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Observations on the bionomics of *Crypturgus* species

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Abstract

Crypturgus bark beetles are only mentioned sporadically in the literature and their significance as the potential predator of developmental stages of other bark beetles is underestimated. An extraordinarily high capture on insecticide-treated trap tipi assembled from three and five timber sections in the form of a pyramid allowed one to determine the interaction of *Ips typographus* flight activity and temperature. The beginning and culmination of the flight activity of *Crypturgus* species are characterised by mean daily temperatures above 11.8 °C and 14.7 °C, respectively. From the beginning until the culmination of the swarming, more specimens of *Crypturgus cinereus* (86%) were captured than of *Crypturgus pusillus* (68%) whose occurrence was extended until mid-August. Only a single generation was demonstrated during the growing period. On a bark beetle infested spruce was disturbed development of *Ips typographus*, because a high density of mother galleries of *Crypturgus* adults was recorded in its galleries.

Key words: *Crypturgus pusillus*; *Crypturgus cinereus*; seasonal dynamics; temperature; *Picea abies*; insecticide-treated trap tipi

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1. Introduction

In spruce stands, forest protection is focused primarily on the elimination of European spruce bark beetle – *Ips typographus* (Linnaeus 1758) (Stadelmann et al. 2013; Økland et al. 2016; Knížek et al. 2023) and accompanying economically important pest species – *Ips duplicatus* (C. R. Sahlberg 1836) (Grodzki 1997; Holuša et al. 2003), *Pityogenes chalcographus* (Linnaeus 1761) (Göthlin et al. 2000; Hedgren 2004). In the conditions of central Europe, the synusia of the subcortical fauna of Norway spruce (*Picea abies* (L.) H. Karst. 1881) includes 39 species (Pfeffer 1995). Many of them are neglected. *Crypturgus* species probably escape attention because of their small size and low economic importance (Michalski & Mazur 1999). Their occurrence is not even confirmed during standard control of bark beetles with the use of pheromone traps. Comprehensive knowledge of their bionomics is missing. A high representation of *Crypturgus cinereus* (Herbst 1793) and *Crypturgus pusillus* (Gyllenhal 1813) captured on the insecticide-treated tripods was surprising, since in slot traps with lures for *I. typographus* or *I. duplicatus* they occur in low representation (Valkama et al. 1997; Galko et al. 2010).

Crypturgus cinereus – an oligophagous and continental species occurring in abundance from France to the Far East and from North Africa to Lapland including Caucasus (Schedl 1945; Wood & Bright 1992) was confirmed in the insect galleries of a wide range of bark beetles on conifers (Pinaceae) *Abies* spp., *Picea* spp., *Pinus* spp., *Larix* spp. (Pfeffer 1942; Schedl 1945; Lompe 2002). Its occurrence in the Mediterranean region is rather rare (López Romero et al. 2007; Rassati et al. 2018).

Crypturgus pusillus occurs in Central Europe mainly on conifers such as *Picea* spp. and *Pinus* spp., and only rarely on *Abies alba* Mill. 1768. It has also been reported from *Cedrus atlantica* (Endl.) Manetti ex Carrière (Schedl 1945). The most frequent records are in the insect galleries of *I. typographus*, *P. chalcographus*, *Dryocoetes autographus* (Ratzeburg 1837), rarely of *Orthotomicus laricis* (Fabricius 1792), *Orthotomicus suturalis* (Gyllenhal 1827) (Schedl 1945; Lompe 2002). The species

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colonises the entire Palearctic region, North America, and North Africa (Schedl 1945; Wood & Bright 1992).

The bionomics of the two monogamous species, *C. cinereus*, *C. pusillus* are similar. Adults swarm in April and May, and a new generation may appear around late July or early August. Adults overwinter either within galleries or in forest litter (Michalski & Mazur 1999; Jurc 2006). The long-term monitoring of the occurrence of *C. cinereus* in France specified the seasonal dynamics. The onset of swarming starts in April, and the swarming culminates in June and July. The activity ends in October. The monitoring methods are not specified by the sources, Inventaire National du Patrimoine Naturel (INPN 2003–2025).

In order to penetrate under bark, beetles need an entrance hole created by larger bark beetle species (Lekander et al. 1977; Digirolomo & Sevigny 2023) or damaged bark on logs felled by harvester (Ait et al. 2025); this is why they search for trees that have already been infested. Females establish a gallery while eating eggs and the youngest larvae of the other bark beetles. The mother galleries are narrow (0.5 mm) and the larval galleries are short. The species are classified as useful; at a high density of aggressive bark beetles, their presence should be promoted (Michalski & Mazur 1999).

Weslien (1992) recorded high numbers of two *Crypturgus* species on Norway spruce four and eight weeks after an attack by the spruce bark beetle, to which these small bark beetles are not competitive in terms of feeding or spatial distribution. *Crypturgus pusillus* was even detected from the dead four-year old spruce branches and *Crypturgus hispidulus* C. G. Thomson 1870 from the dead one-year spruce branches (Nittérus et al. 2004). They were probably wintering adults.

Crypturgus borealis Swaine 1917 (5.4%) and *C. pusillus* (5.0%) were recorded as secondary species in traps baited with various semiochemicals targeting bark and longhorn beetles across different site conditions (control, blowdown, salvage) in tornado-damaged forests. Over three years of monitoring, *C. borealis* showed no response to site conditions, whereas *C. pusillus*, although stable in control sites, exhibited a gradual increase in population density in blowdown and salvage areas. This pattern likely reflects the progressive decomposition of the phloem and the associated increase in available food resources (Dodds et al. 2019).

Grodzki (2009) recorded *C. cinereus* and *C. hispidulus* on declining young spruce trees, which he considers to be possible predators of the stages of development of bark beetle. The species prefer coniferous forests damaged by the wind. Their high abundance is observed in reserves (Hjältén et al. 2010), which may explain the attractiveness of selection felling in the released stands and freshly decomposing phloem on stumps and logging debris (Joelsson 2017).

The response of species *Crypturgus* to attractants and pheromones suggests not only the role of host semiochemical substances (α-pinene), but also the general binding of bark beetles to ethanol. In term of the application of commercial pheromones, a response can be assumed to some components contained in them. Captures in Siberian forests revealed that *C. cinereus* reacted to a wider spectrum of substances (S-fuscumol, 1S-α-pinene, 1R-α-pinene, 1S-β-pinene, S-3-carene, R-limonene, α-terpinolene, ethanol) (Sweeney et al. 2016) and to pheromones containing ipsdienol and ipsenol (Terren & De Simon 1983). *C. cinereus* also responded more significantly to components of the pheromone for spruce bark beetle (methylbutenol, *cis*-verbenol, ipsdienol in mixture with α-pinene and ethanol) than to the mere α-pinene and ethanol (Isitt et al. 2023).

Crypturgus cinereus and *C. hispidulus* were very sporadically caught in barrier traps without a pheromone (Modlinger et al. 2009).

The high representation of *C. cinereus* and *C. pusillus* in captures obtained using insecticide-treated trap tipis, constructed from three or five spruce logs and baited with the IT Ecolure classic pheromone, demonstrates that these traps can collect a range of beetle species otherwise undetectable with conventional methods. Therefore, we summarise here the results of their use to improve current knowledge of these species.

2. Material and method

2.1. Research area

Localities (Table 1) for the installation of insecticide-treated trap tipi were located on the territory of the Bohemian Moravian Highlands (Forest District Nové Město na Moravě, CR). The conditions for their selection included increased felling due to bark beetle infestation and a relatively long stand wall with the released area allowing a linear distribution of insecticide-treated trap

Table 1. Characteristics of spruce stands for the placement of insecticide-treated trap tipis (Forest District Nové Město na Moravě, 2023).

Sites	GPS		Altitude (m) a.s.l.	Terrain	Age years	FSTC[1)]	Share of spruce (%)	KZ[2)] (m^3) 2020–2023
Bystřice n/P	N 49°32′35″	E 16°11′48″	618	plane	110	5K[3)]	90	1,588
Bohdalec	N 49°29′06″	E 16°02′17″	550	plane	85	6P[4)]	84	1,554
Věcov	N 49°37′41″	E 16°09′08″	665–674	slight slope	125	6P[4)]	99	738

Notes: [1)]FSTC – Forest site type complex (Viewegh et al. 2003). [2)]KZ – wood volume infested by *Ips typographus* in the period from the beginning of August to the end of March of the following year. [3)]5K – acidic soil, 450–650 m a.s.l.; mean annual temperature 5.5–6 °C; mean annual precipitation 800–900 mm; growing season 130–140 days. [4)]6P – stagnic soil; 650–950 m a.s.l.; mean annual temperature 4.5–5.5 °C; mean annual precipitation 900–1,050 mm; growing season 115–130 days.

tipi according to the valid principles of the Czech standard (ČSN 481000 2005). In each locality, a Thermologger TMS (TOMST, Ltd., CR) was installed in the shaded part of the controlled stand margin to measure air temperatures (2 m above the ground, recording interval 15 min). The mean daily temperature was calculated from temperatures measured at intervals from 0:00 to 24:00/96. Total daily precipitation amounts were taken over from the Hydrometeorological Station at Vatín (537 m altitude, N 49°30´60˝, E 15°58´20˝) (Fig. 1).

2.2. Trap tipi

The insecticide-treated trap tipis were assembled (23 April 2023), as pyramids of three (tripods) or five (pentapods) 2 m long spruce logs characterised by diameter and surface area (tripods: 15.6 ± 1.4 cm, 98.1 ± 8.8 dm^2 and pentapods: 15.2 ± 1.2 cm, 95.2 ± 7.7 dm^2). The intercepting area (1.4 × 1.4 m) was a non-woven geotextile (Juta Geonetex, 100% polyester, JUTA, JSC, CR) which was inserted into the terrain into individually created structures with the height of the walls ca. 0.2 m. The logs were constructed directly on the underlaid geotextile (Fig. 2) allowing to collect a wide range of small non targeted fauna that could not be caught if the commonly used catch frames were used of mesh sized 1 × 1 mm. The space with dead individuals was protected against birds by netting. In each locality, three traps were installed (tripods and pentapods) which alternated at a distance of 50 m and formed a line parallel to the stand wall at a distance of 10–15 m.

The Forester insecticide, a commercial product intended to kill *I. typographus* and other bark beetles contains 100 g l^{-1} of cypermethrin (eAGRI 2022). After dilution with water (10 ml l^{-1}) (Zahradník et al. 2023), it was applied as spray on 2 May 2023, repeatedly in the 4 to 5 week interval for the entire monitoring.

The IT Ecolure classic pheromone (Fytofarm CZ, Ltd.), a lure for *I. typographus* compounded of (S)-*cis*-verbenol (3%), alcohols and solvents (85.2%), synergic components (11.8%) packed in a classic clipping bag (Nakládal & Sova 2010; Ridex 2023) was installed in shade right under the top of trap logs and activated on 4 May and then on 26 June 2023.

The fauna sample collection was carried out on the terrain for 14 days (in total nine checks) using an aspirator during the period from 12 May to 26 August 2023, with the dry conservation of samples. The other author determined bark beetles.

Captured fauna was collected using an aspirator and subsequently the number of adults captured from *Crypturgus* spp. was determined by direct counting in the laboratory. The density was calculated as the ratio of the total number of beetles captured to the total surface area of all logs used on tripods and pentapods. The calculation was performed for each site separately.

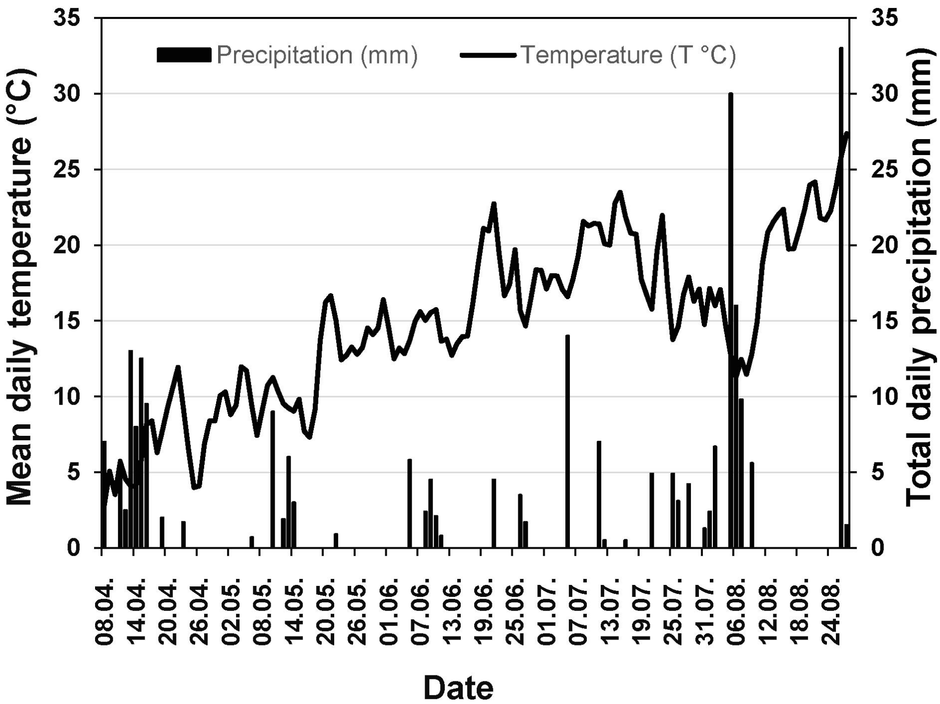

Fig. 1. The course of mean daily temperatures (forest research locations) and amounts of total daily precipitation (Hydrometeorological Station Vatín).

Fig. 2. Insecticide-treated trap tipis situated within the intercepting space from non-woven geotextile (tripod left, pentapod right) (2023).

2.3. Data processing and their presentation

The data obtained included the number of beetles at the monitored locations. This dependent variable was, according to the purpose of the analysis, further sorted by collection date, locations, and methods. Statistical testing was performed in the STATISTICA programme (TIBCO Software Inc. 2020) using the module Nonparametrics/Kruskal-Wallis ANOVA & Median test (K-W test). The results are presented in text, supplemented by bar graphs and, if necessary, a table. More details are given in the results section.

3. Results

3.1. Generally

Apart from *I. typographus*, 21,317 samples of non targeted bark beetles (26 species) were captured on the insecticide treated traps tipis (tripods and pentapods). Eudominant species included *C. cinereus* (39.1%) and *C. pusillus* (13.3%) and *C. subcribrosus* (0.02%) was confirmed as a subrecent occurrence. Other recorded eudominant species were *P. chalcographus* (17.0%) and *I. duplicatus* (11.3%).

3.2. Swarming

Capture of *I. typographus* fluctuated during the period from May 12 to June 30 (spring generation), then increased significantly until July 15 (swarming summer generation). In the period from 2 to 12 May when the mean daily temperatures oscillated between 7.0 and 13.8 °C (mean 8.6 °C), adults of *I. typographus* were captured as the only ones (Fig. 3). The beginning of *Crypturgus* spp. flight activity in the monitored localities was late from 12 and 26 May, when the mean daily temperatures oscillated between 6.8–16.5 °C (mean 11.8 °C). The catches of *Crypturgus* spp. are variable in the monitored period, more notable during June. Although the graph indicates a difference between both *Cryptorgus* spp. when checking on 8 and 21 June, the difference is not statistically significant (K-W test: 8 June – $H(1, N=36) = 0.20$, $p = 0.6574$; 21 June – $H(1, N=36) = 3.80$, $p = 0.0511$). This is related to the binomial nature of beetles and the different population density, which results in considerable variability in the number of beetles caught (Fig. 3).

The flight activity of *C. cinereus* adults in the Věcov locality began already in the period from 27 May to 8 June (mean daily temperatures 14.7 °C). In the remaining localities, *C. cinereus* and *C. pusillus* culminated in the period of 8 to 21 June with mean daily temperatures ranging from 12.7 to 22.6 °C (mean 16.2 °C).

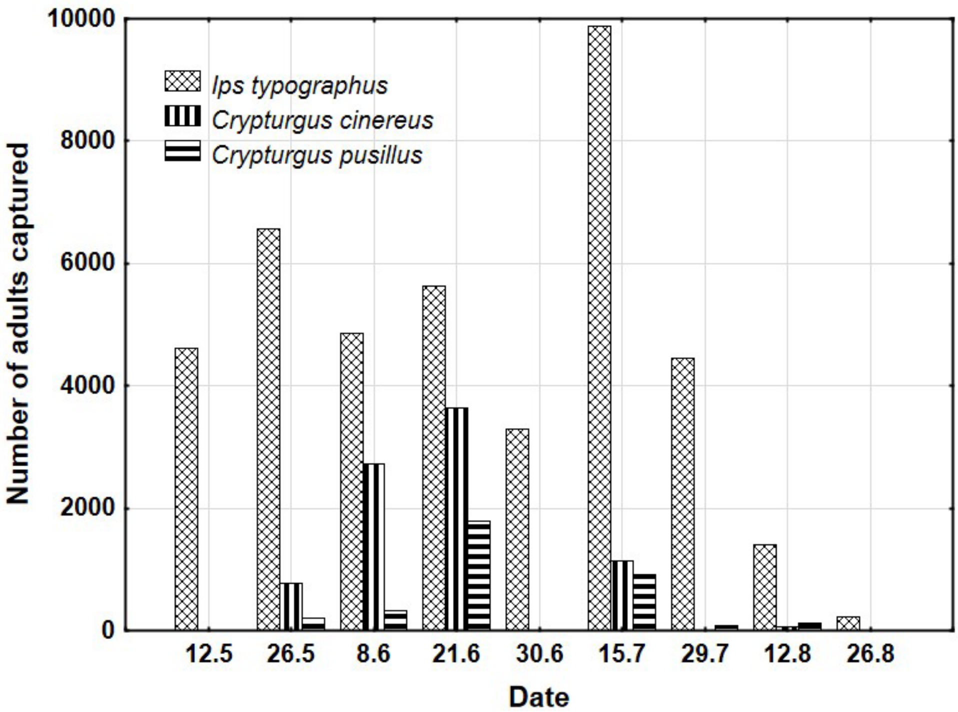

Fig. 3. Capture of flight activity of *Ips typographus* and *Crypturgus* spp. (pooled localities and methods trap tipis 2023).

From the beginning of the swarming to the culmination, 86% of the adults *C. cinereus* were caught and the flight activity of the species then decreased quickly at the beginning of July. In *C. pusillus*, only 68% of the individuals swarmed before the culmination and the adults exhibited increased activity until mid-July (26%) with their occurrence prolonged until mid-August (6%).

3.3. Relative abundance of *Crypturgus* species in localities

The total number of adults captured at individual locations, pooled for tripods and pentapods, was clearly the highest at the Bystřice n/P location (82.6%) (Table 2). Statistically significantly higher numbers of *C. cinereus* caught (K-W test H (2, N=108) = 29.12, p = 0.0000) and *C. pusillus* (K-W test H (2, N=108) = 10.43, p = 0.0054) were recorded in the locality of Bystřice n/P. The *Crypturgus subcribrosus* data were not statistically tested.

3.4. Relative abundance of *Crypturgus* species on insecticide-treated trap tipi

A slightly higher total number of adult *C. pusillus* beetles was found on tripods compared to *C. cinereus*, while clearly 3-times more *C. cinereus* beetles were captured on pentapods than *C. pusillus* (Fig. 4).

Taking into account the available surface of tripods (mean 882 ±4 dm^2) and pentapods (mean 1,428 ±57 dm^2) for the expression of the density 'abundance' of infestation by adults of *Crypturgus* spp., a higher capture was confirmed in pentapods. The highest density of adults was recorded on pentapods at the Bystřice n/P site. This corresponds to the fact that the incidence of adults was highest at this site (Fig. 5).

The significance of the tripods/pentapods position or source (place of development) of *Crypturgus* spp. suggests an uneven capture of the monitored species in the individual localities where they occurred in a line situated and alternating with the tripods/pentapods. In all monitored locations, *C. cinereus* was concentrated in one trap

Table 2. Abundance of *Crypturgus* spp. captured with tripods and pentapods in 2023 at the study sites. The total counts and percentage share of each locality are provided.

Localities/Species	*C. cinereus*	*C. pusillus*	*C. subcribrosus*	*Crypturgus* spp.	
				total	%
Bystřice n/P	7,452	2,292	5	9,749	82.60
Bohdalec	490	885	0	1375	11.65
Věcov	385	294	0	679	5.75
Sum (pcs)	8,327	3,471	5	11,803	

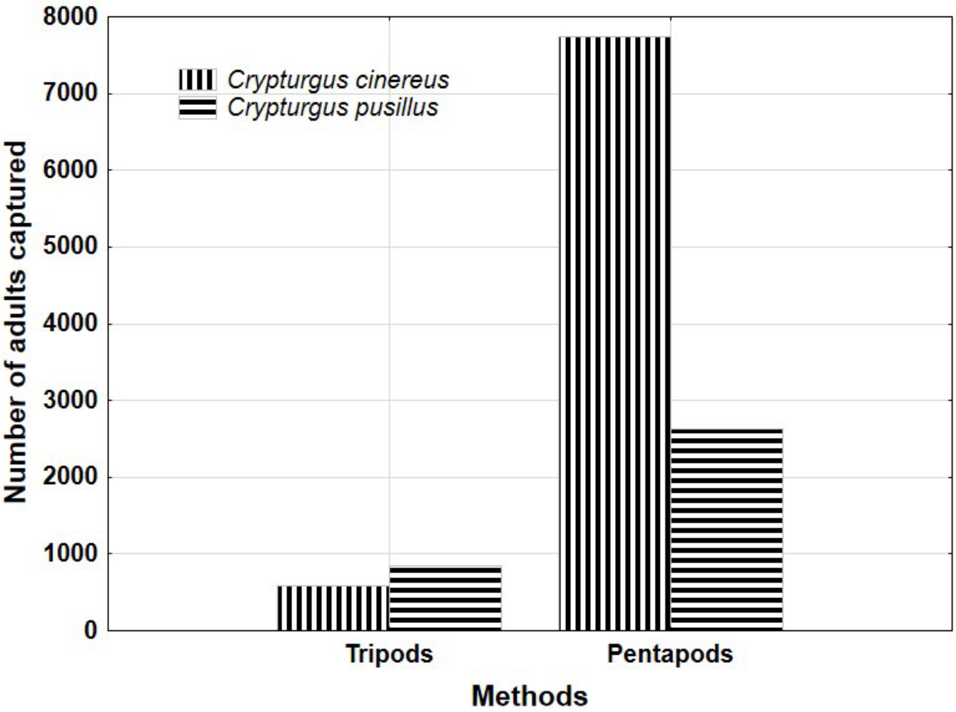

Fig. 4. Total number of capture of *Crypturgus* spp. on insecticide-treated tripods and pentapods in the monitored locations (2023).

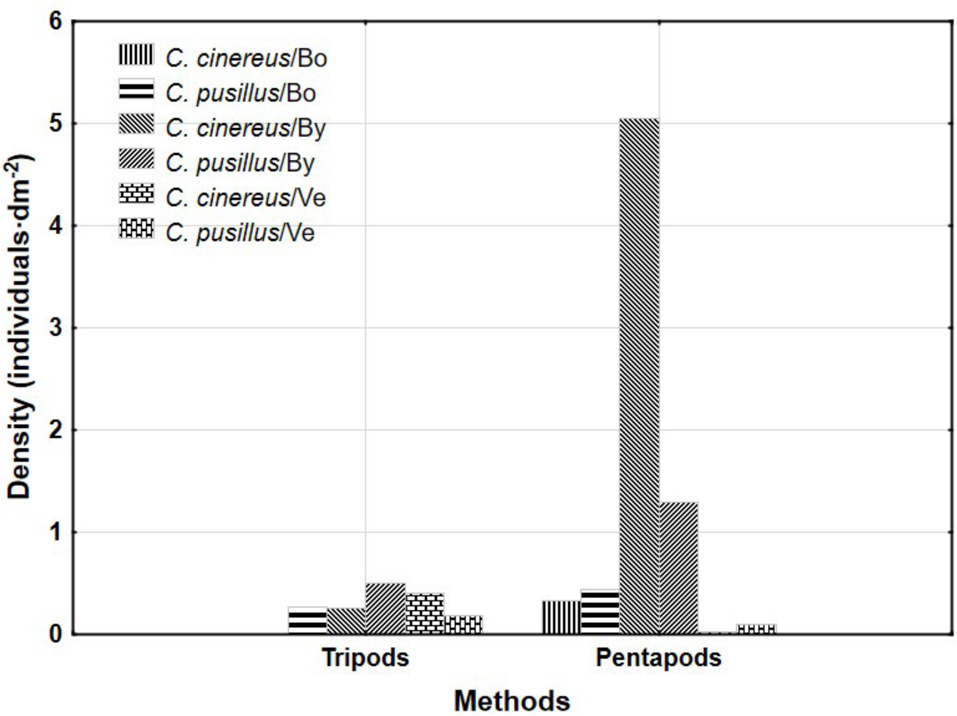

Fig. 5. Density of *Crypturgus* spp. on insecticide-treated tripods and pentapods in the monitored localities (Bo – Bohdalec, By – Bystřice n/P, Ve – Věcov, 2023).

tipi (Bohdalec, Bystřice n/P – pentapods; Věcov – tripods) (Fig. 6). *Crypturgus pusillus* was more significantly dispersed in the locality according to the partial representation on the respective tripods/pentapods at a lower density (Bohdalec, Věcov). In the location Bystřice n/P with the highest occurrence, it was concentrated to one pentapod (Fig. 6).

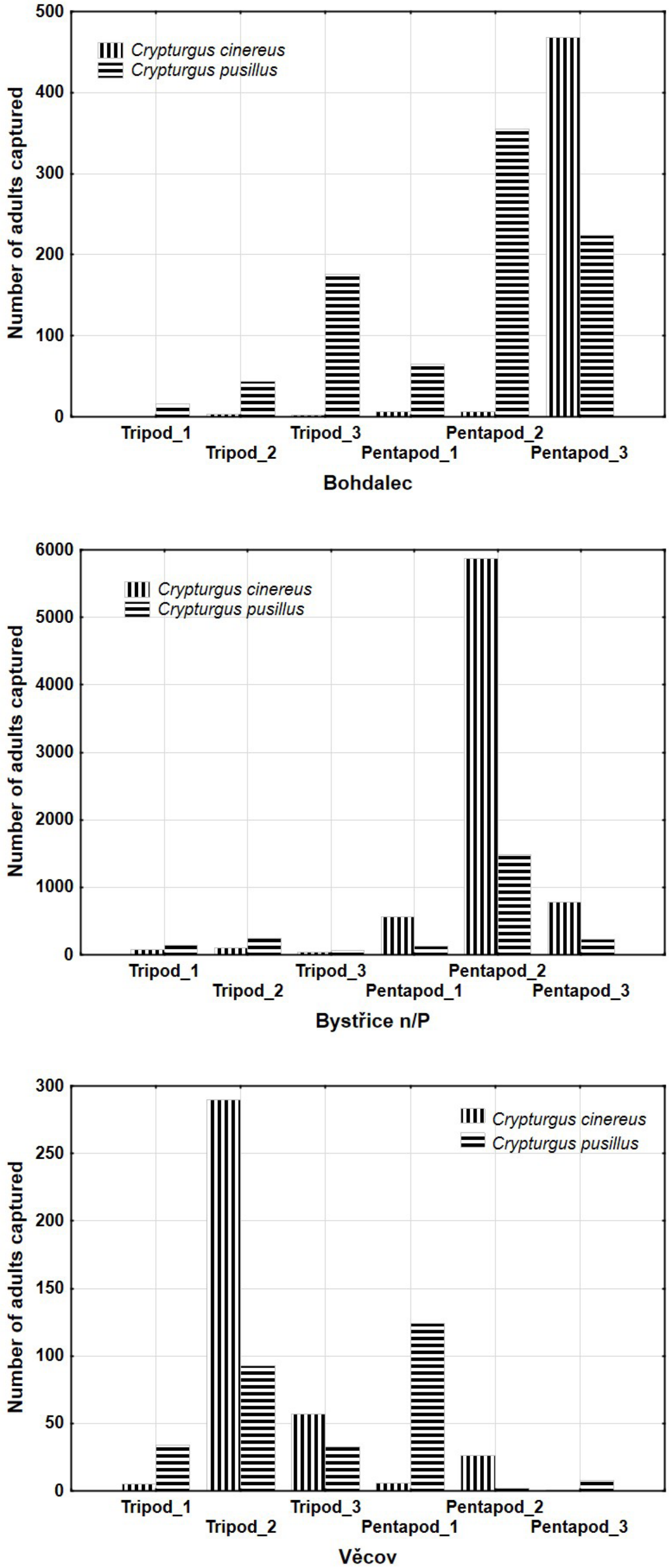

Fig. 6. Total number of capture of *Crypturgus* spp. on the individual tripods/pentapods in the monitored localities (2023).

4. Discussion

In most bark beetle species, the onset of swarming is associated with temperatures approaching 15 °C, with higher temperatures, low airflow, and the absence of rainfall further promoting flight activity (Lobinger & Skatulla 1996). The temperatures recorded in relation to the capture of adults from *C. cinereus* and *C. pusillus* confirm that the adults were not captured on the first sampling date with sporadic mean daily temperatures reaching 11 °C, while *I. typographus* was active. In the following period, when only 8% of *Crypturgus* individuals were caught, temperatures above 15 °C were recorded only in the second half of May and in that period *I. typographus* had already reached the culmination of spring swarming (Kula et al. 2024). From the end of May, the mean daily temperatures exceeded 15 °C and the flight activity reached its culmination (second half of June). This time gap may also be related to the creation of mother galleries by the spruce bark beetle and the concurrent swarm of accompanying species creating standard galleries on spruce (*P. chalcographus*, *I. duplicatus*). It can be assumed that the higher temperature required for swarming of *Crypturgus* species creates a time gap necessary for *Ips* species to make galleries. The conclusion is corroborated by the fact that the occurrence of *Crypturgus* under bark increased within a time gap of 4 and 8 weeks from the arrival of *I. typographus* adults (Weslien 1992). Some species of *Crypturgus* spp. (*C. pusillus*, *C. cinereus*, *C. hispidulus*) are ranked as predators (Michalski & Mazur 1999; Isitt et al. 2023) as they eat among other things the eggs and larvae of the first instar of bark beetles the galleries of which they enter at a time gap when the egg laying occur. A competitive environment (*Crypturgus* × *Ips*), in which the development of important bark beetles in forest management may be disturbed (Appendix A1).

Independent colonization of the log by *Crypturgus* spp. was observed (Knížek & Lindelöw, personal observation, unpublished). Also in the case of occupation of the phloem through other bark beetle species, there are exit holes of *Crypturgus* spp., which clearly means that the species of *Crypturgus* are able to bore through the bark on their own. Therefore, the ecological significance of this behavior remains unclear. Consequently, their usefulness is ambiguous.

During flight activity, a single culmination was detected. A similar finding was reported by the Inventaire National du Patrimoine Naturel (INPN 2003–2025), when the occurrence in France in the period from March to October had only one culmination (June/July). However, Michalski & Mazur (1999) assume two generations (April/May and July/August).

The insecticide-treated trap tipi method allowed the acquisition of a representative sample of adults from adult of *Crypturgus* (11,793 specimens) because the intercept space under the tripods/pentapods minimised losses. Theysohn pheromone slot traps in the same locality did not confirm the occurrence of *C. cinereus* and *C. pusillus*, although they were baited with the same pheromone. According to Isitt et al. (2023), *C. cinereus* reacts to methylbutenol, *cis*-verbenol, ipsdienol. The aggregation pheromone in the IT Ecolure evaporator is created by the active substance of (S)-*cis*-verbenol (3%) that can be hydroxylated in the intestine by the spruce bark beetle under natural conditions from (S)-(-)-α-pinene (Mori 2005).

A substantial capture of *C. pusillus* on tripods and pentapods, along with an unconfirmed occurrence in pheromone traps, suggests that both the type of trap and the semiochemicals released from the spruce logs forming the tripods/pentapods influence the number of adults arriving and being captured (Kalinová et al. 2014; Fang et al. 2021).

The high capture of *Crypturgus* species in the Bystřice n/P locality may have been facilitated by the extensive clear-cut area without understory following a bark beetle outbreak, due to the high proportion of stumps and logging debris, which were relatively scarce in the other monitored sites. At the Bohdalec site, increased captures of *Crypturgus* adults were observed at certain pentapods and tripods located near a standing dead pine (*Pinus*) attacked by *Tomicus* bark beetles. Logging debris is known to be one of the main factors contributing to bark beetle population increases (Dodds et al. 2019; Fiala & Holuša 2022). The aggregation of *C. cinereus* adults on one of the available tripods or pentapods appears to be influenced more by the trap's proximity to suitable host material than by the IT Ecolure pheromone. Sweeney et al. (2016) report higher sensitivity of pheromone components to *I. typographus* In *C. pusillus*, captures were more evenly distributed among the traps, except at Bystřice n/P, where both species intensively colonized the same five-log structure. A higher number of *C. cinereus* compared to *C. pusillus* was also recorded in the Białowieża Forest in Poland (Mokrzycki 1995).

5. Conclusions

The flight activity of *Crypturgus* bark beetles was delayed by approximately 2–4 weeks compared to *Ips typographus* swarming. This supports their dependence on the occupation of galleries created by other bark beetle species. The presence of species of *Crypturgus* was affected by the differentiated amount of material suitable for their development. In central Europe, *Crypturgus* escapes attention because it does not cause damage to forests.

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References

Ait, K., Palm-Hellenurm, K., Õunap, H., Kaart, T., Vodde, F., Orumaa, A. et al., 2025: Trap log felling methods drive bark beetle communities without affecting *Ips typographus* (L.) densities on Norway spruce. European Journal of Forest Research, 144:683–698.

Digirolomo, M. F., Sevigny, J. L., 2023: A palearctic bark beetle, *Crypturgus hispidulus* Thomson (Coleoptera: Curculionidae: Scolytinae), new to North America discovered in New England, U.S.A. Zootaxa, 5325:429–435.

Dodds, K. J., Digirolomo, M. F., Fraver, S., 2019: Response of bark beetles and woodborers to tornado damage and subsequent salvage logging in northern coniferous forests of Maine, USA. Forest Ecology and Management, 450:117489.

Fang, J.-X., Zhang, S.-F., Liu, F., Cheng, B., Zhang, Z., Zhang, Q.-H. et al., 2021: Functional investigation of monoterpenes for improved understanding of the relationship between hosts and bark beetles. Journal of Applied Entomology, 145:303–311.

Fiala, T., Holuša, J., 2022: Outbreak of *Pityogenes chalcographus* and *Pityophthorus pityographus* on spruce seedlings resulting from inappropriate management in a forest nursery. Forests, 13:987.

Galko, J., Gubka, A., Vakula, J., Brutovský, D., 2010: Porovnanie odchytov lykožrúta smrekového (*Ips typographus* L.) (Coleoptera: Scolytidae) do feromónových lapačov kanadskej a európskej produkcie. Lesnícky časopis, 56:337–347. (In Slovak).

Göthlin, E., Schroeder, L. M., Lindelöw, A., 2000: Attacks by *Ips typographus* and *Pityogenes chalcographus* on windthrown spruces (*Picea abies*) during the two years following a storm felling. Scandinavian Journal of Forest Research, 15:542–549.

Grodzki, W., 1997: Możliwości kontroli liczebności populacji kornika zrosłozębnego *Ips duplicatus* C. R. Sahlb. na południu Polski. Sylwan, 141:25–36. (In Polish).

Grodzki, W., 2009: Entomofauna of dying young spruces *Picea abies* (L.) Karst. in the area after forest decline in the Izerskie Mountains. Folia Forestalia Polonica, 51:161–170.

Hedgren, P. O., 2004: The bark beetle *Pityogenes chalcographus* (L.) (Scolytidae) in living trees: reproductive success, tree mortality and interaction with *Ips typographus*. Journal of Applied Entomology, 128:161–166.

Hjältén, J., Stenbacka, F., Andersson, J., 2010: Saproxylic beetle assemblages on low stumps, high stumps and logs: Implications for environmental effects of stump harvesting. Forest Ecology and Management, 260:1149–1155.

Holuša, J., Zahradník, P., Knížek, M., Drápela, K., 2003: Seasonal flight activity of the double-spined spruce bark beetle *Ips duplicatus* (Coleoptera, Curculionidae, Scolytinae) in Silesia (Czech Republic). Biologia (Bratislava), 58:935–941.

Isitt, R., Økland, B., Krokene, P., Sweeney, J., Heard, S. B., Pureswaran, D. S., 2023: Using semiochemicals to predict biotic resistance and facilitation of introduced species. Biological Invasions, 25:441–454.

Joelsson, K., 2017: Uneven-aged silviculture as a management tool to mitigate biodiversity loss. A case study of beetles in boreal forests. Doctoral thesis. Umeå, Swedish University of Agricultural Sciences.

Jurc, M., 2006: Navadna smreka. Žuželke na deblih, vejah in v lesu. Gozdarski Vestnik, 64:17–32. (In Slovenian).

Kalinová, B., Břízová, R., Knížek, M., Turčáni, M., Hoskovec, M., 2014: Volatiles from spruce trap-trees detected by *Ips typographus* bark beetles: chemical and electrophysiological analyses. Arthropot-Plant Interaction, 8:305–316.

Knížek, M., Liška, J., 2023: Výskyt lesních škodlivých činitelů v roce 2022 a jejich očekávaný stav v roce 2023. Forestry and Game Management Research Institute, Strnady. p. 86. (In Czech).

Kula, E., Holuša, J., Hrdlička, P., Resnerová, K., 2024: Optimalizace otráveného lapáku pro maximální odchyt lýkožrouta smrkového (*Ips typographus* L.). Mendel University in Brno, Czech University of Life Sciences Prague, 182 p. (In Czech).

Lekander, B., Bejer-Petersen, B., Kangas, E., Bakke, A., 1977: The distribution of bark beetles in the Nordic countries. Acta Entomologica Fennica, 32:1–37.

Lobinger, G., Skatulla, U., 1996: Untersuchungen zum Einfluß von Sonnenlicht auf das Schwärmverhalten von Borkenkäfern. Anzeiger für Schädlingskunde, Pflanzen- und Umweltschutz/Journal of Pest Science, 69:183–185. (In German).

López Romero, S., Romón Ochoa, P., Iturrondobeitia Bilbao, J. C., Goldaracena Lafuente, A., 2007: Los Escolítidos de las Coníferas del País Vasco: Guía Práctica para su Identificación y Control. Estudios Gráficos ZURE, SA, 190 p. (In Spanish).

Michalski, J., Mazur, A., 1999: Korniki. Praktyczny przewodnik dla lesników. Swiat, Warszava, 188 p. (In Polish).

Modlinger, R., Holuša, J., Liška, J., Knížek, M., 2009: Stav populace lýkožrouta smrkového *Ips typographus* (L.) v NPR Žofínský prales (Novohradské hory, Česká republika). Silva Gabreta, 15:143–154. (In Czech).

Mokrzycki, T., 1995: Effect of pine forest stand age on bark beetle communities (Coleoptera: Scolytidae) in Puczcza Białowieska. Fragmenta Faunistica, 38:411–417.

Mori, K., 2005: Organic synthesis in pheromone science. Molecules, 10:1023–1047.

Nakládal, O., Sova, J., 2010: Comparison of two types of ECOLURE lure on *Ips typographus* (L.) (Coleoptera: Scolytidae). Journal of Forest Science, 56:609–613.

Nittérus, K., Gunnarson, B., Axelsson, E., 2004: Insects reared from logging residue on clear-cuts. Entomologica Fennica, 15:53–61.

Økland, B., Nikolov, Ch., Krokene, P., Vakula, J., 2016: Transition from windfall- to patch-driven outbreak dynamics of the spruce bark beetle *Ips typographus*. Forest Ecology and Management, 363:63–73.

Pfeffer, A., 1942: Notulae ipidologicae V. Příspěvek k poznání rodu *Crypturgus* Erichs. Sborník Entomologického Oddělení Zemského Muzea v Praze, XX:207–222.

Pfeffer, A., 1995: Zentral- und westpaläarktische Borken- und Kernkäfer (Coleoptera: Scolytidae, Platypodidae). Basel, Naturhistorisches Museum, p. 310. (In German).

Rassati, D., Haack, R. A., Knížek, M., Faccoli, M., 2018: National trade can drive range expansion of bark- and wood-boring beetles. Journal of Economic Entomology, 111:260–268.

Stadelmann, G., Bugmann, H., Meier, F., Wermelinger, B., Bigler, C., 2013: Effects of salvage logging and sanitation felling on bark beetle (*Ips typographus* L.) infestations. Forest Ecology and Management, 305:273–281.

Sweeney, J. D., Silk, P., Grebennikov, V., Mandelshtam, M., 2016: Efficacy of semiochemical-baited traps for detection of Scolytinae species (Coleoptera: Curculionidae) in the Russian Far East. European Journal of Entomology, 113:84–97.

Terren, C. A., De Simon, R. J., 1983: Use of 'Pherotrap' in quantitative sampling of forest Microcoleoptera (Coleoptera, Scolytidae) in the Roncal Valley (Navarre). Actas del I Congreso Iberico de Entomologia, Leon, 1:39–50.

Valkama, H., Räty, M., Niemelä, P., 1997: Entomologica Fennica, 8:153–159.

Viewegh, J., Kusbach, A., Mikeska, M., 2003: Czech forest ecosystem classification. Journal of Forestry Science, 49:74–82.

Weslien, J., 1992: The arthropod complex associated with *Ips typographus* (L.) (Coleoptera, Scolytidae): species composition, phenology, and impact on bark beetle productivity. Entomologica Fennica, 3:205–213.

Other sources

ČSN 481000, 2005: Ochrana lesa proti kůrovcům na smrku. 8 p. Available at https://seznamcsn.agentura-cas.cz/Detailnormy.aspx?k=72354 (accessed 09 November 2024). (In Czech).

eAGRI, 2022: Forester (4744-0) Register of plant protection products. Available at https://eagri.cz/public/app/eagriapp/POR/Detail.aspx?id=37756&stamp=638377241838766481 (accessed 09 December 2023). (In Czech).

INPN, 2003–2025: MNHN & OFB [Ed]. Sheet of *Crypturgus cinereus* (Herbst, 1793). Inventaire national du patrimoine naturel (INPN). Available at https://inpn.mnhn.fr/espece/cd_nom/242261. (Accessed 17 April 2024).

Lompe, A., 2002: Die Käfer Europas (Beetle of Europe). Ein Bestimmungswerk im Internet. Available at https://bugguide.net/node/view/763205. (Accessed 17 April 2024).

Ridex 40-201, 2023: IT Ecolure klasik. Available at https://www.ridex.cz/it-ecolure-klasik-ks-236cz38/. (In Czech).

Schedl, K. E., 1945: Bestimmungstabellen der palaearktischen Borkenkäfer. Zentralblatt für das Gesamgebiet der Entomologie 1 (1). (In German).

TIBCO Software Inc., 2020: TIBCO Software Inc. Data Science Workbench, version 14. Available at http://tibco.com.

Wood, S. L., Bright, D. E., 1992: A catalog of Scolytidae and Platypodidae (Coleoptera), Part 2. Taxonomic Index. Great Basin Naturalist Memoirs 13:1–1553.

Zahradník, P., Zahradníková, M., Mikulčíková, P., 2023: Integrovaná ochrana rostlin – lesní porosty. Příloha 1 Seznam povolených přípravků a dalších prostředků na ochranu lesa. Metodická příručka. 92 p. (In Czech).

Appendix A

Appendix A1. *Crypturgus* spp. disturbed the development of *Ips typographus* by establishing its own galleries in the mother gallery of the spruce bark beetle and by eating its eggs (Photo L. Půlpán).