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Preliminary Results on Predation of Gypsy Moth Pupae during a Period of Latency in Slovakia

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Abstract - Predation of gypsy moth pupae was studied from 2000 –2003 in Slovakia. Predation on artificially reared pupae was recorded and linear regression was used to test the hypothesis that predation follows a type II vs. type III functional response. The role of pupal predation in gypsy moth population dynamics was also investigated. The relative importance of predation of pupae by invertebrates vs. vertebrates was estimated using exclosures. During the study, population densities remained very low and stable. In general, invertebrates caused 55.8% and vertebrates 44.2 % of total predation. K-values varied from 0.20 to 3.00 and plots of abundance vs. k-values suggested that total predation was density independent during a period of latency. The ultimate role of predation on gypsy moth pupae remains unclear, however there are some indications that pupal predation plays a significant role in the dynamics of gypsy moth populations.

I. Introduction

The gypsy moth (*Lymantria dispar L.*) is the most serious pest of broadleaved stands, mainly oak stands, in Slovakia. Outbreaks recurr in cycles of 9 to 12 years. During the last outbreak (1992 – 1994), gypsy moth severely damaged more than 30,000 ha of forest land. In stands exhibiting patterns of long-term oak decline, defoliation can cause increased tree mortality in subsequent years and therefore, infested stands are often treated with biopesticides, mainly *Bacillus thuringiensis (Bt)*. The key biotic factors influencing population dynamics during the latency phase are not well known in Slovakia. Conversely, the bioregulation complex of gypsy moth is better understood in the U.S.A. [1, 2]. The goal of this paper is to present results on a study of gypsy moth pupal predation during the latency phase. The objectives of this study were to: determine the relationship between predation and gypsy moth densities (i.g. identify the type of functional response); evaluate the role of pupal predation in gypsy moth population dynamics; and quantify the relative levels of predation caused by vertebrates vs invertebrates.

II. Material and Methods

A. Survey of population density

A series of 12 study plots were established across the outbreak area of gypsy moth in southern Slovakia (Fig.1). Surveys of population density were conducted using the modified Turcek method (MTM) [3]. MTM consists of the following steps: count the number of egg masses on trunks from ground level to 5-8 m on 4 points (every point consists of 30 trees) in the study site; if the average number was over 1.00 egg mass per tree, the survey was terminated, if it was below 1.00 egg masses per tree, counting continued on another 4 points (together 240 trees); If the population density was below 0.3 egg masses, another 8 points were taken. The total arrangement consisted of 480 trees.

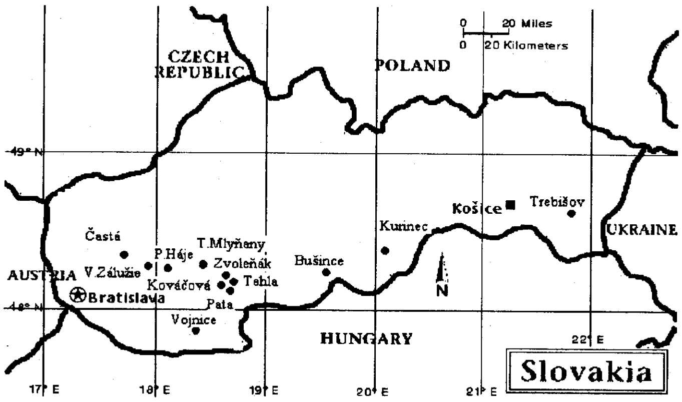


Fig. 1. Placement of study plots (•) in the Slovak Republic

B. Pupal predation

In July 2000-2003, artificially reared pupae were deployed at each site in each year. Predation was recorded by conducting inspections of pupae on three subsequent days following the day of their deployment; the condition of each pupa was recorded and we determined if the pupa was damaged by vertebrates or invertebrates.

The effect of density on predation levels was studied by comparing predation levels at different sites in different years. Predation was expressed as k-values at each site in each year. Density dependence was tested by regressing predation of pupae vs. egg mass density prior to deployment of pupae. Linear regression was used to test the hypothesis that predation follows a type II vs. type III functional response [4].

The impact of pupal predation on population growth was evaluated by plotting egg masses R (Nt+1/Nt) versus k-values from the same year during the entire study period.

The relative contribution of invertebrates vs. vertebrates as agents of predation on pupae was estimated using exclosures [5]. These experiments were conducted at Kurinec and Kováčová in 2000; Tehla, Kováčová, Zvoleňák and P. Háje in 2001; Trebišov, Bušince, Zvoleňák and Častá in 2002; and Trebišov, Kurinec, Bušince, Zvoleňák, Vojnice, V. Zalužie and Častá in 2003. At each site, 150 laboratory reared pupae were attached to small pieces of burlap using honey bee wax, and then deployed on the ground in study plots. Exclosures were then placed around 75 of these pupae.

Exclosures, which consisted of a ~1.5 cm steel mesh ("hardware cloth") cage were placed around each pupa. The damage of each pupa was recorded on three subsequent days following the day of deployment. We assumed that the exclosure excluded all vertebrate predators but did not impede predation by invertebrates. The relative contribution of invertebrate predators was thus estimated by the k-values computed from predation of pupae inside exclosures. K-values for predation by vertebrates was estimated as the difference between k-values from predation of pupae without exclosured and k-values from predation of pupae inside exclosures [5].

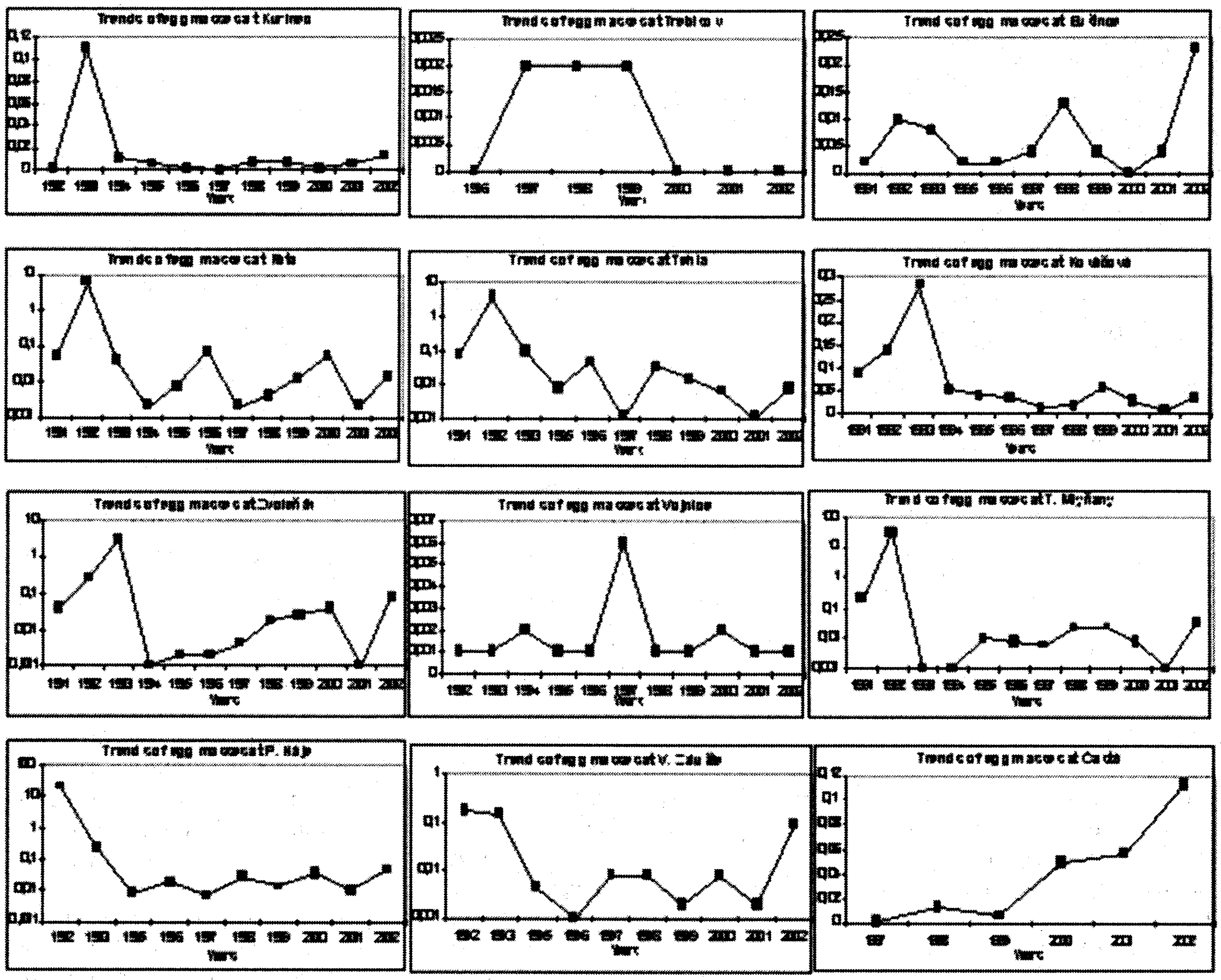


Fig. 2. Abundance of gypsy moth on 12 study plots expressed by average number of egg masses per tree.

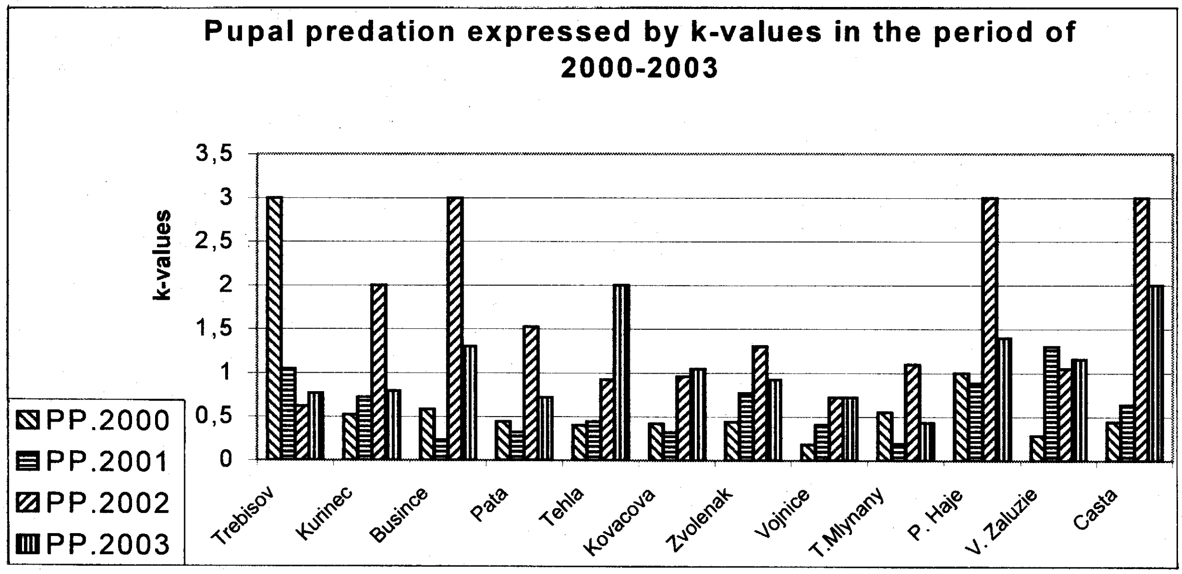
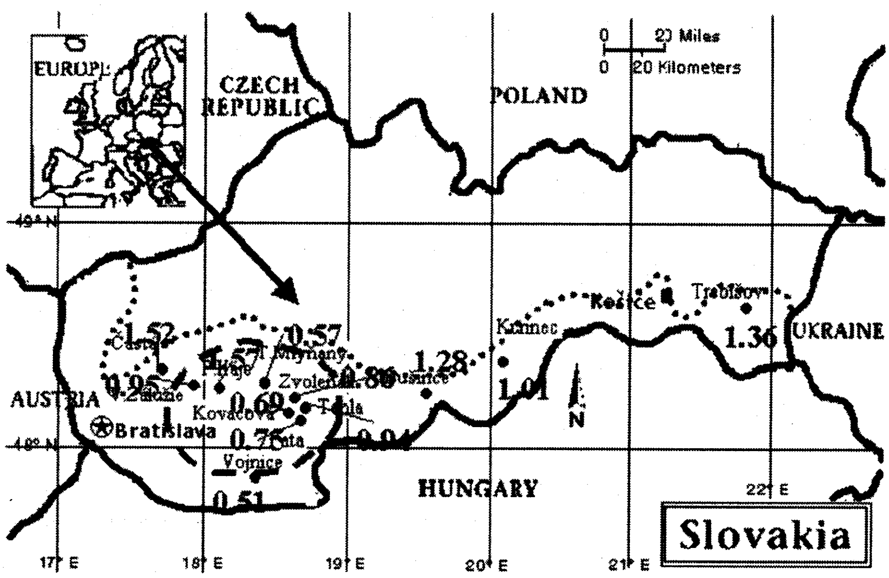


Fig. 3. Predation of pupae expressed by k-values in period 2000-2003.



LEGEND:

.... northern limit of gypsy moth outbreaks in Slovakia

— — — main gypsy moth outbreak area in Slovakia

Fig. 4. Average pupal mortality during study period expressed by k-values on study sites.

III. Results

A. Population density survey

Relatively little change in population density occurred during the period of 2000 – 2003. The range of population density varied from 0 to 0.113 egg masses per tree (0 to 56 egg masses/ha). The values indicate that a period of latency occurred on all of the study plots. Changes in abundance on individual sites during the last 10 years are shown in Figure 2.

B. Predation of artificially reared pupae

Pupal predation was generally high (Fig.3) – k-values ranged from 0.2 to 3.0 and predation was variable among different sites. Generally, the predation in sites located in the main gypsy moth outbreak area in Slovakia was lower that predation levels at locations beyond the outbreak area (Fig.4).

Dependence of predation was estimated based on the relationship between k- values calculated from pupae in the summer and egg mass abundance at the beginning of the same year. Though there was an appearance of a slight positive correlation, it was not statistically significant (Fig.5).

Nevertheless, these data suggest that total predation is density independent during the latency period when the abundance of gypsy moth remains stable.

We found a positive but insignificant correlation between predation (K-values) and change in population density. These results suggest that predation on pupae did not explain significant levels of variation in changes of gypsy moth population density (Fig 6).

C. Determination of the relative levels of predation caused by vertebrates vs. invertebrates

Relative levels of predation caused by vertebrates (V) vs. invertebrates (I) was as follows: 2000:V 0.24 I 0.34, 2001: V 1.45 I 0.51, 2002: V 0.39 I 1.84, 2003: V 0.53 I 0.60 (Fig.7). Generally, vertebrates caused 44.2% predation, and invertebrates caused 55.8% predation. It is possible that in several cases, predation by vertebrates could have occurred also in exclosures (e.g. by immature shrews). In that case, predation caused by invertebrates may have been overestimated in this study.

We used live traps to estimate which species of mice were present in habitats. Ninety percent of captured animals were identified as *Apodemus flavicollis/sylvatica* and 10 percent were *Clethrionomys glareolus*.

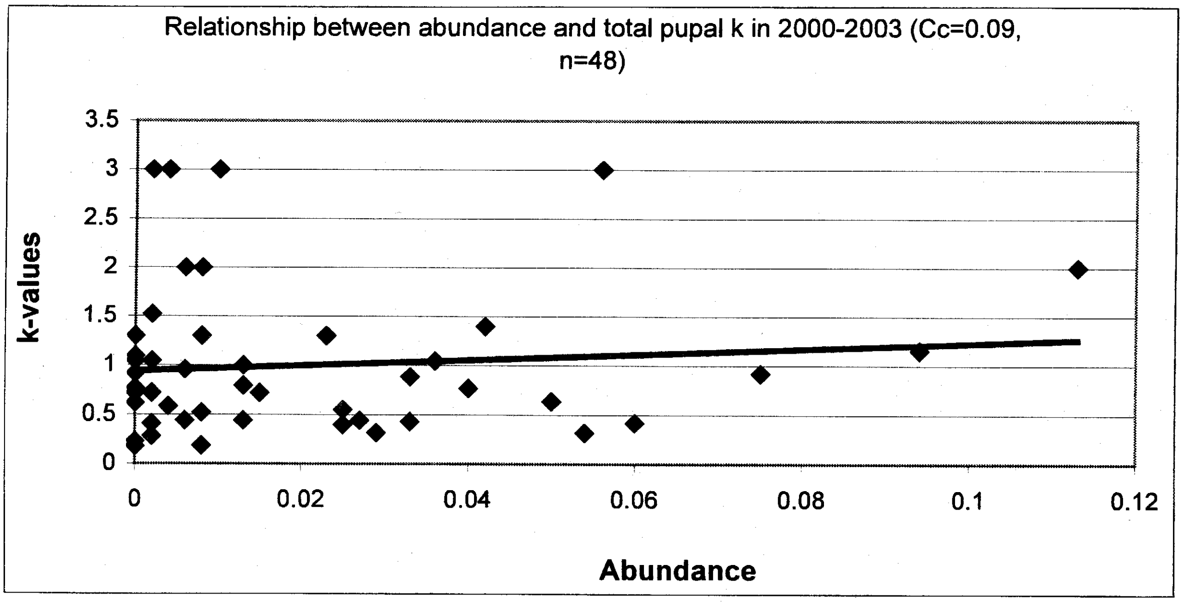


Figure 5. Relationship between abundance (expressed by egg masses per tree) and mortality of pupae (expressed by k-values) in the period 2000-2003.

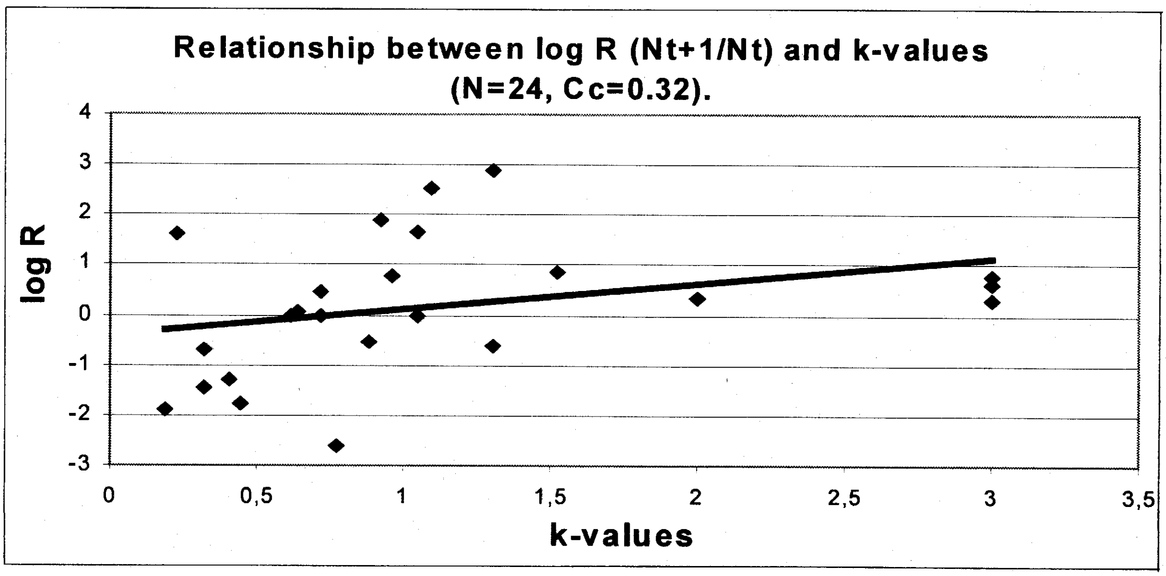


Fig. 6. Relationship between change in population rate (expressed by egg masses) and mortality (expressed by k-values).

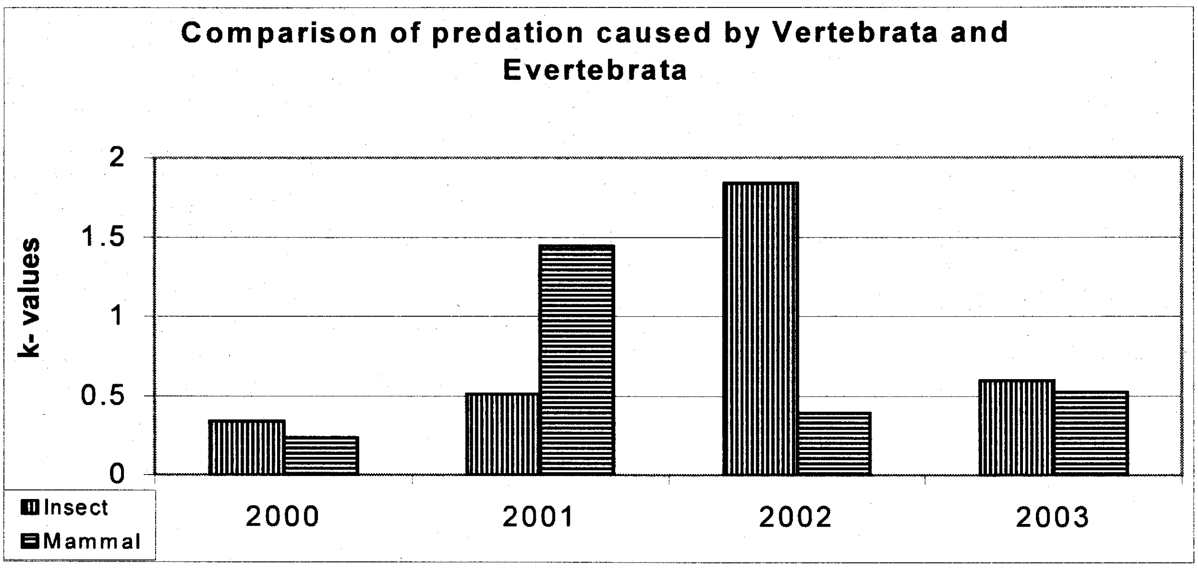


Fig. 7. Comparison of predation caused by vertebrates and invertebrates expressed by k-values during the study period.

IV. Discussion

Until now, little was known about pupal predation by vertebrates and invertebrates on gypsy moth populations in the region of Central Europe. In our study, the percentage of damage was high everywhere during the whole period; k-values only rarely did not exceed 0.5.

A similar study was conducted in Austria by Gschwanter et al [6]. Gypsy moth abundance during this study was estimated to be 0.01 egg masses per tree and the average pupal mortality reached about 80%. Predation at one plot was caused by mice 46.3%, *Calosoma sycophanta* 1.4%, other predators 4.1%; 40.4% of pupae disappeared. Predation on another plot was as follows: mice 36.4%, *Calosoma sycophanta* 3.7%, other predators 4.1% and 22.8% disappeared. It was determined that *Apodemus flavicollis* and *Clethrionomys glareolus* were the most important vertebrate predators in Austria; the same results were confirmed during our study in Slovakia.

Elkinton et al. [7] found that there was a significant relationship between the acorn crop and the abundance of small mammals in North America, however a relationship between gypsy moth abundance and small mammal abundance was not found. The reason for this disparity was that the majority of small mammals and birds are generalist feeders and gypsy moths are only a minor part of their diet. There was an abundance of acorns in Slovakia in 1999, however, since then we have not estimated the acorn crop on our study sites.

During our experiments we were not able to confirm the results of Campbell & Sloan [8], that pupal predation caused by vertebrates was much higher than that caused by invertebrates. Apparently the relative importance of predation is very different in North America than in Europe.

Turček [9] and Randík [10] listed the following species of birds as predators of gypsy moth pupae in Slovakia during outbreaks: *Oriolus oriolus*, *Sitta europaea*, *Parus maior*, *Lanius collurio*, *Dryobates maior* and *Dryobates minor*. We did not make direct observations of birds that predated gypsy moth pupae in our study.

Elkinton & Liebhold [2] consider *Calosoma sycophanta* as an important predator of larvae and pupae. Weseloh et all. [11] found that *C. sycophanta* consumed about 75% of pupae on the trunk, but a smaller percentage on leaves and thin branches. The abundance of *C. sycophanta* remained at low levels during the period of our study.

V. Conclusions

· Population densities were very low and relatively stable during the study period.

· K-values varied from 0.20 to 3.00 and total predation was density independent.

· The ultimate role of predation on gypsy moth pupae is not clear, however there are some indications that predation of pupae plays some role in gypsy moth populations in Slovakia.

· These experiments indicate that invertebrates are more important predators of pupae (causing 55.8% predation) than vertebrates (causing 44.2% predation) in low level gypsy moth populations in Slovakia.

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