SYLWAN 167 (12): 791-803, December 2023
https://doi.org/10.26202/sylwan.2023114
Journal homepage: https://sylwan-journal.pl

ORIGINAL PAPER

Altitudinal expansion of the double spined bark beetle *Ips duplicatus* (C.R. Sahlberg, 1836) (Col.: Scolytinae) in the western edge of the Carpathians in Poland

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ABSTRACT

The double spined bark beetle *Ips duplicatus*, till the last decade of the 20th century, was known as occurring in areas located up to 500-600 m a.s.l. During last decades, the spread to higher altitudes has been observed in Central European countries. In 2014, a limited survey using pheromone baited traps with ID Ecolure was done in Ujsoły Forest District only, and in 2020 extended to 8 forest districts which were located in 5 mountain mesoregions. One Theysohn trap per location was installed and emptied during the entire period of the insect's flight activity, and the captured beetles were identified and counted. No quantitative data (number of collected beetles) was used for analysis, but only the presence of the species at a given location. In 2014, beetles were collected in 14 out of 22 locations including 11 at an altitude between 700-900 m a.s.l. and on 1 above 900 m a.s.l. In 2020, beetles were collected at 52 out of 98 locations including 12 at an altitude between 700-900 m a.s.l. and at 8 above this altitude. The presence of beetle specimens above 900 m a.s.l. was recorded in the mesoregions of Beskid Śląski and Beskid Żywiecko-Orawski but not in the most southern mesoregion of Beskid Żywiecko-Kysucki. The results from these three mesoregions, located in higher mountains and characterised by a higher share of Norway spruce, indicate the spread of *I. duplicatus* to higher altitudes as a more general phenomenon which has been observed in the other Central-European countries together with its expansion southward. In the future, the species can be a threat to Norway spruce stands at higher altitudes in the Carpathians taking into account the climatic changes and difficulty in implementing effective control methods of bark beetle populations.

KEY WORDS

bark beetles, climate change, distribution, mesoregions, mountains, *Picea abies*

Introduction

Norway spruce *Picea abies* (L.) H.Karst. is not a main tree species in Polish forests with a 4.5% share in the area of state-owned forests managed by the State Forests Holding (Wyniki, 2022). This tree species is not homogenously distributed throughout the country occurring in the two

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Received: 19 December 2023; Revised: 23 January 2023; Accepted: 26 January 2023; Available online: 23 February 2024

following main ranges: north-eastern (lowland) and southern (mountains) and separated by a wide belt recently recognised as an area with a scattered distribution (Boratyński, 1998). In some parts of the country, especially in the mountains, the share of Norway spruce is much higher reaching almost 80% in individual Forest Districts (BDL, 2023).

Ips duplicatus (Sahlb.) has been known to occur in Poland for a very long time with the first mention of its occurrence in 1912 (Łomnicki, 1913; Burakowski *et al.*, 1992). It is considered a native species that is abundant and widespread initially in the lowland's Norway spruce north--eastern range (Karpiński, 1932) with local outbreaks occurring between World War I and II (Karpiński, 1935). This species was also known in some locations in the uplands (southern Poland) up to the elevations of about 600 m a.s.l. (Burakowski *et al.*, 1992). In the last decade of 20th century, an outbreak of the species took place in the Silesian Upland in Poland (Grodzki, 1997) and at the same time in Northern Moravia and Silesia in the Czech Republic (Knížek and Zahradník, 1996; Zahradník and Knížek, 1998). The occurrence of *I. duplicatus* was later recorded in north-western Slovakia, where it is considered as invasive species and able to spread in lower elevations below 900 m a.s.l. (Turcani *et al.*, 2001). In 2001-2002 a survey of *I. duplicatus* distribution in the mountain areas of southern Poland revealed its occurrence in Norway spruce stands above 800 m a.s.l., mainly in the western part of Carpathians as well as in the eastern edge of Sudetes but not in the central or western Sudetes. However, *I. duplicatus* adults were eventually collected from spruce logs sampled in this area, as well as having been recorded there by some authors (Grodzki, 2003).

The double spined bark beetle is distributed within the northern zone of Europe, Siberia, and Sakhalin where it feeds on spruces, mainly *P. abies* (Pfeffer and Knížek, 1995). The feeding of this beetle on pine *Pinus sylvestris* L. which grows together with spruce is rather exceptional (Karpiński, 1932; Holuša and Grodzki, 2008). In the northern spruce range one generation per year (exceptionally two generations) is usually produced (Schnaider and Sierpiński, 1955). However, in the southern range up to three generations in a growing season were observed (Grodzki, 1997; Holuša *et al.* 2003). In non-outbreak conditions the species infests mainly the upper most part of the stem within the crown zone while during periods of extremely high population levels infestation of the middle and lower part of stem and high competition with *I. typographus* (L.) was observed (Grodzki, 2012). Therefore, in favourable conditions *I. duplicatus* can be considered a serious forest pest which is difficult to control and often by inefficient means (Grodzki, 1997).

The aim of the survey presented in this paper was to detect the occurrence of *I. duplicatus* in Norway spruce stands located in the mountain areas of the Western Carpathians at various altitudes. We hypothesized that the species is to be found at higher elevations including those located above 900 m a.s.l.

Materials and methods

The survey was done in the Forest Districts within the territory of the Regional Directorate of State Forests in Katowice located in the western part of the Carpathians in Poland and the foothills adjacent to the north (Fig. 1). In order to define the altitudinal range of *I. duplicatus* two series of survey were done which included a limited one (the southern part of Beskid Żywiecki) in 2014 and an extended one (whole area of interest) in 2020.

Limited survey in 2014. Pheromone traps baited with ID Ecolure (1 trap per location) were installed in 20 locations distributed in the Ujsoły Forest District at altitudes between 650 and 950 m a.s.l. (Fig. 2). Additionally, 2 traps were installed in locations at 1000 m a.s.l. in the Jeleśnia and Sucha Forest Districts (Table 1, locations not included in Fig. 2). The traps were regularly

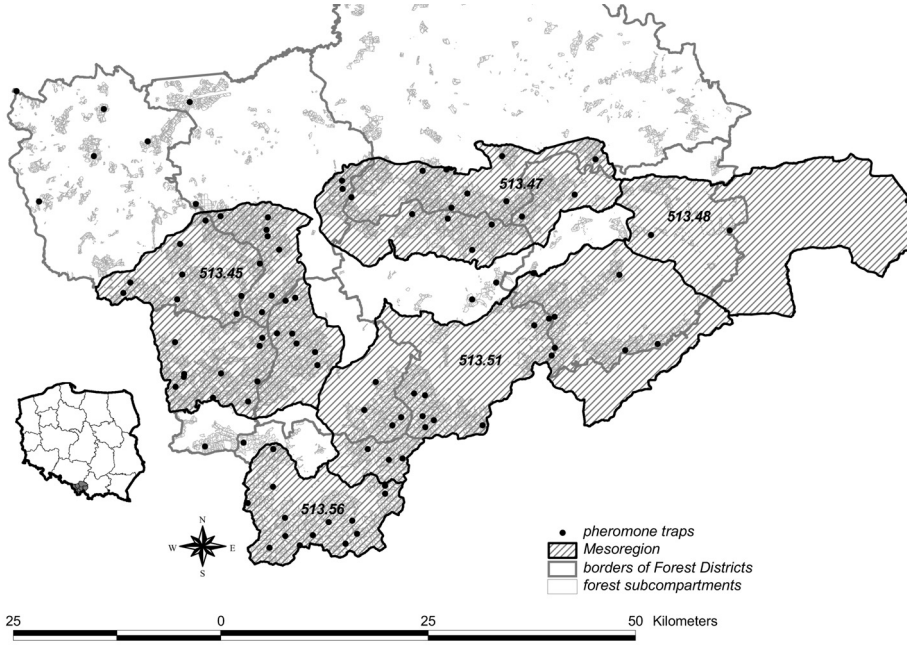

Fig. 1.

Location of sampling points in the study area mesoregions: 513.45 Beskid Śląski, 513.47 Beskid Mały, 513.48 Beskid Makowski, 513.51 Beskid Żywiecko-Orawski and 513.56 Beskid Żywiecko-Kysucki

checked and the total amount of *I. duplicatus* beetles collected in individual locations during the growing season was determined.

Extended survey in 2020. Pheromone traps (1 per location) baited with ID Ecolure were installed in 98 locations within the following 8 Forest Districts: Andrychów, Bielsko, Jeleśnia, Sucha, Ujsoły, Ustroń, Węgierska Górka and Wisła (Fig. 1) at altitudes between 260 and 1,224 m a.s.l. The traps were regularly checked and the total amount of *I. duplicatus* beetles collected in individual locations during the growing season was determined.

In both surveys the synthetic pheromone ID Ecolure (Fytofarm, Slovakia) was applied as it is the most effective from locally available dispensers (Holuša *et al.*, 2010a).

The locations of the traps (both from 2014 and 2020) were classified to mesoregions defined by Kondracki and Richling (1994) using the updated digital data appended to the publication by Solon *et al.* (2018) concerning their verification and adjustment of boundaries on the basis of contemporary spatial data. According to the aim of the study, the mesoregions covering the main mountain massifs were considered as follows (the highest peak and its altitude in brackets): 513.45 Beskid Śląski (Skrzyczne 1,257 m a.s.l.), 513.47 Beskid Mały (Czupel 930 m a.s.l.), 513.48 Beskid Makowski (Lubomir 904 m a.s.l.), 513.51 Beskid Żywiecko-Orawski (Babia Góra 1,725 m a.s.l.), and 513.56 Beskid Żywiecko-Kysucki (Wielka Racza 1,236 m a.s.l.) (Fig. 1). The traps located outside those mesoregions are grouped as 'others'. For data visualisation and spatial analyses ArcView 3.2 (ESRI) software was used.

The aim of the study was to find the presence/absence of *I. duplicatus* based on the captures in pheromone traps that were then analysed in order to define the altitudinal distribution of the species.

Results

LIMITED SURVEY IN 2014. *Ips duplicatus* beetles were collected at 14 out of 22 locations. Out of these 2 were located below 700 m a.s.l., 11 at an altitude between 700-900 m a.s.l., and 1 above 900 m a.s.l. (Table 1, Fig. 2).

In the mesoregion of Beskid Żywiecko-Orawski, *I. duplicatus* was found at 2 out of 5 locations. All were placed above 700 m a.s.l. (no traps were located below) and 1 was above 900 m a.s.l. (Sucha Forest District, 1000 m a.s.l., not included in Fig. 2).

In the mesoregion of Beskid Żywiecko-Kysucki, *I. duplicatus* was collected at 9 out of 15 locations including 8 at the altitude of 700-900 m a.s.l. and none above this elevation.

In other locations outside those two mesoregions *I. duplicatus* was found at 2 out of 2 sites including 1 at the altitude of 700-900 m a.s.l. (Table 1, Fig. 2).

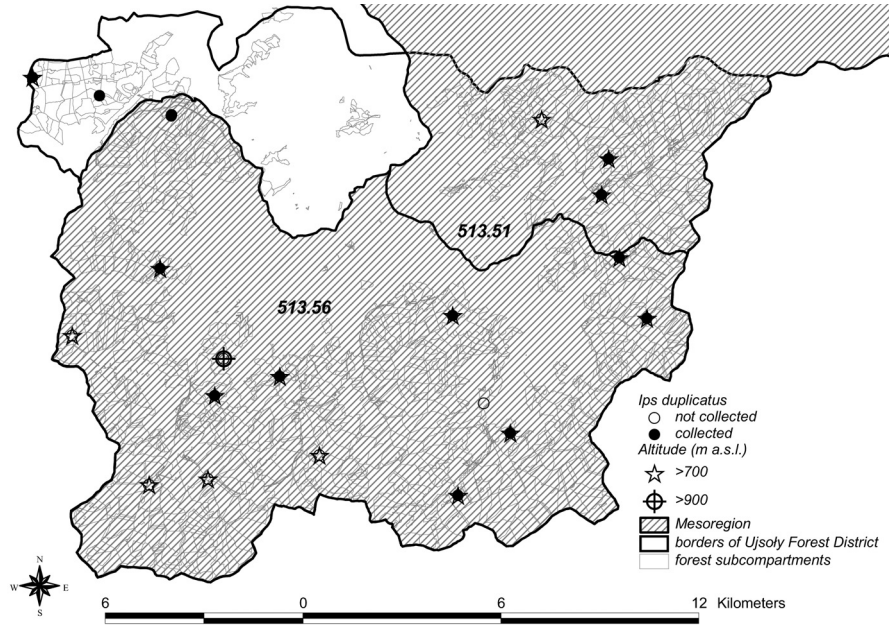

Fig. 2.

Location of pheromone traps with and without captured *I. duplicatus* in Ujsoły Forest District in 2014 – the traps located above 700 and 900 m a.s.l. are indicated; for more detailed data about the locations with captured specimens see Appendix

Table 1.

Number of locations with confirmed *I. duplicatus* (ID) occurrence and total number of sampled locations in individual mesoregions and elevation zones in 2014

Mesoregion	Number of locations in the elevation zone (m a.s.l.):						
	total	<700		701-900		>900	
		total	with ID	total	with ID	total	with ID
Beskid Żywiecko-Orawski	5	0	0	3	2	2	1
Beskid Żywiecko-Kysucki	15	2	1	12	8	1	0
Others	2	1	1	1	1	0	0
Total	22	3	2	16	11	3	1

Extended survey in 2020. *Ips duplicatus* beetles were collected at 52 out of 98 locations out of which 32 were located below 700 m a.s.l., 12 between 700-900 m a.s.l., and 8 above 900 m a.s.l. (Table 2, Fig. 3).

In the mesoregions of Beskid Makowski and Beskid Mały, the species was captured at 9 out of 18 locations which were mostly below 700 m a.s.l. However, 2 were located at the altitude of 700-900 m a.s.l.

In the mesoregion of Beskid Śląski, *I. duplicatus* was found at 20 out of 33 locations including 4 at the altitude between 700-900 m a.s.l. and 3 above 900 m a.s.l.

In the mesoregion of Beskid Żywiecko-Kysucki, *I. duplicatus* was captured at 4 out of 14 locations including 2 between 700-900 m a.s.l. with no beetles caught above this altitude.

Table 2.

Number of locations with confirmed *I. duplicatus* (ID) occurrence and total number of sampled locations in individual mesoregions and elevation zones in 2020

Mesoregion	Number of locations in the elevation zone (m a.s.l.):						
	total	<700		701-900		>900	
		total	with ID	total	with ID	total	with ID
Beskid Makowski	2	1	0	1	0	0	0
Beskid Mały	16	13	7	3	2	0	0
Beskid Śląski	33	14	13	11	4	8	3
Beskid Żywiecko-Orawski	22	1	1	9	3	12	5
Beskid Żywiecko-Kysucki	14	3	2	8	2	3	0
Others	11	10	9	1	1	0	0
Total	98	42	32	33	12	23	8

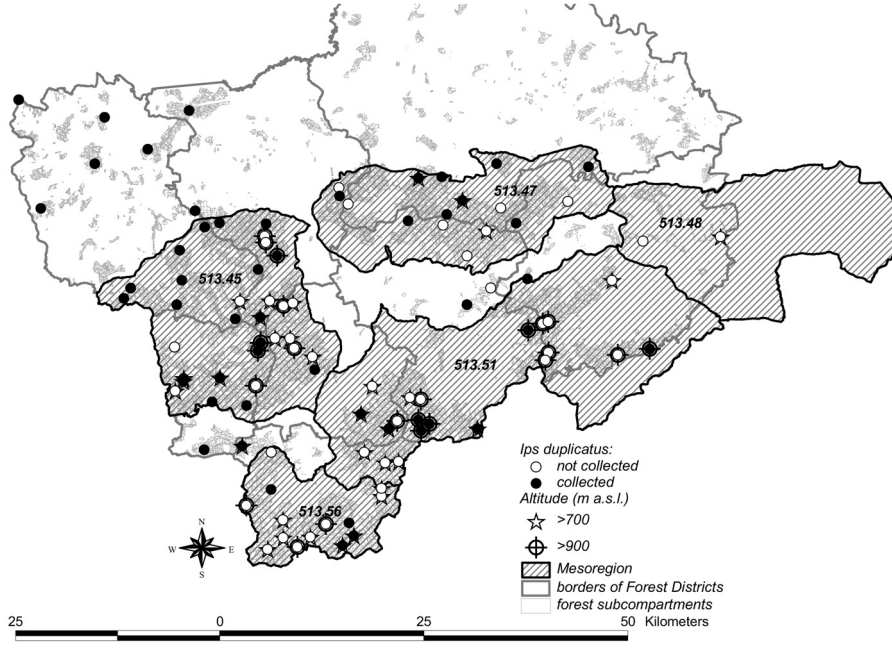

Fig. 3.

Location of pheromone traps with and without captured *I. duplicatus* in 6 forest districts in Beskidy in 2020 – the traps located above 700 and 900 m a.s.l. are indicated; for more detailed data about the locations with captured specimens see Appendix

In the mesoregion of Beskid Żywiecko-Orawski, the species was found at 9 out of 22 locations including 3 between 700-900 m a.s.l. and 5 above this altitude.

Discussion

The area covered by the presented survey is not homogenous in both physiographic features and forest characteristics. That is why the mesoregions based on their natural features were used for the analysis more as basic territorial units and not the forest districts which, more or less, have artificial borders. In two mesoregions (Beskid Mały and Beskid Makowski) the altitude zone above 900 m a.s.l. is very limited as the highest peaks reach 930 and 904 m a.s.l., respectively. The share of Norway spruce (area/volume) is quite low in this part of the area reaching (state as for 1.01.2020) between 6.0/5.4% in the Andrychów Forest District and 16.3/12.8% in the Sucha Forest District (BDL, 2023). In the other three mesoregions, located in the southern part of the area, all altitude zones, including this above 900 m a.s.l., are represented as the highest peaks reach between 1,257 (Beskid Śląski) and 1,725 m a.s.l. (Beskid Żywiecko-Orawski). The share of Norway spruce is much higher there, reaching between 36.7/32.5% in the Jeleśnia Forest District and 76.5/77.9% in the Wisła Forest District. In the context of this study, the data regarding the occurrence of *I. duplicatus* is much more important for the southern part of the area with higher mountains and a higher share of Norway spruce. The captures in the altitude zone between 700-900 m a.s.l., and especially above 900 m a.s.l. (recorded in the two mesoregions of Beskid Śląski and Beskid Żywiecko-Orawski), indicate the spread of the species to stands located at higher altitudes. It is, however, surprising that the species was not captured in the highest altitude zone of the third mesoregion (Beskid Orawsko-Kysucki located the most southward) in 2014 nor in 2020, as the share of Norway spruce in the Ujsoły Forest District (almost entirely located in this mesoregion) is very high reaching 72.4/77.7% (BDL, 2023). Nevertheless, the risk of a new threat for Norway spruce stands represented by *I. duplicatus* seem to be becoming more and more pressing.

Until the last decade of the 20th century, *I. duplicatus* was considered a bark beetle species with lower importance, found mainly in Norway spruce stands growing at low elevations (below 500-600 m a.s.l.) (Mrkva, 1994; Grodzki, 1997) – in Poland especially in the north-eastern range of *Picea abies* distribution (Burakowski *et al.*, 1992). In the last two decades, the spread of *I. duplicatus* to higher elevations has been observed. Already in 2001-2002 some individuals were collected using traps baited with a specific pheromone in the Western Carpathians in Beskid Śląski (Skrzyczne Massif) and Beskid Żywiecki (Police Massif) at altitudes between 1,000-1,050 m a.s.l. (Grodzki, 2003). In 2013-2014, during the survey on altitudinal transects in the Tatra Mts., the beetles were collected between 1,000 and 1,400 m a.s.l., where *I. duplicatus* had never been found before (Grodzki, 2020). Also, during the survey conducted in Lower Silesia and Sudety in 2014 the beetles were captured with pheromone traps located in the altitude zone between 700-900 m a.s.l. Unfortunately, the position of those traps is not provided (Otto *et al.*, 2016). Therefore, the upward altitudinal spread of this species is conclusive both in the Polish mountains and in the Central-European countries.

In Slovakia until 1995, the species, which is considered as invasive, was not present (Turčáni, 1995). However, one record is known from the beginning of the 20th century from eastern Slovakia (Turcani *et al.*, 2001). Between 1997-1999, pheromone monitoring revealed its presence in northern Slovakia in areas located close to the border with Poland and high capture rates starting in 2009 were recorded in the Central Carpathians at altitudes above 800 m a.s.l. (Vakula *et al.* 2017).

I. duplicatus was recorded for the first time in the Tatra National Park (TANAP) in Slovakia in 2016 (Vakula *et al.* 2017), and then higher numbers of captured specimens in 2017 in the western part of Tatra, although no information about altitudes was available (Vakula *et al.* 2018). In the years following, the beetles spread to new areas as well as to higher altitudes with this pattern including areas to the south of the study area, although the precise locations were not published (Vakula *et al.*, 2018).

In Czechia, the species was known to be an important factor in Norway spruce mortality during its outbreak in the last decade of the 20th century in the north-eastern part of the country (North Moravia and Silesia) close to the outbreak area in Poland (Silesian Upland) in stands at relatively low altitudes (Grodzki, 1997; Holusa *et al.*, 2010b). Holuša *et al.* (2013) found trees infested by *I. duplicatus* in the location adjacent to our study area in Moravskoslezské Beskydy at the elevation of about 600 m a.s.l., *i.e.* in the 'traditional' altitudinal range typical for this species (Zahradník and Knížek, 1998; Grodzki, 2003). However, earlier research by Holuša (2004) reported beetles captured in pheromone traps located in the Ostrý Mountain (western edge of the Carpathians close to Beskid Śląski in Poland) at an altitude between 700 and 1000 m a.s.l. In the following years, the spread to higher altitudes was observed also in southern Czechia, close to the Šumava Mountains. During the monitoring of this species in 2018, the beetles were collected at the Mount Boubín at an altitude of 1,050 m a.s.l. (Knížek, 2019).

A survey done in 2010 in Romanian part of the Carpathians on a transect between 340 and 1,280 m a.s.l. revealed the presence of this species in the entire altitudinal profile (including the zone at an altitude above 1,000 m a.s.l.) with an observed trend of decreasing amounts of captured beetles with increasing elevation (Olenici *et al.*, 2011). In 2019, a survey of this beetle species using pheromone traps was done in the Rhine valley in Switzerland and Liechtenstein. The maximum number of captured specimens in Switzerland were found at 830 m a.s.l. However, this was the maximum elevation at which the traps were installed (Wermelinger *et al.*, 2020). It is quite probable that *I. duplicatus* beetles could be collected at higher altitudes (if the traps would have been installed there) as it was in the other countries in Europe.

This species is spreading southward across Europe. The most recent records concerning its occurrence come from Slovenia, where *I. duplicatus* was detected in the central part of the country at lower elevations (approximately 400 m a.s.l.), but not at higher altitudes (up to 1,500 m a.s.l.) where the traps were installed as well (Kavčič *et al.*, 2023). The spread to higher elevations seems to be possible in the upcoming years.

As mentioned earlier, we used no quantitative data (*i.e.* the number of collected beetles) but only the presence of the species at a given location. The reason for this approach is that the effectiveness of pheromone traps depends on several factors which are not directly related to the abundance of the species (Grodzki, 2007). Therefore, directly using of the number of captured individuals could lead to conclusions that are not fully justified. The most important defined aim of the survey was the occurrence of the species in the altitudinal zones where it had not been recorded before.

The double spined bark beetle attacks mainly, or even exclusively, standing trees within the stand and not the lying (fallen or felled) ones (Schnaider and Sierpiński, 1955; Lubojacký *et al.*, 2018). Two types of infestation were described in Poland as follows: 'typical' – *i.e.* in the upper stem zone and within the crown, and 'southern' – with galleries abundant also in the lower parts of the stem (Grodzki, 2012). The relevant question is which type of infestation exists in the mountains. The first one is less harmful but more difficult to control – the infested

trees within the stands are not easily identifiable as the symptoms are present in the highest parts of the stem. The second one, easier to identify as the galleries are present even at the level of human eyes, indicates very high population levels of the species, therefore a higher risk of increased tree mortality (Grodzki, 1997). Thus, it is not easy to assess which of these two patterns would be more dangerous to the Norway spruce stands at higher elevations.

Until the beginning of the 20th century, *Ips duplicatus* occurred only in the Euro-Siberian taiga from Sweden to Sakhalin, and in the Alps (Pfeffer, 1955), later its distribution in Europe was limited to areas at lower altitudes, most probably due to more favourable conditions for reproduction and breeding (Holuša *et al*., 2003, 2006). The spread of this species observed in the preceding decades could be attributed to the changing climate as the pattern is very distinct in the altitudinally diversified landscape in the mountains. This pattern, which is understood to impact the outbreak dynamics of *I. typographus* by inducing upward altitude shifts of the attacks, was already described in several areas in Europe including those in the mountains (Jönsson *et al*., 2007; Marini *et al*., 2012, 2017). It is very probable that similar patterns concern *I. duplicatus* with its spreading towards higher altitudes that prior (till very recently) had cold climatic conditions that were limiting the development of this species as well, as overwintering as adults (Schnaider and Sierpiński, 1955; Mrkva, 1995).

Conclusions

- The double spined bark beetle *I. duplicatus*, considered for a long time as the species abundant in the north-eastern range of Norway spruce and (although sporadically) in the uplands up to 500-600 m a.s.l., spreads towards higher elevations even above 1,000 m a.s.l.
- The survey conducted in numerous managed stands of the western Carpathians confirm its occurrence at several locations above 900 m a.s.l., where it was not recorded earlier (similarly in higher locations of the Tatra or Sudety Mountains).
- The spread of *I. duplicatus* to higher altitudes is a more general phenomenon being observed also in the other Central-European countries together with its expansion southward.
- In the future, the species can be a threat to Norway spruce stands at higher altitudes in the Carpathians taking into account the climatic changes and difficulty in implementing effective control methods of this bark beetle populations.

Authors' contributions

W.G. – concept, methodology, data processing, manuscript writing; R.B. – survey design, setup and supervision, data collection, co-editing, M.H. – insect determination, data collection, co-editing

Conflict of interest

The authors declare no conflict of interest.

Funding source

This work was done within the current activities of the State Forests National Forest Holding and the Forest Research Institute.

Acknowledgements

Special thanks to the foresters from the forest districts included in the survey for their help in the operation of traps and collection of insects.

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Appendix

Location of traps in which *I. duplicatus* beetles were collected during the surveys in 2014 and 2020

Forest District	Forest Range	Forest compartment	Forest address	Altitude m a.s.l.	Mesoregion
		Survey 2014			
Sucha	Skawica	385 c	02-30-1-09-385 -c -00	1000	513.51
Ujsoły	Kiczora	71 a	02-34-1-10-71 -a -00	650	513.56
	Zwardoń	26 b	02-34-1-11-26 -b -00	700	513.56
	Zwardoń	36 a	02-34-1-11-36 -a -00	650	513.56
	Sól	99 a	02-34-1-12-99 -a -00	700	513.56
	Rycerki	171 a	02-34-1-13-171 -a -00	700	513.56
	Plaskurówka	196 a	02-34-1-15-196 -a -00	750	513.56
	Gawłowskie	32 c	02-34-2-01-32 -c -00	800	513.51
	Okrągłe	91 a	02-34-2-02-91 -a -00	700	513.51
	Złatna	108 c	02-34-2-03-108 -c -00	800	513.56
	Glinka	144 b	02-34-2-05-14 -b -00	800	513.56
	Cicha	191 a	02-34-2-06-191 -a -00	750	513.56
	Danielka	265 b	02-34-2-08-265 -b -00	850	513.56
	Morgi	222 c	02-34-2-09-222 -c -00	750	513.56
		Survey 2020			
Andrychów	Roczyny	109 b	02-01-1-03-109 -a -00	620	513.47
	Targanice	129 a	02-01-1-04-129 -a -00	708	513.47
	Inwałd	210 a	02-01-1-06-210 -a -00	480	513.47
	Łękawica	186 a	02-01-2-10-186 -a -00	410	513.47
	Czaniec	13 g	02-01-3-11-13 -g -00	753	513.47
	Roztoka	38 b	02-01-3-12-38 -b -00	660	513.47
Bielsko	Straconka	41 c	02-02-1-02-41 -c -00	664	513.47
	Biła	103 a	02-02-1-04-103 -a -00	1050	513.45
	Salmopol	161 a	02-02-1-06-161 -a -00	750	513.45
	Kamienica	91 c	02-02-2-11-91 -c -00	675	513.45
	Jaworze	178 d	02-02-2-13-178 -d -00	670	513.45
Jeleśnia	Koszarawa Bystra	43 a	02-08-1-03-43 -a -00	1010	513.51
	Korbielów	99 k	02-08-1-04-99 -k -00	805	513.51
	Sopotnia Dolna	162 g	02-08-1-05-162 -g -00	1025	513.51
	Sopotnia Górna	175 a	02-08-1-06-175 -a -00	1011	513.51
	Sopotnia Potok	200 a	02-08-1-07-200 -a -00	950	513.51
	Czernichów	90 b	02-08-2-13-90 -b -00	466	513.47
Sucha	Tarnawa	165 c	02-30-1-02-165 -c -00	581	513.47
	Lachowice	253 g	02-30-1-04-253 -g -99	481	513.51
	Juszczyn	366 b	02-30-1-08-366 -b -00	1011	513.51
Ujsoły	Sól	98 b	02-34-1-12-98 -b -00	679	513.56
	Cicha	213 a	02-34-2-06-213 -a -00	728	513.56
	Petkówka	302 h	02-34-2-07-302 -h -00	652	513.56
	Morgi	222 c	02-34-2-09-222 -c -00	811	513.56
Ustroń	Górki	14 b	02-35-1-01-14 -b -00	570	513.45
	Cisowa	154 d	02-35-1-02-154 -d -00	480	513.45
	Bukowa	68 a	02-35-1-04-68 -a -00	632	513.45
	Leśnica	105 f	02-35-1-05-105 -f -00	635	513.45
	Równica	18 g	02-35-3-11-18 -g -00	556	513.45

Appendix continued

Forest District	Forest Range	Forest compartment	Forest address	Altitude m a.s.l.	Mesoregion
Ustroń	Dobka	43 b	02-35-3-12-43 -b -00	474	513.45
	Czantoria	70 c	02-35-3-13-70 -c -00	560	513.45
	Dzięgielów	77 b	02-35-3-14-77 -b -00	555	513.45
Węgierska Górka	Boracza	66 f	02-36-2-03-66 -f -00	781	513.51
	Prusów	100 b	02-36-2-04-100 -b -00	748	513.51
	Zielona	137 f	02-36-2-07-137 -f -00	681	513.45
Wisła	Gańczorka	87 d	02-37-1-01-87 -d -00	687	513.45
	Beskidek	57 d	02-37-1-02-57 -d -00	565	513.45
	Olza	30 a	02-37-1-03-30 -a -02	742	513.45
	Malinka	108 a	02-37-2-07-108 -a -99	916	513.45
	Barania	102 h	02-37-2-08-102 -h -00	924	513.45
	Czarne	55 g	02-37-2-10-55 -g -00	721	513.45
	Łabajów	32 c	02-37-2-12-32 -c -00	790	513.45

STRESZCZENIE

Ekspansja kornika zrosłozębnego *Ips duplicatus* (Sahlb.) (Col.: Scolytinae) w wyższe położenia górskie na zachodnim krańcu polskich Karpat

Kornik zrosłozębny *Ips duplicatus* (Sahlb.) (Col.: Curculionidae) do lat 90. ubiegłego wieku uważany był za gatunek związany z obszarami położonymi na niewielkich wysokościach (zwłaszcza w północno-wschodnim zasięgu świerka, gdzie uznawany był za licznie występujący), a także na rozproszonych stanowiskach na wyżynnych terenach południowej Polski (również Czech), do wysokości ok. 600 m n.p.m. Po rozległej gradacji na Wyżynie Śląskiej w latach 1992-1995 podjęto w latach 2000-2002 próby określenia zasięgu jego występowania w południowej Polsce przy zastosowaniu pułapek feromonowych, odnotowując odłowy pojedynczych chrząszczy w Karpatach na wysokości ponad 800, a nawet ponad 1000 m n.p.m. Podczas badań monitoringowych w latach 2014-2015 stwierdzona została obecność tego kornika w Sudetach na wysokości 700-900 m n.p.m., a wykonane w latach 2013-2014 badania na transektach w Tatrach wykazały obecność *I. duplicatus* w pułapkach feromonowych umieszczonych na wysokości 1000-1400 m n.p.m. Wobec zaznaczających się symptomów wzmożonego występowania tego gatunku chrząszcza w świerczynach Beskidu Śląskiego i Żywieckiego podjęto kolejne próby określenia zasięgu jego występowania w tym rejonie Karpat (ryc. 1), najpierw na ograniczonym obszarze Beskidu Żywieckiego – w Nadleśnictwie Ujsoły (2014 r. – 22 stanowiska; ryc. 2), a następnie na obszarze 8 nadleśnictw beskidzkich (Andrychów, Bielsko, Jeleśnia, Sucha, Ujsoły, Ustroń, Węgierska Górka i Wisła) znajdujących się w granicach RDLP w Katowicach (2020 r. – 98 stanowisk; ryc. 1, 3), instalując pułapki feromonowe na różnych wysokościach n.p.m. W artykule przedstawiono wyniki przeprowadzonego rozpoznania w układzie 5 górskich mezoregionów pokrywających obszar tych badań: Beskidu Małego, Beskidu Makowskiego, Beskidu Śląskiego, Beskidu Żywiecko-Orawskiego i Beskidu Żywiecko-Kysuckiego (ryc. 1). W 2014 r. chrząszcze *I. duplicatus* odłowione zostały na 14 spośród 22 stanowisk, w tym na 11 stanowiskach w strefie 700-900 m n.p.m. oraz na jednym powyżej 900 m n.p.m. (tab. 1; ryc. 2).

W 2020 r. chrząszcze odłowiono na 52 spośród 98 stanowisk, w tym na 12 w strefie 700-900 m n.p.m. oraz na 8 powyżej 900 m n.p.m. (tab. 2; ryc. 3). Stanowiska położone na wysokości ponad 900 m n.p.m., na których odnotowano obecność *I. duplicatus*, zlokalizowane były na obszarze mezoregionów Beskid Śląski oraz Beskid Żywiecko-Orawski, natomiast na terenie wysuniętego najdalej na południe mezoregionu Beskid Żywiecko-Kysucki chrząszczy w tej strefie wysokościowej nie odłowiono w 2014 ani w 2020 r. Stwierdzenia *I. duplicatus* na znacznych wysokościach w południowych mezoregionach, obejmujących wyższe położenia oraz drzewostany ze znacznie wyższym udziałem świerka, mają istotne znaczenie dla kształtowania się przyszłego zagrożenia świerczyn. Wyniki te wskazują na dalsze stopniowe poszerzanie się pionowego zasięgu występowania kornika zrosłozębnego w Karpatach, co sygnalizowane jest także z innych górskich rejonów Europy. W świetle zebranych danych, a także w obliczu zmian klimatu, należy liczyć się ze wzrostem znaczenia tego gatunku w świerczynach wyższych położeń górskich, co stanowić może nowe istotne zagrożenie dla tych drzewostanów.