Pre-winter Diet Composition of Red Deer (*Cervus elaphus* L.) in Estonia

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Ligi, K. and Randveer, T. 2012. Pre-winter Diet Composition of Red Deer (*Cervus elaphus* L.) in Estonia. *Baltic Forestry* 18(1): 150–155.

Abstract

The present study was carried out on three different red deer (*Cervus elaphus* L.) local populations in Estonia, located on the islands of Saaremaa and Hiiumaa and in Southern Estonia. The diet composition of red deer was studied from September to the end of November by analysing rumen contents of 141 animals, culled during the hunting seasons from 2004 – 2009. Grasses and forbs formed the main component of red deer diet throughout the period, comprising on average 81% of the volume. The dietary diversity was higher in September and November, when red deer consumed more shoots from deciduous trees, fruits, lichen, crops and dwarf shrubs, and lower in October when red deer consumed mainly grasses. Conifers are less frequently used as a food source than deciduous trees. The results of the study show that red deer browsing in pre-winter period has no significant effect on silviculture because the main tree species in red deer diet are not economically significant. However, the situation may change in late winter, when, due to the limited availability of grasses, the percentage of woody plants in the red deer diet probably increases.

Key words: red deer, *Cervus elaphus*, diet composition, rumen content

Introduction

The abundance of large herbivores is a major driver of forest ecosystem structure and function. The best-known effects of high densities of herbivores are the altered structure and composition of woodlands, which may change the successional development (Maeji et al. 1999, Gill and Beardall 2001, Cōté et al. 2004, Tremblay et al. 2007). The composition can be altered by directly damaging seedling by browsing and by reducing seedling growth, thus impairing the regeneration process, or by the creation of competitive advantage for species that are tolerant of or resistant to browsing (Hortsley et al. 2003). Browsing by white-tailed deer (*Odocoileus virginianus* Zimm.) has been identified as the principal cause in the conversion of eastern hemlock (*Tsuga canadensis* L.) dominated forest toward sugar maple (*Acer saccharum* Marsh.) and mixed hardwood forest (Alverson and Waller 1997). Moose (*Alces alces* L.) is also able to accelerate the succession of pine-dominated forest toward spruce-dominated forest, and in the taiga, can reduce the annual height increment of young pines by 50%, thus giving a competitive edge to spruces (Кузнецов 1983).

Red deer (*Cervus elaphus* L.) consume plant species of both high and low nutritional value and are able to digest plants with high crude fibre content (Hofmann 1989). Mátrai and Kabai (1989) have shown that in Hungary, in areas where food is abundant, broad-leaved trees and forbs dominate in red deer diet during the vegetation period. In early spring and late autumn the proportion of grasses increases; in winter, their content remains high. The proportion of grasses in the diet increases in early spring and late autumn and the usage of grasses remains high throughout the winter. However, in areas where food supply is limited, grasses dominate in the red deer diet over the year. If conifers are present, needles can form more than one third of the diet volume during winter (Mátrai and Kabai 1989). In areas where fields are close to forest, crops can form a very important part of the diet of red deer (Jensen 1968, Lochman 1985).

Red deer is a newcomer in Estonian fauna, with its distribution and numbers increasing (Randveer and Niittee 2003). Red deer can cause significant forest damage in areas where they congregate with high density (Ueckermann 1987, Pépin et al. 2006), which is a cause of concern to Estonian foresters. However, the diet composition of Estonian red deer has not been studied yet. The aims of the presented study were (1) to present data on the composition of the pre-winter diet of red deer in Estonia, (2) to determine the main

components of the red deer diet, and (3) to assess the potential impact of red deer on silviculture during the study period based on rumen content analysis.

Material and methods

Study area

The study was conducted on the western islands and southern part of Estonia. The climate is midway between maritime and continental (mean September and mean November temperatures are 11.2 and 3.5 ŚC respectively). Forest covers approximately 50% of the study area; the remaining land includes agricultural landscape, bogs, inland water bodies and settlements. The forest is mainly comprised of Scots pine (*Pinus silvestris* L.), silver birch (*Betula pendula* Roth.) and Norway spruce (*Picea abies* Karst.). The shrub layer contains mainly buckthorn (*Frangula alnus* L.), common juniper (*Juniperus communis* L.) and different species of willow (*Salix* sp.).

Rumen content analysis

Rumen content analysis is a widely used method for studying the diet of wild animals (e.g. Picard et al. 1991, Latham et al. 1999, Yokoyama et al. 2000, Borkowski and Obidziński 2003). Rumen content analysis has considerably less pronounced differential digestibility and degradation of food objects comparing to faeces analysis (Gebert and Verheyden-Tixier 2001) and both methods differ quantitatively (Homolka and Heroldová 1992, Chapuis et al. 2001). The drawback of rumen content analysis is that it is difficult to associate the data collected from rumen content analysis with different habitats (Cornelis et al. 1999). That is the reason why habitats have not been specified in this study.

The rumen samples from 141 culled red deer were collected during the three months (September, October and November) of hunting seasons from 2004–2009. Approximately one litre of rumen contents was collected for each sample. The samples were washed through 5 mm and 1 mm sieves. The fractions belonging to different food groups that were retained on both sieves were manually segregated. In the course of the analysis the volume of each food group in a sample was measured, so it was possible to establish the quantitative composition of the red deer diet. Individual components in samples were classified as accurately as possible (species, family or genus level). If accurate classification was not possible, items were divided into main feeding groups such as deciduous trees or grasses. The samples were grouped into one-month periods, to describe the diet composition change.

Statistical analysis

For statistical analysis and testing of potential differences in the diet composition between months, the food components were divided into six categories: deciduous trees; conifers; grasses and forbs; shrubs; fruits and grains; others. The group "others" consists of many different components like ferns, lichen, mushrooms and some unidentified items that were pooled together due to their low volume in the rumen samples. Normality of the variables was checked by Lillefors and Shapiro-Wilk tests. One-Way ANOVA (Fishers least significant difference Post-Hoc Test) was used to assess the possible differences in diet composition between months and "month" was used as a factor in the ANOVA analysis. The average volume (%v) is the mean of the volumes obtained from the rumen sample analysis. The frequency of different food groups (%f = 100 x n / N where n is the number of samples where the group was present and N is the total number of samples) was calculated according to Obrtel and Holišová (1974). The software STATISTICA 8.0 (StatSoft Inc.) was used and the level of significance α=0.05 was accepted in all cases.

Results

The diet compositions of red deer did not differ significantly between years (ANOVA, $p>0.05$ all comparisons); consequently samples were grouped together for further analysis.

The most important group in the red deer diet during the period under study was grasses and forbs with the mean volume of 81%, and this group was also the most frequently used food group (Table 1). The volume of grasses and forbs did not change significantly between the months ($p>0.05$, Figure 1-A).

In the diet of red deer, the second important group was twigs and leaves of deciduous trees comprising on the average 9% of volume. The consumption of this group by red deer changes significantly during the period ($p=0.027$). The volume of deciduous trees in rumen samples in September was significant-

Table 1. Components in red deer diet (%v – percentage of volume, %f – relative frequency)

ITEMS	September (N=60)		October (N=37)		November (N=44)	
	%v	%f	%v	%f	%v	%f
Grasses and forbs	76.5	94.0	85.7	80.6	79.9	100.0
Deciduous trees	13.1	65.7	5.6	30.6	5.5	38.1
Conifers	1.6	7.5	0.2	8.3	1.0	11.9
Dwarf shrubs	0.3	7.5	1.5	16.7	10.4	52.4
Fruits and grains	4.1	13.4	2.9	13.9	2.0	19.0
Others	4.3	16.4	4.2	22.2	1.3	19.0

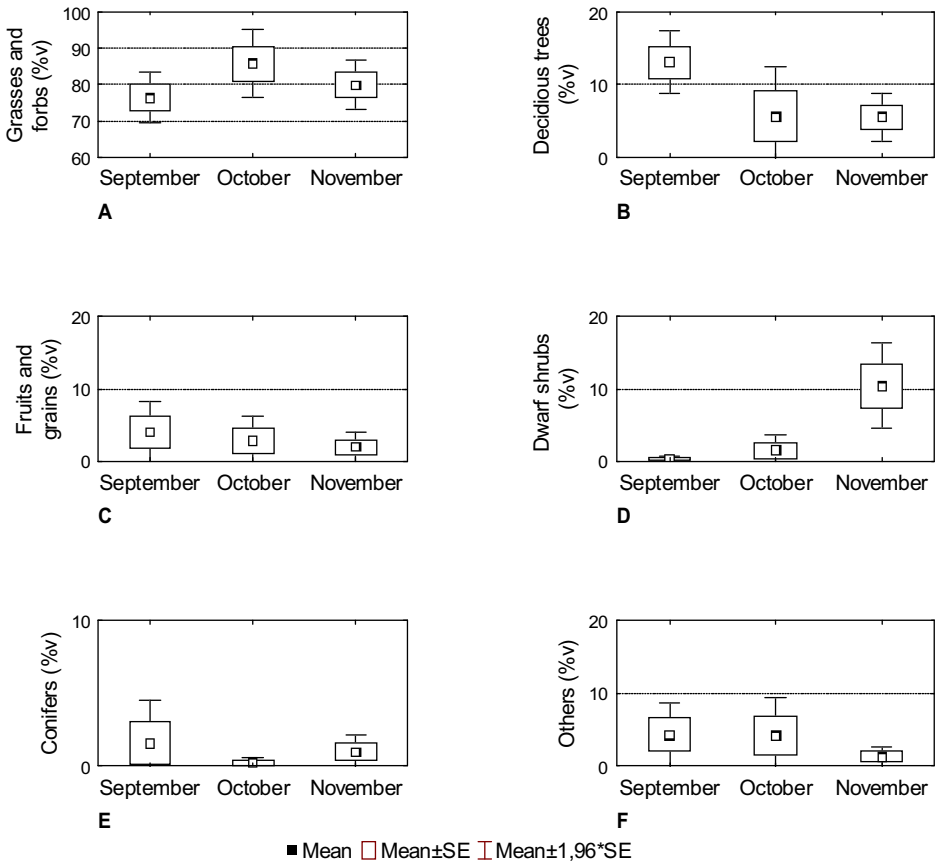

Figure 1. The volume (%v) of six feeding categories in red deer diet (boxes indicate standard error and bars indicate 95% confidence interval)

ly higher than in October and November (p=0.042 and p=0.019 respectively). No significant difference occurred between October and November (Figure 1-B). Although this group had a smaller proportion in the diet than grasses and forbs the frequency of deciduous trees in the samples was relatively high, being the highest in September. The fragments, that were identified, belong to the following species: buckthorn (*Frangula alnus* Mill.), silver birch (*Betula pendula* Roth.), aspen (*Populus tremula* L.), oak (*Quercus robur* L.) and different willow species (*Salix* sp.).

The volume of fruits and grains was low in comparison with the two main components with the average volume of 3%. The volume of this group showed a declining trend toward the winter, but the differences were not significant (p>0.05) (Figure 1-C). The frequency revealed a different trend, increasing toward winter. Main components in this food group were apples from orchards and wild apple trees.

The average volume of dwarf shrubs in rumen samples was 4.2% of overall volume, but there was a significant variance (p>0.001) in the usage depending on the month (Figure 1-D). There was no significant difference between September and October, but November differed significantly from September (p>0.001) and October (p>0.001). The frequency showed a similar trend to that of volume, increasing from September to November. The main species used as a food source in this group were heather (*Calluna vulgaris* L.), bilberry (*Vaccinum myrtyllus* L.) and lingonberry (*Vaccinum vitis-idaea* L.).

The group "Others" had an average volume of 3.3% in red deer rumen samples and there was no significant difference between months (p>0.05) (Figure 1-E). The frequency of this group in rumen samples was relatively high (average frequency 19.2%) considering the low volume.

Conifers were little used as a food source by red deer with the average volume of 0.9%. The usage of conifers did not change significantly (p=0.780) between months (Figure 1-F). The frequency of conifers in the samples has shown a slight increase towards the winter, but despite being more frequent the volumes in rumen samples did not increase as the frequency did. Only two species of conifers were identified from the rumen samples: common juniper (*Juniperus communis* L.) and Scots pine (*Pinus silvestris* L.). Of the two species, juniper was more frequently used and, in the case of Scots pine, only needles were present in the samples.

Discussion and conclusions

The pre-winter diet composition of red deer in Estonia was characterized by a high share of grasses and forbs. Based on the data obtained by the rumen content analysis we presume that despite the availability of browse, red deer tends to prefer grasses and forbs as the main component in its diet. Compared to studies conducted in the Czech Republic (Lochman 1985, Prokešová 2004), the red deer in Estonia seemed to consume more grasses and fewer woody plants during the autumn. However, the red deer diet in Estonia is similar to the red deer diets in Scottish forests (Latham et al. 1999) where browse is not the main food source. In Poland, the diet composition of red deer consists of the same components with the same priority rating but the volume distribution is different (Dzięciołowski (1967, 1970); grasses and forbs make up only 37% of volume there, whereas in Estonia red deer consumes twice as many grasses and forbs with lesser consumption of deciduous browse and dwarf shrubs.

Presumably the dominance of grasses in the diet could be explained by the low abundance of woody plants available for browsing, in which case grasses are preferred, making up 50-90% of the diet volume (Heroldová 1993, Latham et al. 1999). Differences in hunting pressure may also explain the differences in usage of grasses. It has been noted that, during the hunting season, roe deer tend to avoid open areas (Benhaiem et al. 2008); the same behaviour may also occur in red deer, so that in areas with high hunting pressure red deer tend to spend more time in forested areas.

Changes in the usage of browse of deciduous trees can be explained by the quality of food. During September the leaves are still nutritious and are preferred as a food source, while in October trees shed their leaves and grasses become even more prevalent in the diet. In November the availability of grasses declines and the usage of deciduous browse increases. Roughly the same reasons cause the increase in the consumption of shrubs during November. This explanation is supported by Hofmann's (1985) classification, according to which red deer is classified as an intermediate feeder. Intermediate feeders are characterised as animals which "choose a mixed diet but avoid fibre as long and as much as possible. When forage plants lignify these animals switch to browse or falling fruit and seeds" (Hofmann 1989). The same behaviour has also been observed in moose in Estonia (Tõnisson and Mardiste 1996), with the difference that moose replaces deciduous trees with conifers when red deer starts to use more dwarf-shrubs.

The dynamics in the usage of fruits and grains can be explained by the availability of these food objects. When fruits (especially apples) and grains are abundant in early autumn they are used as a food source until the abundance declines towards winter.

This study suggests that red deer has no significant impact on silviculture in Estonia during the months under study, as different tree species form only a small percentage of the red deer diet and only a few of the identified woody plant species are economically significant (silver birch and Scots pine). Furthermore, most of the forest damage is caused by moose, which use greater amounts of woody plants (especially Scots pine) than red deer. A study conducted by Tõnisson and Mardiste (1996) has showed that the diet of moose in autumn consists mainly of deciduous and coniferous browse (80–90% of diet). Also, the consumption of conifers was already substantially high in October (up to 10% of the diet) and increased further in November (up to 24% of the diet) (Tõnisson and Mardiste 1996). The problem of forest damage may arise when the population density of red deer rises significantly, in which case they may have a negative impact on forest regeneration. Studies show that in lowland Britain regeneration of forest is most likely to be inadequate at deer densities above 14 deer km^{-2} (Gill and Morgan 2010). However, the current population densities of red deer in Estonia are substantially lower, being approximately 0.1–5 deer km^{-2} (Randveer et al. 2009). Due to the limited observation period, generalized conclusions about the year-round diet composition and impact on forest regeneration cannot be made. More damage to forest by red deer is probably caused in the winter when the proportion of woody plants in their diet, especially conifers, may rise because of the snow cover which limits the availability of grasses, forbs and shrubs. This assumption is supported by studies conducted on roe deer in Finland (Helle 1980) and Scotland (Latham et al. 1999) as well as studies about red deer browsing on Scots pine seedlings in Scotland, where the results showed that browsing incidences increased in winter (Palmer and Truscott 2003). Unfortunately, collecting rumen samples in winter is difficult because the hunting season ends in January; consequently, the season with probably the highest proportion of woody plants in diets of red deer cannot be included in rumen sample studies.

References

Alverson, W.S. and Waller, D.M. 1997. Deer populations and the widespread failure of hemlock regeneration in northern forests. In: W. J. McShea, H. B. Underwood and J. H. Rappole (Editors), The Science of Overabundance: Deer Ecology and Population Management. Washington DC, p. 280–297.

Barančeková, M. 2004. The roe deer diet: Is floodplain forest optimal habitat? *Folia Zoologica* 53: 285–292.

Benhaiem, S., Delon, M., Lourtet, B., Cargnelutti, B., Aulagnier, S., Hewison, M.A.J., Morellet, N. and Verheyden, H. 2008. Hunting increases vigilance levels in roe deer and modifies feeding site selection. *Animal Behaviour* 76: 611–618.

Borowski, J. and Obidziński, A. 2003. The composition of the autumn and winter diets in two Polish populations of fallow deer. *Acta Theriologica* 48 (4): 539–546.

Chapuis, J-L., Boussés, P., Pisanu, B. And Réale, D. 2001. Comparative ruman and fecal diet microhistological determinations of European mouflon. *Journal of Range Management* 54: 239–243.

Cornelis, J., Caesar, J. and Hermy, M. 1999. Impact of season, habitat and research techniques on diet composition of roe deer (*Capreolus capreolus*): a review. *Journal of Zoology* 248: 195–207.

Cōté, S.D., Rooney, T.P., Tremblay, J.-P., Dussault, C. and Waller, D.M. 2004. Ecological impacts of deer overabundance. *The Annual Review of Ecology, Evolution and Systematics* 35: 113–147.

Dzięciołowski, R. 1967. Food of the red deer in an annual cycle. *Acta Theriologica* 12(36): 503–520.

Dzięciołowski, R. 1970. Foods of the red deer as determined by rumen content analyses. *Acta Theriologica* 15(6): 89–110.

Gill, R.M.A. and Beardall, V. 2001. The impact of deer on woodlands: the effects of browsing and seed dispersal on vegetation structure and composition. *Forestry* 74: 209–218.

Gill, R.M.A. and Morgan, G. 2010. The effects of varying deer density on natural regeneration in woodlands in lowland Britain. *Forestry* 83 (1): 53–63.

Gebert, C. and Verheyden-Tixier, H. 2001. Variations of diet composition of Red Deer (*Cervus elaphus* L.) in Europe. *Mammal Review* 31 (3): 189–201.

Helle, P. 1980. Food composition and feeding habits of the roe deer in winter in Central Finland. *Acta Theriologica* 25: 395–402.

Heroldová, M. 1993. The food of red deer (*Cervus elaphus*) in a part of the Krušné hory Mountains affected by emission. *Folia Zoologica* 42: 381–382.

Hofmann, R.R. 1985. Digestive physiology of the Deer – their morphophysiological specialisation and adaptation. *The Royal Society of New Zealand Bulletin* 22: 393–407.

Hofmann, R.R. 1989. Evolutionary steps of ecophysical adaptation and diversification of ruminants: a comparative view of their digestive system. *Oecologica* 78 (4): 443–457.

Homolka, M. and Heroldová, M. 1992. Similarity of the results of stomach and faecal contents analyses in studies of the ungulate diet. *Folia Zoologica* 41: 193–208.

Horsley, S.B., Stout, S.L. and deCalesta, D.S. 2003. White-tailed deer impact on the vegetation dynamics of a northern hardwood forest. *Ecological Applications* 13 (1): 98–118.

Jensen, P. 1968. Food selection of the Danish red deer (*Cervus elaphus*) as determined by examination of the rumen content. *Danish Review of Game Biology* 5: 1–44.

Latham, J., Staines, B.W. and Gorman, M.L. 1999. Comparative feeding ecology of red (*Cervus elaphus*) and roe deer (*Capreolus capreolus*) in Scottish plantation forests. *Journal of Zoology* 247: 409–418.

Lochman, J. 1985. Jelení zver [Red deer]. SZN, Praha (In Czech).

Maeji, I., Yokoyama, S. and Shibata, E. 1999. Population density and range use of sĕř a deer, *Cervus nippon*, on Mt. Ohdaigahara, central Japan. *Journal of Forest Research* 4: 235–239.

Mátrai, K. and Kabai, P. 1989. Winter plant selection by red and roe deer in a forest habitat in Hungary. *Acta Theriologica* 34: 227–234.

Obrtel, R. and Holišová, V. 1974. Trophic niches of *Apodemus flavicollis* and *Clethrionomus glareolus* in a lowland forest. *Acta Scientiarum Naturalium* 8 (7): 1–37.

Palmer, S.C.F. and Truscott, A.-M. 2003. Browsing by deer on naturally regenerating Scots pine (*Pinus sylvestris* L.) and its effects on sapling growth. *Forest Ecology and Management* 182: 31–47

Pépin, D., Renaud, P.-C., Boscardin, Y., Goulard, M., Mallet, C., Anglard, F. and Ballon, P. 2006. Relative impact of browsing by red deer on mixed coniferus and broad-leaved seedlings– An enclosure-based experiment. *Forest Ecology and Management* 222 (1-2): 302-313.

Picard, J.F., Oleffe, P. and Boisaubert, B. 1991. Influence of oak mast on feeding behaviour of red deer (*Cervus elaphus* L.). *Annals of Forest Science* 48: 547–559.

Prokešová, J. 2004. Red deer in the floodplain forest: the browse specialist? *Folia Zoologica* 53: 293–302.

Randveer, T. and Niittee, E. 2003. Red deer as a newcomer in Estonian Fauna. Should we hinder the spreading of the species? Dynamics of game animal populations in northern Europe. Proceedings of the 3rd International Symposium, 2002: 140–144.

Randveer, T., Tõnisson, J. and Mardiste, M. 2009. Sõralised 2008. a. aruanne [Ungulates 2008 report]. Tartu, 41 pp. (In Estonian).

Tremblay, J.P., Huot, J. and Potvin, F. 2007. Density related effects of deer browsing on the regeneration dynamics of boreal forests. *Journal of Applied Ecology* 44: 522–562.

Tõnisson, J. and Mardiste, M. 1996. About the pre-winter nutrition of moose. *Forestry Studies* 28: 155–164.

Ueckermann, E. 1987. Managing German red deer (*Cervus elaphus* L.) populations. In: C.M. Wemmer (Editor), Biology and Management of the Cervidae. Washington D.C. p. 505-516.

Yokoyama, M., Kaji, K., and Suzuki, M. 2000. Food habits of Sika deer and nutritional value of Sika deer diets in eastern Hokkaido, Japan. *Ecological Research* 15: 345–355.

Кузнецов, Г.В. 1983. Влияние лося на лесную растительность вюжной тайге [Influence of the moose on forest vegetation in the southern taiga]. Бюл. Моск. О-ВА Испытателей Природы. ОТД. Биол., 88: 28–35 (In Russian).

Received 04 March 2011
Accepted 18 May 2012

СОСТАВ ПРЕДЗИМНЕГО РАЦИОНА БЛАГОРОДНОГО ОЛЕНЯ (*CERVUS ELAPHUS* L.) В ЭСТОНИИ

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Резюме

Благородный олень – вид относительно новый в фауне Эстонии. Исследования, проведенные в других регионах ареала, показали, что благородный олень может играть существенную роль в причинении повреждений лесу. Цель настоящего исследования – сбор информации о питании оленей в природных условиях Эстонии и оценка влияния вида на лесное хозяйство. Для этого изучили состав содержимого желудков 141 особи, отстрелянной в осенний период (с сентября по ноябрь). Пробы содержимого желудков проанализировали методом промывания через сита, при этом оценили частоту встречаемости и среднюю долю/процентное содержание найденных компонентов питания (травянистые растения, кустарнички, лиственные деревья, хвойные деревья, плоды и прочее).

Главным объектом питания в течение всего периода были травянистые растения (со средним объемом 81%), на втором месте находились лиственные деревья (9%). Доля лиственных деревьев была больше в сентябре, из видов преобладали крушина, береза и ивы. Доля растений кустарничкового яруса в питании составляла в исследованный период в среднем 4,2%, и в разрезе трех месяцев отмечался тренд роста. Доля плодов, из которых существенную часть составляли яблоки, составляла в среднем 3%, и яблоки употреблялись больше в сентябре, когда их доступность была хорошей. Доля хвойных деревьев в содержимом желудков была очень низкой (в среднем 0,9% от объема), хотя частота встречаемости была относительно высокой (встречались в 8–11% содержимого желудков). Основным видом был можжевельник, не представляющий особого хозяйственного интереса. Доля группы «прочие объекты питания» (лишайники, грибы и т. д.) в содержимом желудков была в сентябре и октябре одинаковой (около 4%) и упала в ноябре (1%).

В питании благородного оленя в Эстонии были обнаружены сходные черты с питанием оленей в Шотландии (большая доля травянистых растений) и различия в сравнении с популяциями материковой части Европы (низкое употребление лиственных и хвойных деревьев). Исходя из полученных в ходе настоящего исследования данных, можно утверждать, что по крайней мере в осенний период роль оленей в причинении повреждений лесу незначительная. Однако ситуация может измениться поздней зимой, когда из-за недоступности травянистых растений употребление древесных растений в пищу, вероятно, возрастет.

Ключевые слова: олень, питание, содержимое желудка