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Population and seasonal dynamics of Eriophyid mites in birch stands in the Krušné hory Mts (Czech Republic)

Emanuel Kula

Department of Forest Protection and Game Management, Mendel University, Zemědělská 3, 613 00 Brno, Czech Republic, E-mail: kula@mendelu.cz

Abstract

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Long term (1995–2007) and seasonal population dynamics of two gall mites *Acalitus rudis* (Canestrini) and *Eriophyes leionotus* (Nalepa) was examined in birch (*Betula pendula* Roth) stands in the Krušné hory Mts. *E. leionotus* showed a gradual continual increase probably affected by changes in air pollution load and food quality. *A. rudis* indicated a six-year cycle of population dynamics. Overwintering deutogynes of *A. rudis/E.leionotus* were activated from mid-April/late on April, when sum of effective temperatures reached a value of 50.8/60.5 °C, and birch buds began to burst. On the basis of seasonal dynamics, termination of the creation of erinea and galls, it is possible to qualify *A. rudis* and *E. leionotus* as monovoltine. Partial differences between the eriophyid mites in the spring induce creation of galls and their leaving in autumn are affected by the host and its response to site conditions.

Key words

Acalitus rudis, *Betula pendula,* bionomics, *Eriophyes leionotus*, Eriophyidae, Krušné hory Mts (Ore Mts), population ecology, seasonal dynamics

Introduction

Forest ecosystems in the Krušné hory Mts, are often heavy attacked by eriophyid mites. Knowledge on the bionomics and harmfulness of gall mites feeding on forest trees is quite insufficient (Jeppson et al., 1975). Gall-forming mites *Acalitus rudis* (Canestrini) and *Eriophyes leionotus* (Nalepa) (Vaněčková-Skuhravá, 1996a) belong to the crown fauna of birch *Betula pendula* Roth in the region of the Krušné hory Mts (Czech Republic). These species create specific galls on leaves of birch (Buhr, 1965; Schnaider, 1991) the quantity of which reflects the rate of the attack (Buchta et al., 2004). Over the broad spectrum of study sites, the most progressive attack to birch leaves by eriophyid mites was observed at 500–700 m a.s.l. in stands aged less than 40 years (Kula et al. 1999, 2000; Buchta and Kula, 2005). An increased feeding activity of eriophyid mites can negatively affect photosynthesis and induce physiological stress in the host plant. This fact has been reported also by Puchalska (2006) for *Oligonychus ununguis* Jacobi sucking on *Picea glauca* Conica, by Mobley and Martini (1990) for *Tetranychus urticae* (Koch) feeding on apple and pear leaves and by Andrews and La Pre (1979) for *Tetranychus pacificus* (Mc Gregor) on almond tree. The background of this fact is accumulation of phenolic substances in plant tissues (Puchalska, 2006; Kolodziej, 1976).

In spite of partial data of Keifer et al. (1982), the life cycle of the examined eriophyid mites feeding on birch has not been sufficiently known yet. Vaněčková-Skuhravá (1996b) described the bionomics of the univoltine mite *Eriophyes tiliae* ssp. *liosoma* sucking linden leaves in climatic conditions of Central Europe. The activity of overwintering deutogynes coincides with the budbreak in linden, because the sucking begins on unfolding leaves where galls have already been created at the beginning of May. The highest population density of *E. tiliae* was reached in mid-June when all developmental stages could be noted. In the first half of July,

the frequency of mites on leaves decreased, and the occurrence of the new generation of deutogynes was evident.

The aim of this paper is to determine the population density of *A. rudis* and *E. leionotus* depending on changes in the basic climatic characteristics and to specify the phenology of occurrence and the seasonal dynamics of Eriophyidae colonizing birch stands in the Krušné hory Mts.

Material and methods

Population dynamics of eriophyid mites was examined on permanent sample trees in birch stands (aged 15–60 years) at four altitudinal transects from 500 to 1,000 m a.s.l. (100 m interval) situated in the area of the eastern Krušné hory Mts (Fig. 1). Branches were sampled from various parts of the tree profile at the end of June and August (1995–2007). Cohorts consisting of 70 leaves were taken from the individual branches with galls of eriophyid mites in a spring aspect. The total data at the level of transect and year were compared with precipitation totals and temperature means (meteorological stations CHMI Měděnec and Nová Ves v Horách).

Fig. 1. Altitudinal transects and separate experimental birch stands in the Ore Mountains. Transects: KLA – Klášterec, JAN – Janov, LIT – Litvínov, SNE – Sněžník. Experimental plots: KAL – Kalek, MEZ – Mezihoří

The seasonal dynamics of eriophyid mites was studied at the Janov transect: Kalek locality (altitude 760 m, 50°34'23.712" N, 13°18'4.211" E) and Mezihoří locality (altitude 660 m, 50°32'3.446" N, 13°21'44.244" E) (Fig. 1). The temperature in the studied stands was measured continually, with using a digital thermometer. Phenology of birch leaves unfolding was evaluated in 20 trees over a one-week period during spring season in 2005. In the same year the occurrence of developmental stages of eriophyid mites was determined by washing leaves in 75% ethanol at 14-day intervals always in three sample trees in Kalek and two sample trees in Mezihoří. In the Mezihoří locality, *E. leionotus* was a dominant, while *A. rudis* occurred in the Kalek locality. The methodology of Zacharda et al. (1987) for washing mites with ethanol was adapted for sampling mites from birch. A sample – twig with 70 leaves – was put in a bottle (0.7 l) and shaken in about 100 ml 75% ethanol. After sedimentation the number of individuals in the sample was determined with a microscope.

In the selected group of 240 leaves (4 trees each 60 leaves) in each locality, the increase of gall density was assessed based on the percentage of the attacked area.

Thermometers with shaded sensors were placed in the lower crown parts (6 m above the ground) representing the tree part with the highest occurrence of eriophyid mites (Buchta et al., 2004). Temperature was measured at 1-hour intervals. The sum of effective temperatures (SET) was determined as the sum of positive mean temperature values >5 °C. Birch phenophases were evaluated according to the modified methodology of the phenological stations of the Czech Hydrometeorological Institute (Chmi, 1987; Kaňová and Kula, 2003). The extent of leaf unfolding and foliage was classified with degrees 10%, 50%, 75% and 100% across the whole vertical crown profile, separately for each sample tree.

Results

Population dynamics of eriophyid mites

In 1995–2007, the trend in the fluctuation in the attack intensity by eriophyid mites changed differently. In spite of significant differences in the occurrence of galls between particular transects, the trends of dynamic changes for the given mite species were congruent. In the studied area of the Krušné hory Mts, *A. rudis* was characterized by two significant culminations of the attack on leaf area (1999 and 2006), whereas the occurrence of *E. leionotus* increased continually (from 1995 to 2007).

Significant differences occurred in the attack intensity (in spite of similarity in the general trend) between particular transects. *A. rudis* showed changes in the attack dynamics in the Klášterec transect and partly in the Sněžník transect (heavy attack). In the Janov transect, the trend did not become significantly evident. In the Litvínov transect, low population density was not possible to evaluate (Fig. 2). *E. leionotus* attack was concentrated in the Klášterec transect (at the most in 2000, fluctuation and slight decrease in abundance) and Janov transect (at the most in 2007). In the Litvínov transect, the occurrence was noted as late as in 2005 showing a slight increase till 2007. *E. leionotus* has not been noted in the Sněžník transect (Fig. 3).

Population density of eriophyid mites having attacked birch did not correlate either with the course of annual precipitation totals or with the mean annual temperatures within the period under study (11 years). The occurrence of eriophyid mites did not depend on the fluctuation in climatic factors (correlation coefficient of 0.16 for temperatures and 0.03 for precipitation totals).

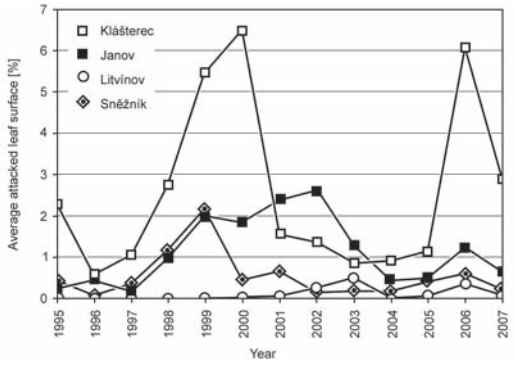

Fig 2. Average attack rates of *Acalitus rudis* in altitudinal transects in June 1995–2007

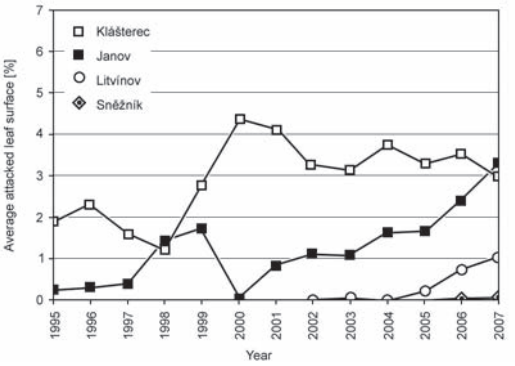

Fig. 3. Average attack rates of *Eriophyes leionotus* in altitudinal transects in 1995–2007

Seasonal dynamics and the life cycle of eriophyid mites

Overwintering deutogynes of *A. rudis* were activated from mid-April when SET reached a value of 50.8 °C, and birch buds began to burst. In the period mid-April to mid-May, spring activity on leaves culminated by creation of galls (erinea) the abundance of which was relatively low (17–40 individuals/70 leaves). In the period mid-May to mid-July, the free movement of the registered eriophyid mites on leaves was reduced because they lived under the protection of erinea. Individuals of a new generation left erinea from the end of July and their abundance culminated at the beginning of September. In connection with the change in food quality and approaching leaf fall deutogynes increase the intensity of leaving the erinea and search for places suitable for hibernation in buds and bark fissures (Fig. 4).

The first galls of *E. leionotus* were noted in mid-April on 13.3% checked leaves. The proportion of attacked leaves and the extent of erinea on the leaf area increased till the end of June when the proportion of attacked leaves amounted to 45.4%. The first erinea of *A. rudis* occurred on 39.5% leaves in the same period, and their increase stopped at the beginning of June when 60.8% attacked leaves were registered in a check sample (Fig. 5). The creation of galls was terminated in both mite species in May, and new galls and erinea occured only sporadically in June. Thus the abundance of galls was stabilized towards the end of the growing season. The distribution of leaves according to the attack degree was similar in both species. With increasing control area the number of attacked leaves decreased (Fig. 5).

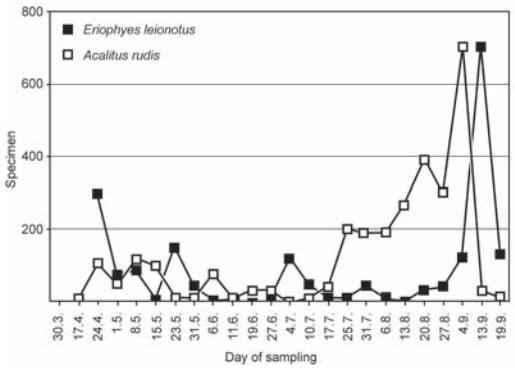

Fig. 4. Gall mites sampled from foliage on experimental plots in 2005 (average number per tree – 70 leaves)

Wintering deutogynes of *E. leionotus* were culminated late on April 24 when SET increased to 72 °C. The sporadic occurrence of galls on leaves was noted as early as April 17 (SET 60.5 °C, 95% trees budded). The development of leaves was advanced (70% trees with leaves long 1.5–3 cm, 30% trees fully budded). The spring abundance of activating deutogynes culminated in the 3rd ten-day period of April. Gradually with

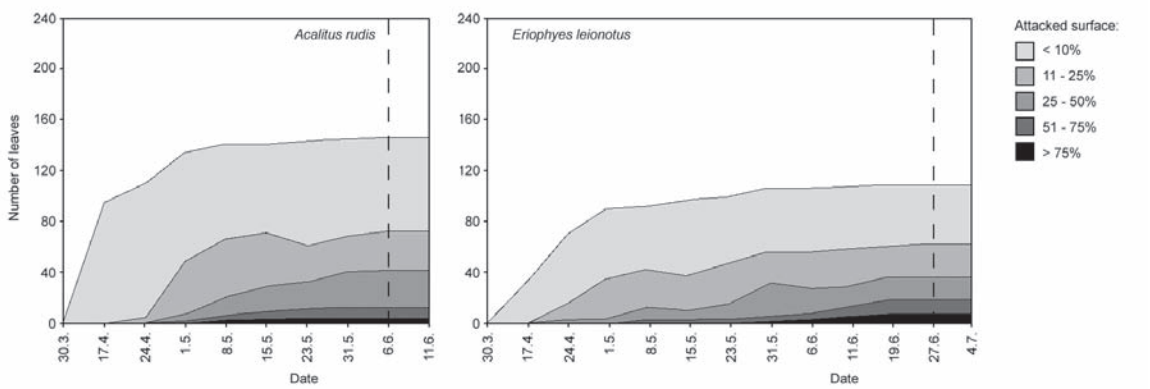

Fig 5. Growth of galls during vegetation season in 2005 (categorized by leaf surface damage)

the creation of galls, the number of individuals freely moving on birch leaves decreased. In June, the mite did not occur outside galls. Irregular but relatively numerous catching in July is interesting. The new generation left galls and searched for a place for wintering out of a leaf in the 3rd ten-day period of August, and culminated in mid-September. The drop in abundance in the 2nd ten-day period of September was related to the leaf fall (Fig. 4).

In both eriophyid mites, their seasonal dynamics is affected by birch budbreak. The mites differed in abundance in the spring season. The balanced spring proportion of *A. rudis* and the live fast decline in *E. leionotus* were probably related to the strategy of erinea and gall creation and the sampling of individuals of *A. rudis* was more effective with applying the method of washing. In both mites, the period of gall establishment can be specified by the beginning of budbreak termination ranging within 14 days. The occurrence of a new generation of *A. rudis* started before *E. leionotus*, the culmination points were shifted, and *E. leionotus* remained longer on leaves. Population density markedly increased in *A. rudis* (4 times) and *E. leionotus* (2 to 3 times).

Differences in temperature course between the localities affected budbreak and thus also the activity of wintering deunogynes. SET at the level of 50 °C is a limiting factor for both birch mites. The rate of gall creation and the development of a new generation can be partly differentiated in the course of temperatures. The Mezihoří locality is warmer than Kalek and the difference in SET exceeded 10 °C at the end of May (Fig. 6).

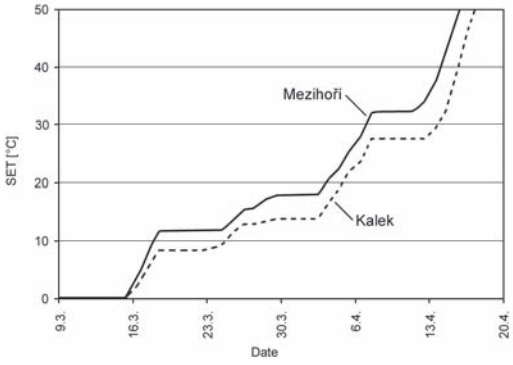

Fig. 6. Sum of effective temperatures over 5 °C recorded on experimental plots (2005)

Discussion

The population and seasonal dynamics of eriophyid mites is generally dependent on the course of weather in the period of termination of the dormancy of deutogynes, suitable food supply, intraspecific and interspecific competition, the occurrence of predators (Phytoseidae), pathogens or toxins (Lindquist et al., 1996). The area of the Krušné hory Mts is characterized by specific site conditions – due to high air pollution load from the 60s to 80s of the 20th century and its decline after 1995. The forests in the area responded by high proportion of birch in expense of the dying Norway spruce in the 80s of the 20th century (Kula, 2006), and by changed chemistry of the birch assimilatory organs *B. pendula* (Hrdlička and Kula, 2004) after 1995.

Nutrition quality requirements that birch gall mites put on their host plant are not known yet. On the basis of the observed trends in population dynamics, it is possible to express a hypothesis that *E. leionotus* responded to the drop air pollutant deposity and changes in the quality of assimilatory organs by a continual increase in abundance in the period 1995–2007. Since 2004, it has been spreading eastward to transects Litvínov and Sněžník. The mite also responded positively to liming of forest stands with dolomitic limestone (Kula, Matějková 2007, Kula 2009). In the studied period, it was not affected by occurrence of either extremely dry years (1997, 2001, 2006) or years above-normal in precipitation (1995, 2002). In *A. rudis* were noted cyclic changes in population dynamics – the maximum and minimum species abundance values alternated at intervals of six years. It follows that the ecological requirements of both eriophyid mites on birch are different. In *A. rudis*, climatic factors affecting the budbreak phase, the course of growing season and the food quality show stronger effects.

The activity of the two eriophyid mites on birch leaves was dependent on temperature. The SET values associated with the differences in the beginning of mite activity were affected by location. Particularly at higher locations there occurred shifts related to budbreak typical for Eriophyidae (Lindquist et al., 1996). Also Vaněčková-Skuhravá (1996b) mentions an association between the activity of various species of eriophyid mites and budbreak. Data of Lindquist et al. (1996) prove an increase in the abundance of deutogynes on leaves occurring in the spring aspect at the creation of galls, and before the end of the growing season when individuals of a new generation leave galls and leaves and look for a place for wintering at the base of buds or in bark fissures. The seasonal dynamics of the studied eriophyid mites displays the creation of erinea and galls proceeding up to the end of May; therefore it is possible to suggest that also *A. rudis* and *E. leionotus* create only one generation a year across the area of the Central Europe.

Conclusions

Eriophyid mites on birch (*B. pendula*) *A. rudis* and *E. leionotus* differ in population dynamics derived from the degree of attack to leaf area (1995–2007). *E. lionotus* shows a gradual continual increase probably affected by the change in air pollution load and food quality.

In *A. rudis*, a six-year cycle was indicated in population dynamics although no relationship was proved between the annual dynamics of the erinea occurrence and changes in temperature means and precipitation totals over the period 1996–2006. In year 2005 activation of wintering eriophyid mites (deutogynes) is related to budbreak and to the sum of effective temperatures, which reached (at the selected threshold of 5 °C) 50.8 °C in *A. rudis* and 60.5 °C in *E. leionotus*.

On the basis of the observed seasonal dynamics (the number of developmental stages on leaves in spring and autumn aspect, termination of the creation of erinea and galls in May) *A. rudis* and *E. leionotus* can be classified as monovoltine species. Certain differences between the eriophyid mites are in the spring start of the galls creation. They also differ in leaving the galls in autumn affected by the host tree and its response to the site conditions.

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Populační a sezónní dynamika vlnovníkovitých (Acari, Eriophyidae) v porostech břízy Krušných hor (Česká republika)

Souhrn

U vlnovníků *Acalitus rudis* (Canestrini) a *Eriophyes leionotus* (Nalepa) sající na listech břízy (*Betula pendula* Roth) byla sledována metodou jednotkových větví populační dynamika dle vytvořených hálek na listech (1995–2007) na trvalých vzorníkových stromech ve čtyřech transektech v Krušných horách. Sezónní aktivita obou vlnovníků byla zhodnocena na listech břízy (2005) metodou vymývání v etanolu.

E. lionotus vykázal pozvolný a kontinuální vzestup pravděpodobně ovlivněný změnou imisní zátěže a kvality potravy. U *A. rudis* byl naznačen šestiletý gradační cyklus přesto, že se nepotvrdila vazba meziroční dynamiky výskytu erineí se změnou teplotních průměrů a srážkových úhrnů v období 1996–2006.

Aktivace přezimujících vlnovníků (deutogynes) souvisí s rašením a sumou efektivních teplot, která při zvolené prahové hladině 5 °C dosáhla v roce 2005 u *A. rudis* 50,8 °C a u *E. leionotus* 60,5 °C.

Ze stanovené sezónní dynamiky (počty zachycených vývojových stádií na listech v jarním a podzimním aspektu, ukončení tvorby erineí a hálek v květnu) lze vlnovníky *A. rudis*, *E. leionotus* klasifikovat jako monovoltinní. Dílčí odchylka mezi vlnovníky v jarním nástupu k tvorbě hálek a jejich opouštění na podzim je ovlivněna živnou dřevinou (bříza) a její reakcí na stanovištní podmínky.

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