Keystone Role of Eurasian Beaver, *Castor fiber*, in Creating the Suitable Habitat over the Core Breeding Range for Forest Specialist Species the Three-Toed Woodpecker *Picoides tridactylus*

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Abstract

The European breeding range of the three-toed woodpecker *Picoides tridactylus* overlaps with the distribution range of coniferous and mixed forests with the dominance of Norway spruce *Picea abies* or European silver fir *Abies alba*. The paper describes a new breeding site of the three-toed woodpecker in the Sobibór Forest, eastern Poland outside the distribution range of these two tree species and its possible relationship with Eurasian beaver *Castor fiber*. The birds occurred in dead alder forests and were recorded 3–4 years after the forest started to decline due to the high level of surface waters associated with the keystone role of the beaver. The decay cycle of trees was possible because the area settled by woodpeckers was protected as a nature reserve.

Keywords: isolated breeding site, keystone species, suboptimal habitat, deciduous swamp forest, decaying stands, Western Polesia

Introduction

Europe is inhabited by 11 species of woodpeckers and one of the rarest is the three-toed woodpecker *Picoides tridactylus* (Linnaeus, 1758). Because of their narrow habitat specialisation, three-toed woodpeckers occur mainly in forests with high proportion of dead wood and decaying trees, which strongly affects species density. Ten European woodpecker species excavate cavities in trees, which makes them the keystone species in forests (Paine 1969, Johnsson 1993, Martin et al. 2004, Drever et al. 2008, Remm and Lõhmus 2011, Pakkala et al. 2018a). A similarly keystone role in the Holarctic can be fulfilled by a beaver, *Castor* sp. (Pollock et al. 1995, Wright et al. 2002, Janiszewski et al. 2014). The discovery of new woodpecker breeding sites outside their core range, including the three-toed woodpecker, and a possible correlation between them and the Eura-

sian beaver, *Castor fiber* (Linnaeus 1758), could have a significant impact on the protection of the three-toed woodpecker and its habitats (Pakkala et al. 2014).

The European range of the three-toed woodpecker is associated with the range of Norway spruce *Picea abies* ((L.) H. Karst) and/or European silver fir *Abies alba* (Miller) (their dominance in stands on a wider scale) (Cramp 1985, Pechacek and d'Oleire-Oltmanns 2004, Wesołowski et al. 2005, Pakkala et al. 2018b). It is also representative of the distribution of this species in Poland, where there are two isolated subpopulations: one in the Carpathian Mountains in the south, and the other in the north-eastern part of the country (Tomiałojć and Stawarczyk 2003, Piotrowska and Wesołowski 2007, Ciach and Kajtoch 2016).

Study Area

The Sobibór Forest is located in the eastern part of Poland in Western Polesie. In total the forest covers 256 km^2 and the dominant habitat is fresh pine forest (over 50 % of forests). Water-impermeable carbonate substrate makes up a high share (over 40 %) of moist and swamp habitats (mainly forests), which are very characteristic for this area (Gacka-Grzesikiewicz 1987, Wojciechowska 1999, Kanclerska et al. 2018). Due to post-glacial landscape there are 11 lakes. Overall, the Sobibór Forest is managed, but there are 4 types of protected areas within it. The most valuable habitats are protected in 7 nature reserves (ca 14 km^2) and two Nature 2000 areas (Sobibór Forest PLH060043, Middle Boug Valley PLB060003). The study plot is also a part of Sobibór Landscape Park. As a consequence of high proportion of wetlands and conservation areas the study plot is covered by many forest stands close to a natural character with a large proportion of decaying trees and dead wood. Those are key habitats for specialized forest animals, including birds (Gacka-Grzesikiewicz 1987, Wojciechowska 1999, Kanclerska et al. 2018, Natura 2000 2017). The Sobibór Forest lies outside the core range of Norway spruce and European silver fir. All spruces occurring in the research area are artificially planted as admixtures in forest stands.

Materials and Methods

We conducted our research in a 4-year period between 2012 and 2015. The first observation of a three-toed woodpecker took place in 2012 during the white-backed woodpecker *Dendrocopos leucotos* (Bechstein, 1802) survey. A male of the three-toed woodpecker responded to the white-backed woodpecker calls played from the recording. Through the years 2012-2015 we controlled this site 5 times in the breeding season and on each visit we played drumming and alarm calls of the three-toed woodpecker to increase detectability. Overall, we observed three-toed woodpeckers 10 times. During the observations we focused on the behaviour of birds in order to find evidence of breeding (Walankiewicz et al. 2009).

We used satellite images available in Google Earth Pro to describe the decay cycle of the forest patch settled by woodpeckers. We calculated how the area of decaying trees and dead wood had changed over time in order to determine the causes of woodpecker colonisation in this area. The area is part of "Żółwiowe Błota" nature reserve (724.08 ha), which was created mainly with the European pond turtle *Emys orbicularis* (Linnaeus 1758) and post-glacial habitats in mind. This part of the forest is not being used for timber harvesting.

Results

The observations of the three-toed woodpecker in the Sobibór Forest were conducted in 2012–2014. The most interesting observations came from 2014 when birds were detected 3 times. On March 30, three birds were seen simultaneously: a pair-bonding couple and the second male, which attacked the paired male. The observed birds belonged to the boreal subspecies *P. t. tridactylus* (Figure 1). The observations allow qualifying the species as probably breeding. Since 2015, woodpeckers have not been detected in the discussed location, although attempts to confirm their presence have been made in the following years. All observations of the three-toed woodpeckers were conducted in a small area of approximately 40 hectares in a partially flooded alder forest. The forest stand consisted mainly of black alder mixed with silver birch *Betula pendula* (Roth) and downy birch *Betula pubescens* (Ehrhart). The age of trees at the site was on average 60 years for alder and 55 years for birch.

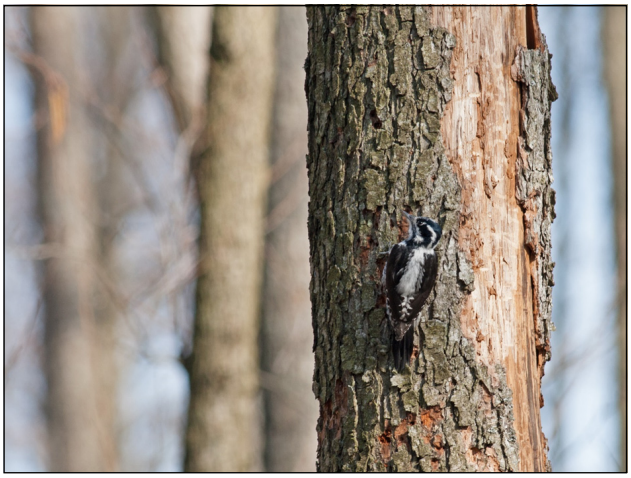

Figure 1. A three-toed woodpecker female (*P. t. tridactylus*) in the Sobibór Forest (photo: T. Chodkiewicz)

Most of the trees were dead or evidently decaying, and the birds fed mainly on dead alders.

The archival satellite images of the described site, available through Google Earth Pro, allowed us to clearly determine that the dieback of the alder stand began in the period of 2008–2009 (Figure 2). The earliest available photographs from 2006–2007 showed that 99 % of trees had live crowns. Photos from 2010 showed large areas of dead, leafless stands with significantly thinned crowns (ca 10 % of trees), which suggests that the habitat of those forest patches tended to be suitable. The observation period of the three-toed woodpecker spanned the years 2012-2014, when the share of dead and decaying trees was much larger (Figure 1). In the satellite images from 2015 the last stage of stand dieback is visible, where an open space with few tree trunks accounts for 56 % of the area. These habitat changes in the Sobibór Forest were mainly due to atmospheric factors and the keystone role of the Eurasian beaver, whose activity led to flooding the area within a short period of time followed by a rapid decrease in water level resulting from the bursting of the dams. After the year 2015 the trees died and most of them were overturned, as a result we did not detect any three-toed woodpeckers. The occurrence of beavers was first recorded in November 2008 through other studies conducted in this area and it was the first time that beavers had been seen here in many years. Since then, their presence was confirmed every year until 2015.

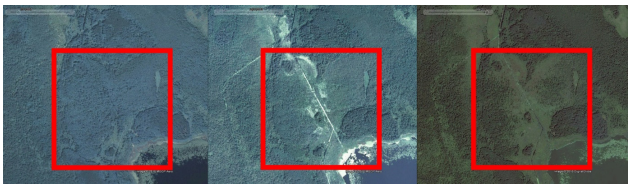

Figure 2. Decaying alder stands at the observation sites (in red frames). Photographs are presented in chronological order: 2007, 2010, 2015 (photos: 2007, 2010 - MGGP Aero, 2015 - DigitalGlobe)

Discussion and Conclusions

The nearest well-known three-toed woodpecker sites in Poland are located near Górny Gród in the Białowieża Forest 130 kilometres to the north (Kajzer and Sobociński 2012) and near Fredropol (the southern part of the Przemyśl Foothills) 200 kilometres south of the Sobibór Forest (Ciach and Kajtoch 2016). To the east, the nearest location at a distance of about 310 kilometres is in Ukraine in the Poleski Nature Reserve, Olewski District, Zhytomyr Oblast (Bumar et al. 2004).

The occurrence of the three-toed woodpecker is strongly correlated with the availability of dead wood in the environment (Cramp 1985, Fayt 1999, Pakkala et al. 2002, 2018b, Angelstam et al. 2003, 2004, Butler et al. 2004, Gorman 2004, Pechacek and d'Oleire-Oltmanns 2004, Roberge et al. 2006, Virkkala 2006, Ciach and Kajtoch 2016). As a boreal species it is associated primarily with dead and decaying spruce trees, the presence of which is considered to be crucial in most places as a necessary condition for the occurrence of these birds (Walankiewicz et al. 2002, Pechacek and d'Oleire-Oltmanns 2004, Wesołowski et al. 2005, Walankiewicz et al. 2009, Ciach and Kajtoch 2016, Pakkala et al. 2018b). Research confirms that this species is encountered in deciduous forests, especially in highly wet forest ecosystems: alder forests, riparian forests and birch forests. However, this still applies to the areas lying within the range of compact spruce forests (Fayt 1999, Gorman 2004, Tumiel 2008, Stachura-Skierczyńska et al. 2009, Pakkala et al. 2018b). The latest data from a 30-year study from Finland suggest that in typical deciduous forests inhabited by three-toed woodpeckers the proportion of healthy trees is lower than in conifer (especially spruce) forests (Pakkala et al. 2018b). Research carried out in the Białowieża Forest (with a high proportion of spruce) shows that the composition of stands (with the presence of spruce or alder) on the micro scale is not as significant for this bird species as stand age (from 100 to 200 years) and the occurrence of wet boreal habitats (Kajzer and Sobociński 2012).

The proportion of spruce at the woodpecker site in the Sobibór Forest was exceptionally small, and it was a young and live forest stand (25–27 years) established by planting and therefore totally unsuitable for woodpeckers. The same could be said of the entire Sobibór Forest, where spruce was most often introduced into young stands as an additional species with only single trees at a mature age. The occurrence of the three-toed woodpecker at the Sobibór Forest breeding site is an interesting case from the zoogeographical and habitat perspective: the birds have settled in a completely new area outside the compact spruce forests, which is their distribution range, in a place where spruce is absent on the macro scale or is not an important addition species for the stands from the point of view of the woodpecker.

The correlation between the occurrence of beavers and three-toed woodpeckers is a rarely discussed issue. However, most researchers believe that the presence of beavers is favourable to the occurrence of this woodpecker species. In the Knyszyńska Forest (north-east Poland), the beaver dams were located close to 65 % (n=22) of the detected three-toed woodpecker sites (Tumiel 2008). According to Kajzer and Sobociński (2012), the presence of beavers does not determine the presence of the three-toed woodpecker in the Białowieża Forest, although it certainly supports this species. They observed

birds at 34 % (n=6) of beaver sites, and only 2 nests (10 % of all detected hollows) were found near them. The coexistence of these two species was also observed in Finland (Fayt 1998) and the United States of America (Short 1974). Due to rapid changes in water level over a short period of time, there was an area in the Sobibór Forest with a significant accumulation of deadwood and decaying trees and as a consequence a large number of cambio- and xylophagous insects.

This situation can be compared to violent disturbances in the forest, e.g. fire or storm. The research conducted in North America on the occurrence of the American three-toed woodpecker *Picoides dorsalis* (Baird, 1858) (taxon separated from *P. tridactylus*) and black-backed woodpecker *Picoides arcticus* (Swainson, 1832), a species closely related to the three-toed woodpecker, describes rapid colonisation of burned areas by these birds in the period of 1–2 years after the forest fire and an equally rapid decline in their numbers in subsequent years (Blacford 1955, Koplin 1969, Bock and Lynch 1970, Apfelbaum and Haney 1981). Some scientists believe that sudden disturbances causing the appearance of dead and decaying stands are as important to the population of Picoides woodpeckers as the stable, old and mature stands (Yeager 1955, Sorvari 1994, Hoyt 2002, Fayt 2003, Pakkala et al. 2018b).

The type of forest management could be the key factor influencing the occurrence of rare forest specialist species, for example woodpeckers (Angelstam and Mikusinski 1994, Wesołowski et al. 2005, Drever et al. 2008, Pakkala et al. 2014). This is the case in the Sobibór Forest, which incorporates many fragments of unmanaged, protected forests, thus facilitating the natural cycle of forest decay under the influence of local flooding, which resulted in the emergence of suitable habitats for such a unique species for this area, the three-toed woodpecker.

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