**Ips typographus** (L.) pheromone trapping in south Alps: spring catches determine damage thresholds

M. Faccoli¹ and F. Stergulc²

¹Department of Environmental Agronomy and Crop Production, University of Padua, Padua, Italy; ²Department of Plant Protection, University of Udine, Udine, Italy

Ms. received: September 16, 2003; accepted: February 11, 2004

### Abstract: **Ips typographus** is one of the major forest pests in the Italian Alps. From 1996, populations of **I. typographus** in Friuli-Venezia Giulia region (NE Italy) have been permanently monitored in areas of outbreak by using pheromone traps. At the same time, damage caused by the insect was estimated annually. Preliminary analysis of the data (1996–2002) reveals some interesting information: (i) the flight activity of **I. typographus** is very extended and occurs over a period of about 4 months (May to August); (ii) there is a high correlation between mean captures per trap and annual damage; (iii) there is a high correlation between spring captures (May to mid-June) and total captures (May to August), and between spring captures (May to mid-June) and annual damage. The correlation between spring captures and damage allows the determination of a reliable risk-damage threshold (about 5000 beetles/trap, in spring), reducing at the same time, the monitoring period and the general costs.

### Key words: **Ips typographus**, damage forecast, Italy, monitoring, spruce, traps

### 1 Introduction

The spruce bark beetle **Ips typographus** (L.) (Col., Scolytidae) is the most destructive scolytid attacking *Picea abies* (Karsten) in Palaearctic regions (Christiansen and Bakke, 1985). In the last decades the beetle has also caused great damage to Italian spruce stands in southern Alps (Ambrosi and Angheben, 1986; Lozzia, 1993; Faccoli, 1999; Frigimelica et al., 2000; Stergulc et al., 2000). Following the identification of the pheromone for **I. typographus** (Bakke et al., 1977), the extensive use of traps and trap trees baited with synthetic pheromone replaced the traditional control strategies usually applied to reduce the risk of outbreaks. Traps can be set up for ‘mass-trapping’ to catch as many flying beetles as possible (Raty et al., 1995), and to have information about beetle biology and density (Bakke, 1985). Pheromone traps could be a useful tool for monitoring **I. typographus** populations and for assessing the risk of tree attacks (Lindeelow and Schroeder, 2001). Specifically, the relationship between the mean number of insects per trap and the damage observed in the stands allows the determination of a capture threshold, which indicates when the population density of the pest is high enough to cause serious damage (Weslien, 1992). When the capture threshold is overcome, the risk of damage is high and intensive control strategies have to be applied.

Most studies that involve monitoring of populations of **I. typographus** have been carried out in northern Europe, where the winters are long and cold and flight activity begins quite late in the season (June–July) (Annila, 1969; Anderbrant, 1985). Therefore, the short summer allows completion of only one generation per year (Annila, 1969) and damage to spruce stands is not always severe, as the trees are subject to only one attempt of bark colonization and vigorous spruces can survive (Kroene et al., 1999). Nevertheless, re-emerging parents are able to establish a second brood, which can account for up to 29% of the killed trees (Anderbrant, 1989). On the contrary, in southern and central European countries **I. typographus** attacks host trees early in spring (end of April), when the mean air temperature reaches 18°C (Ambrosi and Angheben, 1986). In this period, overwintering adults (P) emerge and look for a suitable host for the first generation. Then, at the beginning of July at low altitude (usually < 1000 m a.s.l.) the adults of the first generation emerge (F1) and very often start a second generation (F2), attacking new trees (Ambrosi and Angheben, 1986; Faccoli, 1999; Netherer, 2003). In addition, after the emergence of both overwintering (P) and first generation (F1) adults, it is still possible to observe several captures of mainly re-emerging beetles until the end of August. So, in order to follow the entire spring and summer activities of **I. typographus**, which covers more than 4 months (end of April to mid-September), it is necessary to replace the pheromone dispensers at the middle of the monitoring period (middle to end of June) (Abgrall and Schvester, 1987).
Preliminary results concerning *I. typographus* monitoring and control were recently presented for some Italian populations also (Faccoli and Stergulc, 1999; Marchetti et al., 1999; Frigimelica et al., 2000; Stergulc et al., 2000). Nevertheless, as the largest part of the studies concerning *I. typographus* were carried out in central and northern Europe, in the Alps it is still not clear how to use monitoring data to determine a reliable ‘damage-threshold’, which could be useful to decide if additional specific control strategies have to be applied. In this paper we summarize data obtained from *I. typographus* monitoring over a period of 7 years and discuss how pheromone trap data might be used to forecast damage caused by this species.

**2 Materials and Methods**

Since 1994, a monitoring network called ‘BAUSINVE – Forest Phytopathologic Inventory’ has been checking the status of all pest and disease outbreaks occurring in the forests of Friuli – Venezia Giulia, north-eastern Italy (Stergulc and Frigimelica, 1997). In particular, any kinds of damage caused by pests or diseases are recorded in an electronic database. The forest is daily monitored by about 60 foresters working for the Regional Forest Service and supervised by a team of entomologists and pathologists in collaboration with many scientific institutes. When a pest or disease outbreak occurs, the foresters fill up specific reports, which include information concerning both the pest or disease infesting the stand (species, development instar, density of population), and the total damage amount (number of attacked/killed trees, volume of wood lost, extension of defoliated areas). Moreover, climate conditions (temperature and rain) and sylvicultural characteristics (such as forest composition, tree age, stand origin etc.) of the attacked stand are also reported.

From 1996, the populations of *I. typographus* have been monitored permanently in the main spruce forests of the region (about 10 100 ha) by using approximately 40 pheromone traps per year (Theysohn® slot-trap, Theysohn, Salzgitter, Germany) baited with (Pheroprax®, Pheroprax, Shell Agrar GmbH & Co., KG, Germany). The monitored spruce stands were approximately of 70–80 years old and growing at altitudes varying between 800 and 1200 m a.s.l.

The traps, which were installed and baited each year at the end of April, were checked weekly at which time all beetles captured were determined and counted. All pheromone dispensers were replaced after 8 weeks (mid-June). The trials lasted until September (about 18 weeks) and data were reported as mean captures per trap. At the same time, damage caused by *I. typographus* was recorded from field observations and reported as number of killed trees and volume of timber lost over a circular area of approximately 30 ha around each trap. Thus, about 12% of the total spruce forest area was surveyed. Damage monitoring began on the 1st of May (beginning of *I. typographus* flight) and continued until the 30th of April of the following year, as spruces attacked and killed in summer by the second generation were recognizable only from the next spring.

All data were subjected to analysis of variance (ANOVA) by the general linear model for randomized block designs (Zar, 1999) for determination of differences between the mean values, using the STATISTICA® per WINDOWS® software. Where significant differences occurred, Tukey’s honestly significantly different (HSD) multiple comparison test was applied for mean separation. Relationships between the observed parameters were analysed by a multiple linear regression procedure giving an $R$-value, adjusted for the number of parameters (Zar, 1999). Differences at 0.05 level of confidence were considered significant.

**3 Results**

The flight activity of *I. typographus* is very extended and occurs over a period of about 4 months (May–August) (fig. 1). During the whole monitoring season, it is possible to detect two main periods of capture of *I. typographus*, the first occurring in spring (May to mid-June) and the second in summer (mid-June to August) (fig. 1). Spring captures occur before the pheromone change and include overwintering adults, which, when the mean air temperature is about 18°C (fig. 1), fly looking for suitable spruce trees from where to start the first generation. Summer captures, occurring from the end of June until September, include emerging adults of the first generation, which fly towards new hosts. Although both the flight periods have the same duration (about 8 weeks), spring captures include about the 80% of all beetles caught (fig. 1).

Both mean captures and damage declined considerably over time from 1996 to 2001 (figs 2 and 3). However, captures observed in 1996 are higher than those of the following years (ANOVA, d.f. = 6, 65;
Fig. 2. Mean number of Ips typographus per trap (±S) from 1996 to 2002. Different letters show statistical differences between years (ANOVA, *P* < 0.001).

Fig. 3. Volume of timber lost (m$^3$) following Ips typographus attacks from 1996 to 2002.

Fig. 4. Correlation between volume of timber lost (m$^3$) and number of trees killed by Ips typographus from 1996 to 2002.

F = 4.24, *P* < 0.001; Tukey’s test, *P* < 0.01), until 2002 when a new outbreak seemed to begin (fig. 2). The volume of timber lost between 1996 and 2002, which shows the same temporal trend as the captures do (fig. 3), is highly correlated with the number of trees killed by *I. typographus* (d.f. = 1, 6; *F* = 53.4, *P* < 0.001, $R^2 = 0.989$) (fig. 4). In addition, there is a significant correlation between the mean number of *I. typographus* trapped and the total damage observed (d.f. = 1, 6; *F* = 122.1, *P* < 0.001, $R^2 = 0.928$) (fig. 5). Similarly, there is a significant correlation between the captures observed during the whole monitoring period and those during spring (d.f. = 1, 68; *F* = 1897.4, *P* < 0.001, $R^2 = 0.965$) (fig. 6). Finally, spring captures are correlated with the total annual damage (d.f. = 1, 6; *F* = 219.63, *P* < 0.001, $R^2 = 0.937$) (fig. 7).

4 Discussion

The main target for a monitoring trapping should be to use capture data as the index of the population density. From this point of view, the high correlation between the number of trapped insects and the volume of
timber lost (fig. 5) allows the estimation of the expected damage with the mean captures per trap known. Moreover, it might be possible to determine a ‘catch threshold’ indicating the maximum acceptable damage. In this respect, the catch threshold would be useful to decide about the need for additional control measures useful to reduce the damage below a pre-established threshold. By using a ‘catch threshold’ of approximately 8000 insects per trap during the whole monitoring period (May–August), in the monitored area (approximately 1200 ha) we would expect a damage lower than 100 m³ (fig. 5). Such amount of volume lost seems to be acceptable as efforts made to reduce the damage below this level could probably be more expensive than the value of the saved timber. In addition, below such catch threshold the damage appears to be independent of the captures, which range between 4000 and 8000 (fig. 5). Furthermore, above this threshold, the damage trend becomes exponential, with severe implications for the outbreak control. For comparison, WESLIEN (1992) reports a threshold of 10 000 insects/trap for Sweden, whereas, for the same country, LINDELOW and SCHROEDER (2001) suggest the use of higher levels of capture (15 000 I. typographus per trap). In this respect, northern and central European spruce plantations, following the type of sylviculture and the orographical features, might tolerate higher densities of I. typographus populations, adopting higher capture threshold. In the Alps, control would have to be more intensive as the expansion of severe outbreaks is more difficult to confine on the accentuated slope with a less extensive network of forest roads.

Once the risk-threshold has been overcome, several control strategies could be applied, i.e. increasing the number of the traps, passing in this way from a monitoring-trapping to a mass-trapping, setting-up trap-trees, making a more careful survey of the spruce forests, and eventually cutting recently attacked trees by sanitation programmes. All these actions are carried out to keep Ips typographus populations at endemic levels to avoid outbreaks and following damage.

Unfortunately, monitoring data are available only at the end of summer by which time the flight period of the beetle has concluded and most of the damage has already occurred. Specific control programmes could be applied only from the following spring when the beetles of the overwintering generation fly looking for new host trees. However, during hibernation, several factors could modify the numerical size of the populations (AUSTARÅ et al., 1977; FACCOLI, 2002) making the actions applied the following spring inadequate. Consequently, early forecasts about the damage occurring during the season are very important in determining the need for applying useful and prompt control strategies. As approximately 80% of the beetles are caught in spring, before the change of the pheromone dispensers (fig. 1), it is not surprising to find a strong correlation between spring and total captures (fig. 6), and between spring captures and damage (fig. 7). Nevertheless, this correlation provides us with an opportunity to assess the risk of future outbreaks in advance and the time necessary to apply pest control. To expect an annual damage lower than 100 m³ in the monitored area, the spring captures would be lower than 5000 insects/trap (fig. 7). In addition, the correlation between spring captures and damage is stronger ($R^2 = 0.94$) (fig. 7) than the correlation between total captures (May–August) and damage ($R^2 = 0.93$) (fig. 4), indicating that the first part of the flight period is probably the most relevant in determining the amount of timber lost. LINDELOW and SCHROEDER (2001) reported analogous correlation for northern European I. typographus populations.

A spring catch threshold provides us the possibility to halve the monitoring period, which could be terminated after 2 months (at the end of June) (fig. 1), leaving enough time in summer to plan and apply specific control measures. Besides, the overall costs concerning both pheromone dispensers and workers checking the traps would be reduced. Moreover, the correlation between volume of timber lost and number of attacked trees (fig. 4) suggests to confine the monitoring to spruce stands having trees with a mean volume of at least approximately 1.1 m³ each, as I. typographus breeds mainly in trees having thick barks.

In conclusion, the high correlation between damage and spring catches (May–June) allows the determination of a reliable risk threshold of approximately 5000 beetles per trap, reducing at the same time the period of monitoring and the general costs. The monitoring of I. typographus will continue to improve the knowledge concerning the methods for damage forecasting and risk assessment in southern Alps.

Acknowledgements

The authors are very grateful to Andrea Battisti (University of Padua, Italy), Olle Anderbrant (Lund University, Sweden) and Fredrik Schlyter (SLU University, Sweden) who reviewed the manuscript and provided numerous suggestions for its improvement. We also thank Michael Stastny (Simon Fraser University, British Columbia, Canada) and Ramuné Kukutait (SLU University, Sweden) for the proof-reading of the text.

References


Author’s address: Massimo Faccoli (corresponding author), Department of Environmental Agronomy and Crop Production, Agropolis, Viale dell’Università, 16/a, 35020 Legnano (PD), Italy. E-mail: massimo.faccoli@unipd.it