

## POPULATION PARAMETERS AS AN INDICATOR OF SUSCEPTIBILITY OF ORNAMENTAL CONIFEROUS PLANTS TO SPRUCE SPIDER MITE

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**Abstract:** Bionomy of spruce spider mite (SSM) (*Oligonychus ununguis* Jacobi) on five species/cultivars of spruce and two species of cypress was studied under laboratory conditions during two consecutive growing seasons. The study showed influence of host-plant food on development time, fecundity and longevity of SSM. The comparison of intrinsic rate of natural increase ( $r_m$ ) indicates the highest reproduction potential of SSM on *Picea pungens* (0.18), *P. abies* 'Nidiformis' (0.17), and *P. glauca* 'Conica' (0.14). SSM had much lowest  $r_m$  on *P. omorica* (0.08) and *P. abies* 'Virgata' (0.01). The reproductive potential of SSM on tested species of cypresses was similar: 0.12 and 0.10 on *Chamaecyparis lawsoniana* 'Golden Wonder' and *C. pisifera* 'Nana Aureovariegata', respectively. The results obtained clearly indicate that the population parameters can be a proper indicator of relative susceptibility/resistance of commercially available species/cultivars of spruce and cypress plants to SSM.

**Key words:** spruce spider mite, *Oligonychus ununguis*, conifers, spruce, cypress, population parameters, resistance

### INTRODUCTION

The spruce spider mite (SSM) (*Oligonychus ununguis* Jacobi) is one of the most destructive conifer-feeding pests in many countries of Europe, Asia and North America (Peterson and Hildahl 1969; Loyttyneimi 1970; Boyne and Hain 1983; Godoh 1984). Heavy infested coniferous plants can result in twig browning and premature death (Sierpiński 1972; Godoh 1984; Bogatko et al. 1986; Łabanowski and Orlikowski 1997; Łabanowski et al. 2001). There are few studies demonstrating that development time, fecundity, and survival of SSM depends on its host-plant species/cultivar (Saito 1979; Przygoda 2001; Kiełkiewicz et al. 2002; Czajkowska and Puchalska 2002). However, numerous studies have reported that the life his-

tory of *O. ununguis* is markedly influenced by weather conditions (Steward and Peterson 1960; Peterson and Hildahl 1969; Loyttyneimi 1970; Boyne and Hain 1983; Kaczmarek 1985). Boyne and Hain (1983) noticed that the reproductive potential of *O. ununguis* is more affected by temperature than showers and even heavy rains.

In Poland, commercially available ornamental coniferous plants, come from nursery gardens. Czajkowska et al. (2001) tested 68 taxons of ornamental coniferous, with respect to the presence of SSM. Regardless of nursery location, the highest density of *O. ununguis* was found on spruces: *P. glauca* 'Conica', *P. abies* 'Nidiformis' and *P. pungens*. High degree of infestation of plants of *Chamaecyparis* genus (*C. pisifera* 'Filifera') was also noticed. Those results confirm observations of other authors (Łabanowski and Orlikowski 1997) and suggest that both, spruce and cypress are attractive as host-plants to SSM.

The aim of the present study was: (1) to compare bionomy of SSM on various cultivars/species of spruces and cypresses, in controlled temperature and humidity conditions, and (2) to indicate relatively susceptible/resistant species/cultivars among tested plants based on the life-history of SSM.

## MATERIAL AND METHODS

Bionomy of spruce spider mite (SSM) (*Oligonychus ununguis* Jacobi) was studied on five species/cultivars of spruce (*Picea glauca* 'Conica', *P. abies* 'Nidiformis', *P. abies* 'Virgata', *P. pungens*, *P. omorica*) and two species of cypress (*Chamaecyparis lawsoniana* 'Golden Wonder', *C. pisifera* 'Nana Aureovariegata') during two consecutive growing seasons. The plant material was collected in the Botanical Garden in Powsin and Park Ursynowski in Warsaw. In the first of two experimental series, 5–8 cm long twigs were cut and placed in plastic boxes filled with water and 2–3 females were placed on each twig. After 24 hours, the females were removed and the eggs were counted. Development time (from egg to mature specimen), mortality during development and percentage of males and females in population were calculated on the basis of observation of 200 eggs (20 eggs were treated as one replicate). In the second series, one-day old mature specimens were placed in couples, each couple on a separate twig. Each replicate consisted of 25 females. Every two days, eggs laid by the females were counted and removed. Old twigs were replaced with fresh ones as needed. The observations were carried out until the death of the last specimen. All experiments were conducted in environmentally controlled chamber (L:D = 16/8h; temperature: 25°C/20°C; RH: 60%). The data obtained reflect reproductive potential of the SSM. They were used for calculation of population parameters of *O. ununguis* [ $r_m$  (day<sup>-1</sup>) – intrinsic rate of natural increase,  $R_0$  – net reproduction rate,  $T$  – average period of development of one generation,  $\lambda$  – finite rate of natural increase] according to the formula given by Andrewarth and Birch (1954).

Significance of differences between the mean values was assessed by a non-parametric H Kruskal-Wallis test ( $p=0.05$ ).

## RESULTS AND DISCUSSION

It has been found that SSM underwent its full developmental cycle on cut twigs of spruces and cypresses chosen for the experiments (Tab. 1). However, its period differed from 12.3 days (*P. pungens*) to 17.2 days (*C. pisifera* 'Nana Aureovariegata'). The average development time on spruces (*P. pungens*, *P. abies* 'Nidiformis', *P. glauca* 'Conica'), with the exception of *P. abies* 'Virgata' and *P. omorica*, was similar and lasted 12.3, 13.4 and 12.9 days, respectively. Similar results were noticed by Boyne and Hain (1983) – the average development time of *O. ununguis* on fir (*Abies* spp.) was equal 14.3 days. On both tested species of cypress, development time of the mites was ca 4 days longer in comparison to spruces.

On all tested conifers, females constituted 74 % of the population (Tab. 1). The highest age-specific mortality of the spruce spider mite was observed on *P. abies* 'Virgata' (87%) (Tab. 1). It was almost 4 times higher than on *P. glauca* 'Conica' (20.6%) and *P. abies* 'Nidiformis' (21%). The results obtained in the present investigations correspond with the ones reported by Przygoda and Czajkowska (2001). The authors also reported higher mortality of *O. ununguis* on *P. omorica* in comparison with *P. pungens*.

Life-time fecundity of SSM on spruces: *P. glauca* 'Conica', *P. pungens*, *P. abies* 'Nidiformis', and cypresses: *C. Lawsoniana* 'Golden Wonder' and *Ch. pisifera* 'Nana Aureovariegata' was markedly higher (from 27.4 to 36.6 eggs/female) in comparison with fecundity of females on *P. abies* 'Virgata' (7.4 eggs/female) and *P. omorica* (14.9) (Tab. 1). It suggests significant differences in attraction of tested conifers as hosts to *O. ununguis*. In the experiment of Boyn and Hain (1983), females on fir (*A. fraseri*) lived about 10 days and, during that time, laid on average 27.8 eggs.

The present study also showed a relation between the numbers of eggs laid and the age of the female (Figs. 1a, 2a). The females started laying eggs about 24 hours

Table 1. Comparison of selected bionomy parameters of *O. ununguis* on different ornamental coniferous plants

Species/cultivar	Total fecundity (n=25) x±SD	Longevity (days) (n=25) x±SD	Development time (days) (n=10) x±SD	Mortality (%) x±SD	Female (%) x±SD	Male (%) x±SD
<i>P. glauca</i> 'Conica'	27.4±7.6 bc	9.2±2.3 bc	12.9±0.7 ab	20.6	75.6	22.3
<i>P. pungens</i>	31.9±5.2 cd	14.4±0.9 e	12.3±0.9 a	15.5	74.0	26.0
<i>P. omorica</i>	14.9± 8.6 a	15.6±6.9 cde	15.4±0.7 c	32.5	66.5	33.5
<i>P. abies</i> 'Nidiformis'	30.7±15.3 bcd	8.1±4.2 ab	13.4±0.4 b	21.0	70.0	30.0
<i>P. abies</i> 'Virgata'	7.4±3.3 a	5.3±1.2 a	14.9±3.6 abc	87.0	100.0	0.0
<i>C. lawsoniana</i> 'Golden Wonder'	36.6±10.1 cd	13.2±1.8 d	17.1±0.3 d	44.5	71.5	28.5
<i>C. pisifera</i> 'Nana Aureovariegata'	23.8±4.8 b	11.1±1.2 c	17.2±0.5 d	50.0	70.7	29.3
H test	101.41	103.5	51.7			
P	<0.0001	<0.0001	<0.0001			

Means in columns marked with different letters differ significantly (Kruskal-Wallis test, p=0.05)



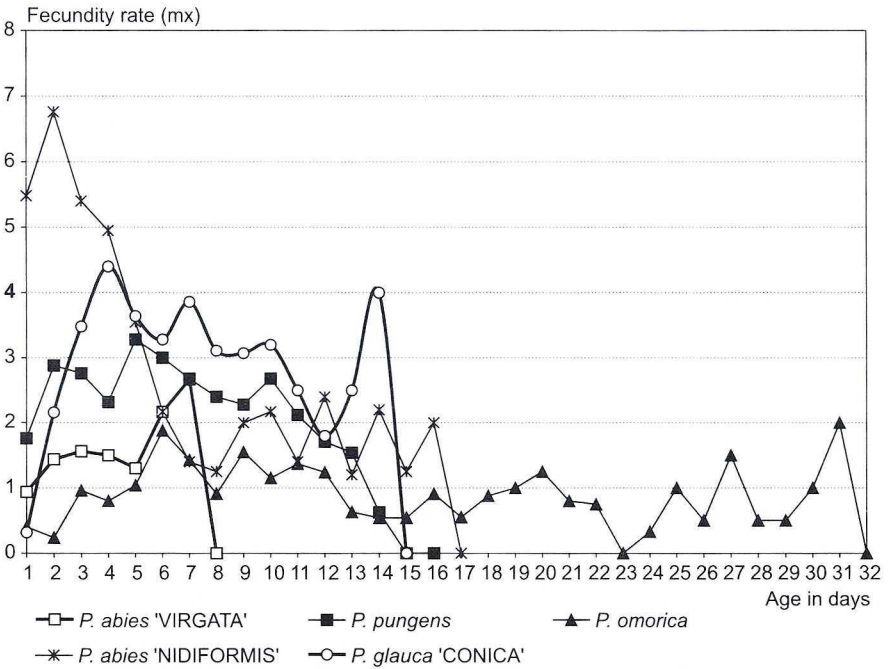


Fig. 1 a. Comparison of age-specific fecundity rate ( $m_x$ ) of *O. ununguis* on five spruce species

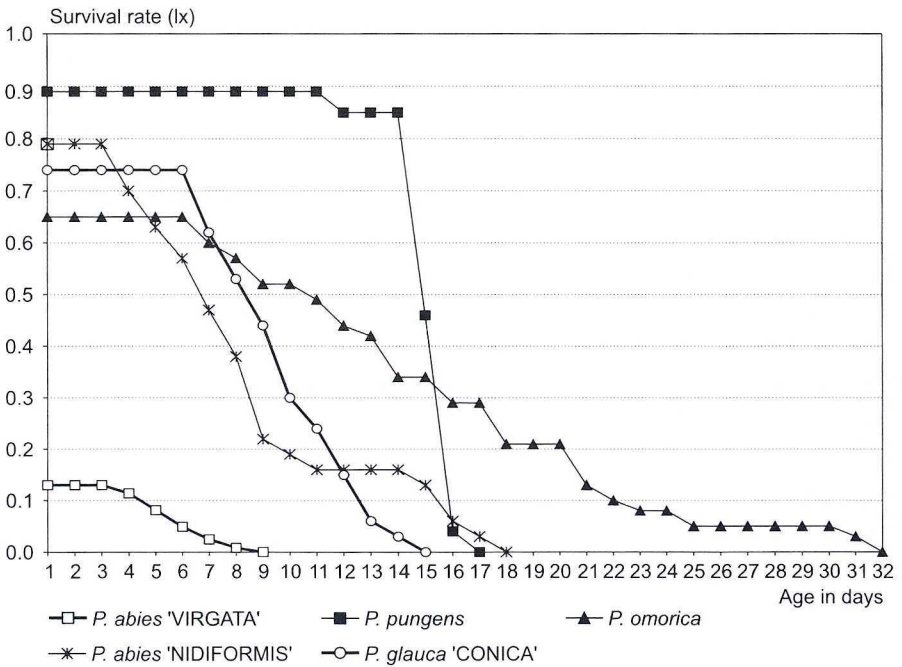


Fig. 1 b. Comparison of age-specific survival rate ( $l_x$ ) of *O. ununguis* on five spruce species

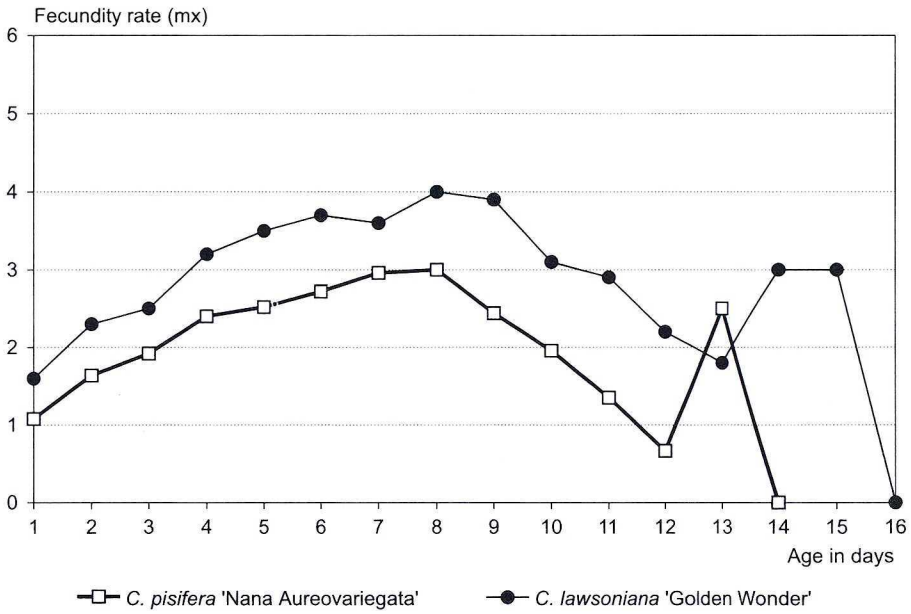


Fig. 2 a. Comparison of age-specific fecundity rate ( $m_x$ ) of *O. unguis* on two species of cypress

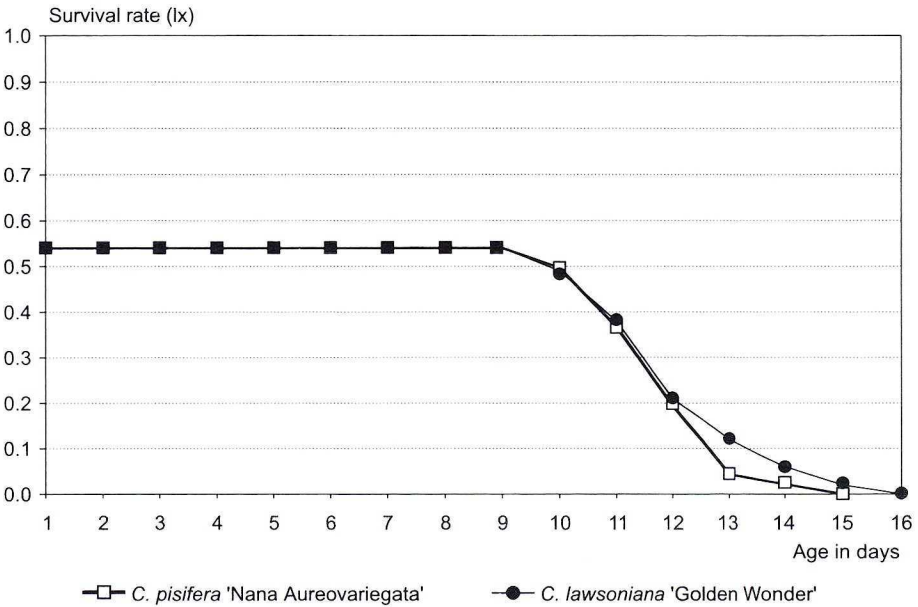


Fig. 2 b. Comparison of age-specific survival rate ( $l_x$ ) of *O. unguis* on two species cypress

Table 2. Population parameters of *O. ununguis* in dependence upon species/cultivar of ornamental coniferous plants

Species/cultivar	$r_m$	$l$	$R_o$	T
<i>P. glauca</i> 'Conica'	0.14	1.15	16.22	19.31
<i>P. pungens</i>	0.18	1.19	19.86	16.69
<i>P. omorica</i>	0.08	1.08	6.19	22.50
<i>P. abies</i> 'Nidiformis'	0.17	1.19	17.02	16.31
<i>P. abies</i> 'Virgata'	0.01	0.99	0.90	18.40
<i>C. lawsoniana</i> 'Golden Wonder'	0.12	1.13	17.41	22.95
<i>C. pisifera</i> 'Nana Aureovariegata'	0.09	1.10	9.52	22.86

after coupling. The second maximum of laying the eggs was observed at the end of the second week. However, the females were much less fertile than in the first week.

The survival rate of females on the tested conifers was different (Figs. 1b, 2b). The first dead females were observed on *P. abies* 'Nidiformis' and 'Virgata' after 3 days and, on *P. glauca* 'Conica' and *P. omorica* after 6 days. On both species of cypress, all females lived 9 days, and on *P. pungens* as long as 14 days. The longevity of females varied, depending on species/cultivar, from 9 days (*P. abies* 'Virgata') to 32 days (*P. omorica*) (Fig. 1b). The data obtained and the results of previous observations (Czajkowska et al. 2001; Przygoda 2001) confirm that *O. ununguis* prefers certain species/cultivars of spruce and cypress more than others.

The intrinsic rate of natural increase ( $r_m$ ) is usually used as an indicator of spider mite performance (Sabelis 1985). The values of  $r_m$  of *O. ununguis* after feeding on the tested conifers varied significantly (Tab. 2). The highest values of  $r_m$  SSM reached on *P. pungens*, *P. abies* 'Nidiformis' and *P. glauca* 'Conica', where  $r_m$  was equal 0.18, 0.17 and 0.14, respectively. A similar value of  $r_m$  was obtained by Boyne and Hain (1983) for SSM on fir ( $r_m = 0.167$ ). A much higher value of  $r_m$  was found on *P. pungens* and *P. glauca* (0.202) (Przygoda and Czajkowska 2001). A much lower value of  $r_m$  (0.12) was obtained by the mite on *Ch. lawsoniana* 'Golden Wonder', and the lowest one on *Ch. pisifera* 'Nana Aureovariegata' and on *P. omorica* and *P. abies* 'Virgata', and it was equal 0.10, 0.08 and 0.01, respectively.

The mean generation time for the *O. ununguis* population on the *P. omorica* and both species of cypresses was similar ( $T=22.5$  and  $22.9$  days), it is possible to compare the  $R_o$  values obtained (Tab. 2). During development of a single generation, population of the mite on cypress – *Ch. lawsoniana* multiplied 17-fold ( $R_o=17.4$ ), whereas on *Ch. pisifera* 9-fold ( $R_o=9.5$ ), and on spruce – *P. omorica* only 6-fold ( $R_o=6.2$ ). On the other hand, similar generation time of *O. ununguis* on the remaining conifers, except the 'Conica' spruce, allows a comparison of the  $R_o$  values obtained on those plants. The data shown in table 2 prove that population density of SSM increased during the development of one generation much faster on *P. pungens* (19.9 times) and *P. abies* 'Nidiformis' (17.0 times), than on *P. abies* 'Virgata' (only 0.9 times). The presented results indicate clearly that the lowest population parameters of *O. ununguis* were obtained while feeding on *P. abies* 'Virgata' and *P. omorica*. To conclude, only those two spruces show a relatively low susceptibility to the spruce spider mite.

## CONCLUSIONS

1. Regardless of the species/cultivar of tested spruces and cypresses, *O. ununguis* underwent its full developmental cycle on cut twigs.
2. Population parameters showed a higher reproductive potential of SSM on *P. glauca* 'Conica', *P. abies* 'Nidiformis', *P. pungens* and on *C. lawsoniana* 'Golden Wonder' than on the remaining conifers (*P. abies* 'Virgata' and *P. omorica*).
3. The high reproductive potential of *O. ununguis* on the above-mentioned species/cultivars of conifers reflects their relatively high susceptibility to SSM.
4. Low values of the intrinsic rate of natural increase of *O. ununguis* on *P. omorica* and *P. abies* 'Virgata' indicate significant resistance of those plants to SSM.
5. *P. omorica* and *P. abies* 'Virgata' infested by small populations of *O. ununguis* did not lose their ornamental value, and they can be planted in towns (in parks, in the area of office buildings, in household gardens).

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## POLISH SUMMARY

### PARAMETRY POPULACYJNE JAKO WSKAŹNIK PODATNOŚCI/ODPORNOŚCI OZDOBNYCH ROŚLIN IGLASTYCH NA ŻEROWANIE PRZĘDZIORKA SOSNOWCA (*OLIGONYCHUS UNUNGUIS* JACOBI)

Badano biologię przędziorka sosnowca (*Oligonychus ununguis* Jacobi) na świerku białym 'Conica' (*Picea glauca* 'Conica'), świerku pospolitym 'Nidiformis' i 'Virgata' (*P. abies* 'Nidiformis', *P. abies* 'Virgata'), świerku kłującym (*P. pungens*) i świerku serbskim (*P. omorica*) oraz na cyprysiku Lawsona 'Golden Wonder' (*Chamaecyparis lawsoniana* 'Golden Wonder') i cyprysiku groszkowym 'Nana Aureovariegata' (*Ch. pisifera* 'Nana Aureovariegata'). Uzyskane dane charakteryzujące potencjał rozrodczy przędziorka sosnowca (czas rozwoju, śmiertelność stadiów rozwojowych, płodność, i długość życia) posłużyły do opracowania parametrów rozwoju populacji na w/w roślinach iglastych. Wykazano, że najwyższe wartości wskaźników rozwoju populacji *O. ununguis* uzyskał na świerku – *P. pungens* ( $r_m = 0,18$ ,  $R_0 = 19,9$ ), *P. abies* 'Nidiformis' ( $r_m = 0,17$ ,  $R_0 = 17,0$ ), *P. glauca* 'Conica' ( $r_m = 0,14$ ,  $R_0 = 16,2$ ) i cyprysiku Lawsona – *Ch. lawsoniana* 'Golden Wonder' ( $r_m = 0,12$ ,  $R_0 = 17,4$ ). Dane te świadczą o znacznej podatności tych iglaków na żerowanie przędziorka sosnowca. Niskie wartości wrodzonego tempa rozwoju populacji ( $r_m$ ) i tempa reprodukcji netto ( $R_0$ ) uzyskane dla przędziorka żerującego na *P. abies* 'Virgata' ( $r_m = 0,01$ ,  $R_0 = 0,9$ ) i *P. omorica* ( $r_m = 0,08$ ,  $R_0 = 6,2$ ) wskazują na relatywną odporność świerka pospolitego odm. 'Virgata' i świerka serbskiego na żerowanie tego roztocza.