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A COMPARISON OF ACCURACY OF TWO METHODS FOR THE DETERMINATION OF POPULATION SIZES OF SAWFLIES (*DIPRIONINAE*)

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Abstract. The precision of insect number determination in forest litter using a method, in which the sample element comprised 10 plots of 0.5 m^2 each, was compared with that of the method, in which the sample element consisted of one plot of 5 m^2. Investigations were conducted in four pine stands aged 59-80 years. The number of cocoons of *Diprioninae* found in the litter was counted. It was found that the precision of the compared methods was very low at a slight density of cocoons and it increased with an increase in their density. It would not be justified to say that the two compared methods of measurement for sawfly cocoon density differ in terms of their precision.

Key words: forest protection, *Diprioninae*, population size measurement, forecasts

INTRODUCTION

A major problem for forest protection in Poland is the insufficient reliability of forecasting the level of threat for pine stands posed by pests [Gawęda 2000, Kolk et al. 2000]. In relation with this fact a new method has been implemented recently in forests to determine the population size of leaf feeding insects wintering in the forest litter [Instrukcja... 2004, Ślusarski 2004]. This method consists in the determination of the number of insects in the stand based on analysis of litter in 10 plots of 0.5 m^2 each. The previous method consisted in the measurement of population sizes of insects only in one plot with an area equivalent to the crown projection area of an average tree.

However, since in the new method each of the ten plots is situated differently in relation to the tree stem it is not possible to accurately calculate the mean number of insects and determine the measurement error – similarly as it was the case when using the previous method.

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Comparisons of the two above-mentioned methods conducted to date in Polish forests were limited to the determination of labour consumption of measurements and to the evaluation which of these methods makes it possible to collect a higher number of insects [Dymek 2008]. Thus still there is no available answer to the question which method is more precise, i.e. with the use of which method a smaller measurement error is made for the density of pest populations.

In a study by Korczyński and Remenda [2007] it was found that the possibility to detect pests in the stand in case of their very limited number depended on the size of the analysed litter area. In contrast, it did not depend on the fact whether the controlled area of 5 m^2 in size constituted one plot or whether it was divided into 10 small plots.

The aim of this study was an attempt to answer the question whether the new method of measuring the number of sawfly cocoons was more precise than the method which had been abandoned.

METHODS

Investigations were conducted in the western part of Poland, in the Drawno Forest District (forest division Dominikowo, compartments 13a and 46a), in the Babki Forest District (forest division Babki, compartment 159Ad) and the Grodziec Forest District (forest division Biała Królikowska, compartment 222i). In the Drawno Forest District the stand growing in compartment 13a was 80 years old, while that in compartment 46a was 70 years old. In the Grodziec Forest District the stand was 78 years old, while that in the Babki Forest District was 59 years old. In the forest districts of Drawno and Grodziec stands were growing on a fresh coniferous forest site, while in the Babki Forest District it was on a fresh mixed forest site. Stands selected for the purpose of this study were characterised by very poor cover of the litter by herbaceous vegetation.

In each stand an experimental mean sample plot of 3 ha was established. Next in a given mean sample plot the number of sawfly cocoons was measured 6, 8 or 10 times using each of the two compared methods.

In the first method the sample element was the result of measurement on one plot with a shape comparable to a circle of 5 m^2 in area, situated around a pine stem. In the other method the sample element was the total of the number of sawflies in 10 rectangular plots, each of 0.5 m^2 in area. Small rectangular plots were distributed in the stand at a distance of approx. 35 m from one another, along the sides of a rectangle of 70 × 105 m [Instrukcja... 2004]. Five of them were located at tree stems, while five were situated at a distance of 1.5 m from a tree stem. Two of these plots were located east of a stem, three to the west, two to the south and three – north of a stem.

Insects were searched for in the forest litter on all the plots in the autumn-winter period.

The primary indication of measurement precision is the coefficient of variation. The smaller the deviations of recorded results – within a sample – from the mean value, the higher the precision of a method is. In these analyses less numerous cocoons containing sawflies and the highly numerous empty cocoons were considered separately, thus obtaining different levels of sawfly population sizes.

Significance of differences between the compared methods was tested using the non-parametric ranked sign test for values forming pairs [Greń 1974].

RESULTS

At a very low density of cocoons (approx. 1-2 cocoons per 5 m^2) measurements of population size using the two methods turned out to be very imprecise (Table 1). Also at an average density of the *Diprioninae* population (approx. 8 cocoons per 5 m^2), at which a limited threat for the stand is observed [Instrukcja... 2004], both methods were comparably imprecise. Coefficients of variation for measurements were very high, amounting to 74-86% mean values. The value of coefficients of variation indicates that the statistical distribution of measurements in the samples was not normal, but cluster-like in character [Bogucki 1979]. This means that the measurement area of the litter used in both methods was too small to eliminate the effects resulting from the cluster distribution of insects.

Table 1. Statistical characteristics of variation in measurement results for the number of cocoons containing sawflies

Tabela 1. Charakterystyka statystyczna zmienności wyników pomiaru liczebności kokonów zawierających boreczniki

Forest District Nadleśnictwo	Characteristics of samples Charakterystyka próby		Number of cocoons in a sample – 5 m^2 Liczba kokonów w próbie – na 5 m^2			
	sample element element próby	number of elements in a sample liczba elementów w próbie	mean średnia	scatter rozstęp	standard deviation odchylenie standardowe	coefficient of variation współczynnik zmienności
Babki	1 large plot	10	1.4	0-3	1.174	83.8
	10 small plots	10	2.4	0-6	2.066	86.1
Drawno, compartment 13	1 large plot	10	8.1	0-18	5.971	73.7
	10 small plots	10	7.9	1-20	6.523	82.6
Drawno, compartment 46a	1 large plot	8	20.6	11-32	7.269	35.3
	10 small plots	8	18.9	10-28	6.244	33.0
Grodziec	1 large plot	6	41.2	16-75	19.854	48.2
	10 small plots	6	29.7	25-37	4.274	14.4

An increase in the sawfly population density to 20-40 cocoons per 5 m^2 contributed to a reduction of the value of coefficient of variation, as they fell within the range of 14-48% (the Drawno Forest Disrict, compartment 46a and the Grodziec Forest District). This means that with an increase in the density of cocoons the precision of both methods improved. At the same time the statistical distribution of results was close to the random distribution.

In both stands, with the lowest density of sawfly cocoons, the method of population size measurement on one crown projection area turned out to be slightly more precise, while in the two other stands the new method proved to be precise (Table 1).

We need to stress here very big differences between the obtained lowest and highest numerical values for density in individual stands, characterised by scatter (Table 1).

Usually extreme values of measurements differed by several hundred percent. Since in the forest protection practice only one measurement of insect population density is taken, the presented minimum and maximum values of measurements make it possible to illustrate an estimated, although slightly underestimated, scale of committed errors. It turns out that an error of one stand threat level is very frequent both when using the former and the new method.

The degree of variation in case of measurement results concerning numbers of cocoons at their very high density is presented in Table 2. The value of means was generally much higher than that indicating that the stand was threatened with the so-called total eating. It needs to be stressed that in each of the experimental plots at a very high density of cocoons (Table 2) coefficients of variation were smaller than those obtained at a low, medium and high density of cocoons (Table 1). This means that the accuracy of measurements increased with an increase in cocoon density. This finding pertained to both methods.

Table 2. Statistical characteristics of variation in measurement results of empty sawfly cocoons
Tabela 2. Charakterystyka statystyczna zmienności wyników pomiaru liczebności pustych kokonów boreczników

Forest District Nadleśnictwo	Characteristics of samples Charakterystyka próby		Number of cocoons in a sample – 5 m^2 Liczba kokonów w próbie – na 5 m^2			
	sample element element próby	number of elements in a sample liczba elementów w próbie	mean średnia	scatter rozstęp	standard deviation odchylenie standardowe	coefficient of variation współczynnik zmienności
Babki	1 large plot	10	48.6	12-94	28.356	58.3
	10 small plots	10	51.6	26-68	13.591	26.8
Drawno, compartment 13	1 large plot	10	30.5	10-67	17.469	57.3
	10 small plots	10	26.3	5-76	22.051	83.8
Drawno, compartment 46a	1 large plot	8	44.8	35-62	12.056	26.9
	10 small plots	8	47.0	39-56	6.547	13.9
Grodziec	1 large plot	6	576.0	352-745	134.690	23.4
	10 small plots	6	568.7	469-633	56.309	9.9

At a very high density of cocoons (Table 2) in three stands the new method proved to be markedly more accurate, while in one stand the previously applied method turned out to be more accurate.

Based on the analysis of statistical significance of differences in numerical values for eight pairs of coefficients of variation (Tables 1 and 2) it may be stated that generally there is no justification for a claim that, on the average, one of these methods was more accurate.

CONCLUSIONS

1. It would not be justified to claim that the two compared methods measuring the density of sawfly cocoons differ in terms of their precision. Thus both methods are equally suitable to forecast the degree of stand threat.

2. It is probable that at a number of cocoons considerably exceeding values indicating the maximum degree of stand threat in a bigger-scale experiment it will be possible to prove a higher accuracy of the method using a big number of small mean sample plots.

3. Accuracy of measurements of population size in case of each of the two methods increases in a given stand with an increase in the density of cocoons.

4. Since it was not shown that one of the compared methods measuring the population size of sawflies is more accurate, in practice this method should be applied, which is more advantageous for other reasons.

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PORÓWNANIE DOKŁADNOŚCI DWÓCH METOD OKREŚLANIA LICZEBNOŚCI BORECZNIKÓW (*DIPRIONINAE*)

Streszczenie. Porównano dokładność metod określania liczebności boreczników w ściółce leśnej. Wykorzystano metodę, w której elementem próby było 10 poletek, każde o wielkości 0,5 m^2 oraz metodę z elementem próby tworzonym przez jedno poletko o wielkości 5 m^2.

Badania wykonano w czterech drzewostanach sosnowych w wieku 59-80 lat. Wykorzystując każdą z dwóch metod, określono liczebność znajdujących się w ściółce kokonów *Diprioninae.* Stwierdzono, że precyzja porównywanych metod była bardzo mała przy niewielkim zagęszczeniu kokonów i zwiększała się wraz ze wzrostem ich zagęszczenia. Brak jest podstaw do twierdzenia, że dwie porównywane metody pomiaru zagęszczenia kokonów boreczników różnią się precyzją.

Słowa kluczowe: drzewostan sosnowy, *Diprioninae*, pomiar liczebności

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