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AN ATTEMPT TO COMPARE TWO METHODS TO DETERMINE POPULATION SIZE OF PINE FOLIOPHAGES WINTERING IN FOREST LITTER

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Abstract. Two methods to determine the population size of foliophagous insects wintering in forest litter were compared in 52 *Pinus sylvestris* stands. It was found that the method consisting in the measurement of the number of insects in the stand in 10 small plots was not markedly better than the method consisting in the measurement of the population size under the crown of one tree.

Key words: *Pinus sylvestris*, foliophagous insects, population size measurement

INTRODUCTION

The assessment of population size of foliophagous insects during their wintering in forest litter has been used for approx. 70 years as the basis for the forecasting of risk to pine (*Pinus sylvestris* L.) stands in Poland [Łuczkiewicz 1935, Śliwa 1992]. Procedures connected with the measurement are extremely labour-intensive and arduous, since they require searching through forest litter at low air temperatures and poor lighting. Until recently the size of the searched area in the stand was equal to the crown projection area of an average tree [Sierpiński 1966, Instrukcja... 1995]. This means that in young stands and those growing on poor soils sample plots were small and in old stands and those growing on fertile soils they were large. In Poland in forest protection practice population density of harmful insects was not determined per unit of soil area, e.g. 1 m^2 or 1 ha, since the result of measurement of insect population size under the canopy of one tree was the direct indicator of the population of harmful insects per one tree in a given stand. A drawback of such a measurement of the number of specimens was the fact that it was impossible to assess its accuracy due to a lack of replications and at times (especially in young stands) the small area of the sample plots. In relation with the rather limited reliability of forecasts it was suggested that it could have been caused to a large extent by the insufficient accuracy of the measurement of insect population size [Gadzikowski 1973, Gawęda 2000, Kolk et al. 2000].

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At present the method to determine insect population density is based on population size measurement in 10 sample plots distributed in a given stand according to a specific pattern. The sample area was identical in all stands, irrespective of their age and the size of pine crowns [Instrukcja... 2004, Ślusarski 2004].

The aim of this study was to partly verify the hypothesis that the new method to measure insect population size facilitates a faster detection of the presence of harmful insects in the stand, and to show whether it is more accurate than the method applied previously.

MATERIAL AND METHODS

Investigations were conducted in the western part of the Notecka Forest, in the Krawin Forest District (the Regional Directorate of State Forests in Szczecin), covering with sample plots the forest complex of 1700 ha. Inventories of insect population size were conducted in 52 pine stands aged 40-100 years (mean 73). Many years before these stands had been selected by the forest administration for the annual inventory of insect population size.

In each stand the population of foliophagous insects was determined by two methods. The first method consisted in the measurement of the population size of insects in the so-called under-canopy surface, defined by the vertical crown projection of an average tree. The other method consisted in the measurement of insect population size in 10 sample plots, arranged every 35 m along the circumference of a rectangle of 70 × 105 m. Each plot was 0.5 × 1.0 m, and their total area was 5 m^2. Among the plots five had their longer side adjacent to the tree trunk and five others were located at a distance of 1.5 m from the tree trunk. Two plots were located on the eastern side of the pine tree trunk, three on the western side, two on the southern and three on the northern side, respectively.

The mean area of the surface under the canopy of one tree was 7.66 m^2 (standard error of the mean was ± 0.295). Thus, the size of the sample area in the first method was much larger than in the latter method, in which it was always 5 m^2.

The inventory of insect population size was performed in November 2004. The significance of differences was tested using the Student's t test for pairs of observations and using the nonparametric sign test [Ruszczyc 1978].

RESULTS

In the litter of pine stands the following pine foliophages were reported: pine sawflies *Diproninae*, the pine beauty *Panolis flammea* (Den. et Schiff.), the pine looper moth *Bupalus piniaria* (L.) and the pine hawk moth *Hyloicus pinastri* (L.).

Insect population density is presented in Table 1. Pine sawflies were found in relatively biggest numbers. Pupae of the pine beauty, pine looper moth and pine hawk moth were scarce. Very large values of standard deviation in relation to the mean showed that the distribution of measurement results was definitely of a cluster type. However, it was found that when measuring the number of sawflies in 10 small plots slightly higher values of their density in the stand were obtained than it was the case with the method consisting in the sifting of litter under the canopy of one tree (Table 1). A slightly better

Table 1. Population density of foliophagous insects (number of specimens per 5 m^2) determined by two methods
Tabela 1. Zagęszczenie populacji foliofagicznych owadów (liczba osobników na 5 m^2) określone dwoma metodami

Taxon Takson	Type of sample plot Rodzaj powierzchni próbnej			
	10 plots 10 poletek		surface under canopy of one tree powierzchnia podokapowa	
	x	± SD	x	± SD
Diprioninae	27.62	± 22.957 a	22.55	± 19.144 b
Bupalus piniaria	0.14	± 0.397 a	0.13	± 0.361 a
Panolis flammea	0.48	± 1.129 a	0.46	± 0.684 a
Hyloicus pinastri	0.29	± 0.605 a	0.32	± 0.456 a

x – mean.
SD – standard deviation.
If numerical values in a given line are denoted with different letters, their means differ statistically significantly.
x – średnia.
SD – odchylenie standardowe.
Jeżeli w wierszu wartości liczbowe oznaczone są różnymi literami, to średnie różnią się statystycznie istotnie.

effectiveness of measurement of the sawfly population size in 10 plots was caused by the fact that in this method 50% of the surveyed area is found at the trunk of a tree (5 plots), and sawflies are found in biggest numbers usually at the trunk [Zander 2003]. However, it needs to be observed that the fact whether a given method always shows a bigger or always smaller density is of little practical importance, since for each method risk rates for trees may be appropriately adopted in the process of risk forecasting.

A bigger practical importance may be ascribed to the precision of measurement, which may be expressed e.g. by the size of the coefficient of variation for measurements. It results from data presented in Table 2 that the variation in the values of insect population density measurements in a forest complex was very high. Both compared methods in terms of their accuracy probably did not differ much. However, it may be assumed that at a slight density of the *Lepidoptera* population the traditional method was more accurate, as using it much lower values of the coefficient of variation were found (Table 2).

From the point of view of forest protection practice it is essential to have the possibility to detect the presence of dangerous insect species in the stand as early as possible. It turned out that in this respect the method consisting in the use of 10 small plots was inferior to the method consisting in the survey of the area under the canopy of one tree (Table 3). All butterfly species were detected more frequently in areas under the canopy of trees. This could have been caused by the fact that the surfaces under the canopy of individual trees were much larger (mean 7.66 m^2) than the total size of 10 plots with the area of 0.5 m^2 each.

Table 2. Coefficient of variation for 52 measurements of insect population density, %
Tabela 2. Współczynnik zmienności 52 pomiarów zagęszczenia populacji owadów, %

Taxon Takson	Type of sample plot Rodzaj powierzchni próbnej	
	10 plots 10 poletek	surface under canopy of one tree powierzchnia podokapowa
Diprioninae	83.1	84.9
Bupalus piniaria	283.6	277.7
Panolis flammea	235.2	148.7
Hyloicus pinastri	208.6	142.5

Table 3. The number of stands in which harmful *Lepidoptera* species were found using a specific inventory method (for 52 stands used in the study)
Tabela 3. Liczba drzewostanów, w których stwierdzono występowanie szkodliwych gatunków motyli daną metodą kontroli (na 52 drzewostany wykorzystane w badaniach)

Taxon Takson	Type of sample plot Rodzaj powierzchni próbnej		
	10 plots 10 poletek	surface under canopy of one tree powierzchnia podokapowa	both obie łącznie
Lepidoptera, in them – w tym:	25 a	35 b	39
Bupalus piniaria	5 a	7 a	11
Panolis flammea	14 a	23 b	28
Hyloicus pinastri	10 a	18 a	21

If numerical values in a given line are denoted with different letters, their means differ statistically significantly.
Jeżeli w wierszu wartości liczbowe oznaczone są różnymi literami, to metody różnią się statystycznie istotnie.

It may be assumed that in older stands and those growing on good sites, in which crowns of trees are large (and the area under the canopy of a tree is bigger than 5 m^2), harmful insects may be detected more frequently in areas under the canopy of trees. In turn, in stands younger than 40-50 years and those growing on poor sites, where tree crowns and the areas of crown projection are small [Czuraj 1997], harmful insects may be detected more frequently using 10 plots with a total area of 5 m^2.

In conclusion it needs to be emphasized that the low reliability of the risk rate forecast for stands may occur irrespective of the degree of accuracy of the population size determination for insects wintering in forest litter and it is caused by a lack of statistically correlation between the number of nymphs found in litter in autumn and winter and the population size of the next generation of insects in tree crowns [Szmidt 1977].

CONCLUSIONS

1. The new method to determine the population size of harmful insects in pine stands does not ensure a more accurate determination of their population size than the method used previously.

2. The probability of showing the presence of harmful insects in the stand depends probably primarily on the size of the surveyed area of forest litter. Thus the new determination method may be superior only in pine stands aged below 40-50 years, in which areas under the canopy of individual trees are small.

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PRÓBA PORÓWNANIA DWÓCH METOD OKREŚLANIA LICZEBNOŚCI FOLIOFAGÓW SOSNY ZIMUJĄCYCH W ŚCIÓŁCE LEŚNEJ

Streszczenie. W 52 drzewostanach *Pinus sylvestris* porównano dwie metody określania liczebności foliofagicznych owadów zimujących w ściółce leśnej. Stwierdzono, że metoda polegająca na pomiarze w drzewostanie liczebności owadów na 10 małych poletkach nie jest wyraźnie lepsza od metody polegającej na pomiarze liczebności pod koroną jednego drzewa.

Słowa kluczowe: *Pinus sylvestris*, owady foliofagiczne, pomiar liczebności

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