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ORIGINAL PAPER

Insect assemblages associated with *Pissodes castaneus* (De Geer) on *Pinus sylvestris* L. trees

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ABSTRACT

In Poland, *Pissodes castaneus* (De Geer), the small banded pine weevil, is increasingly common in young Scots pine *Pinus sylvestris* L. stands weakened by various biotic (root diseases, deer) and abiotic (drought, hail, etc.) factors. In Europe, an increasing threat to young *P. sylvestris* stands by this pest has been observed since the early 2000s, most likely due to ongoing climate change. It seems that weakening of young trees by droughts may have contributed to the increase in pest numbers. The intensification of damage caused by *P. castaneus*, as well as the lack of effective protection methods, justified conducting research on the insects co-occurring with *P. castaneus* on *P. sylvestris*, with special emphasis on its natural enemies. The 3-5-year-old *P. sylvestris* trees colonized by *P. castaneus* were collected in 2015-2017 at three locations in Central Poland. All these trees were weakened mainly by drought. Their roots and stems were divided into sections according to their diameters and kept in the laboratory until the emergence of associated insects was complete. A total of 13 species of Coleoptera and 2 species of Hymenoptera were collected from the trees colonized by *P. castaneus*. Among the co-occurring insects (not trophically related to the pest), the Curculionidae family was most numerous, in which *Pityogenes bidentatus* (Herbst) dominated, with a proportion of almost 90% of the collected insects, followed by *Pogonocherus fasciculatus* (De Geer) (5% share) and *Magdalis phlegmatica* (Herbst) (2%). Only two co-occurring species were found in the fragments of the stems with a diameter >3 cm: *Rhagium inquisitor* (L.) and *P. bidentatus*. In stems <1 cm only *Ernobius nigrinus* (Sturm) and *M. phlegmatica* were observed. Most species (5) were observed in stems 1-3 cm in diameter: *Phaenops formaneki* Jacobs, *Anthaxia quadripunctata* (L.), *Chrysobothris igniventris* Reitt, *P. fasciculatus*, and *P. bidentatus*. *P. castaneus* occurred over the entire height of the stems. The share of natural enemies of *P. castaneus* was negligible – less than 3%. In this group of insects, the parasitoid *Coeloides melanostigma* Strand was the most numerous (1.4%), followed by the predators *Crypturgus pusillus* (Gyll.) and *Corticeus linearis* (Fabr.), both with 0.5% share. The results indicate that predatory insects and parasitoids have little influence on the number of *P. castaneus*. Several beetles and larvae of *Hylobius abietis* (L.) were reared from the roots of trees colonized by *P. castaneus*. This publication is the first report on the occurrence of this species on weakened but still living *P. sylvestris* young trees.

KEY WORDS

co-occurrence, *Hylobius abietis*, natural enemies, reforestations, pine weevils, thickets

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Introduction

The small banded pine weevil *Pissodes castaneus* (De Geer) (hereafter referred to as small pine weevil) is one of the most dangerous pests of Scots pine *Pinus sylvestris* L. plantations and thickets, where the trees are infested by root fungi and/or damaged by game and weakened due to an improperly developed root system or by abiotic factors, *e.g.*, drought and frost. Young stands growing on post-fire or post-agricultural areas are particularly vulnerable to damage from this pest.

P. castaneus is distributed throughout Europe, especially in northern Italy, Austria, Germany, the Asian part of Russia and Turkey, and northern Africa (CABI, 2021). It was transferred into South America in 2001 and first seen in Brazil and then in Argentina, Uruguay, and Chile in 2003 (Iede *et al*., 2007, 2010; Gomez *et al*., 2013). In Europe, this pest occurs on other pine species, including *Pinus halepensis* Mill., *P. brutia* Ten., *P. pinaster* Aiton, *P. pinea* L. (Day *et al*., 2004). In South America, it damages *Pinus taeda* L. and *Pseudotsuga menziesii* (Mirb.) Franco (Iede *et al*., 2007; Gomez *et al*., 2013).

With the mass occurrence of *P. castaneus* beetles, the growth of pine shoots may be inhibited and the trees seriously damaged. The severe damage is caused by larvae that dig tunnels under the bark of the tree stems during the growing season, which contributes to great economic losses.

In the 20th century, this species was not an economic problem in Europe, and perhaps this was the reason for the limited interest in this species, as evidenced by the limited number of publications from this period. These mainly concerned the parasitoids of the pest (Alauzet, 1982, 1987; Kenis and Mills, 1994; Kenis, 1997). Some information summarizing the state of knowledge on European species of *Pissodes* is provided in the study by Day *et al*. (2004). On the other hand, an increase in the threat of this species to young Scots pine stands has been observed since the early 2000s. It is suggested that climate change, which has been progressing in the past few decades, especially evident in droughts that weaken the stands, may have contributed to the increased threat by this pest. Despite the increased risk, knowledge about this species is still very limited. Practically, the only source of information on European populations of *P. castaneus* is the paper of Panzavolta and Tiberi (2010) on the biology and dynamics of the pest population in Italy.

In Poland, cyclic outbreaks of small pine weevil have been observed since the early 2000s, occurring every 5 years and covering more and more areas (Fig. 1). Massive occurrence of this pest, especially in 2-5-year-old reforestations, leads to complete destruction of the pines. The increase of the endangered area and the intensification of the damage caused by *P. castaneus* in the past two decades justified multidirectional research on the biology and ecology of this weevil, as well as on the entomofauna coexisting on the trees inhabited by the pest. The objective of the present study was to determine the species composition of insects found in association with *P. castaneus* in Scots pines.

Material and methods

The study was conducted in 2015-2017, *i.e.*, during the increasing outbreak of *P. castaneus* (Fig. 1). The main factor that initiated the weakening of forest stands during this period, increasing their susceptibility to the colonization of the pest, was the 2015 drought. In Poland, 2015 was classified as very or anomalously warm. The average annual temperature was 1.8°C higher than the long-term 1971-2000 standard (Brodzińska *et al*., 2015). In terms of moisture conditions, 2015 was also generally rated as dry, with no annual precipitation exceeding the norm across the country. The most severe precipitation deficit was observed in the central and southern parts of the country (from -40% to -50% of the norm).

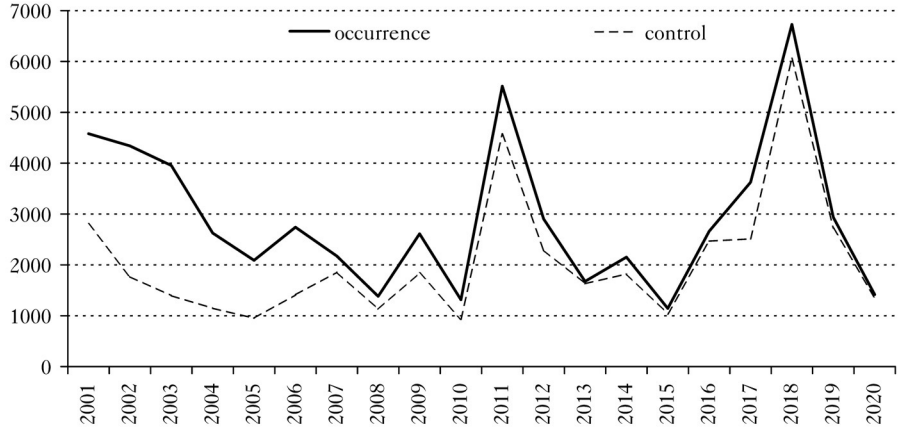

Fig. 1.

Occurrence and control of *Pissodes castaneus* in Poland in 2001-2020 (ha); source: unpublished data of the State Forests. Control includes measures to remove trees infested with the pest from the stand.

The study was conducted in three Scots pine reforestations: two in central Poland (coordinates of Forest Districts in Garwolin 51.92560 N, 21.59174 E and Celestynów: 52.06459 N, 21.38710 E) and one in the southern part (Forest District in Mielec: 50.32460 N, 21.51879 E). Experimental reforestations with a share of 80% of 3-5-year-old Scots pine were established on 3-4 ha clearcut areas. In July-August of each year, 20 trees infested with *P. castaneus* were randomly selected on each experimental reforestation. These trees were still alive but showed the visible signs of colonization by the pest, i.e. discoloration in about 50-70% of the needles and resin oozing from oviposition sites and feeding holes on the lower parts of the stems.

The selected trees (20 trees × 3 areas × 3 years, 180 in total) were excavated and transported to the laboratory, where they were stripped of needles and divided into 4 sections: roots, sections of stems and branches with diameter <1 cm, 1.1-3 cm, ≥3.1 cm. The fragments of each tree belonging to each section were placed in separate plastic containers (dimensions 50 × 30 × 40 cm) with a lid in which the ventilation hole was secured with a net. Inside each container, a water reservoir covered with a net was placed to prevent the tree sections from drying out, which was refilled with water as needed. In addition, the cut trees were lightly sprinkled once a week. Insect rearing was carried out at a temperature of 20 ±2°C and humidity of approximately 60% for 6 months. Every day the emerging insects were checked and then identified to species or family using morphological techniques. Analysing the results, two major groups of insects were distinguished: (1) insects co-occurring, *i.e.* not trophically related to *P. castaneus*, and (2) natural enemies of *P. castaneus* (predators and parasitoids).

Results and discussion

Entomofauna co-occurring with *P. castaneus*. A total of 3,566 individuals were reared from trees colonized by small pine weevil, including 13 species of Coleoptera and 2 species of Hymenoptera (Table 1).

Among Coleoptera, the Curculionidae family was the most numerous, dominated by the two-toothed engraver *Pityogenes bidentatus* (Herbst), one of the most common and abundant bark beetle species in Poland. Its main host is Scots pine, less frequently other coniferous species, including *Picea* A.Dietr., *Larix* Mill. and *Abies* Mill. *P. bidentatus* breeds in young trees and in the

Table 1.

Insects associated with the small banded pine weevil *Pissodes castaneus* occurring on *Pinus sylvestris* trees; number of trees examined =180

Order / Family	Species	Relationship to *P. castaneus*	No. of trees with insects	No of insects (adults/larvae)	Mean no. of insects/tree (±SD)	Location in the tree				
						roots collar	root Lower	Part of the stem (diameter in cm) Middle (>3)	Upper (1-3)	(<1)
COLEOPTERA										
Ptinidae	*Ernobius nigrinus* (Sturm)	co-occurrence	3	8 (8/0)	2.4 ±1.2	–	–	–	–	×
Buprestidae	*Phaenops formaneki* Jakobson	co-occurrence	3	5 (5/0)	1.7 ±0.5	–	–	–	×	–
	Anthaxia quadripunctata (Linnaeus)	co-occurrence	6	26 (26/0)	4.3 ±1.1	–	–	–	×	–
	Chrysobothris igniventris Reitter	co-occurrence	4	4 (4/0)	1.0 ±0.0	–	–	–	×	–
Cerambycidae	*Pogonocherus fasciculatus* (DeGeer)	co-occurrence	28	190 (190/0)	6.8 ±1.4	–	–	–	×	–
	Rhagium inquisitor (Linnaeus)	co-occurrence	1	3 (1/2)	–	–	×	×	–	–
Cleridae	*Thanasimus formicarius* (Linnaeus)	predator	3	3 (3/0)	1.0 ±0.0	–	–	–	×	–
Curculionidae	*Magdalis phlegmatica* (Herbst)	co-occurrence	19	68 (68/0)	3.6 ±1.7	–	–	–	–	×
	Pityogenes bidentatus (Herbst)	co-occurrence	94	3162 (3162/0)	33.6 ±12.7	–	–	×	×	–
	Hylobius abietis (Linnaeus)	co-occurrence	5	5 (2/3)	1.0 ±0.0	×	–	–	–	–
	Crypturgus pusillus (Gyllenhal)	predator	5	20 (20/0)	4.0 ±1.4	–	–	–	×	×
Tenebrionidae	*Corticeus linearis* (Fabricius)	predator	7	20 (20/0)	2.8 ±1.0	–	–	×	–	–
HYMENOPTERA										
Braconidae	*Coeloides melanostigma* (Strand)	parasitoid	35	50 (50/0)	1.4 ±0.5	–	–	–	–	×
Chalcididae	–	parasitoid	2	2 (2/0)	1.0 ±0.0	–	–	–	×	–

branches of old trees, as well as in logging residues (Martikainen *et al*., 1996; Korczyński and Kuźmiński, 2007; Borkowski and Skrzecz, 2016). The bark beetle attacks trees that are severely weakened by fire, root diseases, or damage by other insects and game. This species accounted for almost 90% of the insects collected, and its beetles were found on more than 50% of the trees studied, ranging from 10 to 58 beetles per tree.

Magdalis phlegmatica (Herbst) was the second most abundant Curculionidae species. Its share in the total number of insects found was almost 2%. The species occurs throughout Poland and develops mainly in dying branches of *P. sylvestris* and, less frequently, in Norway spruce *Picea abies* (L.) H. Karst (Grodzki, 2009). In our study, larvae of *M. phlegmatica* were located mainly in the thinnest fragments of the stems.

An unusual observation was the finding of the large pine weevil *Hylobius abietis* (L.), whose development was observed in the primary root (taproot) of trees inhabited by *P. castaneus* (Fig. 2). We found larvae in a feeding tunnel in the primary root, about 10 cm below the root collar of the tree, and adult beetles emerging from pupal chambers in the primary roots of a tree, about 5 cm below the ground level. Literature on the large pine weevil describes this species as developing in conifer stumps, branches left from windbreaks, windthrows and from thinning (Nordenhem, 1989; Leather *et al*., 1999; Day *et al*., 2004). To date, there is no published information on the development of this species on several-years-old trees weakened by colonization with other insects. This study is the first information of its kind on the development of the large pine weevil in the roots of young trees that are still alive but severely weakened by *P. castaneus*. We found two larvae feeding in the roots about 5 cm below the root collar of the tree and three beetles emerged from pupal chambers located up to 10 cm below the soil surface.

Among the Cerambycidae, *Pogonocherus fasciculatus* (De Geer) was the most abundant representative of this family, accounting for about 5% of the total number of insects. This species

Fig. 2.

Hylobius abietis larva in the root of 4-year-old *Pinus sylvestris* tree inhabited by *Pissodes castaneus* (photo by Cezary Bystrowski)

feeds in the tree canopy. Starzyk *et al.* (2008) found the development of this species on small twigs in the crowns of *P. sylvestris* that were damaged or lying in the forest after thinning, as well as on pine twigs within the felled material. Moreover, these authors showed that *P. fasciculatus* coexisted most frequently with *P. bidentatus*, forming a 2-species complex that was most abundant on pine branches with a diameter of 2.6-4.5 cm left on clearcuttings.

Rhagium inquisitor (L). was the second species of Cerambycidae represented by only three individuals in the collected material. This beetle inhabits standing and lying weakened pines, spruces, larches, and firs, as well as their stumps (Weslien and Schroeder, 1999; Doychev *et al*., 2017). In our study, 1 beetle and 2 larvae of this species were found. The pupal chamber with one beetle was located at the level of the root collar of only one tree.

Coleoptera were also represented by some members of the family Buprestidae (0.8% share), which includes physiological pests that inhabit weakened or dying trees. These species usually have a 2-year generation, so weakened trees seem to be more suitable for their development than dying trees, which do not provide the species with a suitable breeding base for complete 2-year development due to the rapid decomposition of the wood. *Anthaxia quadripunctata* (L.) dominated among the representatives of the Buprestidae family. Its larvae develop mainly in pine and spruce, less often in fir and larch, previously attacked by other pests. This species is most common in young stands, where it inhabits weakened trees, and chooses for reproduction mainly thicker branches growing from the lower whorls, and rarely the stems (Gutowski *et al*., 2010). In the collected material, larvae of *A. quadripunctata* fed on stems with a diameter not exceeding 2 cm.

Several individuals of *Chrysobothris igniventris* Reitt. and *Phaenops formaneki* Jacobs. from the family Buprestidae were found. In the case of *Ch. igniventris*, its larvae were found on stems 1-3 cm in diameter. *P. formaneki*, on the other hand, was observed on trees taken from reforested areas where the water was in depressions in spring. These observations are confirmed to data from Finland, where this species was found on small (up to 2 m high) dying pines of *P. sylvestris* in swamps (Heliövaara *et al*., 1990). *P. formaneki* prefers weakened trees growing in the open canopy, preferring trees 2 to 3 m high (Heliövaara *et al*., 1990, Schmidl, 2016).

Ernobius nigrinus (Sturm) is the only representative of Ptinidae reared from collected trees. According to the literature, the development of this species occurs most frequently in thin, dying Scots pine twigs, where the larvae feed in the core area (Foit, 2010). It is a secondary pest inhabiting trees weakened by other insects. *E. nigrinus* were found only in stems less than 1 cm in diameter.

Based on the list of species present on *P. sylvestris* trees inhabited by small pine weevil, a list of insects co-occurring in the stems according to their thickness was prepared. The largest number of species (5) was found in the middle part of the trees, i.e. in the stems with a diameter of 1-3 cm. Only two species each were observed in the upper part of the trees (stem diameter up to 1 cm) and in the lowest parts (stem diameter >3 cm). *P. castaneus* developed along the entire height of the tree, regardless of stem diameter.

Predators. Three species of predators were also found, accounting for about 0.6% of the total number of insects collected. Most of them were *Corticeus linearis* (Fabr.), which usually inhabits the feeding tunnels of bark beetles in the upper part of the trunk and in the thin tips of the branches, especially *P. sylvestris* and *P. abies* (Grodzki, 2009). This species is frequently found in the feeding tunnels of *e.g. Pityogenes chalcographus* (L.), *P. bidentatus*, *Ips duplicatus* (Sahlb.) and *I. typographus* (L.) (Grodzki, 2009; Horák and Nakládal, 2009; Wegensteiner *et al*., 2015). In the studies presented here, *C. linearis* was found in the feeding tunnels of *P. castaneus*.

Individual beetles of *Thanasimus formicarius* (L.), a species penetrating trees and stumps in reforestations to feed, typically on the larvae of Scolytinae, *Pissodes*, and Buprestidae, were also found in the feeding tunnels of *P. fasciculatus* (Kenis *et al*., 2004). Alauzet (1982) observed that *T. formicarius* feed preferentially on emerging beetles of *P. castaneus* than on eggs and larvae, which are difficult to reach.

Several beetles of *Crypturgus pusillus* Gyll. were also cultured. This species often grows in the stumps and logs of Scots pine and Norway spruce in the larval galleries of Scolytinae, Cerambycidae, Curculionidae and Buprestidae, where it may feed on the eggs or young larvae of its hosts (Starzyk *et al*., 2008; Hjältén *et al*., 2010).

Parasitoids. The genus *Coeloides* Wesmael of the family Braconidae includes a group of parasitoids that commonly develop in the larvae of various species of *Scolytinae* and *Pissodes* spp. *Coeloides melanostigma* Strand was dominant among the collected insects (1.4% share). Its occurrence on *P. castaneus* has been described in several European countries (Alauzet, 1987; Kenis, 1997). Kenis and Mills (1994) described *C. melanostigma* as a major parasitoid of *Pissodes* spp. feeding on *Pinus* trees.

Analysis of insects developed from collected trees made it possible to observe that about 70% individuals of *C. melanostigma* were found on older larvae of *P. castaneus* preparing pupal chamber pupae, while the remaining individuals were obtained from younger larvae feeding in the tunnels. Pupation of *C. melanostigma* occurred upon to the host's body. Of the larvae of *P. castaneus*, usually only the head and sometimes small fragments of the body remained. In addition, several individuals of Chalcididae were observed on a larva of *P. castaneus* in the pupal chamber.

Other organisms. The presence of *Acari* sp. was detected on a few *P. castaneus* larvae in pupal chambers located on one tree only (Fig. 3). Apart from *Acari* spp., dead *P. castaneus* larvae were also observed in pupal chambers in a few cases. Pathogenic microorganisms were probably the cause of larval death, but their role in the mortality of *Pissodes* weevils has never been studied (Kenis *et al*., 2004).

Mortality of *P. castaneus* caused by natural enemies. The results showed a slight influence of natural enemies on the number of *P. castaneus*, most frequently in the larval stage. Parasitoids

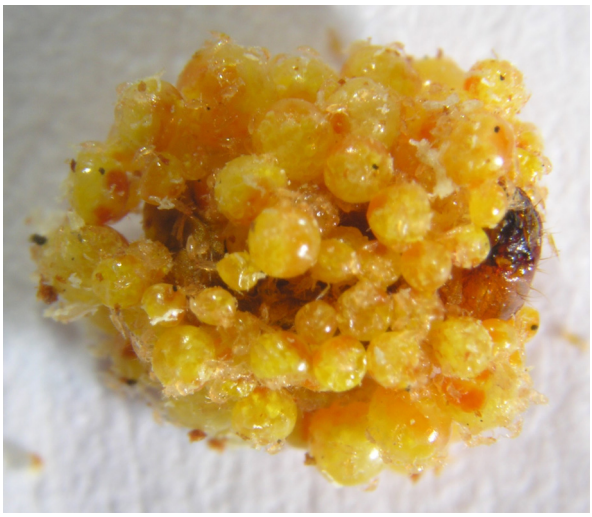

Fig. 3.
Acari spp. on *Pissodes castaneus* larva taken from a pupal chamber (photo by Cezary Bystrowski)

from the Braconidae family, the most numerous enemies found in collected insects, parasitized up to 10% of *P. castaneus* larvae. Contrasting results were obtained by Kenis and Mills (1994), who found a significant effect of *C. melanostigma* on mortality of *P. castaneus*, especially in France and Great Britain, where parasitisation rates ranged from 25 to 75%. Other parasitoid species had a much smaller effect on *P. castaneus* occurrence. Predators, mites, and pathogens were found sporadically in individual larvae of *P. castaneus*, confirming observations by other scientists (*e.g.*, Kenis *et al*., 2004) that insect predators and pathogens are not important mortality factors for European *Pissodes* spp.

Summary

P. bidentatus was the numerically dominant species among the entomofauna co-occurring with *P. castaneus*, which constituted nearly 90% of the collected insects. *P. fasciculatus* (5% share) and *M. phlegmatica* (2% share) were the next most abundant species.

Only two co-occurring species were found in the fragments of the stems with the largest diameter (over 3 cm): *R. inquisitor* and *P. bidentatus* and with the smallest diameter (up to 1 cm): *E. nigrinus* and *M. phlegmatica*. Most species (5) were observed in the fragments of stems 1-3 cm in diameter: *P. formaneki*, *A. quadripunctata*, *C. igniventris*. *P. fasciculatus*, *P. bidentatus*. *P. castaneus* developed over the entire height of the stems.

The presence of *H. abietis* was found in the roots of trees inhabited by *P. castaneus*. This paper is the first report confirming the development of this species in the roots of severely weakened but still living *P. sylvestris* trees at 3-5 years old.

The share of natural enemies of *P. castaneus* in the total number of insects collected was low, amounting to 0.6% for predators and less than 3% for parasitoids. Most of them were found in stems less than 3 cm in diameter, where most insect species co-occurring with *P. castaneus* were also observed. *C. melanostigma* was the most numerous among the parasitoids.

Authors' contributions

I.S. and R.W. – performed the experiments; R.W. – analysed the data; I.S. – wrote the manuscript. Both authors read and approved the manuscript.

Declarations of interest

The authors declare no conflict of interests.

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STRESZCZENIE

Owady współwystępujące z *Pissodes castaneus* (De Geer) na sośnie *Pinus sylvestris* L.

W Polsce smolik znaczony *Pissodes castaneus* (De Geer) jest gatunkiem coraz powszechniej występującym w uprawach i młodnikach sosnowych *Pinus sylvestris* L. osłabionych działaniem różnych czynników biotycznych (choroby korzeni, zwierzyna) i abiotycznych (susza, grad itp.). W Europie od początku lat 2000 obserwuje się wzrost zagrożenia młodych drzewostanów przez ten gatunek, najprawdopodobniej wskutek postępujących zmian klimatycznych. Wydaje się, że do wzrostu liczebności szkodnika mogły przyczynić się susze osłabiające uprawy i młodniki. Intensyfikacja szkód wyrządzanych przez ten gatunek, a także brak skutecznych metod ochronnych uzasadnił podjęcie badań, których celem było poznanie owadów współwystępujących z *P. castaneus*, ze szczególnym uwzględnieniem jego wrogów naturalnych.

Badania wykonano w latach 2015-2017, tj. w czasie narastającej gradacji smolika znaczonego (ryc. 1). Głównym czynnikiem, który zainicjował osłabienie upraw leśnych w tym okresie, była susza w 2015 r. Powierzchnie doświadczalne założono w trzech uprawach leśnych zlokalizowanych na terenach nadleśnictw Celestynów i Garwolin (Regionalna Dyrekcja Lasów Państwowych w Warszawie) oraz Mielec (RDLP w Krośnie). Były to uprawy w wieku 3-5 lat z dominującym udziałem sosny (80%), założone na zrębach zupełnych o powierzchni 3-4 ha. Każdego roku na każdej z tych powierzchni wykopywano w lipcu-sierpniu po 20 drzewek zasiedlonych przez smolika znaczonego, łącznie 180 drzewek. Wszystkie te drzewka były osłabione, ale nie martwe. W laboratorium drzewka oczyszczono z igliwia oraz podzielono na 4 sekcje: korzenie, odcinki strzałek o średnicy <1 cm, 1,1-3 cm, ≥3,1 cm. Odcinki każdego drzewka należące do poszczególnych sekcji umieszczano w oddzielnych pojemnikach. Hodowlę prowadzono w temperaturze 22 ±2°C i wilgotności ok. 60% przez 6 miesięcy. Każdego dnia kontrolowano wylęgające się owady, które następnie identyfikowano do gatunku lub rodziny.

Wśród entomofauny towarzyszącej, niepowiązanej troficznie ze smolikiem znaczonym, gatunkiem dominującym był *Pityogenes bidentatus* (Herbst), który stanowił blisko 90% wyhodowanych owadów. Kolejnymi gatunkami były *Pogonocherus fasciculatus* (De Geer) (udział 5%) i *Magdalis phlegmatica* (Herbst) (udział 2%) (tab. 1). W strzałach o największej średnicy (powyżej 3 cm) występo*wały Rhagium inquisitor* (L.) i *P. bidentatus*. Najwięcej gatunków (5) stwierdzono w strzałkach o średnicy 1-3 cm: *P. fasciculatus*, *P. bidentatus*, *Phaenops formaneki* Jacobs., *Anthaxia quadripunctata* (L.) i *Chrysobothris igniventris* Reitt. W górnej części drzewek, na strzałkach o średnicy do 1 cm, znaleziono *Ernobius nigrinus* (Sturm) i *M. phlegmatica*. Smolik znaczony rozwijał się na całej wysokości strzałek.

W korzeniach drzewek zasiedlonych przez smolika stwierdzono obecność *Hylobius abietis* (L.). Jest to pierwsze doniesienie potwierdzające rozwój tego gatunku w korzeniach silnie osłabionych, ale nie martwych drzewek *P. sylvestris* w wieku 3-5 lat (ryc. 2).

Stwierdzono niewielki wpływ wrogów naturalnych na liczebność smolika znaczonego. Ich udział w łącznej liczbie wyhodowanych owadów wynosił 0,6% dla drapieżców i niecałe 3% dla parazytoidów (ryc. 3). Wśród parazytoidów najliczniej występował *Coeloides melanostigma* Strand.