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The use of attractants in reducing the occurrence of the *Prunus serotina* (Ehrh.)

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Abstract

Black cherry, which occurs in European forests, contributes to their distortion or degradation of native ecosystems. Therefore, measures are taken to reduce its occurrence. One of them is the biological method involving grazing animals.

The aim of this research was to develop and identify an attractant that would increase the attractiveness of black cherry as a feeding base for deer, which would limit its occurrence.

This research was carried out in Zielonka (17.10941 E 52.553975 N). In the experiment, 3-year-olds were used: *Tilia cordata, Acer pseudoplatanus*, *A. platanoides, Fagus sylvatica* and *Prunus serotina*. Before planting the seedlings, their height was measured. The control (K, 10 trees) consisted of trees of each species that were not sprayed with attractants. Another set of 10 trees were treated over the entire surface of the shoots with a bait mixture (MW), and the next 10 trees were sprayed with a 10% aqueous solution of NaCl. The attractant spraying was repeated six times. All damage observed was recorded. The inventoried tree damage was divided into four categories: 0%, no damage; I, 1–20% damaged trees; II, 21–50% damaged trees and III, more than 50% damaged trees.

The results of the Mann–Whitney *U* test ($p = 0.0109$), at the assumed level of significance ($\alpha = 0.05$), showed that slightly higher seedlings were browsed.

These studies indicate the potential of using attractants as preparations influencing the palatability of the black cherry for deer. All recorded bites were classified as degree I damage. The trees were gnawed by fallow deer, 35.33% of trees were not damaged by game at all, and 64.66% of trees were damaged in degree I. In the case of sycamore maple, Norway maple and linden, the bait mixture did not increase the number of nibbled buds and leaves, while NaCl increased the attractiveness of beech and black cherry as a feeding base.

Conducting further research studies on the improvement of preparations may give a chance to reduce the use of chemicals in forest protection and give the possibility of using attractants where it is impossible to use herbicides.

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Key words

shoot feed, food intake, gnawing, replenishing food, deer, black cherry, invasive species, biological control

Introduction

Chemical agents for the protection of forest crops include, for example, repellents whose task is to scare herbivores away from protected plants (Bavane et al. 2018). Attractants which are used, for example, in the protection of the forest against insects, have a reverse effect (Jiménez and Poveda 2009). The principle of action of repellents and attractants is based on the reaction of animals to a stimulus that causes a deterrent or luring reflex. One of the stimuli whose mechanism of action is used in these substances (both repellents and attractants) is an appetite stimulus (Węgorek and Giebel 2005). "Push–pull" is a behaviour manipulation strategy in which behaviour-modifying stimuli are integrated with a pest control agent (attractants ("pull"), repellents ("push") or both ("push–pull") (Nalyanya et al. 2000). Appetizing stimuli leads to contact with attractive and positive stimuli, such as food. These stimuli concern not only humans but also animals (Yarmolinsky et al. 2009). The sense of taste is a specialized chemosensory system dedicated to the evaluation of food and drink. Despite the fact that vertebrates and insects have independently evolved distinct anatomic and molecular pathways for taste sensation, there are clear parallels in the organization and coding logic between the two systems (Yarmolinsky et al. 2009).

The increase in the number of deer, observed for many years, causes an increase in the share of crops and young trees damaged as a result of browsing and bark stripping (Reyes and Vasseur 2003; Akashi and Terazawa 2005). This, in combination with the second factor, which is the expansion of the black cherry, leads to problems with the removal of crops. Into European stands, a species that is reluctantly eaten by deer (Fruziński and Danielewicz 1998) causes effects of great economic importance. Damage caused by deer is concentrated in unprotected places, and it is also very severe in economic terms and may endanger the sustainability of forests (Gačić and Danilović 2009). Black cherry is often considered a low to moderately preferred browse species, relative to most other co-occurring tree species. Low foliage, stems and fruit are unpalatable because of the presence of cyanogenic glycosides prunasin and amygdalin, which are toxic (Bischoff and Smith 2011). In this context, the presence in the forest ecosystem of a species with the features of an invasive species, which is the black cherry, is important in forest breeding, because its mass occurrence limits the renewal, growth and development of native species of trees and shrubs (Starfinger et al. 2003; Bueno et al. 2021). It is believed that the black cherry, which occurs in European forests, contributes to their distortion or degradation of native ecosystems (Halarewicz 2012; Halarewicz et al. 2021), thus reducing the foraging base of deer. Therefore, measures are taken to reduce its occurrence, but some methods are very labour-intensive (Namura-Ochalska 2012), and others, such as chemical methods, are controversial (Starfinger et al. 2003; Najberek and Solarz 2011). Therefore, other directions and alternative methods to control black cherry are being sought. One of them is the biological method involving, for example, grazing animals, which in Denmark and the Netherlands had positive effects in terms of reducing the population of black cherry seedlings. Cows, goats and sheep gnawed young black cherry shoots despite the content of cyanogenic glycosides (Vanhellemont 2009). In Hungary, 2 years of continuous grazing after cutting the black cherry led to its complete elimination in an area of 2 ha (Demeter and Lesku 2015). Within the natural range of black cherry (North America) (Segura et al. 2018), high levels of the deer population may lead to complete elimination of black cherry trees from forest stands (Marquis 1987). The population of young black cherry in its natural range is limited, among others, by white-tailed mule deer (virgin deer, *Odocoileus virginianus* Zimmermann, 1780) (Marquis 1987; Royo et al. 2021). The current high density of deer is a widespread phenomenon that occurs both in Europe and in North America and is probably caused by a combination of forestry practices, low hunting pressure and extermination of large carnivores, mainly wolves (*Canis lupus* L.) (Wright et al. 2012; Carpio et al. 2021). In Poland, black cherry biting by deer is sporadic (Fruziński and Danielewicz 1998). Taking into account the high status of game, the mass occurrence of black cherry, the food preferences of the game and the growing importance of biological plant protection methods, the aim of this research was to develop and identify an attractant that would increase the attractiveness of black cherry as a feeding base for deer, which would limit its occurrence. It was assumed that (1) native species will be more likely to be browsed by game than black cherry, (2) black cherry treated with attractant will be more likely to be browsed than that untreated with attractant and (3) black cherry treated with attractant will be browsed similarly to native tree species treated with attractant. This research was carried out in the forest.

Material and methods

This research was carried out for 30 days from 10th April to 9th May 2020 in the Forest Arboretum in Zielonka (Murowana Goślina Forest Experimental Station; 17.10941 E 52.553975 N), within the borders of the "Zielonka" Animal Breeding Centre, where the dominant species in game states is fallow deer (*Dama dama* L.). The experiment was located 20 m from a path trodden by game (string) under the canopy of an oak stand. The research area (1 ar) was located in the forest part of the Arboretum. The dominant species (100% share) was the pedunculate oak (116 years old), which grew in the fresh mixed forest habitat. The average annual rainfall for this area is 564 mm, and the average temperature is 8.7°C. The growing season lasts 200 days. In the experiment, thirty 3-year-olds were used: seedlings of small-leaved limes (Tc, *Tilia cordata* Mill.), sycamore maples (App, *Acer pseudoplatanus* L.), Norway maples (Ap, *Acer platanoides* L.), common beech trees (Fs, *Fagus sylvatica* L.) and black cherry (Ps). The trees were planted in 5-liter round pots, which were dug into the belt – flush with the upper edge of the pots, and placed in blocks of 10 lots of one material. All seedlings were planted as 1-year-olds in 2018 under the same conditions in the Dendrology Garden of the Poznań University of Life Sciences.

Before planting the seedlings, their diameter was measured at the height of the root collar (electronic caliper, accuracy – 0.01 mm) and height (tape measure, roll, accuracy – 0.1 cm). The trees were dug in the pots to prevent any uncontrolled tool from spreading the black cherry. Blocks purchased randomly within 2 m of each other (Fig. 1)

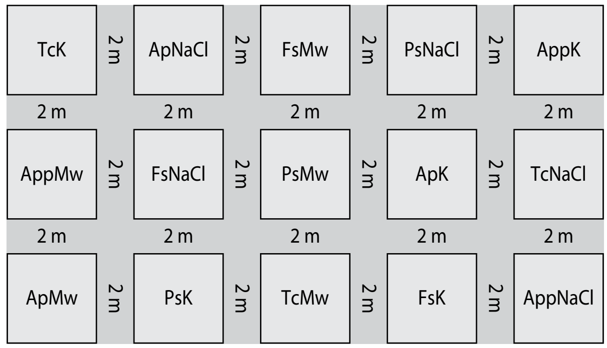

Figure 1. Scheme of the experiment in a block system. In each variant of the experiment, 10 trees were tested. Tc, linden; Ap, sycamore maple; App, Norway maple; Fs, beech; Ps, black cherry; K, control; MW, bait mixture; NaCl, 10% aqueous solution of common salt.

Each variant of the experiment consisted of 10 trees which were evenly sprayed over the entire surface of the shoots with two attractants: bait mixture (MW) and 10% aqueous solution of NaCl. The control (K, 10 trees) consisted of trees of each species that were not sprayed with attractants. Another set of 10 trees were treated over the entire surface of the shoots with a bait mixture (MW), and the next 10 trees were sprayed with a 10% aqueous solution of NaCl. The attractant spraying was repeated six times. The bait mixture (MW) included Arabic gum, sodium chloride, glucose, fructose, pure ethanolic alcohol 96%, Hippocastani fructus tincture (Hippocastani fructus recentis intractum (1:1 v/v)), mistletoe tincture (Visci herbae recentis intractum (1:1 v/v)), and acorn extract (*Quercus pedunculat*a ghiande extr.). First, 4.1 g Arabic gum was dissolved in 100 ml distilled water at a temperature 60°C. After the homogenization of the solution, 14.0 g fructose, 20.2 g glucose and 7.0 g sodium chloride were added, and the whole mixture was diluted with 100 ml distilled water. Then, the solution was cooled, and 4 ml acorn extract, 8 ml Hippocastani fructus tincture and/or 8 ml mistletoe tincture were added. Finally, the whole mixture was diluted with pure ethanol (96%) and distilled water up to final ethanol concentration 50% and final volume 1.0 L. All mixtures were based only on natural ingredients that are 100% safe for both humans and animals.

Table 1. Statistical characteristics of diameter [mm] and high [cm] of experimental trees ($\bar{X}$ – mean, Me – median, Min – minimum, Max – maximum, MS – variance, SD – standard deviation, V – coefficient of variation. Homogeneous groups determined by Tukey's test α = 0.05)

Variant	$\bar{X}$	Me	Min	Max	SD	V	Homogeneous groups
Diameter [mm]							
Linden	9.64	9.88	4.90	13.79	2.08	21.62	C
Norway maple	7.96	7.77	4.22	11.77	1.51	19.03	AB
Sycamore maples	6.92	6.75	4.11	10.67	1.56	22.55	A
Beech	8.41	8.21	5.05	13.82	1.84	21.93	BC
Black cherry	7.68	7.26	4.25	12.71	2.09	27.25	AB
High [cm]							
Linden	34.30	37.90	11.30	75.00	13.16	38.38	A
Norway maple	28.89	29.00	13.10	50.00	9.95	34.44	A
Sycamore maples	33.93	33.60	14.80	65.00	11.99	35.33	A
Beech	34.43	34.95	17.30	49.80	7.70	22.36	A
Black cherry	56.88	56.55	30.20	91.20	14.29	25.12	B

The attractant spraying was repeated six times: 10th April 2020 (leafless shoots), 13th April 2020 (leafless shoots), 16th April 2020 (broken buds), 23th April 2020 (first leaves and broken buds), 30th April 2020 (first leaves) and 7th May 2020 (leafy shoots). All damage observed was recorded. Damage was recorded once on 10th May 2020. The percentage share of damaged and undamaged trees was calculated for each tree species in each variant of the experiment. The inventoried tree damage was divided into four categories (Górecki et al. 2016): 0%, no damage; I, 1–20% damaged of trees (bitten buds and leaves); II, 21–50% damaged of trees (bitten buds, leaves and apical shoots) and III, more than 50% damaged of trees (bitten half and more tree). The scale developed by Górecki et al. (2016) has been modified this statement.

The species of tree-biting animals was identified on the basis of camera images (FULL HD 36IR hunting camera trap), droppings and tracks.

The statistical analysis of the obtained results was carried out in the Statistica program (version 10).

Results

The average diameter of the trees used in the experiment ranged from 6.92 mm (sycamore) to 9.65 mm (linden) (Tab. 1). The diameters of the sycamores were significantly smaller than those of the limes and beeches (8.41 cm). The black cherry was 56 cm on average, and it was significantly higher than other tree species by at least 20 cm (the lowest clones, 28.89 cm). The results of the Mann–Whitney *U* test (p = 0.0109), at the assumed level of significance (α = 0.05), showed that slightly higher seedlings were browsed. However, diameter did not affect their biting (p = 0.1357; α = 0.05).

On the basis of tracks, droppings and camera photos, it was found that the trees were gnawed by fallow deer. However, the results of the NW (highest likelihood) chi-square test (p = 0) at the assumed significance level (α = 0.05) indicate no significant differences between the browsed seedlings in each of the experimental variants. In all, 35.34% of trees were not damaged by game at all, while 64.66% of trees were damaged in degree I. Small-leaved linden turned out to be the least attractive feeding base for deer, and 66.67% of trees of this species were not bitten. However, black cherry was the species that turned out to be the most frequently browsed by game, and only

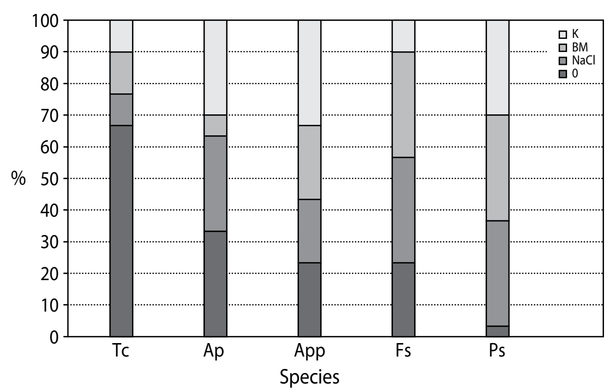

Figure 2. Percentage share of the browsed trees of given tree species for individual variants of the experiment. Tc, linden; Ap, sycamore maple; App, Norway maple; Fs, beech; Ps, black cherry; K, control; MW, bait mixture; NaCl, 10% aqueous solution of common salt; 0, no bites

3.33% of black cherry was not damaged. In the case of sycamore maple, Norway maple and linden, the bait mixture did not increase the number of nibbled buds and leaves, while sodium chloride solution (NaCl) increased the attractiveness of beech and black cherry as a feeding base (Fig. 2 and 3).

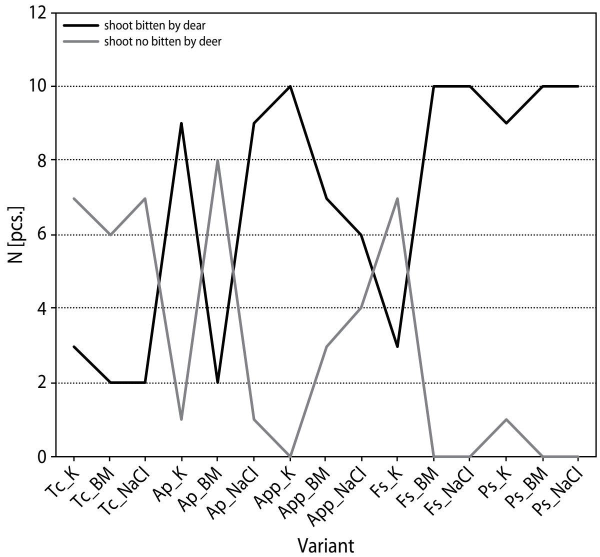

Figure 3. The relationship between the bitten and unbitten seedlings of individual tree species in each of the experimental variants (Tc - linden; Ap - sycamore maple; App - Norway maple; Fs - beech; Ps - black cherry; K - control; MW - bait mixture; NaCl - 10% aqueous solution of common salt; 0 - no bites)

Discussion

"Biting" in the context of damage to young trees by animals is associated with damage to shoots, leaves, buds and flowers. In the case of forest crops, cuttings with roots are also pulled out during browsing. The extent of damage depends to a large extent on the tree species and season. The location of tree damage as a result of deer browsing is usually located along the entire length of the main shoot, which reduces the resistance of the young tree. For example, in the Sitka spruce crops, trees between 40–55 cm and 30–60 cm in height were most susceptible to browsing (Piechowski 1994). Our research was carried out on trees whose height did not differ from the height of spruces, although Nasiadka and Lipski (2006) suggest that the height of plants should not be taken into account when protecting trees against damage caused by animals. The results of our research indicate that taller seedlings were browsed more often than lower ones. So far, the relationship between plant phenology and their browsing by animals has not been studied. Therefore, in our studies, it was assumed, similar to Nasiadka and Lipski (2006), that the strongest pressure on woody vegetation usually occurs during winter and early spring, because food is less available during this period. In subsequent studies, the phenological development of the examined trees should be taken into account.

In food samples collected from the rumen of fallow deer and hind in November–December period, traces of black cherry leaves were found (Fruziński and Danielewicz 1998). Due to the systematic and selective browsing of deer on selected species of forest trees, there are changes in the species composition of stands by eliminating or changing the share of some of them (Slater and Anderson 2014). One of the ways animals damage plants is to gnaw them (Milne-Rostkowska et al. 2020). The effect of tree browsing is most often their dieback or growth retardation along with reduced resistance to adverse biotic and abiotic factors (Górecki et al. 2016). The species composition of the above experiment was not selected by chance, because the most frequently browsed tree species are deciduous species (Szukiel and Borowski 2000). In the research study by Borowski et al (2021), deer most often browsed sycamore and hornbeam, oak was consumed according to availability, and European beech and silver fir were the least selected. This result was in line with other previous studies (Kuijper et al. 2010; Ohse et al. 2017). The obtained research results indicate that the use of attractants could enrich the diet of deer with the black cherry. The biting of the black cherry by deer in Polish forests would be a desirable phenomenon and could constitute one of the foundations of biological limitation of its occurrence. This method would be useful especially in forest crops with the simultaneous use of attractants on species whose presence we want to reduce by feeding deer and repellents, which would deter them/discourage them from feeding on the desired tree species.

So far, no research study has been conducted on making the feeding base of wild animals living in Poland more attractive. The subject of the researchers' interest is rather repellents, which reduce the browsing and burning of trees by game (Szukiel 1998). The effectiveness of the repellents varies from season to season. The effectiveness of repellents is influenced by weather conditions – resistance to washing off (durability), as well as the number of game (Szukiel and Borowski 2000). Identical factors influence the effectiveness of attractants. Therefore, spraying with attractants was repeated six times. The season of the year also influenced the obtained results, because in spring the game has greater access to the feeding base. They should be repeated in winter, taking into account the methods used in the studies evaluating the effectiveness of repellents (Szukiel and Borowski 2000).

The use of NaCl solution as an attractant was dictated by the use of salt to feed animals in licks (Sokół 2009). The solution of table salt made the black cherry feeding base more attractive, but its high concentration may negatively affect the leaves (they can be burned) and the soil (Widłak 2016). Hence, despite the low costs, particular caution is recommended when using this type of plant spraying agents and it is recommended to use this type of attractant only on the buds.

The use of horse chestnut as an attractant was based on the data published by Górecki and Kasprzak (1998), who considered chestnuts, apples, cabbage and sugar beets as the best bait for catching fallow deer. Mistletoe is also considered a delicacy for deer, and it is recommended to improve the taste of silage in farms with crushed mistletoe (Podkówka 2014).

Conclusions

Research studies on the use of horse chestnut and mistletoe as attractants should be continued. These studies indicate the potential of using attractants as preparations influencing the palatability of the black cherry for deer. Conducting further research on the improvement of preparations may give a chance to reduce the use of chemicals in forest protection and give the possibility of using attractants where it is impossible to use herbicides.

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