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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

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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.) Karts.) 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, Weslien et al. 1989).

For masstrapping 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 Ecolure[2]; Pheagr IT[3]; Pheroprax[4]; Ipsgone[5]). Traps baited with pheromone lures (Bakke 1982, Furuta et al. 1984, Bakke 1989) are

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[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/

commonly used for monitoring or mass trapping of the spruce bark beetle (Jakuš 1998, Schlyter and Birgersson 1999, Hrašovec et al. 2011).

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 (Knížek 2005, Zahradník 2005, Zahradník and Knížek 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, Zahradník and Knížek 2007).

Experiments with trap trees treated with insecticides such as Gesarol (DDT) or cyclohexane (HCH) were made long ago, in late 1940s and early 1950s (Kučera 1951, Martinek 1952). The same applies to tests of insecticide efficiency on *I. typographus* (Novák 1955). In the 1960s, two approaches evolved for the preparation of poisoned trap trees: the insecticide was either applied to the surface of a lying trap tree (Novák 1955) or the phloem and surface of the sapwood were saturated with it (Hašek 1961). Since the discovery of aggregation pheromones, the attractiveness of the treated trap trees has been improved by a pheromone lure (Klimetzek and Adlung 1977, Klimetzek 1978a, Klimetzek 1978b, Zumr 1985, Abgrall 1987, Abgrall and Schvester 1987, Raty et al. 1995), while earlier, only surface-treated baitless trap trees had been used. In practice, it is advisable to put wax paper (Zumr 1985) or fabric (Zahradník 2005, Zahradník and Knížek 2007) under the TRIPODs for visual check up of their efficiency. Foresters can thus easily monitor whether or not the TRIPODs are really killing the bark beetles.

Trap trees treated with insecticides and baited with aggregation pheromone lures exhibit several advantages compared to the traditional trap trees: lures will make any spruce timber attractive to spruce bark beetle, capture does not cease after colonization of a tree, trap trees need not be debarked at a particular time and, consequently, they require significantly less surveillance (Abgrall and Schvester 1987). Number of authors, however, recommend using treated trap logs only exceptionally, as they also kill a large number of entomophagous insects (Werner et al. 1983, Okland et al. 1996, Zahradník 2005, Zahradník and Knížek 2007).

There are only few works that specifically compare the trapping efficiency of TRIPODs and other trapping devices. Adlung et al. (1986) found similar efficiency for drain-pipe traps and 3 m baited and poisoned billets, as did Jeniš and Vrba (2007) for captures using Theysohn pheromone traps and TRIPODs. According to Abgrall (1987), whole felled, baited and poisoned trees caught more beetles than did pheromone traps. Similarly, Drumont et al. (1992) and Raty et al. (1995) state that standing baited and poisoned trap trees captured two or three times more beetles than did the pheromone traps. Bombosch (1988) showed that 4 m poisoned and baited billets captured much more beetles compared to slot traps.

The main aim of this research was to compare the trapping efficacy of TRIPODs treated with the insecticide and baited with *I. typographus* pheromone lures versus trapping efficacy of Theysohn traps, standard pheromone trap used in today's forest practice.

MATERIALS AND METHODS – Materijali i metode rada

The study was conducted in the north-east of the Czech Republic (in the Nízký Jeseník hills) at three study plots: (i) 17°57'11" E, 49°51'04" N; (ii) 17°56'21" E, 49°51'16" N; and (iii) 17°56'15" E, 49°51'46" N at elevations of 475–495 m a.s.l. The plots were ca. 1 km apart. On April 16, 2010, five pheromone traps and five TRIPODs were installed at each plot, along the edge of a forest stand 96–109 years old, alternating in a single line with 10 m spacing. The distance of the pheromone traps and TRIPODs from the nearest living spruce tree never was less than 10 m. The volume of spruce timber infested by bark beetles amounted 2.52 m^3/ha (of spruce stands) in the year 2009 and 1.5 m^3/ha in 2010. The volume of infested spruce timber in the surroundings (<100m) of experimental plots varied: (i) 7.07 m^3/ha, (ii) 4.01 m^3/ha, and (iii) 7.56 m^3/ha respectfully, in 2010. Weather data for the period of monitoring are presented in Figure 2.

TRIPODs comprised of three spruce logs, 2 m in length and minimum 12 cm in diameter. Logs were taken from freshly cut healthy spruces. Upper parts of logs were leaning against each other to create a tripod structure (Figure 1). A steel rod 10 mm in diameter and 30 cm long was driven 10 cm deep into the lower part of each log such that these protruded outward from the perimeter defined by the TRIPODs. The free end of each rod, then, rested on a wooden block ca. 20 cm high. The entire TRIPODs structure was thus raised, which allowed a beetle collecting frame to be inserted beneath the entire vertical projection of the TRIPODs. The frame was in the shape of square, 1 m of side length and constructed from wooden planks of 10 cm 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[6] 0.5 %, colorant[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[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®[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® Office) and evaluated in the program Statsoft® Statistica 8.0 (using Wilcoxon matched pair test and box-and-whisker plots). Differences were considered significant at the 0.05 probability level.

Figure 1 Experimental TRIPODs with collection frame

Slika 1. Kemijski tretirani TRIPODs lovni trupčići sa lovnom kutijom za analizu ulovljenih potkornjaka na dnu (gornji rub kutije prekriven je mrežicom krupnog oka radi onemogućavanja ishrane ptica sa otrovanim i uginulim potkornjacima).

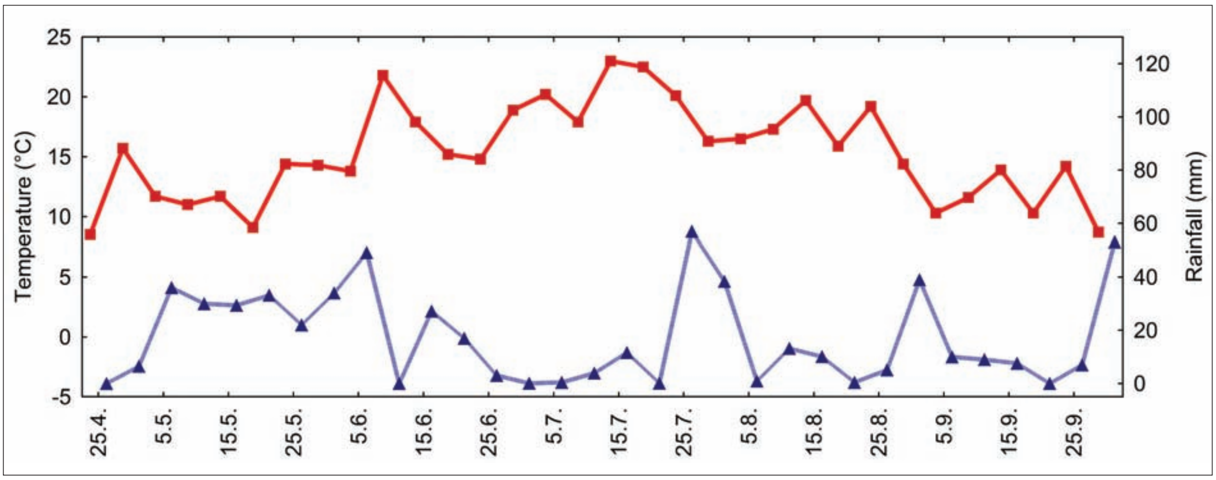

Figure 2 Mean air temperature (°C; squares-red line) and total precipitation (mm; triangles-blue line) in a 5-day intervals at the Opava hydrometeorological station (elevation 272 m a.s.l.) [9]

Slika 2. Srednja dnevna temperatura (° C; kvadratići-puna crvena linija) i ukupne količine oborina (mm; trokutići-plava linija) u 5-dnevnim intervalima na hidrometeorološkoj stanici Opava (nadmorska visina 272 m nm)

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6 insecticide - commercial name Vaztak 10 SC®, suspension concentrate with 100 g/l active formulation alpha-cypermethrin; manufacturer: BASF AG, D-67056 Ludwigshafen, Germany)

7 colorant - commercial name Scolycid C®; manufacturer: NeraAgro, spol. s r.o., Neratovice, Czech Republic

8 dispenser - commercial name Pheagr IT®, active formulations; 2-methyl-3-buten-2-ol (91%), (S)-cis-verbenol (3.9–4.3%), stabilizer: 2,6-diterc.butyl-4-metylfenol (4.7%); manufacturer: SciTech® s.r.o., Prague, Czech Republic

9 Data used from meauserments of the Czech hydrometeorological institute, www.chmi.cz. Mean air temperature is calculated as average of three measurements in 7:00, 14:00 and 21:00 oclock during five (six) days period. Rainfall is sum of precipitation during five (six) days.

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)

Tablica 1. Broj ulovljenih jedinki I. typographus *na lovnim trupčićima (TRIPODs) i feromonskim klopkama (TPTs)*

Experimental plots *Pokusne plohe*	TRIPODs				TPTs			
	Males *Mužjaci*	Females *Ženke*	Total *Ukupno*	Proportion of males *Udio mužjaka*	Males *Mužjaci*	Females *Ženke*	Total *Ukupno*	Proportion of males *Udio mužjaka*
Plot A	1199	1369	2568	0,47	1473	2465	3938	0,37
Plot B	700	777	1477	0,47	679	1172	1851	0,37
Plot C	1096	1113	2209	0,50	1196	2418	3614	0,33

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).

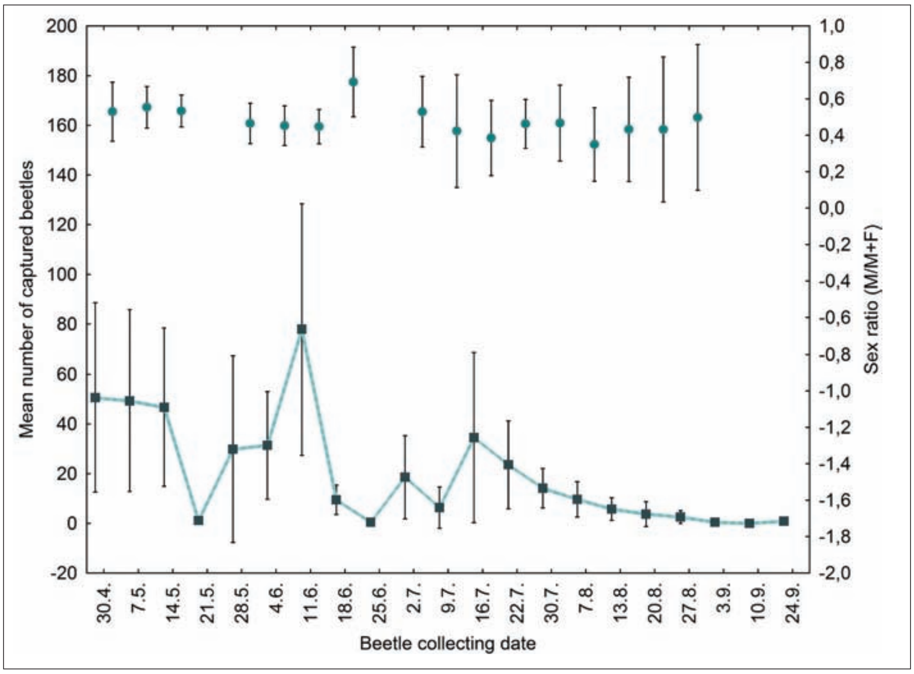

Figure 3 Mean numbers of captured *I. typographus* beetles (squares-green dotted line) ±SD and sex ratio (green circles) ±SD recorded on TRIPODs during the entire period of flight activity in 2010

Slika 3. Srednje vrijednosti ulova I. typographus (kvadratići-zelena linija) ± SD i omjer spolova (zeleni kružići) ± SD na TRIPOD lovnim trupčićima tijekom čitavog razdoblja rojenja smrekova potkornjaka u 2010. godini

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).

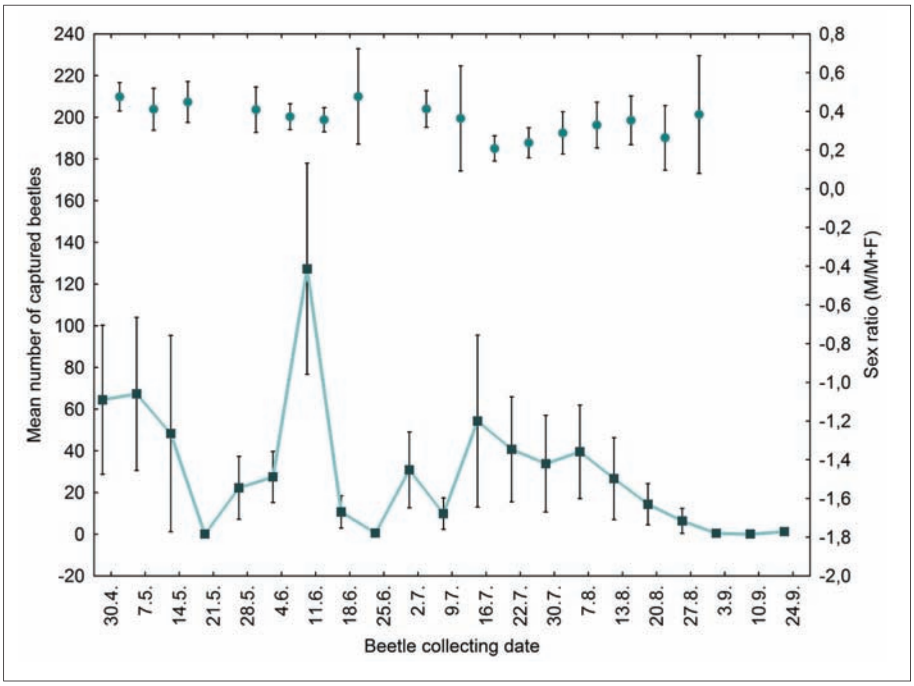

Figure 4 Mean numbers of captured *I. typographus* beetles (squares-green dotted line) ±SD and sex ratio (green circles) ±SD recorded on TPTs during the entire period of flight activity in 2010

Slika 4. Srednje vrijednosti ulova I. typographus (kvadratići-zelena linija) ± SD i omjer spolova (zeleni kružići) ± SD na TPT feromonskim klopkama tijekom čitavog razdoblja rojenja smrekova potkonjaka u 2010. godini

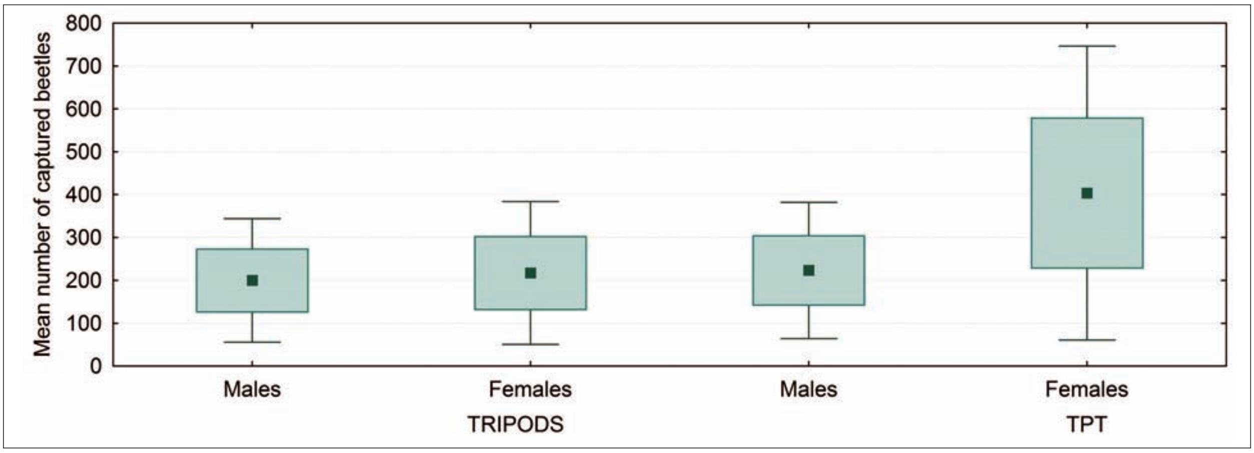

Figure 5 Numbers of spruce bark beetles (*I. typographus*) captured by TRIPODs and TPTs (small, centre square – mean; box plot – SD; whiskers – 1.96 SD)

Slika 5. Broj ulovljenih jedinki I. typographus na TRIPOD lovnim trupčićima i TPT feromonskim klopkama (srednje vrijednosti, SD i 1.96 SD)

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 (Wermelinger 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 TRIPODs). In a study conducted in 2007 and 2008, Vrba (2009) caught more individuals in TPTs than in TRIPODs baited with Fesex Typo dispensers and sprayed by insecticide alpha-cypermethrin (commercial name Vaztak). Jeniš and Vrba (2007), however, reported similar catch levels comparing TRIPODs baited with Fesex Typo dispensers and sprayed by 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 Abgrall (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. Drumont 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 Jeniš and Vrba (2007) and of Vrba (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 (Jeniš and Vrba 2007, Vrba 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 (Annila 1971, Zumr 1982, Lindelöw and Weslien 1986, Schlyter et al. 1987, Weslien and Bylund 1988, Faccoli and Buffo 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 (Faccoli and Buffo 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 (Gara 1963, Kirkendall 1983) and sister brood flight after the first bark colonisation (Anderbrant 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 (Vité 1989). Therefore, the capture of males is important to reduce tree attacks (Jakuš and Blaženec 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 ration 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 (Byers 1983).

A number of authors, however, recommend the use of TRIPODs only exceptionally, as their use kills also the large numbers of entomophagous insects (Werner et al. 1983, Okland et al. 1996, Zahradník 2005, Zahradník and Knížek 2007), these being potentially a key natural reducing factor in bark beetle population dynamics (Turchin 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. 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.

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SAŽETAK: Provedenim istraživanjem testirana je učinkovitost ulova smrekova pisara (Ips typographus) na kemijski tretiranim lovnim trupčićima (TRIPODs) u odnosu na feromonske klopke tipa Thesohn (TPTs). Tijekom 2010. godine, na svakoj od tri eksperimentalne lokacije u Češkoj, postavljeno je po 5 lovnih TRIPODs i TPTs kompozicija opremljenih feromonom Pheagr IT međusobno udaljenih 10 metara. Jednom tjedno lovne kompozicije obilažene su i sakupljan je ulov smrekina pisara kroz cijelo razdoblje njegova rojenja (30. travnja do 1. listopada). Lovni trupčići, načinjeni od svježe posječenih smrekovih stabala, tretirani su piretroidnim insekticidom Vaztak 10 SC 23. travnja i zatim ponovno, svakih 7 tjedana, usporedo sa zamjenom feromonskih dispenzera (Slika 1). Tijekom čitavog razdoblja trajanja eksperimenta ukupno je ulovljeno 15.657 jedinki smrekova pisara, od čega 6.343 mužjaka i 9.314 ženki. U lovnim kutijama postavljenim ispod kemijski tretiranih lovnih trupčića ukupno je ulovljeno 6.254 jedinki potkornjaka, od čega 2.995 mužjaka i 3.529 ženki. Na feromonskim klopkama ukupno je ulovljeno 9.403 jedinki potkornjaka, od čega 3.348 mužjaka i 6.055 ženki (Tablica 1).

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 smrekinog pisara na oba tipa lovnih kompozicija nisu utvrđene (Slika 3 i 4). Dva glavna maksimuma u ulovu smrekinog pisara tijekom 2010. godine predstavljaju pojavu dvije generacije na području istraživanja. Ovakav biološki ciklus tipičan je za područje središnje 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 ljetima i druga generacija u potpunosti razvije do spolno zrelih imaga. Na istraživanom području 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, prava ljetna generacija smrekinog pisara). Rojenje ženki druge serije polaganja imaga (sestrinske generacije) bilo je slabo izraženo i vidljivo je 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 lovne kutije postavljene ispod trupčića. Također, korištenje trupčića duljine 2 metra (Slika 1) osigurava funkcionalnost lovne kompozicije tijekom sezone 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. Gubitak nepoznatog udjela jedinki postoji i kod feromonskih klopki (doduše, bez naknadnog ugibanja), a za obje je metode problematična i činjenica da u izvjesnoj mjeri love (i usmrćuju) korisne kukce – prirodne neprijatelje potkornjaka.

Razlike u ulovima mužjaka i ženki smrekinog pisara na TRIPODs lovnim trupčićima nisu bile signifikantne ($z = 1.48$; $p > 0.05$) dok su te razlike u ulovima na TPTs feromonskim klopkama bile signifikantne ($z = 3.41$; $p < 0.001$) sa dominirajućim ulovom ženki. Također, nisu utvrđene statistički značajne razlike u ulovima mužjaka na TRIPODs lovnim kompozicijama i TPTs feromonskim klopkama ($z = 1.48$; $p > 0.05$) dok su kod ulova ženki razlike bile signifikantne ($z = 3.45$; $p < 0.001$). Brojna su istraživanja potvrdila statistički značajne razlike u omjeru spolova na ulovima feromonskih klopki gdje su ulovi ženki brojniji od ulova mužjaka. 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 započinju 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 smole). Dok ženke u načelu nisu sposobne izazvati prvi napad/ubušivanje (osim dijela populacije koji formira sestrinsku generaciju), mužjaci mogu izazvati sušenje i propadanje stabala tijekom inicijalnog ubušivanja, pogotovo u epidemičnim gustoćama populacije. Stoga je redukcija mužjaka u rojećoj populaciji potkornjaka iznimno važna sa stajališta opće 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. Ss tog gledišta, uporaba TRIPODs lovnih trupčića povoljnija je sa stajališta redukcije populacije smrekinog potkornjaka od primjene samih feromonskih klopki. Objašnjenje ovakvoj pojavi leži u biologiji potkornjaka: dok se mužjaci u načelu šire nastojeći kolonizirati materijal u blizini već naseljenog (i "markiranog" feromonom), ženke se ponašaju upravo suprotno, bivaju privučene višim koncentracijama populacijskog feromona. Posljedično, razmjerno visoke koncentracije feromona u feromonskim klopkama jače privlači ženke od mužjaka, što se i pokazalo 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 lovni trupčići, te da je u ulovima iz feromonskih klopki bilo gotovo dvostruko više ženki nego u ulovima na TRIPODs lovnim trupčićima. Ulovi mužjaka na obje lovne kompozicije bili su podjednaki.

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