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Do pheromone trapping always reflect *Ips typographus* (L.) population level? A study from the Tatra National Park in Poland

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Abstract

Pheromone traps are used for monitoring *I. typographus* populations in Norway spruce stands of the Tatra National Park (TPN) in Poland. The presented study is based on the set of pheromone traps of precisely known location (23) located in the whole area of the TPN and operated continuously in 2010–2019. The data on the captures of beetles were compared with two kinds of data concerning the mortality: the area covered by standing dead trees (airborne photographs) in the no-intervention zone, and the volume of trees infested by bark beetles processed in the active protection zone. No relationship was found between the mean numbers of beetles captured yearly in all pheromone traps in the whole TPN area and the volume of infested trees removed from the stands in the active protection zone. The captures in the two selected study areas were correlated with the area of spots with dead trees in the 500 m circle around the traps, however, this correlation is not statistically significant. There is no relation of captures to the volume of processed infested trees. The captures decreased in the growing seasons after the wind damage, and increased markedly after the drought started in 2015. The results of pheromone trapping are affected by several factors, as wind damage and defence potential of trees resulting from their physiological status. Pheromone traps represent valuable source of information about the bark beetle *I. typographus* population dynamics, although the collected data do not enable direct definition of its population level, especially in the protected areas with different and unstable (changed in 2017) approach to the protection of stands. As most of the information on beetles is captured in the first half of the growing season, the data collected till the end of July are sufficient for monitoring purposes; thus, the trapping should be reduced to the period May–July.

Key words

pheromone monitoring, bark beetles, protected areas, *Picea abies*, mountains, Tatra

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Introduction

The European spruce bark beetle *Ips typographus* (Col., Scolytinae) is an immanent element of the forest ecosystems dominated by the Norway spruce *Picea abies* (L.) Karst. This concerns both economic forests, in which this insect is considered as an important pest, but also the forest ecosystems remaining under nature protection regime – in nature reserves and national parks. Nevertheless, in all the cases, *I. typographus* substantially contributes to the natural or human-driven dynamics of such ecosystems. Therefore, usually, it is necessary to gather the information about the dynamics of its populations, using various methods. Among the commonly applied approaches, the artificial traps baited with synthetic pheromones are installed and operated, and the data about the numbers of captured beetles are believed to be useful for monitoring of the population and prediction of damage risk (e.g., Niemeyer 1992; Faccoli and Stergulc 1999, 2006; Lindelöw and Schroeder 2001; Grodzki 2007).

The use of this tool has already quite a long history – pheromone baited traps were proposed for monitoring bark beetle populations shortly after those synthetic attractants were introduced into the forestry practice (Bakke 1985). This concerns both short-term survey within a single growing season (Faccoli and Buffo 2004), as well as the long-term monitoring aimed to the definition of changes in the population density between subsequent seasons (Holly 2005; Pontuali et al. 2008). This approach seems to have higher importance in the protected areas, especially when the active protection treatments are limited or excluded. In such a case, the pheromone traps could serve mainly (or exclusively) as the source of information about *I. typographus* population level. However, it is generally known that the interpretation of such data is not possible in a direct way, as there is a lot of environmental factors that influence the results of pheromone trapping (Bakke 1992; Niemeyer 1992; Grodzki 2007).

In the Tatra National Park (TPN) in Poland, the pheromone traps for monitoring *I. typographus* populations are used since 1992. Their number, reaching initially (1992–2002) 200–400 traps, since 2003 gradually decreased, to 61 pieces in 2016. During this period, various trap types (e.g., Borregaard, Theysohn) and pheromone dispensers (Pheroprax, Ipsodor) were in use, also the location of traps was not stable. Due to this inconsequence, the collected data are much more difficult to interpret. Since 2003, when the number of operated traps decreased markedly, their location and methodology were more less stabilized. It seems that the data collected during last 10 years are more interpretable, thus such attempt is undertaken in this paper. The main aim of the study was to test if and to what extent the result of this monitoring reflect the observed effects of the bark beetle activity (spruce mortality), therefore, if and how it is justified to continue those activities.

Material and methods

The study design is based on the set of pheromone traps located in the whole area of the TPN and operated in the years 2010–2019. Only the traps of precisely known location within the study period were taken into consideration. Finally, the data from 23 locations (only the traps operated in all years) were used (Fig. 1); 10 traps were located in the zone between 860 and 1000 m a.s.l. (zone 1), 11 traps in the zone between 1001 and 1200 m a.s.l. (zone 2) and 2 traps – above 1200 m a.s.l. (zone 3), approximately at the upper limit of the lower montane belt (Piękoś-Mirkowa and Mirek 1996). Most of the traps were located on eastern and northern slopes (15 and 8, respectively), while only 5 on western, and 3 on southern ones. The slit traps were usually (except one) installed by 2 pieces in one locality, pheromone dispenser was inserted at the beginning of May, a new one was added at the beginning of July, and the data about the number of captured beetles were collected monthly by the professional staff of the TPN. The data on the captures of beetles were then compared with two kinds of data concerning the mortality: the area covered by standing dead trees in the no-intervention zone, and the volume of trees infested by bark beetles processed in the intervention (active protection) zone. Due to instability of the range of individual protection zones, and the lack of precise spatial data concerning the sanitary/salvage felling in adequate resolution, it was not possible to include these two kinds of data in one analysis. Therefore, some approaches were applied.

The data concerning standing dead trees were derived from the numerical layer containing the spots with such trees delimited and digitized by Marcin Bukowski

(TPN) based on the airborne photographs of the Park, taken in the autumns of 2011, 2012, 2013, 2014, 2015 and 2017 (the appropriate images from 2016 were not available). Mapping was conducted manually by comparing aerial orthophotos taken in individual years in ESRI ArcGIS 10.2. (Sproull et al. 2017). For every year, only the newly detected clusters of dead trees were delimited and digitized. For each locality of concern, three circular concentric zones of 100, 200 and 500 m radius were delimited and the total area covered by dead trees was calculated for each zone around each locality in all the years. It was assumed that the tree mortality derived in such a way was caused exclusively or at least mainly by bark beetle infestation, as no terrestrial verification was done.

The data concerning the infested trees processed in the stands in active protection zone come from the official reports that are supplied yearly by the TPN to the Forest Research Institute for evidence/forecast of threats to forests. The data from the entire active protection zone in the TPN area were used for general characteristics of the dynamics of spruce mortality. As the data are organized by the protection ranges (no retrospective data at higher resolution are accessible), such figures were used for the interpretation of captures. For this purpose, two characteristic areas (called "western" and "eastern") comparable in extent and represented by equal number of traps, but affected by extended wind damage in different years, were chosen (Fig. 1). The "western" one (A) with the area of 3725 ha, located

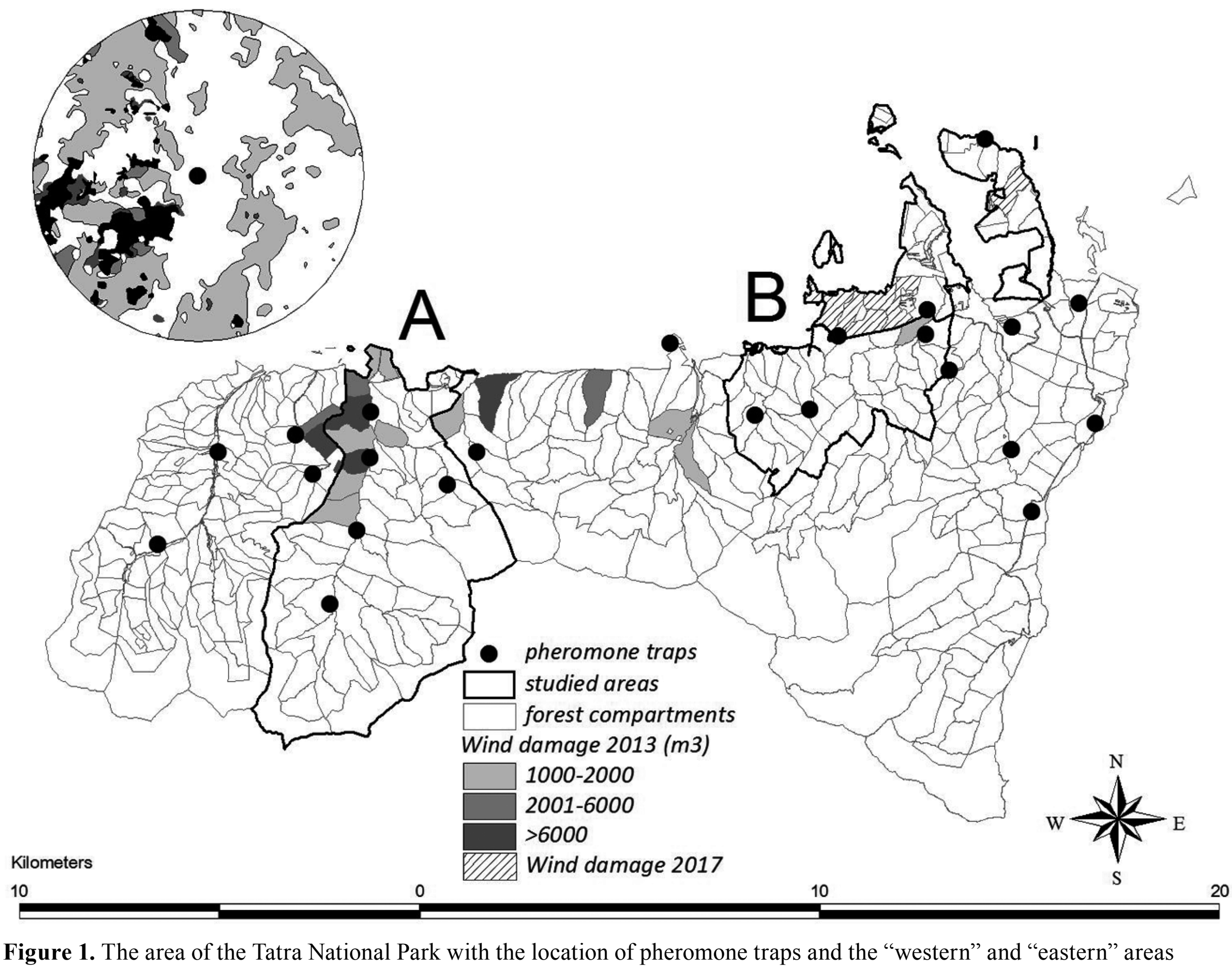

Figure 1. The area of the Tatra National Park with the location of pheromone traps and the "western" and "eastern" areas affected by wind damage used for the analysis; an example of spots with standing dead trees detected in the subsequent years in a circular zone of 500 m around the trap is shown in the upper left corner

in the Kościeliska Protection Range, includes 2326 ha of forests growing between 920 and 1550 m a.s.l. (up to the upper timberline) and the non-forested zone of 1399 ha (mainly rocks above the upper timberline and meadows), and was affected by wind damage in 2013 (Grodzki and Gąsienica Fronek 2017). The "eastern" one (B) with the area of 2695 ha of forests, located in the Brzeziny and Kośne Hamry Protection Ranges and growing between 820 and 1550 m a.s.l., does not include the zone above the upper timberline, and was affected by wind damage in 2017 (Grodzki and Gąsienica Fronek 2019). Both study areas remain partially under active (lower parts), and partially – active protection regime. The data from the pheromone traps (5 in each, as the most northern trap in area B, see Fig. 1, was excluded) exposed in those two areas in comparable altitudinal range (940/925–1150/1240 m a.s.l., respectively) were related to the respective data concerning sanitary felling in those areas. The information about the location of wind damage was kindly provided by the TPN administration.

In case of bark beetle captures, the data from the entire trapping seasons (May–August) in 2010–2019 were used. As traps were usually located in pairs, the mean values per 1 trap were used for each location – thus, the data concerning one location will be called "trap". The raw data was kindly provided by the TPN administration.

The data processing was done on 3 levels: at the whole TPN area level and all the traps, at the level of the selected "eastern" and "western" area, and at the level of individual locations of traps and surrounding circular zones. The data from 3 above described sources (standing dead trees, processed infested trees, captures of beetles) were compared and discussed. For the statistical analyses (descriptive statistics, linear and Spearman rank correlations, Kruskal-Wallis tests) Statistica 13 (TIBCO Software Inc. 2017) was used.

Results

Standing dead trees

The spatial analyses of the occurrence of standing dead trees in circular zones around all 23 traps located in the entire TPN area revealed that the results obtained for 100 and 200 m radius are very scarce and not representative for further comparisons (Tab. 1). In case of 100 m radius, the number of localities with standing dead trees varied in individual years within the range 0–7 (out of 23), for 200 m radius it was 1–16 locations, while in case of 500 m radius, it was 6–21 locations. Therefore, the last ones were used for analysis.

Table 1. Area of detected occurrence of new standing dead trees detected in subsequent years in the concentric zones around the 23 locations of pheromone traps in the entire TPN area, using 100, 200 and 500 m radius

Radius of concentric zone (m)	Area (ha) with standing dead trees within the zones in the year					
	2011	2012	2013	2014	2015	2017
100	0.00	0.06	0.00	0.00	0.08	1.15
200	1.30	0.28	0.49	0.35	0.10	12.48
500	28.10	8.37	13.57	3.62	1.17	126.07

The detected tree mortality defined in the circular zones around all 23 traps varied between years, reaching relatively high level at the beginning of the period covered by the analysis, then decreasing gradually till 2015 and dramatically increasing in 2017 (Tab. 1). However, it should be pointed out that the area detected in 2017 results from 2-years mortality and the proportion between 2016 and 2017 remains unknown. The between-years variability in the main area with dead trees around the trap reveals the same pattern (Fig. 2).

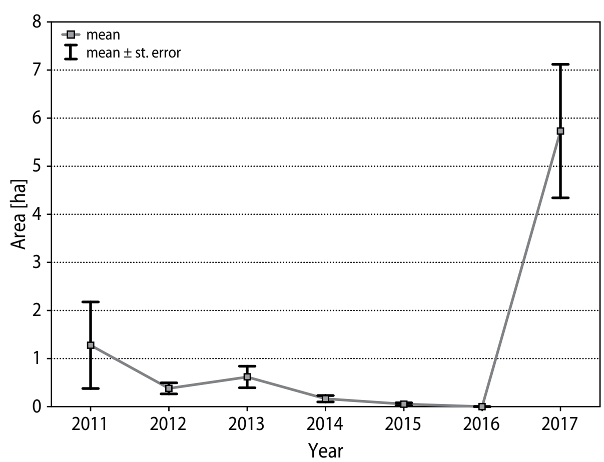

Figure 2. Mean area with standing dead trees detected in 500 m circular zone around 23 locations with the traps in the TPN area in individual years (2016 – no data)

The spots with dead trees detected in the entire range of the two selected study areas occurred most distinctly at the beginning and the end of the period covered by the analysis. In 2011, the total area of spots with dead trees in the entire "western" area was 3 times as large as in the "eastern" one, while in 2017 – more than twice, but in the meantime, those areas were comparable, with slightly higher values in the "eastern" area (Fig. 3).

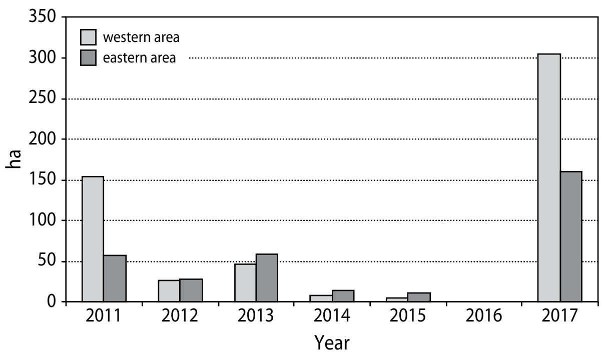

Figure 3. The total area with standing dead trees detected in the "western" and "eastern" area of study in individual years (2016 – no data)

Processed infested trees

During the decade 2010–2019, the yearly volume of trees infested by bark beetles, processed in the active protection zone of the TPN varied between 7.1 and 33.6 thousand m^3 with two peaks – in 2012 and 2016, and 2 periods on relatively low level – in 2014–2015 and 2017–2019 (Fig. 4). The active protection zone was not stable during this decade, initially covering about 27% of the TPN area and reduced to about 16% starting from 2017. It should be pointed out, that the active measures aimed at the reduction of bark beetle populations (removal of trees with living insects under the bark) were not applied in all those areas, formally belonging to active protection zone.

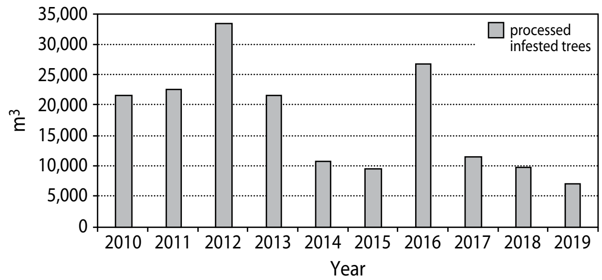

Figure 4. Volume of trees infested by bark beetles processed in the entire active protection zone of the Tatra National Park in the years 2010–2019

The dynamics of sanitary felling was not homogenous in the entire active protection zone of the TPN. In the "western" area, the volume of removed trees identified as "infested by bark beetles" was relatively high in 2010–2012, then decreased in 2013–2015, increased in 2016 and decreased again in 2017–2019. At the same time, the share of removed trees already left by the bark beetles in 2010–2012 remained between 55% and 70%, while in 2015, it was only 1%. During the second half of the analysed decade, the share of such trees was between 1% and 36% (Fig. 5A). In the "eastern" area, the volume of removed trees infested by bark beetles was also the highest in the first years (2010–2012), then decreased in

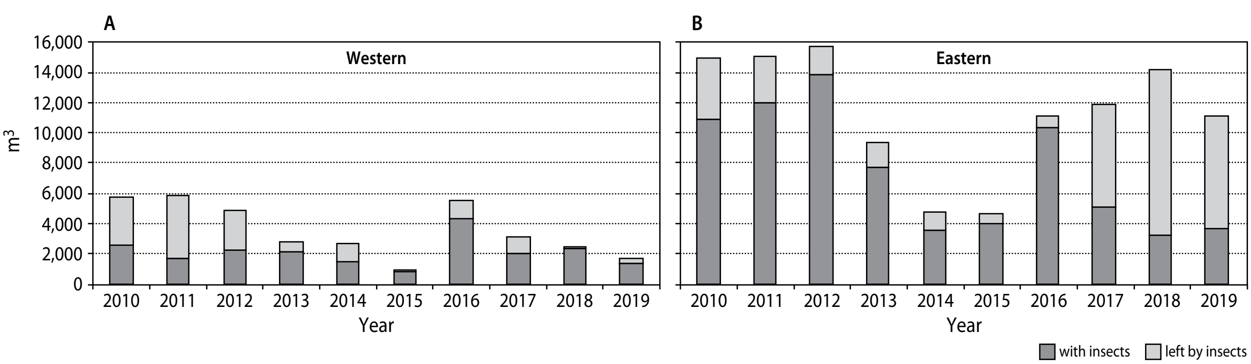

Figure 5. Volume of trees infested by bark beetles processed in the "western" (A) and "eastern" (B) area of study in individual years in 2010–2019

2013–2015 and increased again starting from 2016. The share of removed trees already left by bark beetles during the first 3 years did not reach more than 27%, while in 2017–2019, those trees prevailed (57%–77%) (Fig. 5B).

Captures in pheromone traps

The mean numbers of *I. typographus* beetles, calculated from all traps (23 operated yearly) for individual years, in 2010–2013 remained at relatively stable level between 4323 and 7243 individuals per trap. In 2014, the mean number of beetles markedly decreased to 2959 beetles, and then continuously increased till 2017, when the maximum value (20,450 beetles) was recorded (Fig. 6). After a decrease in 2018, the mean captures reached again relatively high level of 12,474 beetles per trap. The captures from individual years differ significantly (*K-W* test H = 98.96; $p < 0.001$), however, the significant differences occur only between some years. No relationship was found between the mean numbers of beetles captured yearly in all pheromone traps in the whole TPN area and the volume of infested trees removed from the stands in the active protection zone (Spearman rank correlation $r_s = -0.16$, n = 10). The occurrence of standing dead trees on reasonable number of localities was detected only in 2011 and 2017, but no relationship between the number of beetles captured during the growing season and tree mortality expressed by the area of spots with dead spruces was found (respectively: $r_s = 0.15$ and $r_s = -0.04$; n = 23).

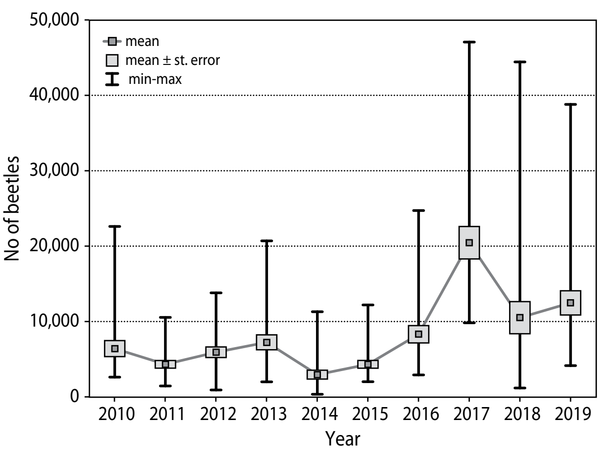

Figure 6. Mean number of *I. typographus* beetles captured in one trap in individual years, calculated from all 23 traps operated in the TPN

The captures in individual months of the studied years remained in quite stable pattern in all the years, when the swarming (and number of caught beetles) had the highest dynamics in the first half of the growing season. The number of beetles captured till the end of June in individual years was between 23.6% in 2015 and 70.2% in 2018, but this share was much higher till the end of July, reaching between 71.6% in 2017 and 87.0% in 2010. Both the captures recorded till the end of June and till the end of July were highly correlated with the captures from the entire trapping period (Tab. 2).

Table 2. Share of beetles captured in all the 23 pheromone traps in individual years till the end of June and July and correlation coefficients related to the captures from entire trapping period (May–August). All the correlations are significant at p < 0.01

Year	Beetles captured till the end of June		Beetles captured till the end of July	
	share [%]	correlation r	share [%]	correlation r
2010	52.6	0.845	87.0	0.987
2011	57.3	0.980	86.4	0.998
2012	60.4	0.975	85.4	0.991
2013	49.8	0.916	76.2	0.980
2014	45.8	0.942	77.8	0.983
2015	23.6	0.815	79.9	0.964
2016	32.2	0.846	76.3	0.981
2017	31.8	0.519	71.6	0.969
2018	70.2	0.933	85.9	0.990
2019	54.7	0.935	81.6	0.969

Regarding the altitudinal distribution, the highest mean (± std. deviation) number of beetles calculated from all the traps and years were recorded in the zone 2 (9342 ± 8799), lower in the zone 1 (7576 ± 6972) and the lowest in zone 3 (6106 ± 4500), however, the effect of altitude was not significant (*K-W* test H = 3.31; $p = 0.19$). Higher mean number of beetles was captured on western (9358 ± 7577), northern (8832 ± 8621) and eastern (8193 ± 7800) slopes, while much lower (4194 ± 2648) – on the southern ones, and the effect of slope exposure was significant (*K-W* test H = 10.39; $p < 0.05$).

The dynamics of *I. typographus* captures in individual years within the study period differed in the two selected areas. In the “western” area, the values were relatively stable in 2011–2013, then dramatically decreased in 2014 and rapidly increased in 2015–2017 to the highest level in the whole decade (16300 beetles) and decreased stepwise in the last 2 years (Fig. 7). In the “eastern” area, the captures in 2010–2014 slightly varied in the range between 3206 (2011) and 7617 (2013) beetles, then the high peak was recorded in 2017 (21,661 beetles) and deep collapse in 2018–2019 (Fig. 7). It has to be recalled that extensive wind damage affected the stands in “western” area in 2013, however, those in the “eastern” part were affected by the wind in 2017. On the other hand, the fast increase in the tree mortality, recorded based on the data from 2017 (Fig. 2), had some response also in the increase of captures recorded in 2017 (Fig. 6).

The captures in both areas are correlated with the area of spots with dead trees in the 500 m circle around the traps, however, this correlation is not statistically significant (Tab. 3). There is no relation of captures to the volume of processed infested trees in both areas (Tab. 3). Nevertheless, the mean captures from individual years, calculated for “eastern” and “western” area, are correlated (r = 0.69; $p < 0.05$; n = 10), which can indicate the existence of a general trend of the dynamics of *I. typographus* captures in the TPN area.

Table 3. Spearman rank correlation coefficients between mean yearly captures per trap and tree mortality

Tree mortality expressed by	Western area		Eastern area	
	r_s	p	r_s	p
Area of spots with dead trees	0.714	n.s.	0.657	n.s.
Volume of processed trees with and left by insects	0.018	n.s.	0.055	n.s.
Volume of processed trees with insects	0.430	n.s.	0.067	n.s.

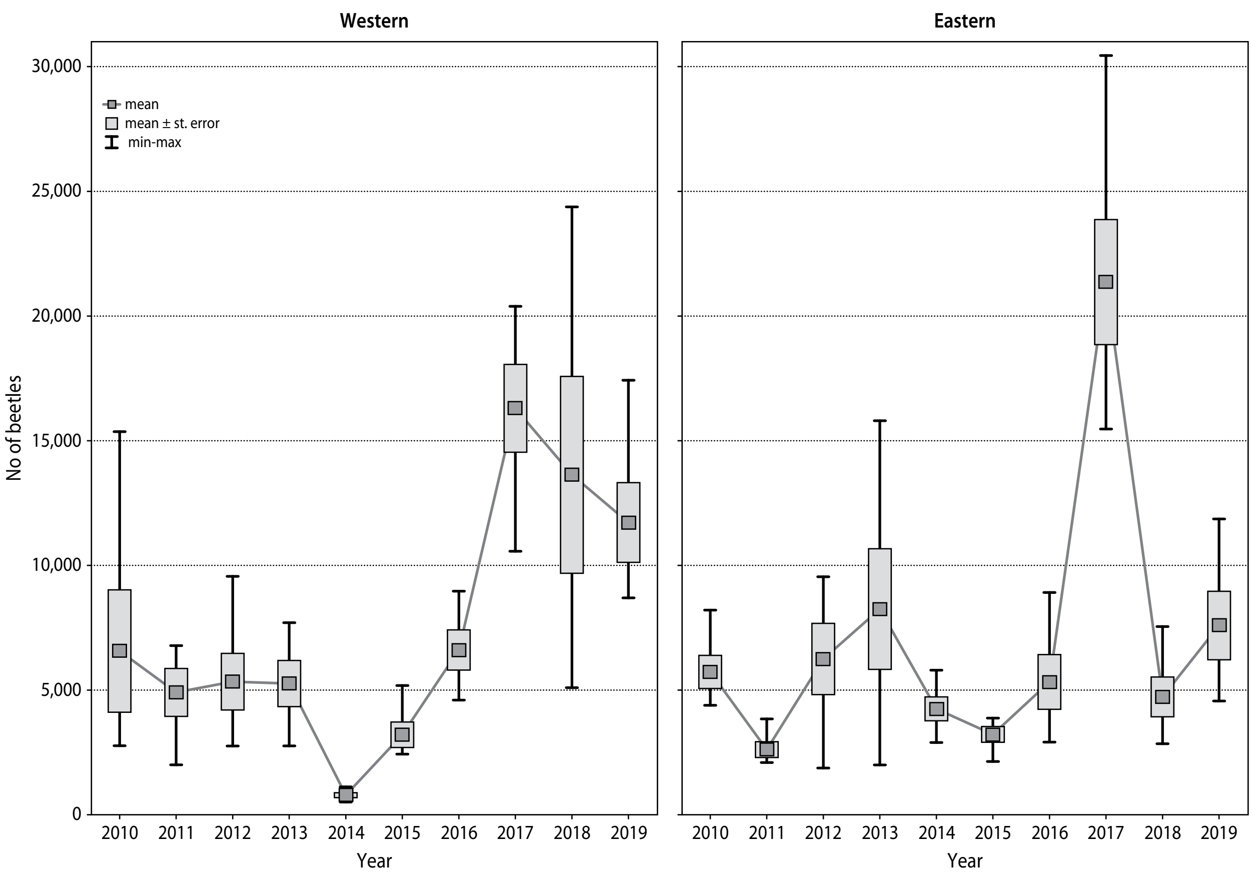

Figure 7. Mean number of *I. typographus* beetles captured in one trap in individual years, calculated for “western” (5 localities) and “eastern” (5 localities) study area in the TPN

Discussion

Pheromone traps are often recommended as the source of data for monitoring *I. typographus* populations, especially in relation to the effects of bark beetle activity expressed by the mortality of its host tree – the Norway spruce *P. abies* (Bakke 1985; Hübertz et al. 1991; Holly 2005; Grodzki 2007; and many others). Some authors also suggested that the data collected using pheromone traps can be useful for predicting Norway spruce mortality caused by *I. typographus*, usually called "damage" (Weslien et al. 1989; Weslien 1992b; Faccoli and Stergulc 1999, 2004; Lindelöw and Schroeder 2001; and many others). Most of those papers are based on the results collected in the forest objects with relatively low *I. typographus* population level, thus the term "non-epidemic conditions" often appears. In addition, the survey was usually done in commercial forests, where classic forest protection measures aimed to control bark beetle populations were applied. The proposed model(s) were then based on relatively simple design, enabling direct comparison of the data on bark beetle captures and damage, that is, tree mortality, in a given year. Therefore, the question arises: how does this monitoring work in protected areas, with diversified and unstable approach to bark beetle populations, and the occurrence of other kind damage caused in forests, for example, by abiotic factors.

We used two kinds of data to describe the effects of bark beetle activity, that is, the mortality of Norway spruce trees. However, the data of these two kinds were not available in comparable resolution: the volume of trees removed in sanitary felling concerned only the stands in the active protection zone, contrarily to the data on standing dead trees on relatively large areas, containing the stands under (formally) both active and passive protection. Therefore, the data on sanitary felling concerned only a part of the study areas, mainly the stands growing on lower altitudes (according to the TPN zonation). At the same time, in the other parts of the study areas, the bark beetle populations remained out of control, and the emerged beetles of new generations were able to freely disperse and infest/kill the trees surrounding those in which they completed their development. It is obvious that *I. typographus* beetles attacked standing trees in relatively high number of individuals, in order to overcome their defence reaction (Christiansen et al. 1987), however, the attack intensity most probably decreased in 2016–2019 due to the weakening of trees stressed by drought from 2015 and following years (Christiansen and Bakke 1996; Grodzki and Gąsienica Fronek 2018). This "lower effort" of attacking beetles is probably reflected also in higher captures recorded in this period. Nevertheless, the occurrence of such newly infested trees is reflected by the data concerning the spots of dead spruces, however, the cause of individual tree mortality was not defined (bark beetle infestation is only an supposition). Anyway, the occurrence of "new" dead trees in 500 m circular zones around the traps is somehow (although not significantly) correlated with the number of captured beetles, thus this relationship could be considered as existing.

At this point, the question arises concerning the radius of the zones used for the analysis. Initially, we started from the 100 m radius, according to the knowledge concerning the attraction range R_A, estimated in bark beetles to 19–97 m (Schlyter 1992), which was roughly confirmed as about 100 m in mark-recapture experiments (Weslien, Lindelöw 1990; Zahradník et al. 1993; Zolubas and Byers 1995). Under epidemic (outbreak) conditions, 90% of new infestations occurs within 10 m of an old attack (Wichmann and Ravn 2001). Unfortunately, in our study, it was not possible to obtain a reasonable sample size applying 100 m radius (dead trees around the traps) to be used in the analysis; the same appeared in case of 200 m radius. Finally, the circular zones of 500 m radius were used, as the flight and dispersal potential in *I. typographus* is much larger than this 100 m zone (Forsse and Solbreck 1985; Gries 1985), and even over 500 m (Duelli et al. 1997). It should also be pointed out that the area with dead trees defined in 2017 represents the effect of tree mortality that occurred in 2 years (as no data from 2016 are available), thus the effects of bark beetle activity in individual years remain undefined. On the other hand, it is not possible to use somehow "summarized" or "mean" data on tree mortality to be distributed between these two years. This circumstance, together with the lack of data on tree mortality in 2018–2019, should be considered as important factors disturbing the interpretation of results and searching for relationships.

Another important phenomenon affecting the definition of possible patterns is the damage caused by the wind. The distinct collapse in the captures, recorded in individual study areas (in 2014 in "western" and in 2017 in "eastern" area) correspond with the wind damage that occurred at the end of 2013, and in March 2017, respectively (Grodzki and Gąsienica Fronek 2017, 2019). In both cases, the fresh broken and fallen trees represented an attractive and "easy" breeding material for bark beetles in the first growing season after the damage (thus: 2014 and 2018, respectively). It is known that fresh broken and fallen trees attract *I. typographus* beetles more efficiently than pheromone traps (Król and Bakke 1986; Abgrall and Schvester 1987; Grodzki et al. 2008). Therefore, the wind damage should be considered as another important factor disturbing the captures, thus complicating the interpretation of results collected using pheromone traps. On the other hand, the correlation between the captures in the two selected study areas suggests the existence of a more general pattern of the bark beetle population dynamics in the TPN area, thus indicating the possibility of its assessment based on the pheromone monitoring.

It is commonly known that both wind damage and high temperatures during the growing season are the main factors contributing to bark beetle outbreaks in spruce forests (Mezei et al. 2017; Biedermann et al. 2020), however, in case of the Polish part of the Carpathian mountains, the spruce mortality due to bark beetle infestation, expressed by the volume of processed infested trees, started to decrease in 2017 (Sierota et al. 2019). Therefore, the observed increase of captures starting from 2017 may be the effect of the change in the extent of active protection measures (Grodzki and Gąsienica Fronek 2018, 2019) or insufficient effectiveness of applied treatments (Vanická et al. 2020). The infested trees were not removed even in the stands formally located in the active protection zone. All traps were placed in the areas (locations) that remained formally in active protection zone, but at the same time, the spots with standing (i.e., not removed) dead trees have been detected in 500 m circular zones around almost all (21/23) traps, thus, in fact, the active protection measures were not applied there. On the other hand, also the cutting of infested trees in some stands, but with high share of trees that were already left by insects, indicates that those – not timely removed – trees represented additional source of beetles to be captured in the traps.

The analysis if the data collected during 10 subsequent growing seasons revealed high percentage of beetles captured in the first half of the growing season (till the end of July), regardless the installation of fresh dispensers at the beginning of July, and very high correlation of those with the results from the entire growing season (till the end of August). This finding remains in accordance with the results of Faccoli and Stergulc (2004, 2006), who suggested that the spring catches (till the end of July) can be used for forecasting damage in the current growing season. Also, Grodzki (2007) demonstrated that in three national parks in the Carpathians (Bieszczady NP, Gorce NP, Tatra NP), the share of *I. typographus* beetles captured till the end of July was usually much over 80% in relation to the entire trapping period, with high correlation to the whole-season captures. Our findings confirm that for monitoring purposes, the trapping till the end of July would provide satisfactory data, and such solution could help to minimize the human intervention in the protected areas.

Pheromone monitoring of *I. typographus* populations is then possible and recommended under non-epidemic conditions (Hübertz et al. 1991; Weslien 1992b), but could not be used to forecast high damage levels (Weslien 1992a). It should be therefore stressed that the data analysed in the presented study were collected during long-lasting *I. typographus* outbreak and recurring wind damage, known as a factor accelerating bark beetle reproduction (Göthlin et al 2000; Forster et al. 2003; Grodzki and Gąsienica Fronek 2017, 2019). It was also demonstrated that in the conditions of protected areas in the Polish mountains, but also in Scandinavian forests, the relationships between captures and tree mortality are usually reduced to the current year (Weslien 1992b; Grodzki 2007; Faccoli and Stergulc 2004). Weslien et al. (1989) demonstrated a strong linear correlation between mean catches in pheromone traps and log-transformed tree mortality, however, looking at the figures describing tree mortality, the investigations were not done in the heavy outbreak conditions, as it was in our case. In addition, as the survey was done in commercial forests, the infested trees were probably removed according to the forest protection rules, while in the TPN, a majority of trees around the traps remained out of human intervention, that enabled free release of new *I. typographus* generations. Therefore, the data collected in pheromone traps installed in the TPN area are difficult for interpretation and do not directly reflect the real fluctuation of *I. typographus* population level, even in multi-year dimension.

Conclusions

1. Pheromone traps represent valuable source of information about the bark beetle *I. typographus* population dynamics, although the collected data does not enable direct definition of its population level, especially in the protected areas with different and unstable approach to the active/passive protection of stands. Nevertheless, those data can be used to define long-term population dynamics, but with regard to the additional, external factors.
2. The results of pheromone trapping are affected by several factors that influence the number of captured beetles. The most important are: wind damage, defence potential of trees resulting from their physiological status and nature protection regime. Another important circumstance disturbing the data analysis results from the lack of coherent data reflecting the effect of bark beetle activity, that is, tree mortality.
3. As most of the beetles are captured in the first half of the growing season, the data collected till the end of July is sufficient for monitoring purposes; in order to minimize human intervention in the protected areas, the monitoring, at reasonable number of localities, should be reduced to the period May–July.

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