Population dynamics of eriophyoid mites (Acari: Eriophyoidea) living on grasses in Poland

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Abstract: Population dynamics of seven grass-inhabiting eriophyoid species were observed on two study plots in Wielkopolska from April 1999 to March 2000. Our hypothesis was that the influence of the host plant on the population density of a mite species is considerably greater than that of locality-specific factors. Pairwise comparisons of population dynamics (measured by the Pearson correlation coefficient) between three experimental groups were used to test this hypothesis. No significant correlation was found between population densities on the same host plants from the same study plot (mean correlation: $r = -0.14$, 95% CI: -0.33-0.09), and between densities on different host species from the same plots ($r = 0.18$, 95% CI: 0.01-0.38), whereas a low, but significant, positive correlation was found between densities on the same host species from different study plots ($r = 0.20$, 95% CI: 0.03-0.45). Population fluctuations of all eriophyoids, regardless of species, were irregular. Mites were found to be active throughout the year. However, their population densities usually reached the highest levels in summer and autumn, decreasing markedly in winter. We conclude that population densities of grass-feeding eriophyoids are mostly affected by temporary and unpredictable factors, which are independent of both host- and site-specific effects.

Key words: Acari, Eriophyoidea, population density, Abacarus acutatus, Abacarus hystric, Aceria aculiformia, Aceria exiguum, Aceria toxicella, Aculodes dubius, Aculodes mckenziei, grasses

INTRODUCTION

Eriophyoid mites are obligatorily phytophagous and infest all plant parts except the roots. Many species are of a great economic importance because their feeding causes plant abnormalities. Moreover, several species are vectors of plant viruses (OLDFIELD 1996). Eriophyoids disperse passively on air currents from one plant host to another (LINDQUIST & OLDFIELD 1996), which facilitates their quick and wide dispersal among plants. Hence, research on the factors affecting the population den-
sity and dynamics of eriophyoids is important in defining their potential role as plant pests, pathogen vectors or biological control agents of weeds.

So far, the ecology of eriophyoid mites has been studied in detail in only few species. Although there are several works that have focused on their population dynamics (Gordon & Taylor 1976, Easterbrook 1978, 1979, Abou-Awad 1981, Kozlowski & Boczek 1989, Bącic & Petanovic 1995, Walde et al., 1997, Perez-Moreno & Moraza-Zorrilla 1998, Shi 2001), information about factors affecting densities is still scarce. As far as grass-inhabiting eriophyoid species are concerned, the population dynamics of only five have been studied in detail: *Abacarus hystrix* (NaL), *Aceria tosichella* Keif., *Aculodes mckenziei* (Keif.), *Aculodes dubius* (NaL) (Gibson 1976, Nault & Styer 1969, Proeseler 1972, Gillespie et al. 1997) and *Aculus bambusae* Kuang (Zhang et al. 2001).

The aim of this paper is to characterize the population dynamics of seven grass-infesting eriophyoids and to determine whether host plant or locality-specific factors affect the pattern of their fluctuations. We tested the hypothesis that the influence of the host plant on the population density of an eriophyoid mite species is considerably greater than that of locality-specific factors.

**MATERIAL AND METHODS**

Plant samples were collected monthly (April 1999 to March 2000) from two study plots in Poznań: (1) eastern part of Marcinell forest (LM, 16°52'E, 52°23'N), a shaded meadow near the forest; and (2) north-eastern part of Cytadela park (CYT, 16°55'E, 52°25'N), a sun-heated scarp. If one grass species was collected from two localities within one study plot, these localities were designated as LM1 and LM2 for the first study plot and CYT1 and CYT2 for the second study plot. Sampling localities within the study plots were spaced not farther than 15 meters apart. Each sample consisted of 10 individual shoots of the same grass species, collected randomly from each locality. Shoots were cut just above ground and placed into a plastic bag. The bags were carried to the laboratory and stored in a refrigerator. Then, the grasses were identified (Falkowski 1982, Szafer et al. 1986, Rutkowski 1998) and examined with a stereomicroscope. Individual mites were counted, collected, slide-mounted in Heinzle medium (Boczek 1994), and identified (Nalepa 1891, 1896, Keifer 1944, 1969, Sukhareva 1983, 1985, 1986, Amrine 1996). All material is deposited in the Department of Animal Taxonomy and Ecology, Adam Mickiewicz University.

Population dynamics of each eriophyoid mite species were analyzed within the three experimental groups as follows:

A – the same grass species, different study plots;
B – different grass species, the same study plot;
C – the same grass species, the same study plot.

Samples of the same eriophyoid species inhabiting the same grass species, collected monthly in the same locality, were defined as a “series”. Eriophyoid species were selected on the basis of the following criteria: (1) at least five occurrences in one series; (2) at least 50 specimens in one series; (3) conditions 1 and 2 were true for more than one host species or more than one locality. Finally, the following seven eriophyoid species and 10 grass species were selected:
• Abacarus acutatus Sukhareva, 1985 – three series: (1) Calamagrostis epigeios (L.) Roth., LM1; (2) C. epigeios, LM2; (3) C. epigeios, CYT.
• Abacarus hystrix (Nalepa, 1896) – seven series: (1) Agropyron repens (L.) P. Beauv., LM; (2) A. repens, CYT; (3) Bromus inermis Leyss., LM; (4) B. inermis, CYT; (5) Dactylis glomerata L., LM; (6) D. glomerata, CYT; (7) Bromus erectus Huds., CYT.
• Aceria aculiformia Sukhareva. 1986 – three series: (1) Festuca rubra L., LM1; (2) F. rubra, LM2; (3) F. rubra, CYT.
• Aceria eximia Sukhareva, 1983 – two series: (1) Calamagrostis epigeios, LM1; (2) C. epigeios, LM2.
• Aceria tosiclilla Keifer, 1969 – seven series: (1) Agropyron repens, LM; (2) A. repens, CYT; (3) Bromus inermis, LM; (4) B. inermis, CYT; (5) Arrhenatherum elatius (L.) P. Beauv. ex J. Presl & C., CYT1; (6) A. elatius, CYT2; (7) Avenula pubescens (Huds.) Dumort., CYT.
• Aculodes dubius (Nalepa, 1891) – three series: (1) Arrhenatherum elatius, LM; (2) A. elatius, CYT1; (3) A. elatius, CYT2.
• Aculodes mckenziei (Keifer, 1944) – six series: (1) Agropyron repens, LM; (2) A. repens, CYT; (3) Bromus inermis, LM; (4) B. inermis, CYT; (5) Dactylis glomerata, CYT; (6) Phalaris arundinacea L., CYT.

Changes in mite density (expressed as the mean number of individuals per shoot) throughout the year were graphed. To measure the similarities between different series (i.e. the similarity of populations as expressed by their dynamics), the Pearson correlation coefficients between all possible pairs of series were calculated. Then, the mean correlations within each experimental group were calculated in order to measure the effects of host plants and locality-specific factors on the population dynamics of the mites. Confidence intervals around mean correlation coefficients were computed with the use of bias-corrected and accelerated bootstrap (EFRON & TIBSHIRANI 1993). Coefficients were regarded as “not significant” when their 95% confidence intervals contained zero, and as “significantly different” when their 95% confidence intervals did not overlap. When comparing more than two means, Bonferroni correction was used while computing confidence intervals.

RESULTS

The population dynamics of all criophyoid species within each experimental group are presented graphically in Figs 1–3.

Numbers of all mite species varied considerably during the year. All species were found to be active throughout the period of observation, reaching their highest densities in summer and autumn. Mite population numbers decreased markedly in winter. The densities of most species were the lowest between January and April, except for Aceria eximia and Abacarus acutatus, whose populations were the largest in January (about 1000 specimens per shoot). The most abundant species was Aculodes mckenziei on Phalaris arundinacea, with over 9000 specimens per shoot in November.

An insignificant negative correlation \( r = -0.14, 95\% \text{ CI:} -0.33-0.09 \) was found between population densities on the same host species from the same study plot (group C). A significant positive, but low correlation, was found between densities
Fig. 1. Population dynamics of eriophyoid species (density expressed as mean number of specimens per shoot) on the same host species from different study plots (group A). Legend for grass species: AGRrep – Agropyron repens, BROine – Bromus inermis, ARRela – Arrhenatherum elatius, FESub – Festuca rubra, CALepi – Calamagrostis epigeios.
on the same host plants from different study plots (group A; \( r = 0.20, \, 95\% \, CI: \, 0.03-0.45 \)). An insignificant positive and low correlation was found between densities on different host plants from the same plots (group B; \( r = 0.18, \, 95\% \, CI: \, -0.01-0.38 \)) (Fig. 4).

Species belonging to separate genera showed different patterns of density changes (Fig. 5). No correlation (\( r = 0.00, \, 95\% \, CI: \, -0.09-0.15 \)) was found between series of Aculodes densities on the same host plant species from different plots (group A). However, a significant and positive correlation (\( r = 0.40, \, 95\% \, CI: \, 0.03-0.69 \)) was found between series on different host plants from the same plots (group B). A positive, but insignificant correlation (\( r = 0.46; \, 95\% \, CI: \, -0.02-0.67 \)) was found between series of Abacarus spp. on the same host plant species from different plots (group A). A significant and positive but low correlation (\( r = 0.25, \, 95\% \, CI: \, 0.02-0.41 \)) was found between a series of Abacarus spp. on different host plants on the same study plot (group B). There were insignificant correlations between the series of Aceria spp. within groups A (\( r = 0.14, \, 95\% \, CI: \, -0.11-0.44 \)) and C (\( r = -0.20, \, 95\% \, CI: \, -0.36-0.11 \)), and a significant negative correlation between population densities within group B (\( r = -0.20, \, 95\% \, CI: \, -0.35 \) - -0.02).
Fig. 3. Population dynamics of eriophyoid species on the same host species from the same study plots (group C).
Legends for grass species: CALepi – Calamagrostis epigeios, ARRela – Arrhenatherum elatius, FESrub – Festuca rubra.

DISCUSSION

Our results do not confirm the hypothesis that the influence of the host plant on the population density of an eriophyoid species is greater than that of locality-specific factors. Moreover, host and locality-specific factors did not seem to affect the population dynamics of eriophyoid species in any way. However, considerable differences between genera were found. Densities of Abacarus spp. were not similar on the same host plant species and on the same sampling plot. In contrast, population fluctuations of Aculodes spp. were more similar on the same sampling plot than on the same host plant. Population dynamics of Aceria spp. were independent of both host plants and locality-specific factors. Nevertheless, the results illustrated in Figs. 4 and 5 demonstrate some inconsistency. There was a significant correlation between mite densities on the same host plant and different plots as well as between mite densities on the same plot and different hosts but, simultaneously, an insignificant correlation between mite densities on the same host plant and plot. Moreover, population fluctuations of all the studied eriophyoid species showed very irregular patterns. Species densities increased and decreased rapidly throughout the year. The
Fig. 4. Mean correlation coefficients between densities of eriophyid populations within three experimental groups: A – the same host species, different study plots; B – different host species, the same study plot; C – the same host species, the same study plot. Bars represent 95% bootstrap confidence intervals around means.

Fig. 5. Mean correlation coefficients between densities of *Aceria*, *Aculodes* and *Abacarus* populations within three experimental groups. Bars represent 95% bootstrap confidence intervals around means.
observations discussed above have led us to conclude that population densities of grass-feeding eriophyoids are mostly affected by temporary and unpredictable factors. The rapid decreases of population densities were probably due to unfavourable conditions affecting mites directly or reducing host plant quality. The rapid increases in population numbers probably resulted from suitable environmental conditions, causing mite populations to develop faster or allowing rapid colonization from other source areas.

Over the whole year, the highest and most frequent peaks of population densities of *Abacarus hystrix*, *Aceria aculiformia*, *A. tosicella*, *Aculodes dusius*, *A. mckenziei* were recorded in summer and autumn. During that period, both the most suitable factors (i.e. high temperature and humidity, intensive growth of some plants) and the most detrimental factors (i.e. maturing of some plants and destruction of tissues, sudden changes of temperature, heavy rain) affect the conditions of mite development and dispersal in Poland. In contrast to the above-mentioned species, population densities of *Aceria eximia* and *Abacarus acutatus* were also high in winter. As mite population densities can be influenced by environmental factors, such as temperature, humidity, wind speed, rainfall, their patterns can be year-specific. Zhang et al. (2001) showed that population fluctuations of *Aculus bambusae* Kuang on *Bambusa* spp. differ from year to year. Similarly, the patterns of population dynamics for *Abacarus hystrix* on *Lotium perenne*, *Agrostis tenuis* and *Dactylis glomerata* in Germany fluctuated every year (Proepler 1972).


However, observations on many other species revealed that population development is mostly regular and shows a similar pattern every year. For example, *Aculus schlechtendali* (Nal.) on apple (Easterbrook 1979, Kozlowski & Boczek 1989), *Caleprimerus vitis* (Nal.) on grapevine (Pérez-Moreno & Moraza-Zorrilla 1998), *Epitrixminus gibbosus* (Nal.) on blackberry (Shi 2001), *Phyllocoptes gracilis* (Nal.) on raspberry (Gordon & Taylor 1976), *Epitrixminus pyri* (Nal.) on pear (Easterbrook 1978) and *Metaculus mangiferae* (Athiah) on mango (Abou-Awad 1981). In those cases, mites left hibernation sites and colonized the expanding leaves in spring. Then, their abundance increased. Population densities were the highest in late summer and declined rapidly in autumn. Such periodical patterns of population fluctuations are typical for species with life-cycles dependent on the deciduous host. Eriophyoid species inhabiting herbaceous and evergreen plants, showed irregular patterns of population dynamics. Although most grasses may be accessible for eriophyoids as a food source throughout the year, these plants are less unstable habitats than trees or shrubs. For example, cultivated grasses and grasslands are exposed to the danger of mechanical damage from mowing, grazing, trampling, etc. Also Gutierrez & Helle (1985) noted that herbaceous plants are a less stable habitat for spider mites. Therefore, the population development of grass-inhabiting eriophyoid species is less dependent on the phenology of the host plant.
Oriphoid population densities depend on temperature and humidity. Of those two factors, temperature was considered to be the most significant in those studies. In contrast, other authors — such as ABOU-AWAD (1981) — stated that temperature does not influence mite density. Still others (PROESELER 1972) indicated that humidity was the most important factor affecting oriophioid densities. BAČIĆ & PETANOVIC (1995) regarded low population densities in winter to be the result of short winter days (a shortened photoperiod), suppressed photosynthesis, and slow plant tissue growth. Food quality and the presence of predators can also affect the dynamics of oriophioid mite populations (KOZŁOWSKI & BOCZEK 1989).

Our observations indicate that the population dynamics of grass-feeding oriophioid mite species show a very irregular pattern, which is independent of the host plant species and locality-specific factors. Therefore, we conclude that the population density of an oriophioid species is mostly affected by temporary and unpredictable factors. Consequently, it would be difficult to predict fluctuations in population densities for the purpose of defining the potential role of oriophioid species as plant pests, pathogen vectors or biocontrol agents of weeds without more research. However, the influence of certain factors on population dynamics of grass-inhabiting oriophioids, as discussed in this study, cannot be ignored and requires further long-term observations and experimental tests.

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REFERENCES