THE IMPACT OF MOOSE ON ASH PRODUCTIVITY

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ABSTRACT: Data characterizing the impact of moose (*Alces alces*) on ash (*Fraxinus* spp.) seedlings in the broad–leaved forests of the Tula region are given. Resistance of ash to the strong browsing pressure is shown and also the resulting peculiarities of crown structure, including the position of shoots and branches. When ash is isolated from moose, annual accretion of shoot phytomass is 5 times more than in locations where ash is exposed to browsing; in leaves, phytomass is 10–12 times more than browsed ash. The large number of shoots and a great quantity of large leaves are considered as an adaptation of the ash tree to survival under the browsing pressure of moose.

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A number of workers have reported on the impact of moose browsing on forest plants, including those of the taiga zone (Kaletskaya 1959, Kozlovsky 1960, Dinesman and Shmalgauzen 1961, Perovsky 1973, Timofeyeva 1974, Fyodorov 1979, Kuznetsov 1980, Filonov 1983, Smirnov 1987). There are fewer reports of moose influence on the arboreal species in the zone of broad–leaved forests. The purpose of this paper is to estimate the moose impact on the ash tree in the closed broad–leaved forests of the Russian Plateau.

STUDY AREA

The forest of the Tula Abatis consists mainly of middle–aged and old stands and harvested sites containing dense regeneration (Kurnayev 1980). It presents a complex mosaic picture. The widely dispersed harvest sites, which are the principal source of browse, and characteristic features of snow cover, determine moose travel routes and feeding locations.

METHODS

To estimate the impact of moose browsing activity on ash seedlings on the harvested sites, constant monitoring of the development of sample trees was carried out from 1979 to 1989. As a control, moose were excluded from some of the seedlings. Before the onset and at the end of the period of revegetation, we measured the supply of available forage and the mass of shoot accretion both on the moose–isolated trees and those exposed to browsing. The mass of shoot accretion was determined by measuring the lengths of all shoots available to moose and calculating the dry weight in grams. As a basis for the calculation, the mass of a shoot was determined (Kuznetsov 1983). Besides the index of annual accretion and removal of the phytomass, we measured the height of the trees, diameter of the trunk, number and the length of shoots of the current year, and the quantity and average length of the leaves. To evaluate the density of shoots, special measurements of shoot length were carried out within a volume of space. The parameters of the environment, the characteristics of plants, and the herbaceous layer at the beginning of the investigation were similar in both the control area and the area exposed to browsing by moose. The density of moose per 1,000 hectare averaged 5 individuals and changed very little during the study period.

RESULTS

In the Tula Abatis, ash is the most important forest tree species, forming both pure middle–aged ash stands and young plantations mixed with oak (*Quercus* sp.), elm (*Ulnus* sp.), linden (*Tilia* sp.), and maple (*Acer* sp.). The ash tree, along with oak, is the main forage of moose during the entire year. At the beginning of the investigation in 1979, the mean annual accretion of ash tree shoots made up 11.0 g of dry matter per tree. However, the small quantity of annual shoot accretion was supplemented with a large accretion of leaf phytomass. The annual accretion of phytomass of leaves on stems protected from moose exceeded the accretion of shoot phytomass of exposed stems as much as 10 times, and as much as 12–13 times in some years. The comparison of mean value of ash accretion in the control areas and on stems exposed to browsing shows that the mean annual accretion in isolation is approximately 5 times more than on the exposed stems. The browsing impact of moose on the ash tree is substantial and uniformly distributed with removal of annual growth reaching 40–60%. However, during the first 10 years of monitoring, no ash tree sampled was noted to be dried up. In our opinion, their relative stability was related to the position of shoots on the stem and the size of shoots.

The ash tree shoots are rather sharply divided into short (1–5 cm) and long ones up to 1 m in length. Another characteristic is the thickness, which reaches 8–10 mm in short shoots that are very thick at the base while at the top the thickness slowly decreases insignificantly up to 10–12 mm. Moose changed the crown structure and position of branches, and plants could not escape the reach of moose. Stem height remained within the limits from 1 to 1.6 m. Browsing of shoots gave the ash crowns a dense appearance. To get objective data characterizing the differences in density of plant shoots subjected to browsing by moose and those on the control area, total length of shoots was measured in a definite volume (a cube with a side of 15 cm), situated in the tree crown (Table 1).

The dense growth of ash tree leaves should be considered as a special adaptation to moose browsing. This is supported by the correlation of moose–damaged phytomass of shoots and leaves (Table 2).

DISCUSSION

From the data given in Table 2, we can conclude that leaves are damaged more often than shoots. Thus, large complex pinnate leaves of the ash tree create a definite "screen", protecting young shoots from damage by moose. This leads to the

Table 1. The total length of ash tree shoots from browsed and protected trees in a volume of 3,375 cm^3.

	Length of ash–tree shoots (cm)	
	Browsed trees	Protected trees
Living shoots	36.2 ± 2.3	24.4 ± 2.6
Dead shoots	7.0 ± 2.0	0.0

Table 2. Damage to ash tree leaves and shoots by moose in 1983–1987 (average per year, %).

	1983	1984	1985	1986	1987	Average
Shoots	17.3 ± 5.4	21.5 ± 8.3	9.7 ± 4.9	7.4 ± 5.2	7.3 ± 2.5	12.6
Leaves	—	23.9 ± 2.9	43.1 ± 10.9	11.4 ± 3.9	6.0 ± 2.1	21.2

preservation of some accessible shoots and limits phytomass removal. Nevertheless, steady moose browsing pressure does not allow ash trees to grow normally. That is why the height–growth of ash trees located where moose are excluded outstrips that of stems exposed to moose browsing. Thus, during the period of monitoring, ash trees protected from browsing reached 12–15 m in height and 15 cm in diameter, and successfully reached the first woody canopy layer. But though such sizes do not allow moose to reach ash tree shoots, this does not protect them against moose damage. Ash tree bark is very attractive forage for moose. But under our conditions, where constant moose pressure occurs, not only was the forage base decreased, but planted ash and oak seedlings were killed, leading to the overgrowing of harvested plots with tree species that are not subjected to browsing by moose (linden, hazel [*Corylus* sp.]). In addition to this, during winter, moose frequently used plots occupied by apple plantings, and the decrease of these plots played a definite part in increasing damage to ash and oak. According to our data, during the winter in the apple orchards, moose ate shoots 30 times more and bark 12 times more than in the forest per 100 m of daily movement. Thus, during the winter–spring period of 1988–1989, moose began to use the bark of large ash trees, 25–30 cm in diameter, situated within large forest tracts. The bark gnawing often girdles large trees and leads to their death. To study the size, degree, and pattern of damage to tree trunks by moose, 6 plots (10 x 10 m) separated by 50 m were established on the harvested site of oak forest covered with young bushes. We examined 903 tree trunks, including 141 ash (Table 3).

Bark gnawing was noted on ash, oak, elm, and common maple. Linden, hazel, and

Table 3. Damage to the bark of ash trees by moose.

Plot	Number of ash trees	Damaged trees (%)	Average area of fresh gnawings / tree (cm^2)	Average area of old gnawings / tree (cm^2)	Average weight of fresh gnawings / tree (g)
1	20	66.1	441.5	254.9	51.0
2	43	58.1	25.7	86.3	17.3
3	26	96.2	526.1	429.0	85.8
4	14	100.0	354.2	244.0	48.8
5	35	80.0	809.6	319.5	63.9
6	3	100.0	0.0	121.0	24.2

Norway maple were not damaged. However, ash was most often damaged. To determine the area of gnawing, the size and the location of gnawing on the trunk was established, and the age of the damage was determined if possible: fresh (last year) or old. The average diameter of damaged ash trees was insignificantly larger than the undamaged ones. Considering that the area of the bark on the tree accessible to moose was situated at the height of 0.5–2.5 m, the consumption of bark by moose reached 1.7% of the total area of available bark of ash trees or 2.0% of the area of the bark of damaged ash trees. The average area of bark removed per tree during 1988–1989 was 1.4–fold higher than for the previous period. This relates to the increased moose impact on the vegetation. Thus, the kind and level of damage to ash by moose (the percentage of phytomass of shoots and bark removed compared to other species) is complicated and changes as the forest community develops.

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