

Table 5. Average density of mites (specimens/100 leaves) depending on the study site

Study site	Tetranychidae		Phytoseiidae	
	Average ±SE		Average ±SE	
PPN 1	21.30 ±3.12	ab	8.50 ±1.14	a
PPN 2	36.23 ±5.11	ab	8.17 ±1.50	a
PPN 3	34.30 ±3.72	ab	8.50 ±1.12	a
PPN 4	17.27 ±1.98	a	7.33 ±1.04	a
Puławy 1	47.65 ±10.72	ab	7.35 ±1.87	a
Puławy 2	75.88 ±21.63	b	9.42 ±1.60	a
Puławy 3	61.50 ±12.50	b	6.96 ±1.09	a
Puławy 4	31.15 ±5.48	ab	9.35 ±1.75	a

Mean values in columns marked with different letters differ significantly

specimens/100 leaves. However these differences were not statistically significant (Table 6).

4. Discussion

During the present study a dependence between the number of mites from the Tetranychidae family and the area of study was observed. The densities of spider mites on oaks subjected to air pollution near the Zakłady Azotowe in Puławy were significantly higher than on the trees growing in the Polesie National Park. This finding confirms numerous results of studies which showed that the condition of the natural environment influences the numbers of herbivorous arthropods. Usually in a polluted environment the number of herbivorous arthropods with piercing-sucking mouthparts increases (Chudzicka 1979; Czechowska et al. 1979; Kropczyńska-Linkiewicz et al. 1990; Cichocka et Goszczyński 1991; Cichocka et al. 1998; Tykarska, 2001; Jaśkiewicz, 2006; Mackoś 2010; Lubiaryz et al. 2011; Lubiaryz et Solski 2012; Mackoś-Iwaszko 2012; Lubiaryz 2013). As proven by Kropczyńska et al. (1988), a higher level of environmental pollution in urban areas had a positive impact on demographic parameters of *Eotetranychus tiliarium* (Hermann 1804). Cichocka et al. (1990a) observed more abundant spider mite populations in trees lining the streets than in city parks and forests. According to the above mentioned authors, environmental pollution may endanger oaks and lindens by providing favourable conditions for abundant occurrence of spider mites. The authors suggest some methods of eradicating these pests but only in the trees growing beside the streets (Cichocka et al. 1990a).

Previous works (Lubiaryz et Cichocka 2005; Lubiaryz 2013) have shown an increase in nitrogen content in the leaves of the studied oaks growing in the vicinity of the Zakłady Azotowe in comparison to the Polesie National Park. It was the most probable cause of an increased number of spider mites in Puławy. A similar phenomenon was observed by Kropczyńska-Linkiewicz (1984) on linden trees in Warsaw. Also Sahajdak et al. (1995) noted the effect of industrial pollution on aphids and mites (Tetranychidae, Eriophyoidea) on the apple tree (*Malus* sp.), raspberry (*Rubus* sp.), tansy (*Tanacetum vulgare* L.) and the wormwood (*Artemisia campestris* L.). In the proximity of industrial plants (Huta Warszawa, Cementownia Warszawa, Elektrociepłownia Żerań, Zakłady Azotowe in Puławy, Petrochemia in Płock), considerably higher numbers of aphids, Eriophyoidea and spider mites were noted than in the control site (Sahajdak et al. 1995). Also Kielkiewicz et al. (1997) noted the effect of pollution on the occurrence of Eriophyoidea on the tansy and the wormwood in the proximity of such industrial plants as Rafineria Płock, Zakłady Azotowe in Puławy, Elektrociepłownia Żerań and Huta Warszawa. In sites located close to those plants the abundance of Eriophyoidea was several times higher than in the control site. It was also noted that the highest densities of Eriophyoidea occurred in the proximity of Elektrociepłownia Żerań, where the highest soluble protein and carbohydrate contents were discovered in wormwood leaves (Kielkiewicz et al. 1997).

The research by Kropczyńska-Linkiewicz (1984) indicates that the number of predatory mites between 0.1–1.0 specimen/leaf was sufficient to maintain the spider mites population on linden trees in urban conditions at a low level. The obtained results allow a conclusion that despite the fact that on the

Table 6. Average density of mites (specimens/100 leaves) depending on the study site and the year of the study

Study site and year of the study	Tetranychidae		Phytoseiidae		
	Average ±SE		Average ±SE		
PPN 1	2002	8.70 ±2.46	a	4.70 ±1.66	a
	2003	32.50 ±5.70	a	14.50 ±3.08	a
	2004	22.70 ±4.85	a	6.30 ±0.94	a
PPN 2	2002	22.00 ±4.47	a	4.60 ±1.39	a
	2003	40.80 ±10.22	a	13.50 ±3.66	a
	2004	45.90 ±9.60	a	6.40 ±1.18	a
PPN 3	2002	39.60 ±9.20	a	7.80 ±2.66	a
	2003	34.90 ±5.03	a	10.20 ±1.62	a
	2004	28.40 ±4.07	a	7.50 ±1.37	a
PPN 4	2002	13.60 ±3.45	a	7.70 ±1.81	a
	2003	20.40 ±3.77	a	8.10 ±2.23	a
	2004	17.80 ±3.05	a	6.20 ±1.40	a
Puławy 1	2002	77.14 ±31.26	a	9.14 ±5.37	a
	2003	53.44 ±11.63	a	10.67 ±2.87	a
	2004	21.80 ±10.96	a	3.10 ±1.33	a
Puławy 2	2002	145.57 ±70.75	a	12.86 ±4.72	a
	2003	60.44 ±20.46	a	8.67 ±1.76	a
	2004	41.00 ±13.09	a	7.70 ±2.06	a
Puławy 3	2002	64.43 ±21.49	a	8.00 ±2.45	a
	2003	56.44 ±22.43	a	5.78 ±1.28	a
	2004	64.00 ±22.53	a	7.30 ±2.07	a
Puławy 4	2002	38.86 ±14.24	a	12.00 ±4.01	a
	2003	21.33 ±5.74	a	6.67 ±1.67	a
	2004	34.60 ±8.96	a	9.90 ±3.31	a

Mean values in columns marked with the same letter do not differ significantly

studied oaks Phytoseiidae reached the bottom level of abundance given by Kropczyńska-Linkiewicz (1984), they were not always capable of maintaining the spider mite population at a low level, especially in the sites situated in Puławy. The development of Phytoseiidae population is not as dependent on the level of environmental pollution and environmental conditions, as it is in the case of development of spider mites (Kropczyńska-Linkiewicz 1984). Similar data were given by

Cichocka et al. (1990a), who noted that factors connected with urbanization, such as air pollution and the presence of dust particles did not negatively affect the occurrence of predators from the family Phytoseiidae. However, it was noted by Kropczyńska et al. (1988) that the Phytoseiidae were able to keep the population of *Eotetranychus tiliarium* under control only in trees growing in parks, and not in those growing beside the streets. Also Sahajdak et al. (1995) noted that predatory

mites from the family Phytoseiidae did not react to industrial emissions and achieved similar densities in the proximity of industrial plants (Huta Warszawa, Elektrociepłownia Żerań, Zakłady Azotowe in Puławy, Petrochemia Płock) and in the control site. Furthermore, in comparison with the control site, much higher numbers of Phytoseiidae were noted in the proximity of Cementownia Warszawa: mite densities in that site were higher, because of much higher density of spider mites (Sahajdak et al. 1995). The present research confirms that the level of environmental pollution does not influence negatively the abundance of predatory mites populations, since in both study areas the mean density of these mites was similar (approximately 8 specimens/100 leaves). In the individual years of study the density of these predators per one leaf was between 0.03 and 0.12 in the sites situated in Puławy, and between 0.04 and 0.14 in the Polesie National Park sites. In the present study, predatory mites from the family Phytoseiidae accompanied spider mites from spring until autumn. Similarly, Cichocka et al. (1990a) and Kropczyńska et al. (1988) observed the occurrence of those predatory mites throughout the whole sampling period. Sometimes they were collected in early spring, even before spider mites occurred (Cichocka et al. 1990ab).

5. Conclusion

As a result of the present study a high number of spider mites on the leaves of studied oaks was found. The highest densities of these mites were noted in the sites near the Zakłady Azotowe in Puławy, whereas in the Polesie National Park they were significantly lower, which might be due to a heightened nitrogen content in oak leaves in Puławy. The number of spider mites in the Polesie National Park was lower in each year of study in comparison to the Puławy area. However, no significant influence of years of study on the number of Tetranychidae was found. Predatory mites (Phytoseiidae) reached similar densities in both study areas and no statistically significant differences between the areas were found. Only the densities in the individual years of study differed significantly from each other.

Conflict of interest

The Author declares lack of potential conflicts.

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