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**Characteristics of riparian trees and shrubs utilized
by the European beaver (*Castor fiber*)
in the Jamy Forest District**

Charakterystyka przybrzeżnej roślinności drzewiastej wykorzystanej
przez bobra europejskiego (*Castor fiber*) w Nadleśnictwie Jamy

Summary. The objective of this study was to identify the characteristic features of trees and shrubs utilized by the European beaver in the Jamy Forest District. A total of 273 trees and shrubs cut down by beavers were analyzed to identify their species, diameter and distance from the watercourse bank. Tree species which were most frequently felled by beavers were the grey alder, black alder and pedunculate oak. At the three monitored sites, beavers showed a preference for trees with a diameter of up to 15.0 cm. Beavers were most likely to utilize trees and shrubs situated at a distance of up to 15.0 m from the watercourse bank.

Key words: European beaver, riparian trees and shrubs, foraging preferences, preferences

INTRODUCTION

Beavers inhabit highly diverse habitats. They colonize naturally occurring marshes, former peat excavation sites, drainage ditches, small watercourses in forests and fields, as well as rivers and lakes [Andrzejewska-Wierzbicka and Bereszyński 2000]. Beavers are also increasingly encountered in crop fields, in the direct vicinity of farms, orchards and camping sites [Dzięciołowski 1996]. No other animal species has equal capacity for modifying and adapting the habitat to its needs. Only beavers are capable of cutting down trees and damming waters to minimize the risk of predatory attacks. The structures erected by beavers have a direct or indirect impact on the colonized sites [Brzuski and Kulczycka 1999]. Beavers show a preference for areas overgrown by softwood trees: alders, birches, hazels, poplars and willows [Karbowski 2002]. The species may also

forage on hardwood species such as oaks and beeches [Dzięciołowski 1996]. Beavers can easily chew through branches and trunks with a diameter of around 70 cm. In addition to the leaves, bark and branches of deciduous trees, they also feed on roots, rhizomes and leaves of aqueous and terrestrial plants. In the spring and summer, beavers graze mostly on fresh green matter in the vicinity of water bodies. In the fall, the animals intensify their tree cutting efforts and store food reserves for the winter. Young shoots are gathered in underwater food stores [Dzięciołowski and Misiukiewicz 2002]. Thicker tree fragments are used for building and repairing dams [Janiszewski *et al.* 2009].

The objective of this study was to identify the characteristic features of riparian trees and shrubs utilized by the European beaver in the Jamy Forest District.

MATERIALS AND METHODS

The study was carried out in the Jamy Forest District in the north-eastern part of the Regional Directorate of State Forests in Toruń. The Jamy Forest District is characterized by a predominance of mixed forests comprising mostly the Scots pine, pedunculate oak, Sessile oak, European beech, small-leaved lime, sycamore maple, Norway maple, common hornbeam, spruce and beech. The pedunculate oak, common ash, elm, field maple, black and white poplar and crack willow are found in stream and river valleys. Marshes and inundated depressions without an outflow are overgrown by black and gray alders [Tarnawski and Grudziecka 2010].

The experiment was conducted between 1 October and 31 December 2011 in two distant forest divisions of Słupy (sites I and II) and Łąkorz (site III). The dimensions of trees at the monitored sites were measured along a one-kilometer section with a width of 30 m, along the bank of the Osa River (sites I and II) and a smaller watercourse (site III).

Trees and shrubs cut down or damaged by beavers were identified and described in the monitored locations. A total of 273 trees and shrubs were characterized during the experiment, including 126 at site I, 80 at site II and 67 at site III.

The analyzed trees and shrubs were identified to species level. Their diameter and distance from the bank were determined. Tree diameter was measured with calipers within an accuracy of 0.5 cm. The distance from the watercourse bank was determined with a measuring tape to the nearest centimeter.

Tree diameter measurements were grouped in 13 categories to accurately describe the beavers' choice of trees: up to 5 cm, 5.1–10.0 cm, 10.1–15.0 cm, 15.1–20.0 cm, 20.1–25.0 cm, 25.1–30.0 cm, 30.1–35.0 cm, 35.1–40.0 cm, 40.1–45.0 cm, 45.1–50.0 cm, 50.1–55.0 cm, 55.1–60.0 cm and above 60.0 cm. The measurements of the distance from the watercourse bank were grouped in seven categories: up to 1.0 m, 1.1–2.0 m, 2.1–3.0 m, 3.1–4.0 m, 4.1–5.0 m, 5.1–10.0 m and above 10.0 m.

The number of trees and shrubs cut down by beavers at various distances from the watercourse bank at each site was determined by one-way analysis of variance.

RESULTS AND DISCUSSION

The gray alder accounted for nearly 50% of all trees and shrubs cut down by beavers in the studied locations (Fig. 1). Other preferred tree species were the black alder (more

than 25%) and oak (more than 16%). The following species had a smaller share of the total population of felled trees and shrubs: hazel (2.26%), bird cherry (2.26%), downy birch (1.13%), European beech (1.13%). The spruce was least frequently utilized by beavers (0.75%).

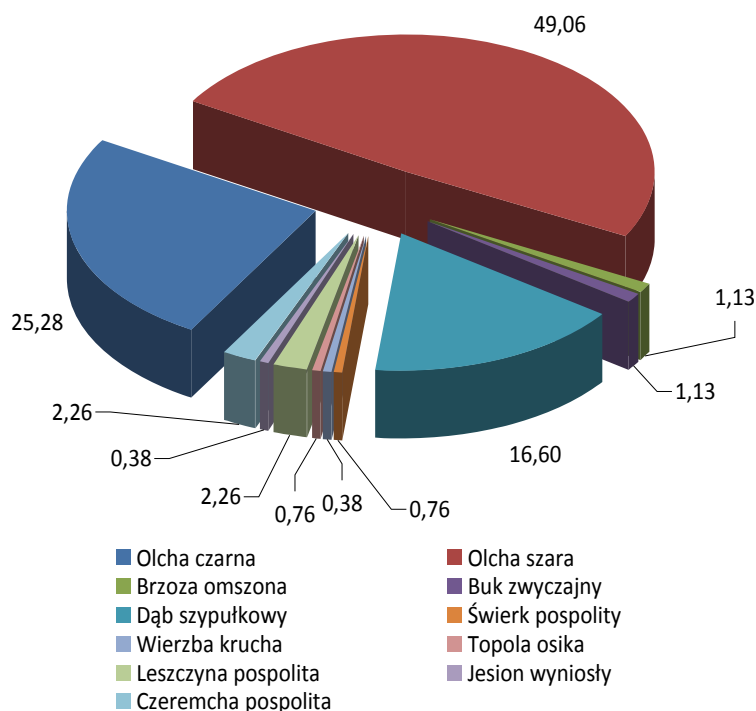


Fig. 1. The percentage of trees cutting by beaver in the Jamy Forest District
Rys. 1. Procent drzew ściętych przez bobry w Nadleśnictwie Jamy

According to many authors, beavers show a clear preference for selected species of deciduous trees, in particular softwood taxa. In a study of the Wielkopolska Region, Bereszyński *et al.* [1998] observed that beavers were most likely to forage on poplars, birches, willows and black alders. Szczepański and Janiszewski [1997] studied two sites on the Pasłęka River in the region of Warmia and Mazury to demonstrate differences in beavers' grazing preferences between the analyzed sites. At the first site, the most frequently cut down trees were hazels (44%), oaks (18%), hornbeams (14%) and beeches (14%), and at the second site – birches (25%), oaks (21%) and alders (14%). In a study of two beaver habitats in an urban area and a protected area, Czyżowski *et al.* [2009] observed that white willows were the most frequently cut down trees. In the city of Lublin, the second most preferred species was black alder owing to its high abundance in the studied region. Bau [2001] investigated tree species felled by beavers in Denmark to report the highest share of willows (71.5%), followed by birches (17.1%) and oaks

(6.3%). Species such as beech, aspen, pine, alder, rowan, bird cherry and spruce were utilized in smaller quantities ($\leq 1\%$). Haarberg and Rosell [2006] investigated the foraging preferences of European beavers in Telemark, Norway, and their results are similar to our findings. In the above study, the most frequently felled tree species were alder (36.7%), followed by rowan (13.4%), willow (7.9%), birch (7.8%), Rosaceae (6.8%), coniferous trees (6.8%) and other taxa (20.6%).

Selected tree species are clearly avoided by beavers. Żurowski [1980] observed that beavers were reluctant to cut down alders, the predominant taxon in beaver habitats, and they showed a preference for birches and willows. According to Borowski [2004], the felling preferences of beavers are largely determined by the availability of a given species in the local habitat. In the Wigry National Park, the animals grazed most readily on willows, birches, alders, poplars and rowans. Beavers showed a preference for trees situated at a considerable distance from the watercourse which sometimes exceeded 100 meters. The preferred tree species were willows and oaks. Beavers did not tolerate the common elder, and they were reluctant to graze on alders, buckthorns and pines.

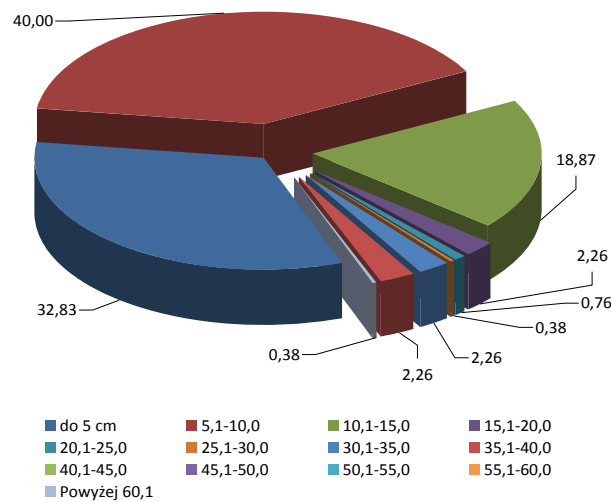


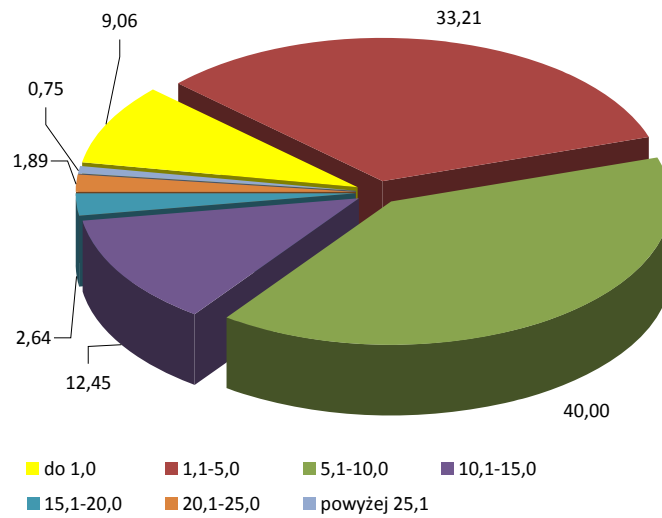
Fig. 2. The percentage of cutting trees in depending on diameter of the tree trunk
Rys. 2. Procent ściętych drzew w zależności od średnicy pnia

The proportion of tree and shrub species cut by beavers is determined not only by the animals' specific preferences, but also by the local availability of those taxa. In a study carried out in Great Britain, O'Connell *et al.* [2008] observed that European beavers grazed on four tree species (alder, aspen, willow and hawthorn). The percentage share of cut trees was not consistent with the availability of those taxa in the investigated region. Willows and alders were the most frequently utilized species, and they accounted for 83% of all felled trees. Although alders were more abundantly represented in the studied area, they had a lower proportion in the group of felled trees (27%). Aspens (16%) were utilized more frequently than hawthorns (1%).

The felling preferences of beavers are also determined by the diameter of the tree trunk. Animals that chew through thinner trees and shrubs spend less time on land, thus minimizing exposure to predation risk. In our study, the diameter of nearly 75% trees cut down by beavers did not exceed 10.0 cm (Fig. 2). The percentage share of trees damaged by beavers decreased with an increase in trunk diameter (above 15.1 cm). No damages were reported in trees with diameters in the range of 40.1 to 60.0 cm, and a very small fraction (0.38%) of trees measuring more than 60.1 cm in diameter showed signs of damage. Similar observations were made by Czyżowski *et al.* [2009] in a study of the Nadwieprzański Landscape Park where beavers damaged mostly thinner trees, and the incidence of damage decreased with an increase in tree diameter measured at breast height. The above correlation was not reported in urban habitats (Lublin) where beavers opted for trees that were most abundantly represented. Szczepański and Janiszewski [1997] demonstrated that in both monitored sites on the Pasłęka River, beavers had a preference for trees with diameters of up to 10 cm and avoided trees with thicker trunks. Our results are also consistent with the findings of Haarberg and Rosell [2006], Brzuski and Kulczycka [1999]. However, in a study by O'Connell *et al.* [2008], trees with diameters of under 10 cm were cut less frequently relative to their abundance, whereas trees with diameters between 10 and 30 cm were utilized more often relative to their availability in a given area. The proportion of felled trees thicker than 30 cm was correlated with their abundance. According to Bau [2001], the majority of cut trees (88.6%) had diameters of up to 3 cm, and the largest tree to be felled by beavers measured 18 cm in diameter.

The distance separating felled trees from the bank of a watercourse or a water body is yet another factor influencing beavers' foraging preferences. At all monitored sites in the Jamy Forest District, the highest proportion of felled trees and shrubs (80%) was observed at a distance of up to 10.0 m from the watercourse. Trees damaged at a distance of 10.1 to 15.0 m had a 12.4% share of the population of cut trees. The proportion of felled trees decreased with an increase in distance from the bank. At sites situated 15.1 to 20.0 m away from the bank, damaged trees accounted for 2.64%, at sites located from 20.1 to 25.0 m – for 1.89%, and at sites situated farther than 25.1 m away from the shore – for only 0.75%.

The distance from the watercourse bank and the number of trees cut by beavers at every monitored site are compared in Table 1. At each site, the number of felled trees differed subject to the distance from the watercourse bank, and in many cases, the observed differences were highly significant (Table 1). At site I, the highest proportion of cut trees (36.36%) was reported at a distance of 5.1 to 10.0 m from the watercourse. In the 1.1–5.0 m distance interval, felled trees accounted for 28.1% of the damaged population, whereas 17.36% of cut trees were found at a distance of 10.1 to 15.0 m from the watercourse. Up to 1.0 m from the shoreline, cut trees had a 9.09% share of the total population. Trees were less frequently felled in remote locations situated more than 15.1 m from the bank – 4.1% at a distance of 15.1 to 20.0 m, 3.31% at a distance of 20.1 to



Rys. 3. Procent ściętych drzew i krzewów z uwzględnieniem odległości od cieków wodnych
 Fig. 3. The percentage of cutting trees in depending on distance separating cutting trees from the bank

Table 1. Percentage and number of trees and shrubs cutting by beavers in depending on distance separating trees from the bank
 Tabela 1. Ilość drzew i krzewów obalonych przez bobry z uwzględnieniem odległości od cieków wodnych na trzech stanowiskach

Distance from the waterbank Odległość od cieków wodnych (m)	Cutting trees and shrubs – Obalone drzewa i krzewy					
	site I stanowisko I		site II stanowisko II		site III stanowisko III	
	%	pcs – szt.	%	pcs – szt.	%	pcs – szt.
< 1,0	9.09	11	10.00 ^a	8	7.81 ^b	5
1.1–5.0	28.10 ^B	34	43.75 ^A	35	29.69 ^B	19
5.1–10.0	36.36 ^B	44	33.75 ^B	27	54.69 ^A	35
10.1–15.0	17.36 ^A	21	8.75 ^B	7	7.81 ^B	5
15.1–20.0	4.13	5	2.50	2	-	-
20.1–25.0	3.31	4	1.25	1	-	-
> 25.1	1.65	2	-	-	-	-
Total Suma	100.00	121	100.00	80	100.00	64

A, B – $P \leq 0.01$
 a, b – $P \leq 0.05$

25.0 m and 1.65% at distances greater than 25.1 m. At site II, the highest proportion of cut trees (43.75%) was observed at a distance of 1.1 to 5.0 m from the watercourse. In the 5.1 to 10.0 m interval, felled trees accounted for 37.75% of the total population, whereas 10% of cut trees were located within 1.0 m from the bank. At a distance of 10.1 to 15.0 m from the shoreline, the proportion of damaged trees was estimated at 8.75%, and at a distance of 15.1 to 20.0 m – at 2.5%. The smallest proportion of trees (1.25%) was felled in the most remote areas located more than 20.1 m from the bank. At site III, the highest proportion of damaged trees (54.69%) was reported at a distance of 5.1 to 10.0 m from the shoreline. The proportion of felled trees was determined at 29.69% in the 1.1 to 5.0 m distance interval and at 7.81% each at a distance of 1.0 m and within the 10.1 to 15.0 m interval. More than 92% of trees at site III were felled within 10 m from the bank. No signs of beaver damage were observed in trees situated farther than 15 m from the shoreline.

In a study of a beaver reserve on the Pasłęka River, Szczepański and Janiszewski [1997] observed that the trees felled at one of the sites were situated up to 15 m away from the river bank. At the second site, trees were cut at distances greater than 30 m from the bank. The above can be attributed to the presence of less abundant riparian vegetation at the second experimental site.

CONCLUSIONS

The results of the study investigating the foraging preferences of beavers in the Jamy Forest District indicate that the following tree and shrub species were most frequently cut down by beavers: the grey alder, black alder and pedunculate oak. The common hazel, bird cherry, downy birch and European beech were less often utilized. Beavers were least likely to cut down the common spruce, aspen, crack willow and common ash. At all monitored sites, beavers most frequently felled trees whose diameters did not exceed 15.0 cm. The percentage of damaged trees decreased with an increase in trunk diameter. Trees and shrubs growing at a distance of up to 15.0 m from the watercourse bank were most frequently utilized by beavers.

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Streszczenie. Badania miały na celu scharakteryzowanie roślinności drzewiastej i krzewiastej wykorzystywanej przez bobra europejskiego bytującego na terenie Nadleśnictwa Jamy. Przeanalizowano łącznie 273 drzewa i krzewy ścięte przez bobry, określając ich przynależność gatunkową, średnicę oraz odległość od brzegu cieków wodnych. Stwierdzono, że najchętniej bobry ścinały olszę szarą, olszę czarną oraz dąb szypułkowy. Bobry na terenie trzech badanych stanowisk najczęściej ścinały drzewa o średnicy nieprzekraczającej 15 cm. W największym stopniu wykorzystywana roślinność drzewiasta i krzewiasta znajdowała się w pasie do 15 m od linii brzegowej cieków wodnych.

Słowa kluczowe: bóbr europejski, roślinność przybrzeżna, preferencje żerowania