COMPARISON OF SPRUCE BARK BEETLE (IPS TYPOGRAPHUS) CATCHES BETWEEN TREATED TRAP LOGS AND PHEROMONE TRAPS

USPOREDBA ULOVA SMREKINOG PISARA (IPS TYPOGRAPHUS) NA KEMIJSKI TRETIRANIM LOVNIM TRUPČIĆIMA I FEROMONSKIM KLOPKAMA

Jan LUBOJACKÝ 1, Jaroslav HOLUŠA 1

ABSTRACT: The numbers of Ips typographus beetles captured in treated tripod trap logs (tripods) were compared to catches from Theysohn pheromone traps (TPTs). In 2010, at each of the three localities, five TPTs and five tripods baited with Pheagr IT pheromone evaporators were installed with 10 m spacing. Weekly inspections were made during the entire period of I. typographus flight activity (April 30 – October 1). The tripods were treated with insecticide Vaztak 10 SC on April 23, 2010 and then repeatedly every seven weeks along with the renewal of the pheromone evaporator. The study showed that the TPTs trapped approximately one-third more beetles than did the tripods. The TPT captures showed a dominance of females over males, while in tripods the sex ratio was balanced. The TPTs and tripods both trapped approximately the same numbers of males, but the females were distinctly more numerous in the TPTs. In both cases, more adults were captured during spring than in summer.

Keywords: Ips typographus, tripod trap logs, pheromone trap, sex ratio

INTRODUCTION – Uvod

The spruce bark beetle, Ips typographus L., is one of the most severe pests of the Norway spruce (Picea abies (L.) Karst) in Eurasia (Schwenke 1974, Annila 1969). It reproduces in freshly withered spruce wood, but when the population density is high it can colonize and kill living trees (Schwenke 1974, Weislen et al. 1989).

For mass trapping of I. typographus, pheromone traps, trap trees, trap logs, baited trees and baited slash are most commonly used (Grégoire and Evans 2004, Zahradník and Knížek 2007). According to several national policies (e.g. Knížek 2005), these trapping devices are regarded as comparable and mutually substitutable if appropriate methods are followed. Trap trees have been used to control I. typographus for more than 200 years (Pfeil 1827). Trapping by means of felled (or artificially stressed) trap trees is expensive and time-consuming (Bakke 1989). Trap trees are not always populated, they are able to capture only a limited number of individuals and require regular inspection (Abgrall and Schvester 1987). Intense use of trap trees has not always brought required results, as in certain areas there are large amounts of stands weakened by Armillaria or drought, and so the focus of the control has shifted to locate attacked trees and sanitation logging (Martinek 1953).

There was a change of strategy in control of this pest in the 1970s, as the aggregation pheromone of I. typographus was discovered and produced (Bakke 1970, Rudinsky et al. 1970, Bakke et al. 1977). The pheromone is used by the male beetles to attract both males and females to suitable breeding material. Currently, there are a number of commercial pheromones available (IT Ecolure2; Pheagr IT3; Pheroprax4; Ipsgone5). Traps baited with pheromone lures (Bakke 1982, Furuta et al. 1984, Bakke 1989) are

1 Jan Lubojacký, Jaroslav Holuša
Česká zemědělská univerzita v Praze, Fakulta lesnická a dřevařská, Kamýcká 1176, 165 21 Praha 6 – Suchdol, Česká republika, e-mail: holusaj@seznam.cz, lubojacky.j@seznam.cz

2 http://www.fytofarm.cz/71-it-ecolure-klasik/
3 http://www.scitech.cz/pheagrit.htm
4 http://www.agrar.basf.at/at/Welcome.do
5 http://www.agrisense.co.uk/
Trap logs baited with pheromone lures and treated with an insecticide represent a combination of the two methods. Fresh logs are sprayed with insecticide over their entire surfaces and arranged into tripods with a pheromone lure positioned below the top (Figure 1). These tripod trap logs (hereinafter just “TRIPODs”) are set up immediately before the assumed start of flight activity (Knižek 2005, Zahradník 2005, Zahradník and Knižek 2007). The installation principles are similar to those of pheromone traps, i.e. a safe distance for the pheromone lure from the nearest living spruce tree should be at least 10 m (Zahradník 2005). The TRIPODs efficiency is maintained during the entire season by repeated spraying of insecticide along with change of the pheromone lure (Knížek 2005). The TRIPODs efficiency is maintained during the entire season by repeated spraying of insecticide along with change of the pheromone lure (Knížek 2005). The TRIPODs efficiency is maintained during the entire season by repeated spraying of insecticide along with change of the pheromone lure (Knížek 2005). The TRIPODs efficiency is maintained during the entire season by repeated spraying of insecticide along with change of the pheromone lure (Knížek 2005). The TRIPODs efficiency is maintained during the entire season by repeated spraying of insecticide along with change of the pheromone lure (Knížek 2005). The TRIPODs efficiency is maintained during the entire season by repeated spraying of insecticide along with change of the pheromone lure (Knížek 2005).
height. A lower layer of fine netting (1 mm mesh size) was fixed to the frame (Figure 1). Above that, an upper layer of coarser netting with 16 mm mesh size was affixed to prevent access for birds to feed on fallen insects. Trap logs were treated with insecticidal mixture (insecticide\textsuperscript{6} 0.5 %, colorant\textsuperscript{7} 1 % diluted in water) on April 23, June 11 and July 30, 2010 (at seven weeks interval). The TRIPODs were baited with aggregation pheromone dispenser\textsuperscript{8}. The dispenser was attached to the top of the TRIPODs on April 23, 2010, and a fresh one again on June 11, and July 30, just like the repeated treatments with insecticidal mixture.

Black Theysohn pheromone slot traps (hereinafter just “TPT”) were arranged between two sticks 2 m above the ground. A 49 x 49 cm collection sheet was installed 1.5 m above the ground. The TPTs were baited with pheromone dispensers Pheagr IT\textsuperscript{7} with the same dates of installation and replacement as in the case of TRIPODs. Beetles were collected each week during April 30 to October 1, 2010.

Sex of the beetles was determined by dissection under a stereomicroscope based on the presence or non-presence of aedeagus. The sex ratio was determined for those inspection dates when at least 20 beetles were collected. The data were analysed using the Excel spreadsheet application (Microsoft\textsuperscript{8} Office) and evaluated in the program Statsoft\textsuperscript{9} Statistica 8.0 (using Wilcoxon matched pair test and box-and-whisker plots). Differences were considered significant at the 0.05 probability level.
RESULTS – Rezultati

During the 2010 bark beetle flight season, a total of 15,657 individuals of *I. typographus* bark beetle were collected, including 6,343 males and 9,314 females. In the collecting frames mounted under TRIPODs, 6,254 individuals (2,995 males and 3,259 females) were collected. TPTs captured 9,403 individuals in total (3,348 males and 6,055 females) (Table 1).

### Table 1 Number of trapped spruce bark beetles (*I. typographus*) on treated trap trees (TRIPODs) and pheromone traps (TPTs)

<table>
<thead>
<tr>
<th>Experimental plots</th>
<th>Males</th>
<th>Females</th>
<th>Total</th>
<th>Proportion of males</th>
<th>Males</th>
<th>Females</th>
<th>Total</th>
<th>Proportion of males</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRIPODs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plot A</td>
<td>1199</td>
<td>1369</td>
<td>2568</td>
<td>0.47</td>
<td>1473</td>
<td>2465</td>
<td>3938</td>
<td>0.37</td>
</tr>
<tr>
<td>Plot B</td>
<td>700</td>
<td>777</td>
<td>1477</td>
<td>0.47</td>
<td>679</td>
<td>1172</td>
<td>1851</td>
<td>0.37</td>
</tr>
<tr>
<td>Plot C</td>
<td>1096</td>
<td>1113</td>
<td>2209</td>
<td>0.50</td>
<td>1196</td>
<td>2418</td>
<td>3614</td>
<td>0.33</td>
</tr>
<tr>
<td>TPTs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The first flight period of the overwintering beetles was recorded in the third week of April (Figures 3 and 4). In the third and fourth week of May, a distinct decline occurred (see Figure 2). The spring flight peak occurred in the first half of June. In early July, the first individuals of the new generation were recorded (light brown beetles). The peak of summer flight activity was noticed in mid July. During August, the flight activity gradually declined and was very low in September. The last individuals were captured in early October. No apparent differences in flight activity patterns were observed between the two methods of trapping (Figures 3 and 4).

On the average, 417±154 individuals were collected per each set of TRIPODs during the whole trapping period, with 200±74 males and 217±85 females (Figure 5). The mean collection per TPT was 627±250 individuals, with 223±81 males and 404±175 females (Figure 5). The lower numbers of beetles collected from TRIPODs than from TPT was statistically significant (Wilcoxon matched pair test; z = 3.07; p < 0.01).

The difference in the numbers of males and females captured by TRIPODs was not statistically significantly (z = 1.48; p > 0.05), but there was a statistically significant difference in the numbers of males and females captured by TPT (z = 3.41; p < 0.001), with females dominating over males. Similarly, the difference in numbers of males captured by TRIPODs and TPT was not statistically different (z = 1.48; p > 0.05), while the difference in the numbers of females was significantly statistically different (z = 3.35; p < 0.001), with females captured by TPT dominating.

Sex ratio varied in samples. In the majority of cases it was female biased. Males dominated only in May (Figures 3 and 4).
DISCUSSION – Rasprava

In 2010, two main peaks in flight activity represent the two generations of *I. typographus* beetles at the studied area. Two generations are common in central Europe, except for the higher elevations (Wermeling and Seifert 1999). In northern Europe, there is usually only one generation per year, while in Southern Europe, with its long, warm summers even the second offspring generation manages to mature fully (Ambrosi and Angheben 1986, Faccoli 1999, Faccoli and Buffo 2004). The weather pattern in 2010 was not favourable for the *I. typographus* breeding and development. The whole of May, second decade of June, late July to early August, and late August to early September were cold and rainy, limiting the flight activity and slowing the maturation of the broods (Figure 2). Therefore, only the overwintering parental beetles (first generation) and their offspring (second generation) were collected. Flight activity of the re-emerged beetles was not measurable, hence only small indistinct peak appeared on July 2 (Figures 3 and 4). For the offspring of the second generation, the beetle collecting did not reveal flight activity from further reproduction, and the individuals in different stages of maturity must have been forced to overwinter beneath the bark of the host tree which is known from previous studies (Faccoli 2002, Faccoli and Buffo 2004).

Significantly higher numbers of *I. typographus* were captured by the TPTs (mean 627 beetles/single TPT) compared to TRIPODs (mean 417 beetles/single TRIPOD). In a study conducted in 2007 and 2008,
pipe traps or slot traps. Drumont et al. (1992) trapped three to five times more beetles than the drain-least 30 cm in base diameter) baited with Pheroprax 238
vicial name Vaztak). Jeníš and Vrba (2007), however, reported similar catch levels comparing TRIPODs baited with Fesex Typo dispensers and sprayed with insecticide alpha-cypermethrin (commercial name Vaztak) and TPTs. Adlung et al. (1986) had found similar efficiency for drain-pipe traps and 3 m billets baited with pheromone dispensers and protected with insecticide lindane (gamma-hexachlorocyclohexane). According to A b r a l l (1987), whole felled trees (at least 30 cm in base diameter) baited with Pheroprax dispensers and sprayed with insecticide deltamethrin, trapped three to five times more beetles than the drain-pipe traps or slot traps. D r u m o n t et al. (1992) reported that trees baited with Pheroprax dispensers and treated with insecticide lambda-cyhalothrin (commercial name Karate) trapped 2–13 times more beetles than the pheromone traps (of the type Kreins and Theysohn). Trees baited with Pheroprax dispensers and sprayed with insecticide lambda-cyhalothrin (commercial name Karate) had been shown to catch up to 30 times more beetles compared to pheromone traps of the Theysohn type (Raty et al. 1995), and especially when the bait was protected from the sun. The differences in capture numbers from the various authors and the resulting conclusions are influenced by a number of factors. The various observations were made in different years, different locations, and different stages of the bark beetle outbreaks. The main reason for such variability of the results, we presume, lies in the differences within the experimental approach of former researchers. Our experimental design is closest to that of J e n i š and V r b a (2007) and of V r b a (2009). Differences in the research outcomes could be a result of different methods, variable bark beetle population densities within the study areas, and influenced by the use of different lure and insecticide types.

The crucial problem in these trials lies in the assessment of the true quantity of dead insect using TRIPODs. There should be a certain amount (J e n i š and V r b a 2007, V r b a 2009) of lost beetles being blown away by wind, washed out in heavier rains, or consumed by birds, small rodents, insectivores and entomophagous arthropods. Some may also be able to fly away if not surviving but dying in other places. For these reasons, it was necessary to invent a new system for capturing the falling dead insects. We suggest that the problems could be solved by using frames to collect dead insects. The frames were inserted beneath the entire vertical projection of the TRIPODs. The frames having side walls (thus eliminating the influence of wind and rain) and netting at the bottom and top to isolate the dropping insects from birds and small rodents. Still, the number of bark beetles landing on the sprayed bark surface, taking off, flying away and dying somewhere else could be studied only by the permanent and detailed in situ observation.

The sex ratio of individuals collected at TRIPODs is similar as in the flying population and no statistically significant difference has been found. In TPTs captures, however, dominance of females is statistically significant. A number of studies have reported statistically significant differences in sex ratios in captures by pheromone traps, where males are usually less numerous than females (A n n i l a 1971, Z u m r 1982, L i n d l ő w and W e s l i e n 1986, S c h l y t e r et al. 1987, W e s l i e n and B y l u n d 1988, F a c c o l i and B u f f o 2004). In the present study both trapping devices captured dominantly males in the first three weeks of flight activity. This can be explained by the fact that males of I. typographus emerge sooner than females as reported earlier (F a c c o l i and B u f f o 2004). Some authors suggest that males sustain higher levels of mortality than females because of greater exposure to predation and host tree resin during the initial attack (G a r a 1963, K i r k e n d a l l 1983) and sister brood flight after the first bark colonisation (A n d e r b r a n t 1989).

While the females are unable to attack a host tree directly, except for the re-emerged females, the males, as the pioneering sex, may attack and cause the death of a tree by burrowing into the fresh phloem (V i t ě 1989). Therefore, the capture of males is important to reduce tree attacks (J a k u š and B l a ž e n e c 2002). From this viewpoint, the TRIPODs, catching a higher proportion of males are preferable in comparison to pheromone traps with a higher proportion of females. The just slightly greater proportion of females in the sex ratio from the TRIPODs and distinctly female biased sex ratio in pheromone traps is a result of different behaviour of sexes. Flying females orient directly to higher concentrations of colonising males in an attacked tree, while males tend to land on the host in adjacent uncolonised areas. Similarly, the attraction response of walking males to the pheromone is progressively reduced at higher concentrations, while female response continues to increase (B y e r s 1983).

A number of authors, however, recommend the use of TRIPODs only exceptionally, as their use kills also the large numbers of entomophagous insects (W e n e r et al. 1983, O k l a n d et al. 1996, Z a h r a d n i k 2005, Z a h r a d n i k and K n i ž e k 2007), these being potentially a key natural reducing factor in bark beetle population dynamics (T u r c h i n et al. 1999). The natural enemies like Thanasimus spp. were also attracted and killed in both kinds of trapping devices in this research. The results considering the impact on entomophagous fauna will be summarized after the inclusion of the new experimental data.
CONCLUSIONS – Zaključci

1. In 2010, the two main peaks in flight activity (recorded as trapped beetles in the first half of June and mid July) represent two generations of \( I. \text{typographus} \) beetles at the studied area.

2. The Theysohn pheromone traps (TPTs) caught about 35% more beetles than treated tripod trap logs (TRIPODs).

3. TPTs caught almost twice more females compared to TRIPODs, otherwise the numbers of captured males were the same.

ACKNOWLEDGMENT – Zahvala

The research was supported by the grant IGA 43150/1312/3139 “Verifying the effectiveness of poisoned traps used against the spruce bark beetle (\( I. \text{typographus} \) L.)” of the University of Life Sciences in Prague and partly by grant No. QH 81136 of the Ministry of Agriculture of the Czech Republic. The authors wish to thank J. Slavíček, M. Gracl and J. Lubojacký for practical suggestions and technical assistance for implementation of the field studies.

REFERENCES – Literatura


Furuta, K., S. Ando, I. Takahashi, 1984: A trial of mass trapping of \( I. \text{typographus} \) japonicus
J. Lubojacký, J. Holuša: COMPARISON OF SPRUCE BARK BEETLE (*Ips typographus*) CATCHES ... Šumarski list br. 5–6, CXXXV (2011), 233-242

240


Prvo proljetno rojenje nakon zimovanja prošlogodišnjih imaga smrekinog pisara, zabilježeno je u trećem kvartalu travnja. U drugoj polovici svibnja došlo je do naglog pada ulova uzrokovanog padom temperature i povećanim padalinama (Slika 2). Maksimum rojenja proljetne generacije potkornjaka zbio se prvom polovicom lipnja. Početkom srpnja zamijećena su prva imaga nove, ljetne generacije (potkornjaci svjetlo smeđe boje). Maksimum rojenja druge, ljetne generacije zbio se sredinom srpnja. Tijekom kolovoza i rujna rojenje je polagano opadalo u intenzitetu i posljednji ulovi potkornjaka datiraju početkom listopada 2010. godine. Razlike u dinamici doleta i ulova smrekina pisara na oba tipa lovnih kompozicija nisu utvrđene (Slika 3 i 4). Dva glavna maksimuma u ulovu smrekina pisara tijekom 2010. godine predstavljaju pojavu dvije generacije na području istraživanja. Ovako rasklanje je za područje srednje Europe, osim u slučaju povišenih nadmorskih visina. Na sjeveru Europe smrekin pisar obično ima samo jednu generaciju godišnje, dok se na njenom jugu, zahvaljujući dugim i toplim letima i druga generacija u potpunosti razvije do spolno zrelih imaga. Na istraživanoj lokaciji tijekom 2010. godine uvjeti za razvoj potkornjaka nisu bili optimalni (Slika 2) tako da su na lovnim kompozicijama lovljena imaga prve proljetne generacije i imaga filijalne generacije (druga, prva ljetna generacija smrekinog psara). Rojenje ženki druge serije polaganja imaga (sestrinske generacije) bilo je slabo izraženo i vidljivo u slabo izraženom maksimumu 2. srpnja. Što se imaga druge generacije tiče, nije bilo zabilježeno rojenje ženki sestrinske generacije jaja, a imaga ove
generacije bivala su zaustavljena u različitim stadijima razvoja ulazeći u dormantnu fazu mirovanja tijekom zime 2010/2011.

U prosjeku, tijekom razdoblje istraživanja ulovljeno je 417 ± 154 jedinki smrekinog pisara na svakoj TRIPODs kompoziciji, od čega 200 ± 74 mužjaka i 217 ± 85 ženki (Slika 5). Srednji ulovi za TPTs feromonske klopke iznosili su 627 ± 250 ukupno, odnosno 223 ± 81 mužjaka i 404 ± 175 ženki (Slika 5). Manji broj potkornjaka ulovljenih na TRIPODs lovnim trupčićima bio je signifikantno različit od ulova na feromonskim klopkama (Wilcoxonov test usklađenih parova: z = 3.07; p < 0.01). U usporedbi sa feromonskim klopkama, glavna prednost TRIPODs lovnih trupčića je jednostavnija i brža kontrola naleta potkornjaka. Ovdje se podrazumijeva jednostavna vizualna kontrola lovnih kutija i uključujući i rasta travne vegetacije, pa nije potrebna košnja ili primjena herbicida. S druge strane, negativno stajalište ove metode lova potkornjaka je nepoznati udio jedinki koje nakon slijetanja na intoksiciranu koru trupčića odlijeću sa kompozicije i ugibaju negdje u okolnom prostoru. Kao problem u evaluaciji učinkovitosti javlja se i mogućnost gubitka već uginulih jedinki uslijed naleta vjetra ili predacije pticama. U usporedbi sa feromonskim klopkama često gubljenje ženki potpuno je smanjeno, dok u TRIPODs kompoziciji potpuno je izbješeno. U provedenom istraživanju obje su lovne kompozicije (TRIPODs i TPTs) u prve tri stjedna lova hvatale više mužjaka nego ženki. Ovo se može objasniti činjenicom da se mužjaci javljaju ranije u prirodi, zbog činjenice da oni počinju s ubušivanjem i produkcijom agregacijskog feromona. Isto vrijedi i za početak naleta druge generacije. Postoje mišljenja da mužjaci smrekinog pisara trpe veći pritisak predatora i redukciju uslijed obrambenih mehanizama smrekovih stabala (pritisak smoje). Dok ženke u načelu nisu sposobne izazvati prvi napad/ubušivanje (osim dajanja populacije koji formiraju rekreaciju), mužjaci mogu izazvati sušenje i propadanje stabala tijekom inicijalnog ubušivanja, pogotovo u epidemiji gustoca populacije. Stoga je redukcija mužjaka u rojenoj populaciji početkom lipnja iznimno važna sa stajališta općeg redukcije njihove populacije i zaštite smrekovih šuma od njihova napada. Ukupno gledajući, TIPODs lovni trupčići lovili su u većem omjeru muški spol u odnosu na TPTs feromonske klopke. Stoga gleda li se potpuno redukcije populacije smrekinog potkornjaka od predmeta samih feromonskih klopki. Objasnjenje ovakvih pojava je u biologiji potkornjaka: dok se mužjaci u načelu šire nastojeći kolonizirati materijal u bližini već naseljenog (i “markiranog”) feromonom. ženke se na prvoj polovici lipnja i sredinom srpnja, kažu da su u novembru i prosincu, bivaju privučene višim koncentracijama populacijskog feromona. Posljednje, razmještano su koncentracije feromona u feromonskim klopkama jače privlači ženke od mužjaka, što se i pokažu u provedenom istraživanju.

Zaključno, može se reći da su u provedenom jednogodišnjem istraživanju zabilježena dva rojenja smrekinog pisara, s maksimumom rojenja u prvoj polovici lipnja i sredinom srpnja, da su TPTs feromonske klopke ulovile oko 35 % više jedinki potkornjaka nego TRIPODs lovnih trupčića, te da je u ulovima iz feromonskih klopki bilo gotovo dvostruko više ženki nego u ulovima na TRIPODs lovnih trupčićima. Ulovi mužjaka na obje lovne kompozicije bili su podjednaki.

Ključne riječi: Ips typographus, lovni trupčići, feromonske klopke, spolni indeks