

The Population and Seasonal Dynamics of Weevils Developing in the Soil of Birch Stands

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Abstract

Curculionidae developing in the soil of birch stands in an air-polluted region were classified using the method of soil photoelectors on the basis of their population dynamics (1986 – 2000) and phenology of their emergence from where they developed. In the course of 15 years we saw two evident culminations in the population density of *Polydrusus undatus*, while the population density of the other species – *Polydrusus (Metallites) impar*, *Phyllobius arborator*, *P. argentatus*, *P. calcaratus*, *Rhinomias forticornis* and *Strophosoma capitatum* culminated only once. We derived the sum of effective temperatures, which characterise the start of activity of a wide range of weevils. Based on the phenology of emerging from where they developed, the dominant species were those weevil species that are active in the spring.

Key words: Curculionidae, weevils, photoelectors, population and seasonal dynamics, birch stands, *Betula pendula* Roth

Introduction

The Curculionidae, the most abundant family of beetles in the Czech Republic (900), are generally found among the phytophagous fauna of birch stands (*Betula pendula* Roth) (Kula 1990/1991). Their harmful effect in the study region has not yet made itself felt to such an extent as the willow leaf beetle, mottled umber moth and winter moth, miners of the genus *Eriocrania* or the case-bearers (Kula 1988a, 1988b, 1989, 1990a, 1990b, 1995, 1998, 2000; Kula and Vaca 1995). Despite this, they include a number of species whose gradation potential is well known so we cannot exclude the impact of their heavy feeding and clear eating (e.g. of the genus *Phyllobius* – *P. pyri* L.) on birch trees (Axelsson et al. 1973).

Ioannisiani et al. (1970) indicated that humidity had a dominant effect on the population dynamics of weevils, although the site, stand density, soil quality, degree of coverage of the soil and light conditions are also important factors.

According to Schauer mann (1987), the population density of weevils which develop in the soil is generally higher under conditions where moderate acid rain occurs. In heavily polluted localities, birch stands are damaged by *Phyllobius arborator* (Herbst.), *P. calcaratus* (Fabr.) and *P. pyri*, and in the moderately polluted birch stands by *Strophosoma capitatum* (Deg.), which undergoes gradation under these conditions and damages up to 50% of the entire assimilation area (Chlodny 1982, Chlodny and Styfi-Bartkiewicz 1982). These are not, however, the only species that appear as they could be accompanied by other species e.g. *Polydrusus cervinus* L. (Tomkow 1976).

The objective of the present study was to evaluate the population and seasonal dynamics of weevils which develop in the soil of birch stands that occur in the air-polluted regions of the Děčín Sandstone Upland (northern Bohemia). Data were collected in the years 1986 – 2000 using the method of photoelectors.

Material and Methods

Weevils were collected in six birch stands (*Betula pendula* Roth) in the forest district Sněžník. In 1986 – 2000, we placed seven soil photoelectors (1 X 1 X 0.3 m) in each of the 5-7 year old stands;

every year in late March they were moved under the projection of crowns of other birch trees. The weevils were collected at seven-day intervals during the entire vegetation period (15 April – 30 October) and were preserved in 75% ethanol.

During the 15 years of our investigations, we used several methods of collection (photoelectors, ground traps, shaking trees, Moericke's dishes) and collected 41,686 imagoes of 122 species of weevils; using photoelectors we collected 20,131 weevils of 83 species, of which 16,862 specimens (73 species) were collected in the birch stands. The sum of effective temperatures (SET) applied to evaluate the onset of activity of the weevils was calculated as the sum of positive temperatures from the beginning of the calendar year.

Identification of the weevils was accomplished with the assistance of Dr. O. Majzlan, CSc. from the Faculty of Teaching of Komenský University in Bratislava, Ing. J. Fremuth from Hradec Králové and R. Stejskal from Znojmo.

Description of the Study Area

The forest district Sněžník is a part of the Děčín Sandstone Upland (northern Bohemia, 14°04' E, 50°46' N, number of square of net fauna mapping 5250) which for many years had been exposed to SO₂ concentrations of more than 60 µg/m³. The region lies in a cold mountain climate (average annual temperature 6°C, average annual precipitation is 800 mm, length of the vegetation period 110 – 120 days, altitude 450 – 700 m), and is currently under a moderate pollutant load. Large areas of spruce stands died in 1979 and were subsequently replaced by stands dominated by birch (*Betula pendula* Roth).

Results

In the study region, the following weevils were the eudominant species: *Polydrusus (Metallites) impar* Des Gozis (10.5%), *P. arborator* (11.7%), *Polydrusus undatus* (Fabr.) (12.7%) and *P. argentatus* (23%). The dominant weevil species were *P. calcaratus* (5.6%), *Rhinomias forticornis* (Boh.) (5.02%) and *S. capitatum* (5.17%). Four species were classified as sub-dominant, i.e. *Barypeithes mollicomus* (Ahrens) (4.79%), *Otiorhynchus (Dorymerus) subdentatus* Bach (3.16%), *Hylobius abietis* (L.) (4.63%) and *Otiorhynchus niger* (Fabr.) (2.39%). The other weevils are recedent (3) and sub-recedent species (111).

Population Density of Weevils in the Soil

The imagoes of weevils whose larvae develop in the soil emerge from where they developed during the vegetation period, usually in the spring. The method of soil photoelectors made it possible to specify the species spectrum of weevils, their abundance, and the population and seasonal dynamics.

In 1986–2000, using the method of photoelectors placed in the birch stands, we collected 16,862 specimens of 73 species which is 59.8% of all the fauna of the region. Two species of the genus *Phyllobius* (i.e. *P. argentatus* 34.9% and *P. arborator* 15.18%) and the species *P. undatus* (14.81%) were eudominant. Two species, i.e. *P. calcaratus* and *Strophosoma melanogrammum* (Forst.), were dominant (6.71% and 6.48%, respectively). Only two species, i.e. *Otiorhynchus singularis* (L.) (2.61%) and *O. subdentatus* Bach (3.68%), were classified as sub-dominant (Table 1).

Generally 22 weevil species occurred in the soil in the study region. In some places the incidence of some of the sub-recedent species (*B. mollicomus*, *P. impar*, *Simo horticornis* Herbst., *Otiorhynchus scaber*) was higher.

P. argentatus was the species most frequently captured in the photoelectors (5,908). Since 1988, the abundance of individuals leaving emergence sites had increased and culminated in 1993–1996 (21.10 – 32.95 specimens/m²). After the culmination in 1996, the number of weevils decreased to 1.36 specimens/m² and then increased to 7.57 specimens/m² in 2000 (Table 1).

Table 1.—Population dynamics of Curculionids in birch stands (1986-2000, photoelectectors, spec/m²)

Species	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Sum	%	Avg.
<i>Barypeithes mollicornis</i> (Ahrens, 1812)	0.00	0.00	0.00	0.00	0.07	0.00	0.07	1.40	0.36	0.83	0.55	0.14	0.17	0.07	0.33	168	1.00	0.267
<i>Ceutorhynchus floralis</i> (Paykull, 1792)	0.00	0.00	0.00	0.00	0.07	0.07	2.50	1.05	0.67	0.33	0.02	0.02	0.40	0.00	0.02	217	1.29	0.344
<i>Metalites impar</i> Des Gozis, 1882	0.00	0.00	0.00	0.12	0.02	0.00	0.14	0.24	0.83	0.05	0.36	0.14	0.29	0.12	0.33	111	0.66	0.176
<i>Otiobrychus niger</i> (Fabricius, 1775)	0.00	0.02	0.07	0.26	0.00	0.62	0.43	0.33	0.19	0.31	0.26	0.00	0.00	0.00	0.02	106	0.63	0.168
<i>Otiobrychus scaber</i> (Linnaeus, 1758)	0.00	0.00	0.00	0.02	0.02	0.17	0.00	0.45	0.38	0.62	0.33	0.24	0.45	0.60	0.93	177	1.05	0.281
<i>Otiobrychus singularis</i> (Linnaeus, 1758)	0.00	0.00	0.00	0.00	0.26	0.19	0.40	1.52	0.86	1.26	0.98	0.71	1.81	1.19	1.29	440	2.61	0.698
<i>Otiobrychus subdentatus</i> Bach, 1854	0.02	0.07	0.31	0.60	0.38	1.02	1.36	1.40	1.74	1.40	2.05	1.14	1.31	0.71	1.24	620	3.68	0.984
<i>Phyllobius arborator</i> (Herbst, 1797)	0.05	5.10	1.05	2.26	10.79	5.52	4.67	14.81	8.64	4.17	3.19	0.07	0.10	0.12	0.43	2560	15.18	4.063
<i>Phyllobius argentatus</i> (Linnaeus, 1758)	0.17	1.43	0.00	0.14	0.40	2.76	8.00	21.10	30.79	27.33	32.95	1.36	3.69	2.43	7.57	5885	34.90	9.341
<i>Phyllobius calcaratus</i> (Fabricius, 1792)	0.02	3.19	0.50	2.90	0.12	2.71	4.55	2.17	3.83	1.57	2.10	0.05	0.88	1.00	1.33	1131	6.71	1.795
<i>Polydrusus cervinus</i> (Linnaeus, 1758)	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.10	0.33	1.10	0.95	0.36	0.17	0.10	0.17	140	0.83	0.222
<i>Polydrusus undatus</i> (Fabricius, 1781)	0.00	0.45	1.02	0.62	0.31	1.14	4.48	2.40	7.55	7.52	4.40	0.52	7.43	6.55	15.07	2498	14.81	3.965
<i>Rhinonias forticornis</i> (Boheman, 1843)	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.12	0.17	0.29	0.31	0.02	0.83	0.31	1.12	135	0.80	0.214
<i>Rhynchaenus ruscii</i> Herbst, 1795	0.00	0.29	0.57	0.45	0.00	0.00	0.00	0.00	0.50	0.10	0.00	0.02	0.21	0.02	0.29	103	0.61	0.163
<i>Simo hirticornis</i> (Herbst, 1795)	0.00	0.00	0.00	0.07	0.07	0.05	0.02	0.31	1.00	0.93	0.67	0.31	0.79	0.71	0.52	229	1.36	0.363
<i>Strophosoma melanogrammum</i> (Forster, 1771)																		
<i>Tachyerges decoratus</i> Germar, 1827	0.00	0.02	0.02	0.02	0.00	0.07	0.33	0.71	2.67	2.50	1.14	0.71	1.83	2.88	13.10	1093	6.48	1.735
<i>Trichapion simile</i> Kirby, 1811	0.00	0.00	0.00	0.00	0.43	0.24	0.62	0.90	0.00	0.05	0.29	0.00	0.00	0.19	0.00	114	0.68	0.181
Total	0.57	11.60	4.21	9.98	13.38	15.14	28.71	50.76	63.55	51.52	54.40	6.48	24.26	20.29	46.62	16862	100	26.77

P. arborator (Herbst) is one of the most abundant species and its population density was very high. The level of abundance increased in 1987 to 5.1 specimens/m² and was followed by a decrease; during the three-year interval we saw a culmination of 10.79 specimens/m² in 1990 and 14.81 specimens/m² in 1993. From 1994 the population density of the weevil in the region decreased to 0.07 – 0.43 specimens/m² in 2000 (Table 1).

During the 15 year period, no important culmination levels of *P. calcaratus* (Fabr.) were recorded; the population density ranged between 0.02 and 4.55 specimens.m⁻², although it varied irregularly in individual years and its abundance was the highest during the period 1991 – 1994 (2.71 – 4.55 specimens.m⁻²).

After a balanced and low population density in 1987 – 1991 (0.3 – 1.14 specimens/m²), *P. undatus* (Rabr.) was the first species to reach the culmination period in 1992 (4.48 specimens/m²) and in 1994 – 1995 (7.55 specimens/m²). After a sudden decrease in 1997, we observed a continuous growth to a maximum density of 15.07 specimens.m⁻² in 2000. This species is a typical representative in birch stands whose population density varies among respective localities.

S. melanogrammum (Forst.) was captured in the photoelectors only sporadically during the period 1986 – 1991. Its population density was the highest in 1994 – 1995 (2.67 and 2.50 specimens/m² respectively) and after two years of recession it culminated at a population density of 13.1 specimens/m² (Table 1).

O. singularis (L.) was not captured in the photoelectors until 1990; in 1993 – 2000 its population density was balanced and ranged between 0.71 and 1.81 specimens/m² (Table 1).

O. subdentatus Bach appeared in the study region in each of the 15 years; its population density increased slightly from 1986 to 1996 (0.02 to 2.05 specimens/m²) and after that its level was balanced (0.71 – 1.31 specimens/m²) (Table 1).

Seasonal Dynamics of Weevils

In terms of phenology, Schauerermann (1973) separated the weevils according to the length of life of the imagos and larval ontogenesis. Based on weevils captured in soil photoelectors in the Sněžník forest district, we can distinguish species active in the spring with an evident culmination and subsequent disappearance of imagos: *Hylobius abietis* L. (no weevils were reported in the region in the summer due to the limited number of coniferous stands); *Coeliodes rubicundinus* (Herbst.), *Rhynchaenus rusci* (Herbst.), *P. undatus*, *Anoplus roboris* Suffr., *Tachyerges decoratus* Germ., *Trichapion simile* Kirby, *P. argentatus*, *P. calcaratus*, *O. niger* appearing sporadically during the entire vegetation period; weevils active in the summer include *Polydrusus cervinus* (L.), *B. mollicornis*, *P. impar*, *P. arborator*, *Simo hirticornis* Herbst.; weevils active in the autumn (*Acale camelus* Fabr.); and weevils with no evident culmination, but with a changing activity when leaving the soil during the entire vegetation period (*Otiorhynchus singularis* (L.), *O. subdentatus* Bach). In spite of the low population density of *Strophosoma melanogrammum* (Forst.) we can define its appearance in spring and autumn with only a hint of culmination.

Weevils Leaving the Soil Regulated by the Sum of Effective Temperatures

The sum of effective temperatures (SET) differentiates the respective weevil species at the start of their activity on leaving the soil environment. We saw some differentiation also within the framework of genera in species that move up into birch crowns. Ioannisiani et al. (1970) reported that the SET from the egg until the imagoes of *P. arborator* leave the soil was 1929°C but they did not define the individual developmental stages. Based on the results of 15 years of collections using soil photoelectors, this species can be expected to appear under an average ambient SET temperature of 574°C. *P. argentatus* and *P. calcaratus* began to be active at SET 456°C and 463°C, respectively, and the later activity of *P. clorpus* is expressed as SET 619°C. The population density of *P. pyri* in the soil was not high enough and showed a separate period of activation at SET 255 – 865°C and 1410 –

1981°C. The increased incidence of this species in birch crowns did not correspond with its population density in the soil. Species of the genus *Polydrusus* belong to the early spring species, i.e. *P. undatus* at SET 236°C (109 – 360°C), while a higher SET characterises the species *P. impar* (784°C). A considerably different SET of the species *Acalles camelus* (Fabr.) and *A. commutatus* Dieckmann (480°C and 1832°C) indicated that both hatching and the subsequent activity were disharmonious. Only the spring activity of the species *A. echinatus* (Germar) was derived from the low population density (388°C). Members of the genus *Anoplus* (*A. roboris* Suff. 280°C) and *A. plantaris* Naeyen 293°C) have an identical activity. The imagoes of the species *Barypeithes mollicomus* (Ahrens) have a high SET value (903°C). The early spring species with a low SET value are *Ceutorhynchus floralis* (Paykull) (282°C), *Coeliodinus rubicundus* (Hbst.) (236°C), *Deporaus betulae* (L.) (259°C) and *Otiorhynchus niger* (Fabr.) (296°C).

Discussion

The broad spectrum of weevils that develop in the soil of birch stands no doubt create a potential complex of pests of the root system of plants, but due to the high degree of weed infestation of the stands, they do not present a very grave danger for the root system. However, insect infestation may increase and cause defoliation due to the site conditions, which are particularly favorable for the development of species subsequently moving up into the birch crowns (*Phyllobius*, *Deporaus*, *Polydrusus*). Members of the genus *Phyllobius* differed not only in the population density, for instance 23% of the weevil fauna was *P. argentatus*, but also in the start and duration of increased population density in the study region in contrast to *P. arborator* (Kula et al. 2000). With the exception of *P. undatus*, no repeatedly increased population density of weevils appeared in the period 1986 – 2000. In 1997 the incidence of weevils in the soil decreased, and this was confirmed by the limited activity both over the soil surface and in the crown fauna. In Denmark the hatching of the species *Otiorhynchus singularis* takes place from late May to late June (Nielsen 1974), while in Germany the weevils hatch continuously from April to October and their culmination is quite evident in May and June (Grimm 1973). The period of hatching in the investigated area corresponded with the data of Grimm (1973), only the culmination was not so evident. The year-round activity with no culmination from mid-April to mid-September was confirmed when we used ground traps (Kula et al. 2000). Spring activity is associated with a relatively low sum of effective temperatures (338°C). Nielsen (1974) explained the phenology of the incidence of weevils and stated that *P. argentatus* adults made their appearance in late April and early May when the temperature of the soil at a depth of 3 cm is 7-9°C. According to Schauer mann (1973) activity does not begin until late May to early July at a soil temperature of 8°C. The defined shift in the appearance of *P. arborator* corresponds with data of Urban (1998). The sum of effective ambient air temperatures defined for the weevil fauna in birch stands (Kula et al. 2000) contributes to their control and to prognoses of their incidence.

Conclusion

The weevil fauna (73 species) developing in the soil of birch stands in the air-polluted region included important phytophagous insects of the genera *Phyllobius*, *Deporaus* and *Polydrusus*, which damage the assimilation area of birch trees. The population dynamics (1986 – 2000) indicated that, with the exception of *P. undatus*, the periodicity of increased population density was greater than five years. Based on the sum of effective ambient air temperatures, which characterizes the initiation of weevil activity, we can derive a prognosis of the culmination of weevil incidence in spite of minor differences due to the discordant development of the larvae.

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