Logistic regression approach to the prediction of tree defoliation caused by sawflies (Hymenoptera: Symphyta)

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ABSTRACT: A relationship between the abundance of phytophagous insects assessed from soil samples (in the case of *Cephalcia lariciphila*) or yellow sticky boards (in the case of *T. nigritus*) and percentage of defoliated trees was characterised by logistic regression.

Keywords: *Cephalcia lariciphila*; soil samples; *Tomostethus nigritus*; yellow sticky boards; tree defoliation; logistic regression

The exact loss of biomass caused by phytophagous insects is very difficult to measure and subjective assessment of defoliation percentage is inaccurate. From the practical aspect, the event of total (or strong) defoliation is important. It is possible to define the presence or absence of defoliation by binomial (presence/absence) or multinomial (several degrees of defoliation) distribution. The probability of an event of defoliation occurrence based on quantified measures (it means the numbers of caught specimens) can be determined by logistic regression.

A logistic regression model was already used to predict gypsy moth *Lymantria dispar* (Linné, 1758) and *Acleris variana* (Fernald, 1886) defoliation on a regional scale (Gribko et al. 1995; Weseloh 1996; Liebhold et al. 1996; Luther et al. 1997). In the case of spruce budworm (*Choristoneura fumiferana* Clemens, 1865) a logistic regression explained the variation in the volume loss of balsam fir (*Abies balsamea* [L.] Mill.) caused by (Clemens, 1865) defoliation (Ostaff, MacLean 1995).

In this paper, we tried to find the relationship between the population density of two sawfly species – *Cephalcia lariciphila* (Wachtl, 1898) and *Tomostethus nigritus* (Fabricius, 1804) – and the consequent portions of defoliated trees using the logistic regression. Entomological methods to estimate population densities as well as the assessment of defoliation were chosen to be the easiest in forest practice to help foresters to decide how to solve the problems with defoliators in forests.

MATERIAL AND METHODS

Study species and plots

In 2000 and 2001, a local outbreak of *Cephalcia lariciphila* occurred by the village of Větrný Jeníkov (15°30´E, 49°28´N) at the altitude of 650 m (Liška, Holuša 2002). Five study plots in 2002 (Nr. 1–5) and eight in 2003 (Nr. 1–8) were established in larch (*Larix decidua* Mill.) patches of mature spruce (*Picea abies* [L.] Karst.) forests (age of 80 years, only the forest in locality Nr. 4 is younger, about 60 years). The distance between patches is about 50 to 100 m.

Tomostethus nigritus (Fabricius, 1804) caused the total defoliation of some ashes near the village of Lanžhot in the period 1999–2000 (Liška, Holuša 2002). Five study plots in 2002 (Nr. 1–5) and eight in 2003 (Nr. 1–8) placed in ash (*Fraxinus excelsior* L. as well as *Fraxinus angustifolia* Vahl.) mature forests (80–100 years) were established in the locality Ruské domy (cadastre of the village of Lanžhot) (16°58´E, 48°38´N).

Methods

Ten and twenty yellow sticky boards (at the distance of 5 to 10 m) were exposed on each of the studied plots at *Cephalcia lariciphila* (2002) and *T. nigritus* (2002 and 2003), respectively. The traps consisted of yellow

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plastic boards 14.8 × 21 cm, coated on both sides with entomological glue (Souveurode®) suspended from dry branches (at *C. lariciphila*) or on hawthorn bushes (at *T. nigritus*) at the eye level. The specimens were taken down using tweezers and preserved in 70% alcohol (leg. et det. J. Holuša, coll. FGMRI Jíloviště-Strnady). Yellow sticky boards were placed in forests before the beginning of sawfly swarming (on 12th April and 28th April 2002, 23rd April 2003) and specimens were counted after the end of sawfly swarming (on 15th May and 20th May 2002, 1st July 2003) in *C. lariciphila* and *T. nigritus*, respectively. The set of fifteen yellow sticky boards was installed in Ruské Domy locality (Nr. 1) on 28th April 2000 (revised on 5th June 2000).

Five soil samples (0.5 × 0.5 m) in 2002 and ten in 2003 at the distance of 5 to 10 m were placed under the larch crowns by the village of Větrný Jeníkov (*C. lariciphila*). The larvae were counted by digging of needle fall on 12th March 2002 and 3rd April 2003.

The species composition of sawfly adults was studied using the Malaise traps in Ruské domy locality in 2000 and 2002. In Větrný Jeníkov locality, one larch was cut at about ten days interval (15th, 26th and 31st May and 10th June 2002) during the larval development. The larvae from 30cm sections of ten branches from all (lower, middle and upper) parts of crowns of sample trees were sampled and determined according to LORENZ and KRAUS (1957).

Evaluation of defoliation

Větrný Jeníkov locality (outbreak of C. lariciphila)

In 2002, the defoliation of fifty larches was assessed using two categories: absence of feeding (no visible feeding was observed) and total defoliation (including strong defoliation – several lower branches of larches were not defoliated).

Under the recent density of sawfly no other degree of defoliation was observed.

In 2003, the variation in defoliation was less distinct; therefore defoliation was assessed using four categories: absence of feeding (no visible feeding was observed); weak defoliation (up to approximately 30% of needles were eaten); strong defoliation (up to approximately 70% of needles were eaten) and total defoliation.

Assessment of defoliation was performed on 12th June 2002 and 25th June 2003.

Ruské domy locality at Lanžhot (occurrence of Tomostethus nigritus)

In 2002, three distinct degrees of defoliation were distinguished in sets of fifty ashes: absence of defoliation (no visible feeding was observed), weak defoliation (some of lower branches were defoliated) and total defoliation.

There was not observed any transition between total defoliation and weak defoliation. Assessment of defoliation was performed on 12th June 2002.

In 2003, four degrees could be distinguished: absence of defoliation (no visible feeding was observed); weak defoliation (some of lower branches were defoliated); strong defoliation (more than 50% leaves were eaten off) and total defoliation (more than 90% leaves were eaten off).

Assessment of defoliation was performed on 1st June 2003.

Statistical analyses

Logistic regression was used for estimation of probability of specific degree of defoliation. Logistic regression is a special case of generalised linear model (GLM). The generalised linear model can be used to predict responses both for dependent variables with discrete distributions and for dependent variables, which are nonlinearly related to the predictors. Normal distribution (or more generally continuous distribution) is not required for dependent variable. The most common used distributions are binomial (dependent variable can take two distinct values) or multinomial (dependent variable can take more than two distinct values). The logit link function is $\ln [\pi/(1 - \pi)] = \alpha + \beta x$ and logistic regression equation

$$\pi = \frac{e^{\alpha + \beta x}}{1 + e^{\alpha + \beta x}}$$

(BERGERUD 1996).

Because of the small sample size in 2002 (5 soil samples and 10 or 20 yellow sticky boards were used on each location), HORN (1983) estimation procedure was used for the mean estimation of caught adults. As the estimation of abundance is very time-consuming and complicated from the technical aspect, used sample sizes are on the very lower limit of possible sample size, according to our experience with other phytophagous sawflies (HOLUŠA, DRÁPELA 2003).

The sample size necessary to achieve the desired level of precision in estimating a population mean is given by the following formula

$$n = \frac{s^2 t^2_{\alpha(2).(n-1)} F_{\beta(1).(n-1,v)}}{d^2}$$

where: s^2 – the sample variance with n degrees of freedom,
d – the half-width of the desired confidence interval. This is subjectively chosen. Based on our experiences (HOLUŠA, DRÁPELA 2003), we used a third of catch mean,
$1 - \alpha$ – the confidence level,
$1 - \beta$ – the assurance that the confidence interval will not be greater than $\pm d$,
t – the two tailed critical value of t-distribution with $(n - 1)$ degrees of freedom (ZAR 1984).

Because of the strong heterogeneity of variance and non-normality (tested by D'Agostino normality test) of some sets, Box-Cox transformation on normality was used to use the mean of catch as representative.

Statistical analyses were performed on the significance level $\alpha = 0.05$ with Statistica 6.0 (logistic regressions), Adstat 2 (Box Cox transformations) and Unistat 5.1 (sample sizes).

Table 1. Coefficients of logistic regression function describing the dependence of probability of feeding (defoliation) on *Cephalcia lariciphila* larvae in soil samples ($p_{(\text{in all cases})} = 0.00$) (*without locality in younger forest)

Coefficients	2002			2002*			2003		
($\pi = e^{\alpha+\beta x}/(1\ e^{\alpha+\beta x})$)	Males	Females	Total	Males	Females	Total	Males	Females	Total
α	2.12	2.01	2.06	12.30	12.30	18.57	19.94	19.96	15.58
ß	–0.14	–0.24	–0.09	–0.92	–0.92	–0.56	–1.47	–1.03	–0.46

RESULTS AND DISCUSSION

Cephalcia lariciphila

There was no statistically significant correlation between mean male catch on yellow sticky board and probability of defoliation ($p = 0.16$) because the numbers of males on some plots were high but the percentage of defoliated trees was low [defoliation of larches was indeed caused by *C. lariciphila* because on all cut larches only larvae of this species were found ($n = 96$)]. This is probably a consequence of the prevalence of males in samples ($n = 13{,}715$; proportion of females 0.003%) and short distance between study plots. Active males fly between plots and change the original density in plots. The use of female samples should be more suitable. Unfortunately, females do not catch on boards. The fact of very small sample can play an important role, too.

In 2002, there was a highly significant relationship between the density of larvae in soil and the percentage of defoliated trees characterised by logistic regression (Table 1, Fig. 1). There is a possibility to deduct "critical numbers" of nymph density (Fig. 1) that cause defoliation of certain percentage of trees. 30 males or 18 females or 50 specimens per 0.25 m^2 should cause the total (strong) defoliation of 90% (with assumption that the percentage of pronymphs is the same).

Based on the data of larvae distribution in soil samples, we established that the sufficient number of soil samples ranged from 15 to 50 (Table 2). It means that the used number of samples was insufficient, but the larger number is not useful from the practical point of view.

In 2003, due to the distinction of four degrees of defoliation, firstly the multinomial distribution was calculated by the generalised logistic model parameters to distinguish all four stages of defoliation. Only the connected stages "absence of defoliation + weak defoliation" and "strong defoliation + total defoliation" could be distinguished. There was a high significant relationship between the density of larvae in soil in spring and the percentage of defoliated trees characterised by logistic regression ($p_{(\text{in all cases})} = 0.00$) (Table 1, Fig. 3). The curves in 2003 are sharper than in 2002. If we exclude the plot in the younger forest (Nr. 4), the curves are more similar (the plot in the younger forest was not included in 2003) (Fig. 2, Table 1).

Due to sharp curves (result of the connection of defoliation stages) "critical numbers" of nymph density (Fig. 3) that caused strong or stronger defoliation of all trees could be deducted (with assumption that the percentage of pronymphs is the same, i.e. 88.8%; $n = 472$).

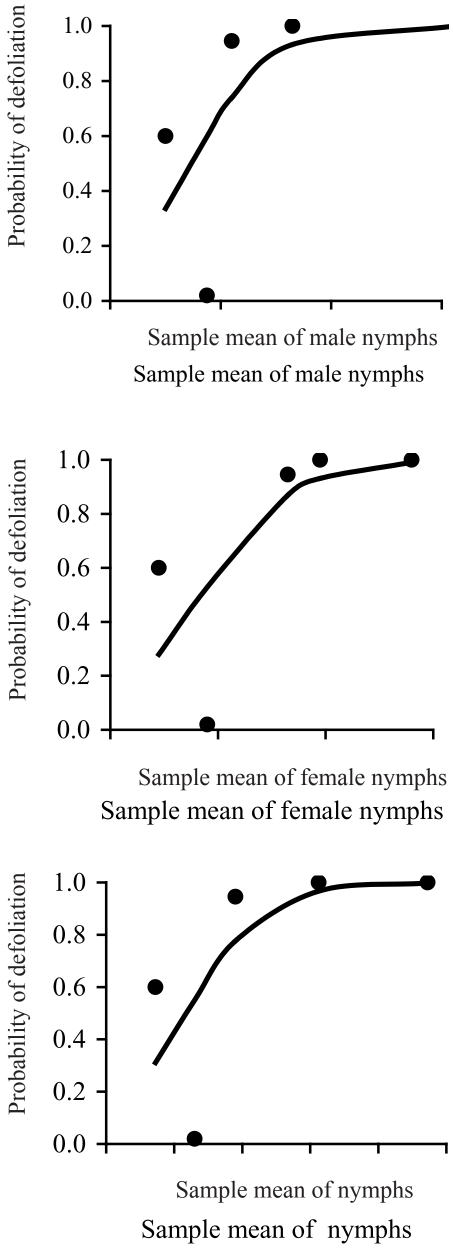

Fig. 1. Logistic regression between the numbers of larvae in soil samples (ex/0.25m^2) in spring 2002 and probability of total defoliation ($\pi = e^{\alpha+\beta x}/1 + e^{\alpha+\beta x}$)

Based on the data of larvae distribution in soil samples, we established that the sufficient number of soil samples ranged from 9 to 21 (Table 3). It means that the

Table 2. Species composition of sawflies associated with ash in Ruské domy locality in 2000 (specimens caught by Malaise trap)

Species	Sex	2000	2002
Tomostethus nigritus (Fabricius, 1804)	male	84	32
	female	7	3
Pachyprotasis antennata (Klug, 1817)	male	18	1
	female	2	0
Pachyprotasis rapae (Linné, 1767)	male	395	477
	female	44	25

Table 3. Sufficient numbers of soil samples and yellow sticky boards for monitoring of sawfly abundance (A – the half-width of the desired confidence interval, NB – number of samples and boards)

Species	Locality	Sample mean ± SD	Transformed catch mean ± SD	A – ca. 1/3 of mean	NB	A	NB	A	NB
C. lariciphila larvae	Nr. 1 (2002)	32.2 ± 7.2		9	15				
C. lariciphila larvae	Nr. 1 (2003)	27.9 ± 15.7		10	12				
C. lariciphila larvae	Nr. 2 (2002)	84.8 ± 42.1		35	31	40	24		
C. lariciphila larvae	Nr. 2 (2003)	73.1 ± 20.47		25	9	20	11		
C. lariciphila larvae	Nr. 3 (2002)	43.2 ± 18.2		13	43	16	29	20	20
C. lariciphila larvae	Nr. 3 (2003)	46.2 ± 22.10		15	11				
C. lariciphila larvae	Nr. 4 (2002)	18.0 ± 6.0		6	24	7	18		
C. lariciphila larvae	Nr. 5 (2002)	61.6 ± 32.6		21	47	35	19		
C. lariciphila larvae	Nr. 5 (2003)	45.3 ± 29.6		15	17	20	11		
C. lariciphila larvae	Nr. 6 (2003)	8.2 ± 5.4		2.5	21	3	16	30	4
C. lariciphila larvae	Nr. 7 (2003)	32.1 ± 22.1		11	18	15	11		
T. nigritus males	Nr. 1 (2000)	13.1 ± 15.5		4	60	5	40	7	22
T. nigritus males	Nr. 1 (2002)	88.4 ± 100.3	54.4 ± 62.3	20	37	30	18		
T. nigritus males	Nr. 1 (2003)	68.5 ± 84.2		22	59	30	32		
T. nigritus males	Nr. 2 (2002)	221.7 ± 138.4	205.7 ± 141.1	70	19				
T. nigritus males	Nr. 2 (2003)	138.5 ± 97.74		45	21	50	17		
T. nigritus males	Nr. 3 (2002)	38.1 ± 75.4	3.6 ± 12.7	1	578	3	67	6	19
T. nigritus males	Nr. 3 (2003)	47.94 ± 70.0	20.94 ± 38.65	7	120	15	28		
T. nigritus males	Nr. 4 (2003)	15.26 ± 21.13	6.37 ± 12.48	2	152	5	27		
T. nigritus males	Nr. 5 (2003)	17.2 ± 46.0	1.7 ± 7.3	0.6	558	2	53		

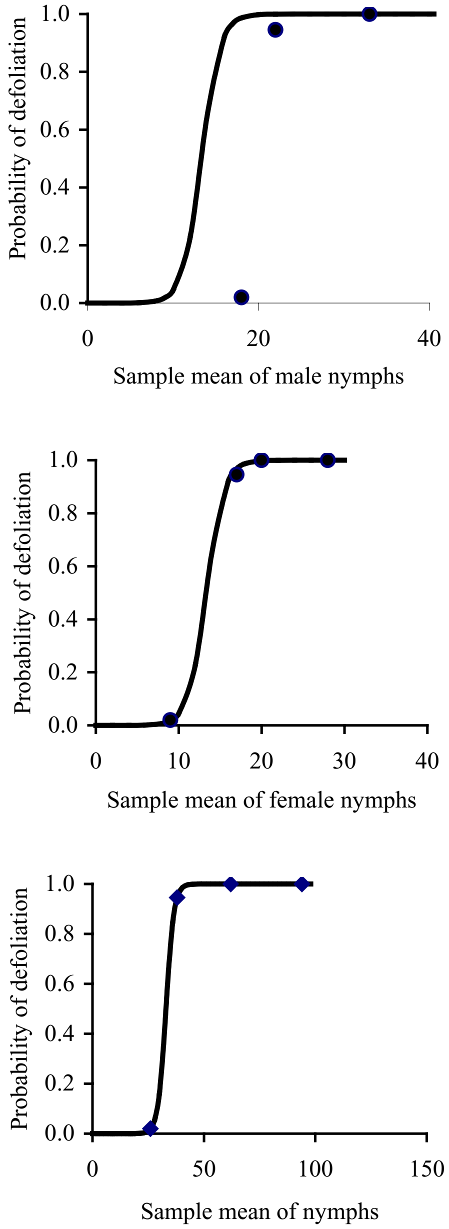

Fig. 2. Logistic regression between the numbers of larvae in soil samples (ex/0.25m^2) in spring 2002 and probability of strong and total defoliation ($\pi = e^{\alpha + \beta x}/1 + e^{\alpha + \beta x}$) with the exclusion of the plot in younger forest

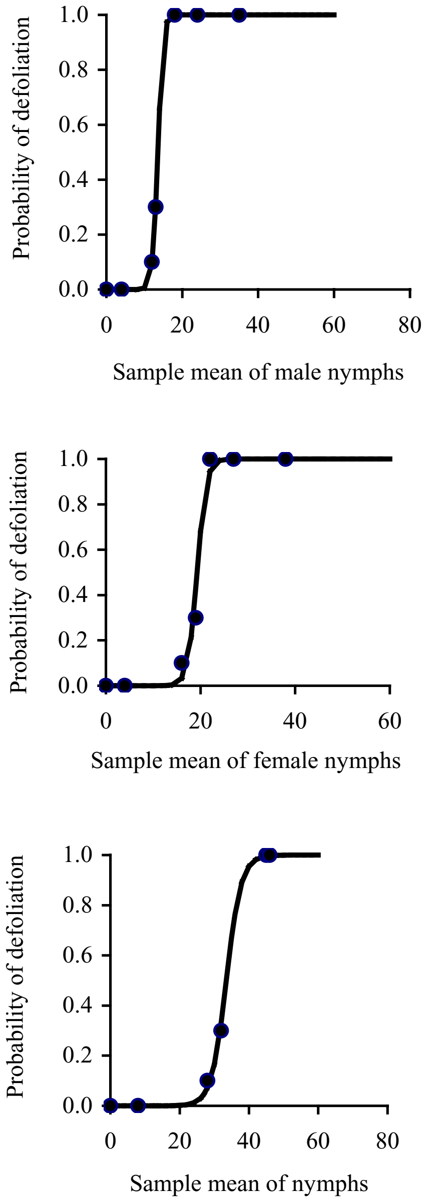

Fig. 3. Logistic regression between the numbers of larvae in soil samples (ex/0.25m^2) in spring 2003 and probability of strong + total defoliation ($\pi = e^{\alpha + \beta x}/1 + e^{\alpha + \beta x}$)

used number of samples was partly sufficient. The set of 20 samples is useful in forest practice.

Tomostethus nigritus

In the Czech Republic, only five sawfly species associated with ash (*Fraxinus*) occur. Only *T. nigritus* is a monophagous species of ash. The others [*Craesus septentrionalis* (Linné, 1758), *Macrophya punctumalbum* (Linné, 1767), *Pachyprotasis antennata* (Klug, 1817), *P. rapae* (Linné, 1767) and *Tenthredo vespa* (Retzius, 1783)] are polyphagous ones and ash as a host plant of *C. septentrionalis* is controversial. Ash as a host plant of *P. rapae* has not been confirmed recently (TAEGER et al. 1998). Three species were found in Ruské domy locality in 2000 as well as in 2002 (Table 2). *P. rapae* was the most abundant but due to the fact mentioned above, its larvae feed from July to September. Larvae of *T. nigritus* caused the ash defoliation already in mid-May, both in 2000 and 2002. Defoliation of ashes followed immediately the swarming of *T. nigritus* (Fig. 4).

In 2002 as well as in 2003, only male catches on yellow sticky boards are efficient for the statistical analyses because males prevailed in samples [n (2002) = 7,002; proportion of females is 0.01%; n (2003) = 6,062; proportion of females is 0.01%]. No females were found on the majority of boards. Due to the distinction of three degrees of defoliation, the multinomial distribution was calculated by the generalised logistic model, which es-

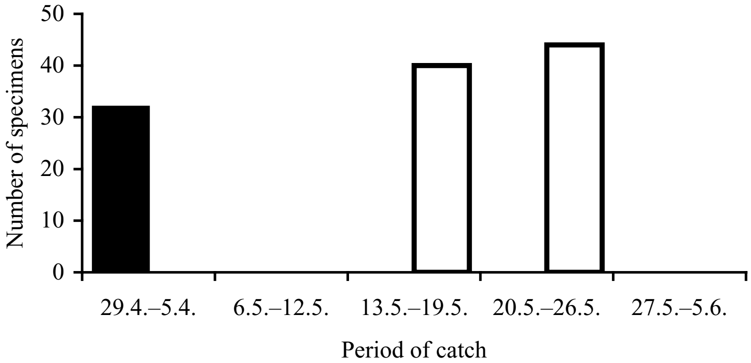

Fig. 4. Seasonal flight activity of *Tomostethus nigritus* males in 2000 (white column) and in 2002 (black column) in Ruské domy locality (Malaise trap)

tablishes model parameters to distinguish all three stages of defoliation.

In 2002, only the binomial model using two stages "absence of defoliation" and "weak defoliation + total defoliation" is statistically significant. This fact is surprising and a logical explanation follows. The abundance of adults was high but the intensity of feeding was low, which may be a result of high egg or larval mortality.

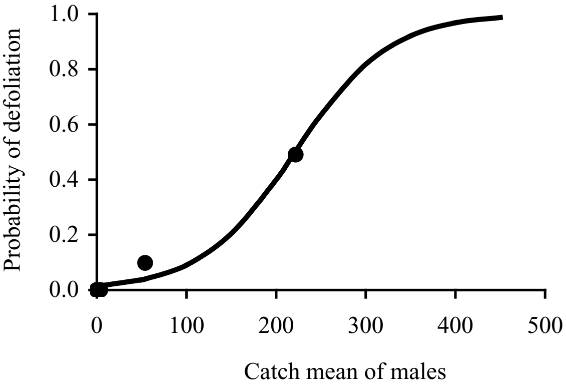

Fig. 5. Dependence of probability of non-defoliated trees on average numbers of caught *Tomostethus nigritus* males on yellow sticky boards in 2002 ($\pi = e^{4.21 - 0.02x}/(1 + e^{4.21 - 0.02x})$

Based on the prediction of model (Fig. 5), the establishment of "critical number" is possible, e.g. mean catch of 300 to 350 males per yellow sticky board causes the defoliation of 90% of ashes in mature forest.

In 2003, only the binomial model using two stages "absence of defoliation + weak defoliation" and "strong defoliation + total defoliation" is statistically significant. Based on the prediction of the model (Fig. 6) the establishment of "critical number" is possible, e.g. mean catch of about 250 males per yellow sticky board causes the defoliation of 90% of ashes in mature forest. The number is lower than in 2002 because in that year the defoliation covered weak defoliation.

Based on the data of male distribution on yellow sticky boards we have established that the sufficient number is about 20 yellow sticky boards in the locality with the highest abundance (Table 3) and use of different half-width of the desired confidence interval in other four localities, too. The abundance in the rest of localities was so low that it cannot provide any useful results. The number of 20 yellow sticky boards is useful in practice.

The results confirm the suitability of logistic regression for these studies as well as in short-time forecast. Two-year results should be confirmed by consequent study. We used the relationship between abundance of adults or nymphs and abundance of larvae of the next generation (indirectly assessed by insect feeding). Therefore there could be a problem with different fertility of sawflies (cool and rainy weather can directly influence the swarming of adults) or fecundity of females could be decreased by low temperature as reported by GRUPPE (1998) for *C. abietis* (Linnaeus, 1758) and egg and larval mortality. As a result, the "critical number" could vary between years.

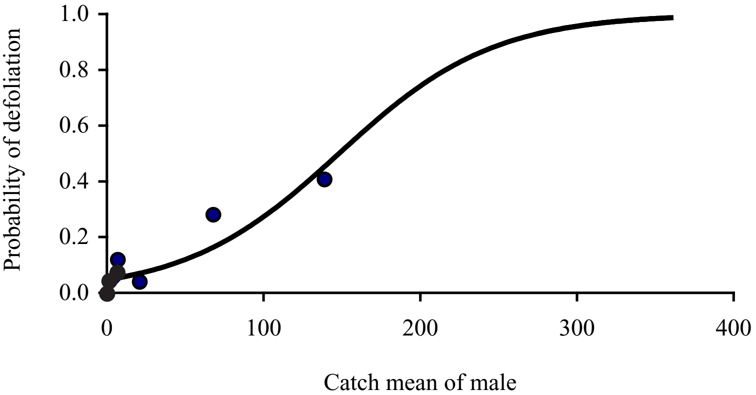

Fig. 6. Dependence of probability of non-defoliated or weakly defoliated trees on average numbers of caught *Tomostethus nigritus* males on yellow sticky boards in 2003 ($\pi = e^{3.02 - 0.02x}/(1 + e^{3.02 - 0.02x})$

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Využití logistické regrese k odhadu defoliace stromů způsobené širopasým hmyzem (Hymenoptera: Symphyta)

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ABSTRAKT: Závislost mezi početností fytofágů zjištěných půdními sondami (u *Cephalcia lariciphila*) nebo pomocí žlutých lepových desek (u *Tomostethus nigritus*) a následným procentem defoliovaných nebo naopak defoliace ušetřených stromů byla charakterizována pomocí logistické regrese.

Klíčová slova: *Cephalcia lariciphila*; půdní sondy; *Tomostethus nigritus*; žluté lepové desky; defoliace stromů; logistická regrese

Vzhledem k tomu, že přesná kvantifikace zničené biomasy listožravým hmyzem je obtížná (a pouhý odhad defoliace stromů naopak nepřesný), z praktického hlediska je postačující odhadnout možnost nastoupení určitého stupně poškození (stupně žíru) na základě kvantifikovatelných faktorů – především počtu odchycených jedinců škůdce. Vzhledem k tomu, že výskyt, resp. absenci stupně žíru lze popsat buď binomickým (výskyt/absence), nebo multinomickým (různé stupně žíru) rozdělením, je možné modelovat pravděpodobnost nastoupení defoliace pomocí logistické regrese, jak již bylo užito v pracích autorů: GRIBKO et al. (1995), OSTAFF a MACLEAN (1995), WESELOH (1996), LIEBHOLD et al. (1998) a DOBBERTIN a BRANG (2001).

V letech 2000 a 2001 se v oblasti Českomoravské vrchoviny [Větrný Jeníkov u Jihlavy; 15°30´ V, 49°28´ S; smíšené smrkové (*Picea abies* [L.] Karst.) kmenoviny (stáří 60–80 let) s modřínem (*Larix decidua* Mill.) na mírném svahu se severozápadní expozicí, v nadmořské výšce kolem 650 m (celková rozloha lokality asi 20 ha)] lokálně přemnožila ploskohřbetka *Cephalcia lariciphila* (Wachtl, 1898) a způsobila holožíry modřínů na ploše asi 4 ha (LIŠKA, HOLUŠA 2002). V letech 1999–2000 se vyskytly holožíry v různě starých jasanových porostech v oblasti Lanžhotu v jasanových kmenovinách (80–100 let) v okolí NPR Soutok (16°58´, 48°38´) způsobené žírem housenic *Tomostethus nigritus* (Fabricius, 1804) (LIŠKA, HOLUŠA 2002).

Pro odchyt dospělců obou druhů byly použity žluté lepové desky formátu A5 (15 × 21 cm), vyrobené z plastu a nastříkané po obou stranách lepem Souveurode®. Soubory desek byly umístěny do úrovně očí člověka pomocí provázků, kterými byly přivázány k suchým větvím (u *C. lariciphila* deset desek v roce 2002) nebo keřům hlohu (*Crataegus* sp.) (u *T. nigritus* po dvaceti deskách v roce 2002 i 2003). Jednotlivé desky byly instalovány v 5–10m rozestupech. Dospělci byli z lepových desek sejmuti pinzetou a vloženi do 70% roztoku alkoholu.

Pět půdních plošek v roce 2002 a 10 v roce 2003 na každé ze studijních ploch (5 a 7) pro *C. lariciphila* bylo umístěno pod koruny stromů v rozestupech 5–10 m po vrstevnici. Na těchto ploškách byla shrábnuta hrabanka a pak svrchní vrstva půdy. Materiál byl pečlivě prohlédnut. Půdní sondy byly provedeny 12. března 2002 a 3. dubna 2003.

Na pěti plochách *Cephalcia lariciphila* bylo v roce 2002 provedeno hodnocení výsledného žíru s použitím jednoduché třístupňové stupnice: 1. slabý žír a bez žíru – defoliace částečná nebo jen neznatelné stopy žíru; 2. silný žír – pouze některé spodní větve s jehličím; 3. holožír, zatímco v roce 2003 bylo možné rozlišit čtyři stupně: 1. bez žíru; 2. slabý žír – defoliace do 30 %; 3. silný žír – defoliace do 70 %; 4. holožír – defoliace nad 90 %.

Obdobné hodnocení bylo provedeno na pěti plochách *T. nigritus*. Výsledný žír byl v roce 2002 hodnocen použitím jednoduché třístupňové stupnice: 1. bez žíru – nebyly pozorovány žádné stopy žíru; 2. žír – některá ze spodních větví byla defoliována; 3. holožír. Nebyly zjištěny přechody mezi „žírem“ a holožírem, zatímco v roce 2003 bylo možné rozlišit čtyři stupně: 1. bez žíru – nebyly pozorovány žádné stopy žíru; 2. slabá defoliace (jako v roce 2002); 3. silná defoliace (více než 50 % listí sežráno); 4. holožír (více než 90 % listí sežráno).

Pro hledání pravděpodobnosti, s jakou dojde k určitému stupni žíru (nepoškození stromu, silné žíry až holožíry), byla užita logistická regrese, což je zvláštní případ zobecněného regresního modelu (GLM), kdy se předpokládá binomické rozdělení.

Cephalcia lariciphila. Mezi průměrným počtem samců nachytaných na žlutých lepových deskách a výsledným žírem nebyla prokázána statisticky významná logistická regrese ($p = 0{,}16$). Na některých plochách s vysokými odchyty samců byly žíry velice nízké. Důvodem je pravděpodobně převládání samců (n = 13 715; podíl samic 0,003 %) na deskách a relativně malá vzdálenost mezi plochami. Aktivní samci přelétají mezi plochami a zkreslují tak skutečnou početnost na lokalitách. Počty samic by byly určitě vhodnější, ty se však na lepové desky prakticky nechytají.

V roce 2002 byla mezi početností housenic (obou pohlaví i dohromady) v půdních sondách na jaře a podílem stromů se silným žírem a holožírem (použito dohromady jako jedna kategorie) prokázána logistická regrese $p_{(\text{ve všech případech})} = 0{,}00$ (tab. 1, obr. 1 a 2). V roce 2003 musely být stupně žíru sloučeny, protože bylo možné odlišit jen stavy "bez žíru + slabý žír" a "silný žír + holožír", aby bylo možné prokázat logistickou regresi. Na základě průběhu křivky (tab. 1, obr. 3) lze odečíst kritické počty housenic, za kterých nastanou silné žíry až holožíry u určitého podílu stromů, které jsou podobné v obou letech.

T. nigritus. Protože v odchytech z roku 2002 i 2003 samci výrazně převažovali, zatímco na většině desek nebyla zjištěna žádná samice [n (2002) = 7 000; podíl samic 0,01 %; n (2003) = 6 062; podíl samic 0,01 %], byly dál zpracovávány jen průměrné odchyty samců. Nejdříve byla použita logistická regrese s multinomickým rozdělením, která potvrdila, že je možné rozlišit jen stavy „bez defoliace“ a „žír + slabý holožír“ v roce 2002 a „bez defoliace + slabá defoliace“ a „silná defoliace + holožír“ v roce 2003. Binomické modely pro dva stavy jsou vysoce statisticky významné. Na základě průběhu a predikce modelů (obr. 5 a 6) můžeme stanovit „kritické počty pro jasanovou kmenovinu“, např. pro hodnotu 90 % stromů s žírem na rozpětí mezi 300 až 350 samci odchytanými na jednu žlutou lepovou desku v roce 2002 a asi 250 samci v roce 2003. Rozdíl je pravděpodobně způsoben sloučením slabého žíru s holožírem v roce 2002.

Uvedené příklady ukazují metodickou vhodnost logistické regrese pro tento typ studia a pravděpodobně i použitelnost v krátkodobé prognóze. Jedná se však o krátkodobé výsledky a je nutné je ověřit dalším studiem. Protože se jedná o zjišťování závislosti mezi populačními hustotami dospělců nebo larev a početností larev dalšího pokolení (odhadnutých nepřímo pomocí žírů), velkým problémem může být eventuální aktuální plodnost samic v jednotlivých letech [na rozdíl od studií s *Lymantria dispar* (Linnaeus, 1758), kdy populační hustoty jsou zjišťovány na základě hubek vajíček – GRIBKO et al. (1995), WESELOH (1996), LIEBHOLD et al. (1998)]. Že samice při nižší teplotě mohou klást menší počet vajíček, dokázal u *Cephalcia abietis* GRUPPE (1998). Potom by se „kritické počty“, založené na stadiu nymf v půdě nebo dospělců, mohly rok od roku lišit.

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