Crown Fauna of Birch Stand Caterpillars in a Pollution Area and their Population Dynamics

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ABSTRACT In a forested area affected by air pollution in FD Snezník (north Bohemia), the fauna of butterfly caterpillars in birch crowns was sampled by shaking foliage. Among 6,068 individuals collected, 119 Lepidoptera species were identified; the most dominant species were those with high outbreak potential: *Cabera pusaria*, *Operophthera fagata* and *Coleophora serratella*. Changes in population dynamics significantly influenced which species was dominant. An apparent 3-to 4-year population density cycle was observed for *C. pusaria*. Two periods of increased caterpillar occurrence in birch crowns were observed each growing season: a spring peak with culmination at the end of May and June, and a summer peak with culmination in mid August.

FROM THE EXISTING spectrum of more than 300 phytophagous insect species developing on birch, the majority of representatives are in the order *Lepidoptera*. Free living or mining caterpillars first damage leaves, then buds and catkins. Caterpillar damage is minimized due to a high birch regeneration capacity, weather conditions and a natural enemy complex.


Kula (1995a) used light traps to sample in the same area as we report upon here and collected a total of 861 butterfly species of which 123 feed upon birch. The goal of this paper is to evaluate the caterpillar fauna of birch crown: their species and numerical representation, phenology, and seasonal and population dynamics.

Materials and Methods

From 1986 to 1995, we collected 6,068 birch caterpillars by shaking crowns. Butterfly fauna in the caterpillar stage were studied in six birch stands of Forest District (FD) Snezník by shaking caterpillars onto 2 x 2 m linen squares. Caterpillar control in birch crowns was carried out in every locality on 5 trees at 14-day intervals throughout the entire vegetative season (mid-April until the end of October). Different sample trees were treated between successive control applications so that the stand, not only sample trees, could be monitored. Collected caterpillars were preserved in 75% ethyl alcohol.
Description of the Study Area

The experiment was carried out in Forest District (FD) Snežník (north Bohemia) between 450 and 600 m in altitude. The area is characterized by rough topography, mountainous climate with an average annual temperature of 6 °C, a total annual precipitation of 800 mm, a vegetative season of 110 to 120 days and a long-term influence of enhanced SO₂ concentrations. Forest stands are situated in the area of maximum (A) and heavy (B) air-pollution endangerment, in complex of forest types (6K) acidic spruce beechwood and is characteristic of substantial weed infestation with dominant representation of *Calamagrostis villosa* (Chaix.) Gmel., *Avenella flexuosa* (L.) Pirl. (Table 1).

Table 1. Characteristics of stands under study

<table>
<thead>
<tr>
<th>Locality</th>
<th>Birch representation (%)</th>
<th>Year of Forestation</th>
<th>Altitude (m)</th>
<th>Degree of pollutant load</th>
<th>Forest types composition</th>
<th>Weed infestation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vlcák</td>
<td>100</td>
<td>1980</td>
<td>NW</td>
<td>B</td>
<td>6K4</td>
<td>100</td>
</tr>
<tr>
<td>K. Hrádek</td>
<td>100</td>
<td>1980</td>
<td>N</td>
<td>500</td>
<td>A</td>
<td>6K4</td>
</tr>
<tr>
<td>Snežník</td>
<td>60</td>
<td>1979</td>
<td>S</td>
<td>560</td>
<td>B</td>
<td>6K1</td>
</tr>
<tr>
<td>Tisá</td>
<td>100</td>
<td>1980</td>
<td>plain</td>
<td>600</td>
<td>A</td>
<td>6K4</td>
</tr>
<tr>
<td>Ostrov</td>
<td>100</td>
<td>1979</td>
<td>N</td>
<td>550</td>
<td>A</td>
<td>6K8</td>
</tr>
<tr>
<td>Letadlo</td>
<td>70</td>
<td>1983</td>
<td>SE</td>
<td>450</td>
<td>B</td>
<td>6K4</td>
</tr>
</tbody>
</table>

Results and Discussion

We collected 6,068 caterpillars belonging to 119 species of *Lepidoptera*. The majority of individuals were collected in birch stands within the K. Hrádek and Vlák localities over 10 years using the shake down method.

Dominant species included *Cabera pusaria* (34.7%), *Coleophora serratella* (7.8%) and *Operophtera fagata* (16.4%); subdominant species included *Cyclophora albipunctata* (4.9%) and *Teleoides proximellus* (2.6%). *Biston betularius* (1.5%), *Operophtera brumata* (1.3%) and *Orthotaenia undulana* (1.3%) were classified as receding, and the 111 remaining species were classified as subreceding (< 1%) (Fig. 1).

Figure 1. Dominant crown caterpillar species of birch stands (FD Snežník, 1986-1995).

Over the 10 years of the study, three peaks of caterpillar abundance were recorded (1988, 1992, 1995), followed by a significant decrease. It is not yet known if there is a 3- or 4- year gradation phase between peaks of population density (Fig. 2).
The seasonal and population dynamics of the crown fauna varied substantially among eudominant and dominant caterpillar species. The decline of *C. pusaria* in 1990 was substituted by local outbreaks of *C. serratella*, and its decreased dominance in 1991-1994 was offset by increases in *O. fagata* and partially by *C. albipunctata*. Subdominant species usually had one population peak in the course of 10 years (5-8%): *O. brumata* (1988), *Paradiarsia similaria* (1989), *Semiothisa notata* (1992) and *O. undulana* (1993).

Eudominant species *C. pusaria* changed dominance in the following pattern: a peak occurred in 1987 (57.9%); after three successive years of decline to 14.6% in 1990, a second peak occurred (60.6%) in 1991, followed by a significant and rapid decrease of dominance (34.4% and 8.9%) in 1992 and 1993, respectively. In 1995, this species had a partial increase of dominance (28.2%). When comparing absolute values of caterpillars shaken down from the same number of trees, a significant population trend appeared, characterized by 2-year peaks in an almost regular, 3-year cycle in 1987-1988, 1991-1992 and 1995 (268 x 329, 494 x 428 pieces, 292 caterpillars).

*C. pusaria* was the most significant species of the study area and reached a eudominant position in all localities. Looper *O. fagata* was a eudominant species from 1986 to 1995 with relatively low dominance from 1986 to 1991 (0 - 7.8%). In 1992, we recorded a peak in this species (31.2%) with a mild decrease the following year. The next peak during the 10-year period occurred in 1994 (39.1%). Evaluation of population dynamics from the absolute number of caterpillars caught showed that since 1989, abundance of this caterpillar species in birch crowns was gradually increasing with a peak in 1992 (389 caterpillars) followed by a decrease. The density of this species remained 2-4 times higher than the density recorded one year before residual (Fig. 3).
Figure 3. Population dynamics of caterpillars in the crown fauna of birch stands (FD Snezník, 1986-1995).

*C. serratella*, a dominant species, showed a sudden peak in 1990. It was not collected in birch crowns from 1986 to 1989. This peak was followed by a sudden decrease of dominance in 1991 (13.4%). The absolute values of shaken caterpillars show that this peak can be characterized in the same way as *C. pusaria* (Fig. 3). A higher occurrence of this species occurred in only three localities.

*C. albipunctata* was a subdominant species, but from 1986 to 1992, we did not collect specimens of this species in birch crowns. In 1993, it appeared as a dominant species. Its representation continually grew to 19.1% (1995); peak absolute values were recorded as well (Fig. 3). *B. betularius*, a receding species, showed long-term, well-balanced dominance within the crown fauna with a slight increase recorded in 1986, 1989 and 1995. *O. undulana* was not found in birch crowns until after 1990; its dominance gradually increased to 7.5% (1994). *T. proximellus* was a dominant species, its dominance gradually decreasing from 1986 (12.2%) to 1991 (0.1%) and then slightly increasing until 1995 (2.4%) (Fig. 3).

During the 10-year period, the dynamics and phenology of the complex butterfly fauna in the caterpillar stage formed two significantly separated stages in FD Snezník. The spring period, which culminated with a peak at the end of May and June, occurred from the beginning of May until mid June. The second caterpillar wave started in mid June and culminated in mid August. The period between the spring and late summer waves of caterpillars was characterized by low, well-balanced caterpillar representation. From phenological point of view, caterpillars were on birch trees from the beginning of leaf flush (last half of April) until the end of the vegetative period at the end of October (Fig. 4).
Figure 4. Phenology and seasonal dynamics of crown caterpillars of birch stands (FD Snezník, 1986-1995).

*O. fagata* which occurred in birch crowns from the beginning of May, was among the important spring species. Its occurrence peaked at the beginning of June and its development was finished by the end of June. The looper, *O. brumata*, occurred at the same time, but it did not reach as high a level of population density.

*O. undulana* caterpillars were active in mid April with a peak in mid May and sporadic presence in samples at the beginning of May; its peak population density occurred at the beginning of June, and a month later it disappeared from birch crowns.

One summer representative is *P. similaria*, which occurred from mid June to mid October with estimated peak abundance at the beginning of August and probable second generation in September. *T. proximellus* was collected from mid July until the end of October, with peak abundance occurring in mid August. Two quite evident generations characterized *C. albipunctata*, which was collected in tree crowns from mid June until the end of October with peaks in mid July and mid September. The occurrence of the second caterpillar generation was recorded in mid August. Two generations with a relatively low caterpillar abundance on birch was characteristic of *S. notata*, which appeared in crowns at the beginning of June and remained until the end of September. The first generation peaked in mid July; the second generation appeared in the second half of August and peaked in mid September.

*C. pusaria* was a late summer species with only one generation. The caterpillars hatched at the beginning of July, a peak lasted from mid August until the beginning of September, and caterpillars were found in birch crowns even at the end of October (Fig. 5).

Phenology and seasonal population density of *C. pusaria* in the 10-year study period showed significant variation in population dynamics, with peaks always occurring after two-year decreasing population density. The timing of caterpillar occurrence from July to October varied among years. In 1992, caterpillars were already developing on birch trees in June. In 1987, 1991, 1993, 1994 and 1995, caterpillars...
were in the crown at the beginning of July. From mid August in 1990 and from the beginning of August in 1987 and 1989, we found caterpillars of this species in birch crowns.

Figure 5. Phenology and seasonal dynamics of *Cabera pusaria* caterpillars (FD Snezník, 1986-1995).

Despite the collection of 119 caterpillar species from birch crowns only a few of these are significant due to their severity of damage (*O. fagata*, *C. pusaria* and others). A substantial number of species developing in birch crowns do not endanger this tree species; these species often occurred only in limited numbers during the 10-year period. The results discussed above are in agreement with the data of Kutenkova (1986).

Wiackowski et al. (1976) collected 401 species of birch crown fauna, 73.5% of which were made up of phytophagous species and 67 species of butterflies. The highest density of caterpillars, *Macrolepidoptera*, appeared in the study area less affected by air pollution. Under these conditions, *O. fagata* outbreaks appeared.

The 119 species of caterpillars which we collected ranged from butterflies to the most significant forest pests of birch. An outbreak of *Erannis defoliaria* occurred in birch stands in the first half of the 1980s (Badalik 1988) and a casebearer (*C. serratella*) outbreak center appeared in FD Snezník (Kula and Vaca 1995). While *E. defoliaria* showed slight representation, *O. fagata* had a high population density accompanied by severe damage of birch crowns. Because this species is widely polyphagous, other broadleaved trees in forest stands in polluted areas are endangered. *O. undulana*, which also attacked broadleaved woody plants, also occurred at high population densities. Information about its outbreak potential is lacking. The casebearer *C. serratella*, which prefers birch, is also a monophagous species. Its local outbreak occurred from 1990 to 1991 (Kula and Vaca 1995). Outbreaks of this species are common in Canada (Raske 1976). This species appeared in the entire Krušné hory mountain area (Kula 1995b).

The occurrence of eudominant and dominant species and their joint seasonal dynamics may be significantly influenced by weather. With the looper *O. fagata*, a 10-year cycle of enhanced population density may occur. If an outbreak appeared at the beginning of the 1980s, it may last until the beginning of the 1990s.

According to Wiackowski et al. (1976), crown fauna and their abundance and species composition can be influenced by the degree of air-pollution. For instance, moths of the species *Acleris ferrugana*, *T. proximellus*, *Hedya atropunctata* and *Spilonota ocellana* occurred more often in moderately polluted localities. The dominant position of *O. fagata*, *Achlya flavicornis* and *Coleophora fuscedinella* was closely associated with the severely polluted area and their occurrence decreased with a decreasing degree of
pollution. On the contrary, miners of *Eriocrania* sp., *Heliozela betulae* and *Lyonetia clerkella* preferred a clean environment. Caterpillars of *Lithocolletis* sp. and *Incurvaria* sp. seemed unaffected by pollution levels. Study areas in FD Snezník are part of a larger area which has been affected by air pollution over a long time. Individual localities do not have very different air pollution histories so they could not be evaluated within an air pollution gradient. Our *C. serratella* outbreak data may support the results of Wiackowski et al. (1976), but on the other hand, *O. brumata* reacted population density in the same conditions.

Conclusions

In the crown fauna of birch stands, we identified 119 caterpillar species (6,068 individuals). Species classified as eudominant included *C. pusaria, C. serratella* and *O. fagata*; dominant species included *C. albipunctata* and *T. proximellus*; and subdominant species included *B. betularius, O. brumata* and *O. undulana*. One hundred and eleven species were classified as subbreeding.

Evaluation of caterpillar abundance over 10 years suggested that a 3- to 4-year outbreak pattern of crown dwelling butterfly caterpillars exists (1988, 1992 and 1995 were outbreak years) which was decidedly influenced by eudominant and dominant species. These species changed their dominance within the outbreak cycle. *C. pusaria* exhibited a population cycle characterized by a 2-year outbreak every 3 years. *O. fagata* populations appeared to peak every 10 years. Outbreaks of *C. serratella* appeared to be as short-lived.

The birch crown fauna caterpillar complex exhibited two distinct periods within each growing season. The spring peak culminated at the end of May and June, and the summer population reached its peak in mid August. The emergence of spring and summer caterpillar populations, as well as their culmination and duration, were heavily influenced by weather conditions in individual years. *C. pusaria, C. serratella* and *O. fagata* were among the most significant butterfly species with outbreak potential in birch stands. Species identified as pests that occur in the caterpillar complex, but have not yet had outbreaks, include *Agriopis aurantiaria, Alcis repandata, Archieariss parthenias, Biston betularius, Campaea margaritata, Colotois pennaria, Cyclophora albipunctata, Ochropacha duplicaris, Orthotaenia undulana, Pandemis cerasana, Semiothisa notata* and *T. proximellus*.

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