). This was comparable to the thickness of palisade parenchyma which was smallest in Primula (72.4 μm) and Lodel (75.9 μm), and largest in Novamac (107.4 μm) and Freedom (119.2 μm). This is affected largely by the ease in finding food for both spider mite species which, as it is known, feed chiefly on spongy and palisade parenchyma cell contents (table 3).

The obtained results indicate that multiplication of the hawthorn spider mite is significantly influenced by the number of stomata on the bottom side of leaf and by the thickness of spongy and palisade parenchyma, as well as by the entire leaf thickness.

### 4 Discussion

In view of the fact that, up till now, studies of the biology of the hawthorn spider mite T. viennensis, and two-spotted spider mite T. urticae, have been concerned mainly with species, but not varieties, of host plants (Müller, 1957; Ljus, 1966; Šatto, 1970; Dąbrowski, 1974; Ferro and Chapman, 1979; Everson, 1980; Götoh, 1985), it is impossible to compare demographic parameters for apple varieties. Only a few studies were conducted on selected apple varieties for the hawthorn and two-spotted spider mites (Skorup ska and Boczek, 1984; Skorup ska, 1993). After comparison of the hawthorn spider mite demographic parameters on such cultivars as McIntosh, Malinowa Oberlandzka, Inflanka, Cortland, Kronselska, Starking, Antonowka, and on the presently studied cultivars, it was found that the longevity of males and females was 2.4- and 1.5-fold higher, respectively, on Primula, Pionier, Lodel, Novamac, and Freedom. The index of the net reproduction rate (R₀) was mostly similar in both groups of apple cultivars, except Novamac and Freedom, where it was essentially higher. The time of generation development (T) was, on average, 1.8-fold lower on scab-resistant apple cultivars than on those studied by Skorup ska and Boczek (1984), whereas the rate of population increase (rm) was 1.8-fold higher on these apple varieties. The index of finite rate of increase (λ) showed no differences between these two groups of cultivars (Skorup ska and Boczek, 1984).

When comparing parameters of the hawthorn spider mite on the studied cultivars with those of the apple spider mite on the cvs. Wealthy, Inflanka, Malinowa Oberlandzka, Antonowka, Cortland, Jonathan, Landsberska, Red Delicious and Bancroft, it was found that the average longevity of males and females, as well as the net reproduction rate index (R₀) was 2.4-, 1.6- and 2.9-fold higher, respectively, in the hawthorn spider mite than in the apple spider mite. The index of the finite rate of increase (λ) was on average 1.3-fold lower for the hawthorn spider mite than for the apple spider mite, except for Jonathan (which was similar to Lodel) (Skorup ska, 1993).

Generally, it may be assumed that adult individuals of the hawthorn spider mite lived longer on the studied scab-resistant apple cultivars and almost is doubled their population during that time in comparison to the previously studied apple cultivars. With regard to the two-spotted spider mite, its reproduction has yet to be studied on the apple cultivars discussed previously, whereas on scab-resistant varieties differences between the both species of spider mites were insignificant.

### Acknowledgement

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### References


Ferro, D.; Chapman, R., 1979: Effect of different constant
humidities and temperatures on two-spotted spider mite egg hatch. Env. Ent. 8, 701-705.


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