SYLWAN 168 (4): 287-295, April 2024
https://doi.org/10.26202/sylwan.2023115
Journal homepage: https://sylwan-journal.pl

ORIGINAL PAPER

Number, density and sex-age of the moose *Alces alces* population in north-eastern Poland after 20 years of hunting ban

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ABSTRACT

The moose hunting ban in Poland resulted in a dramatic growth in population number which is now the cause of major damage to forests and farmlands and numerous traffic accidents. The lack of well-documented data pertaining to moose numbers constitutes the prime barrier to reopening the hunting season. In February 2020, the population density and number of moose were estimated in the Augustów Forest, a large (1102.0 km^2) forest complex in north-eastern Poland. Observations made by a 30-person research team recorded moose numbers in 20 sampling plots on 91.5 km^2 of the total area. The average population density amounted to 1.22 ±0.19 moose/km^2 ($\bar{X}$ ±SE), indicating that 1344 animals were living in the study area. In autumn, among 609 adults, the sex ratio was 1:1.17 in favour of females and the number of calves per 100 females was estimated as 71.3 individuals. In the 2001-2020 period, the number of moose in the study area increased from 211 to 1344 individuals. The annual finite population increase rate (λ) estimated on this basis for the subsequent time intervals (Nt, Nt+1) attained the value of 1.102 of the initial number, *i.e.* 10.2% per year. Reasons of low annual increase in population numbers are discussed.

KEY WORDS

field observations, moose, Poland, population density, sampling plots, sex-age structure

Introduction

In Poland the hunting of moose was suspended in 2001 as the population size and harvest rate had been overstated by hunters and this had led to a dramatic drop in moose numbers. Therefore in order to stem the further depopulation of the species the Ministry of the Environment decided to introduce an indefinite moratorium on moose harvesting which continues today (Raczyński and Ratkiewicz, 2011).

Introduction the moratorium on moose hunting resulted in a dramatic increase in the population numbers. According to Bobek *et al.* (2021), the number of moose in Poland in 2020 was estimated as 60.9 ±11.9 thousand animals (*i.e.*, 95% confidence intervals). The high densities occurring locally have resulted in significant damage to forest stands and farmlands (Wawrzyniak,

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Received: 19 December 2023; Revised: 23 April 2024; Accepted: 24 April 2024; Available online: 12 June 2024

2016) and caused numerous road accidents (Jasińska *et al.*, 2019; Tajchman *et al.*, 2019). The conflicts have resulted in increasing calls to resume moose harvest, however data on population abundance and demography are required to evaluate the advisability of this management decision.

In the years 1998-2001 in the Augustów Forest number of moose was estimated using snow tracking census on line transects and the results were applied to the harvest management of the population. In this study area, the moose sex-ratio and autumn recruitment rate were determined by direct observations (Bobek *et al.*, 2005).

Therefore, the main objective of the present study was to estimate sex-age structure and moose numbers observed in large sampling plots in the Augustów Forest during 2018-2020 period and compare the results obtained with the corresponding data collected there in the years 1998-2001.

Material and methods

STUDY AREA. The study area was located in north-eastern Poland, adjacent to the state borders with Lithuania and Belarus, and covered a forested area of 1102.0 km^2 called the Augustów Forest (Fig. 1). According to the local Polish State Forests Holding, the principal forest habitat types in the Augustów Forest are mesic coniferous and mesic mixed coniferous forest types (Table 1), with Scots pine *Pinus sylvestris* L. predominating in the species composition of forest stands. In the forested area, the percentage area of young forest plantations and thickets aged 20 years and below, as well as the oldest tree stands aged more than 100 years, amounted to 9.3 and 2.2%, respectively.

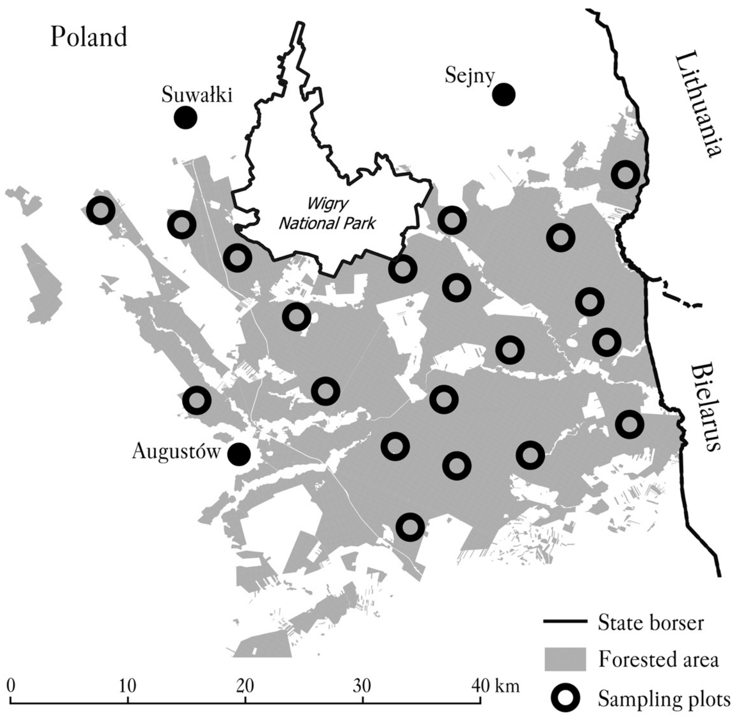

Fig. 1.
Location of the study area. The figure presents the distribution of forested areas and sampling plots used for estimating the moose population numbers in Augustów Forest, northeastern Poland

Table 1.
The area [km^2] and the percentage of the forest types in the Augustów Forest, north-eastern Poland and in sampling plots

Forest types	Augustów Forest		Sampling plots	
	[km^2]	[%]	[km^2]	[%]
Mesic coniferous and mixed coniferous	716.3	65.0	62.6	68.4
Mesic deciduous and mixed deciduous	76.0	6.9	4.9	5.4
Hygric – wet coniferous and mixed coniferous	142.1	12.9	14.1	15.4
Hygric – wet deciduous and mixed deciduous	167.5	15.2	9.9	10.8
Total	1 101.9	100.0	91.5	100.0

Apart from moose, the hunting of which was suspended in 2001, the hunting management of wild ungulates in the area includes red deer *Cervus elaphus* L., roe deer *Capreolus capreolus* L., and wild boar *Sus scrofa* L. Also present are protected species of European bison *Bison bonasus* (L.) and wolves *Canis lupus* L.

In the years following the suspension of moose hunting, the number of moose increased in the Augustów Forest and this caused more damage to both young forest plantations and thickets that were less than 20 years old. To mitigate moose damage following the 2001 hunting memorandum, the State Forests service installed fence enclosures surrounding the youngest forest. According to the local forest districts data, 67.1% of the area occupied by young forest plantations and thickets is now fenced (Bobek *et al.*, 2021). The annual cost of the forest fencing amounts to 227 thousand Euro (Regional Directorate of State Forests in Białystok, unpublished data).

Population census and sex-age structure. Moose numbers in the Augustów Forest were studied by applying a method called the block count technique (Maruyama and Furubayashi, 1983; Bobek and Płaksej, 2020; Bobek *et al.*, 2021). The field work was performed in February of 2020, using direct observations of animals on 20 uniformly arranged sampling plots, covering a total area of 91.5 km^2 (Fig. 1). The areas of sampling plots ranged from 4.43 to 5.59 km^2. Each such plot contained 20 forest compartments identified by unique numbers used by the State Forest Service during forest management practices. The area of forest compartments ranged from 22.1-27.9 hectares. The forest compartments were separated from one another by cleared strips that were several-metres wide and provided good visibility. This determined the limits of forest compartments for those people conducting moose observations. As far as was feasible, attempts were made for sampling plots to be more or less square or circular in shape. Snow cover was not present during the moose population census.

The observations of moose were conducted by a team of 30 people which comprised of employees of the State Forests service, private forest service companies (in Polish: ZUL), hunters from local hunting clubs, and the authors of the presented study. Such a research team was then divided into a group of 20 mobile observers and a group of 10 stationary observers. The first stage involved distributing stationary observers along the perimeter of the sampling plot and marking the site for making observations on the basis of the identification number of the forest compartment. Then, the mobile observers entered the sampling plot and each of them took a position in one forest compartment in line with the identification number of the given compartment. The task of each mobile observer was to penetrate 4 times the assigned compartment for two hours following in 'zig-zag' line pattern and record the number and time of the observed moose, which were divided into solitary individuals and groups of animals. The age of the observed moose was distinguished (calves, adults) and, whenever possible, the sex of adults was also determined.

The above information was also collected by stationary observers for those animals which left the sampling plot during the first hour of observation. In the second hour of observation, the stationary observers joined the mobile observers, penetrating the assigned compartments located on the perimeter of the sampling plots. During the two hours, the observers thoroughly penetrated all forest habitat types and tree stand age classes occurring in the forest compartment.

All results pertaining to the observed animals were then plotted on to a single map which contained the limits and identification numbers of 20 forest compartments. Time-space analysis was used to learn about the number of moose that inhabited the sampling plot. If multiple observations of animals with identical demographic variables (sex, number and the equal composition of the group) were available it was only one such observation that was included in the balance of moose numbers.

In September and October of 2019 and 2020 the sex-age structures of the moose were studied. In observations, adult bulls, cows and calves were distinguished. The autumn recruitment rate, representing the number of calves per 100 cows, was calculated. Each observation concerning the sex-age structure contained the number of forest compartment where it was made and a date. If groups of animals showing the same sex-age structure were observed multiple times during a one-week span in a given forest compartment, only one observation was included in the sum-up. A similar rule was applied to single males and females.

Population increase rate. In the Augustów Forest, using the population numbers in 2001 (Bobek *et al.*, 2005) and in 2020 (this study), the finite rate of population increase (λ) was calculated (Caughley, 1977). The following formula was applied:

$$\lambda = (N_t / N_0)^{1/t} \tag{1}$$

where:

N_0, N_t – population numbers in 2001 and 2020 respectively,

't' – the number of years of increase (Van Ballenberghe and Ballard, 2007).

Results

Population numbers and densities. The percent of forest types in the area of the Augustów Forest and those in the sampling plots (Table 1) were not significantly different (χ^2=2.662, df=3, p=0.448). The number of moose observed in 20 sampling plots amounted to 133 individuals. Applying spatio-temporal analysis of moose distribution limited that number to 112. Moose were present in all sampling plots. Their numbers ranged from one to 14 individuals (0.21-3.40 animals/km^2). The average population densities so obtained 1.22 ±0.19 moose/km^2 ($\bar{x}$ ±SE) display the features of normal distribution (Kolmogorov-Smirnov test d=0.164, p>0.20; Lilliefors p<0.20). The 95% confidence interval for the mean density ranged within ±0.50 (±36.6% of the mean). The total population number estimated this way amounted to 1344 animals.

Sex and age structure. During fieldwork carried out in September and October of 2019 and 2020, 609 moose were observed in total, with males constituting 33.3% while the percentage share of females and calves was 38.9% and 27.8%, correspondingly. Among the observed adults, the sex ratio was 1:1.17 in favour of females and the autumn recruitment rate, *i.e.* the number of calves per 100 cows, was estimated at 71.3 individuals (Table 2). In 2020 the total number of moose in autumn observations represented about 22% of the population size.

Annual population increase rate. The suspension of moose hunting resulted in the increase of moose population numbers within the study area from 211 to 1344 individuals during the 2001-2020 period. The finite rate of population increase 'λ' (Caughley, 1977) amounted to 1.102. Therefore, the annual population increase estimated on this basis for the subsequent time intervals (N_t; N_{t+1}) attained the value 10.2% of the initial number. This result is three times lower than average annual population rate of increase (30.6%) calculated for Augustów Forest during 1998-2001 period (Bobek *et al.*, 2005).

Discussion

In many regions of Poland and in Sweden and Norway, the annual rate of population increase was also higher than in Augustów Forest and varied from 22.9 to 31.0% of the moose number before beginning of hunting season (Sæther *et al.*, 2007; Ueno *et al.*, 2014; Bobek *et al.*, 2021). It does seem that the above differences are caused by different reproduction and mortality patterns, because the population sex-age structure estimated in the study area in 1999-2000 and in 2019-2020 period (Table 2) was not significantly different (χ^2=0.2658; df=2; p=0.875). Predation by wolves does not seem to be a significant factor for the dynamic of moose population numbers as the high for the calf cow ratio (71.3 calves per 100 cows) suggest natural predators are not taking a lot of calves. Illegal moose harvesting (especially of calves) by poachers living in the study area cannot be excluded, however, given the strong presence of State Forests service staff in the woods, the influence of this factor on moose numbers seems marginal. Therefore, differences in the annual population increase between the 1999-2001 and 2001-2020 periods are likely to have been caused mainly by moose competition for food leading to the migration of these animals out of the study area or/and moose mortality in traffic collisions.

Regrettably, there is no summary data on the number of moose that die in traffic collisions annually in the Augustów Forest. There are only abundant media reports on traffic accidents that included human casualties and were caused by moose in the study area. In Podlaskie Voivodeship, where the Augustów Forest lies, traffic volume increased between 2000 and 2020 from 4.2 thousand to 8.1 thousand vehicles per day (Opoczyński, 2001; Zieliński *et al.*, 2021). It is thus highly probable that it resulted in a moose mortality growth, particularly because the study area is traversed by busy roads carrying transit traffic towards Polish-Lithuanian border crossings.

In the Augustów Forest, a potential forage base for moose depends on the season and the age class of tree stands. Published data from 12 lowland Polish forest types showed that the potential

Table 2.

The sex and age structure of moose observed in the Augustów Forest, north-eastern Poland in September and October. Data represents 1999-2000 period (Bobek *et al.*, 2005) and in the 2019-2020 period (this study)

Years 2019-2020	Bulls	Cows	Calves	Total
N	203	237	169	609
[%]	33.3	38.9	27.8	100.0
Years 1999-2000	Bulls	Cows	Calves	Total
N	72	94	61	227
[%]	31.7	41.4	26.9	100.0

moose forage in young forest plantations and thickets amounts to an average 261.4 g of dry mass/m^2 in the growing season, while shrinking to 93.3 g of dry mass/m^2 in winter. Due to forest fencing, the last value is the three times lower and amounts to 31.9 g of dry mass/m^2. In the timber stand, the potential moose forage base is considerably lower and limited to 47.9 g of dry mass/m^2 in summer and 22.8 g of dry mass/m^2 in winter (Dzięciołowski, 1969, 1970; Aulak, 1975; Tomek *et al*., 1976; Perzanowski *et al*., 1982; Bobek *et al*., 1994; Siuta, 2006).

Food intake by moose increases with growing quantities of available forage resources (Morow, 1976; Vivås and Sæther, 1987; Vivås *et al*., 1991; Shipley *et al*., 1998). For this reason the most attractive moose foraging areas in Augustów Forest are young plantations and thickets, though their access is strongly limited by forest fencing. In winter, since a high selectivity of moose towards the youngest age classes of forest stands was demonstrated in the study area. No such relation was found for 21-100 years old timber stands (Bobek *et al*., 2005). In winter, timber stands are not attractive sites for foraging moose because low food resources may generate high energy costs of foraging that are not covered by their daily food intake (Hjeljord *et al*., 1982; Renecker and Hudson, 1986; Schwartz *et al*., 1988a, b). In Augustów Forest 93.1% of moose diet in winter constitute annual twigs of Scots pine (Morow, 1976). Probably drastic decrease in availability of pine browse in young forest plantations and thickets resulted in food competition and early winter emigration of animals from the Augustów Forest to adjacent areas where population densities are perhaps lower. Therefore, the balance of population numbers as determined in February/March during 2001-2020 period did not reflect the real annual population increase.

Movement of moose are caused by spatio-temporal variation in resource availability such as food, thermal-hiding cover, habitat suitable for colonization, level of habitat patchiness and energetic cost of foraging (Cederlund *et al*.,1992; Borowik *et al*., 2020; Ball *et al*., 2001). Such a phenomenon occurred in Poland during 1965-1981, when the population expanded its range of occurrence as since the harvest of moose was lower than the net annual population increase (Tomek, 1977; Szukiel and Nasiadka, 1993).

Conclusions

The principal objective of moose management in Augustów Forest should be to stem the increase in population number as well as to limit the cost of forest fencing and the number of car accidents caused by these animals. In order to achieve this, it is necessary to reliably estimate moose population numbers using the block count method and learn the net annual population increase (NAP). It is impossible to determine the NAP value without conducting an autumn cull of moose as there is likelihood of their outward migration from the study area in late autumn and early winter. Therefore culling a known number of animals from a population whose size is estimated by inventory will allow not only to assess the increase in the population but, above all, to assess the accuracy of the inventory method itself. The estimation of the population size using the block count method and the knowledge of net annual population increase in moose will enable the population of this species in the Augustów Forest to be regulated. A reduction of moose density will decrease the cost of fencing in young forest plantations and thickets as well as lower the number car accidents caused by moose.

Authors' contributions

B.B. – conceptualization and methodology; D.M. – statistical analysis; B.B., J.F., D.M., M.W.-P. – writing-original text preparation.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Founding sources and acknowledgements

We thank all foresters, hunters and local moose managers for their help in population census and reporting of moose observations. We are also grateful to the General Directorate of State Forests in Warsaw and the Polish Wildlife Foundation for contributing financially to this study (grant number OR.271.3.21.2017).

References

Aulak, W., 1975. A comparison of the production of the ground flora and the rate of organic fall in two areas of the association *Circaeo-Alnetum* Oberd 1953 in Białowieża National Park. *Ekologia Polska*, 23: 65-81.

Ball, J.P., Nordengren, C., Wallin, K., 2001. Partial migration by large ungulates: Characteristics of seasonal moose *Alces alces* ranges in northern Sweden. *Wildlife Biology*, 7 (1): 39-47. DOI: https://doi.org/10.2981/wlb.2001.007.

Bobek, B., Perzanowski, K., Kossak, S., Merta, D., 1994. The system of managing wildlife and forest in central Europe. *The Forestry Chronicle*, 70 (5): 550-554. DOI: https://doi.org/10.5558/tfc70550-5.

Bobek, B., Merta, D., Sułkowski, P., Siuta, A., 2005. A moose recovery plan for Poland: Main objectives and tasks. *Alces*, 41: 129-138.

Bobek, B., Płaksej, A., eds. 2020. Gospodarka łowiecka na terenie Regionalnej Dyrekcji Lasów Państwowych we Wrocławiu: stan obecny – propozycje zmian. Kraków: Międzynarodowy Instytut Ekologii Sp. z o.o., 272 pp.

Bobek, B., Błaszczyk, J., Frąckowiak, W., Furtek, J., Morow, K., Wojciuch-Płoskonka, M., Wyrobek, K., 2021. Łoś, *Alces alces* – biologia, ochrona i gospodarka łowiecka. Kraków: Międzynarodowy Instytut Ekologii, 223 pp.

Borowik, T., Ratkiewicz, M., Maślanko, W., Duda, N., Kowalczyk, R., 2020. The level of habitat patchiness movement strategy of moose in eastern Poland. *PLOS ONE*, 15 (3): e0230521. DOI: https://doi.org/10.1371/journal.pone.0230521.

Caughley, G., 1977. Analysis of vertebrate population. New York: John Wiley and Sons., 234 pp.

Cederlund, G.N., Sand, H.K.G., 1992. Dispersal of subadult moose (*Alces alces*) in a nonmigratory population. *Canadian Journal of Zoology*, 70 (7): 1309-1314. DOI: https://doi.org/10.1139/z92-183.

Dzięciołowski, R., 1969. The quality, quantity and seasonal variation of food resources available to red deer in various environmental conditions of forest management. Warsaw: Forest Research Institute, 295 pp.

Dzięciołowski, R., 1970. Net primary production of herbaceous plants in four forest association. *Folia Forestalia Polonica, Series A – Forestry*, 16: 91-108.

Hjeljord, O., Sundstøl, F., Haagenrud, H., 1982. The nutritional value of browse to moose. *The Journal of Wildlife Management*, 46 (2): 333-343. DOI: https://doi.org/10.2307/3808644.

Jasińska, K., Krauze-Gryz, D., Werka, J., 2019. The comparison of roads and railways: Temporal patterns of ungulate-vehicle collisions in Poland. Abstracts 34th IUGB Congress, Sacramento, California, September 22-26, 2019, pp. 74-75. Available from: https://www.icoet.net/2019/program/presentations/302.

Maruyama, N., Furubayashi, K., 1983. Preliminary examination of block count method for estimating numbers of sika deer in Fudakake. *Journal of the Mammalogical Society of Japan*, 9 (6): 274-278.

Morow, K., 1976. Food habits of moose from Augustów Forest. *Acta Theriologica*, 21 (5): 101-116.

Opoczyński, K., 2001. Generalny pomiar ruchu 2000 – synteza wyników. Warszawa: Transprojekt – Warszawa Sp. z o.o., 11 pp.

Perzanowski, K., Pradel, A., Sikorski, D., Mydlarz, J., 1982. Food resources for deer in Niepołomicka Forest. *Acta Theriologica*, 27-36: 509-519.

Raczyński, J., Ratkiewicz, M., 2011. The functioning the moose population in Poland. *Annals of Warsaw University of Life Sciences – SGGW, Animal Science*, 50: 51-56.

Renecker, L.A., Hudson, R.J., 1986. Seasonal energy expenditure and thermoregulatory response of moose. *Canadian Journal of Zoology*, 64 (2): 322-327. DOI: https://doi.org/10.1139/z86-052.

Sæther, B.E., Engen, S., Solberg, E.J., Heim, M., 2007. Estimating the growth of a newly established moose population using reproductive value. *Ecography*, 30: 417-421. DOI: https://doi.org/10.1111/j.0906-7590.2007.05006.x.

Schwartz, C.C., Hubbert, M.E., Franzmann, A.W., 1988a. Energy requirements of adult moose for winter maintenance. *The Journal of Wildlife Management*, 52 (1): 26-33. DOI: https://doi.org/10.2307/3801052.

Schwartz, C.C., Regelin, W.L., Franzmann, A.W., 1988b. Estimates of digestibility of birch, willow, and aspen mixtures in moose. *The Journal of Wildlife Management*, 52 (1): 33-37. DOI: https://doi.org/10.2307/3801053.

Shipley, L.A., Blomquist, S., Danell, K., 1998. Diet choices made by free-ranging moose in northern Sweden in relation to plant distribution, chemistry, and morphology. *Canadian Journal of Zoology*, 76: 1722-1733. DOI: https://doi.org/10.1139/z98-110.

Siuta, A., 2006. Ocena potencjalnej bazy żerowej jelenia szlachetnego (*Cervus elaphus* L.) w Puszczy Rominckiej. [Assessment of the potential feed base for red deer (*Cervus elaphus* L.) in the Romincka Forest]. *Zeszyty Naukowe Akademii Rolniczej w Krakowie*, 313: 7-129.

Szukiel, E., Nasiadka, P., 1993. Dynamika liczebności zwierzyny kopytnej w południowej Polsce. *Sylwan*, 137 (6): 67-77.

Tajchman, K., Gawryluk, A., Drozd, L., Czyżowski, P., Karpiński, M., Goleman, M., 2017. Deer-vehicle collisions in Lubelskie Region in Poland. Safety Coefficients. *Applied Ecology and Environmental Research*, 15 (3): 1485--1498. DOI: http://dx.doi.org/10.15666/aeer/1503_14851498.

Tomek, A., 1977. The occurrence of some ecological parameters in the moose in Poland. *Acta Theriologica*, 22, 33: 485-507.

Tomek, A., Jamrozy, G., Kubacki, T., Tomek, Z., 1976. Standing crop and consumption of herbs plants in a fresh coniferous forest. *Ekologia Polska*, 24 (3): 377-389.

Ueno, M., Solberg, E.J., Iijima, H., Rolandsen, Ch.M., Gangsei, L.E., 2014. Performance of hunting statistics as spatiotemporal density indices of moose (*Alces alces*) in Norway. *Ecosphere*, 5 (2): 1-20. DOI: https://doi.org/10.1890/ES13-00083.1.

Van Ballenberghe, V., Ballard, W.B., 2007. Population dynamics. In: A.W. Franzmann, C.C. Schwartz, eds. *Ecology and management of the North American moose*. Washington: Smithsonian Institution Press, pp. 223-246.

Vivås, H.J., Sæther, B.E., 1987. Interactions between a generalist herbivore, the moose (*Alces alces*) and its food resources: An experimental study of winter foraging behavior in relation to browse availability. *Journal of Animal Ecology*, 56 (2): 509-520. DOI: https://doi.org/10.2307/5064.

Vivås, H.J., Sæther, B.E., Andersen, R., 1991. Optimal twig-size selection of a generalist herbivore, the moose *Alces alces*: Implications for plant-herbivore interactions. *Journal of Animal Ecology*, 60 (2): 395-408. DOI: https://doi.org/10.2307/5286.

Wawrzyniak, P., 2016. Dynamika liczebności, jej wpływ na środowisko bytowania, a konieczność zarządzania populacją łosia *Alces alces* w Polsce. In: *Zarządzanie populacjami zwierząt*. Warszawa: „Łowiec Polski" Polski Związek Łowiecki, pp. 17-27.

Zieliński, J., Tutka, P., Kunikowski, P., Szyszło, A., 2021. Synteza wyników GPR 2020/21 na zamiejskiej sieci dróg krajowych. Warszawa: Heller Consult Sp. z o.o., 35 pp.

STRESZCZENIE

Liczebność, zagęszczenie i struktura płciowo-wiekowa populacji łosia *Alces alces* w objętej 20-letnim zakazem polowań północno-wschodniej Polsce

Głównym celem badań wykonanych na terenie Puszczy Augustowskiej w latach 2019-2020 było poznanie liczebności i struktury płciowo-wiekowej populacji łosi, która od 2001 r. nie znajdowała się pod presją odstrzałów, oraz porównanie uzyskanych wyników z analogicznymi danymi, które opublikowano dla lat 1999-2000, kiedy gatunek na tym terenie był pozyskiwany w drodze polowań. Poprzez porównanie liczebności łosi w latach 2021 i 2020 obliczono wskaźnik ograniczonego tempa wzrostu populacji (λ) oraz przedyskutowano, czy otrzymany wynik może służyć do oceny rocznego przyrostu zrealizowanego badanego gatunku w Puszczy Augustowskiej.

Puszcza Augustowska obejmuje obszar 1102 km^2 zarządzany przez 6 nadleśnictw: Augustów, Głęboki Bród, Płaska, Pomorze, Szczebra i Suwałki. Głównymi typami siedliskowymi lasu są bory świeże i bory mieszane świeże, w których dominującym gatunkiem lasotwórczym jest sosna *Pinus sylvestris*. Zespół dzikich kopytnych reprezentują łosie, jelenie, sarny, żubry oraz dziki. Bytuje tam również populacja wilków. Udział powierzchni upraw leśnych i młodników oraz drzewostanów starszych niż 100 lat wynosi odpowiednio 9,3 oraz 2,5%. Objęcie łosia całorocznym okresem ochronnym spowodowało wzrost liczebności populacji oraz szkód, jakie ten gatunek wyrządza w odnowieniach leśnych. Obecnie 67,1% powierzchni upraw leśnych i młodników jest grodzone w celu obniżenia poziomu szkód powodowanych przez jeleniowate.

W lutym 2020 r. liczebność łosi oceniono metodą bezpośrednich obserwacji zwierząt w 20 blokach taksacyjnych o łącznej powierzchni 91,5 km^2 (ryc. 1). Powierzchnia poszczególnych bloków wahała się w zakresie 4,43-5,59 km^2. Były to grupy 20 sąsiadujących ze sobą oddziałów leśnych. Rejestrację liczby łosi w blokach taksacyjnych prowadziło 6 zespołów obserwacyjnych, z których każdy liczył 30 osób.

W blokach taksacyjnych wykazano obecność 112 łosi. Łosie były obecne we wszystkich blokach, a ich liczebność wahała się od 1 do 14 osobników (0,21-3,40 zwierząt/km^2). Przeciętne zagęszczenie populacji oceniono na 1,22 ±0,19 łosi/km^2 ($\bar{x}$ ±SE). Obliczony 95-procentowy przedział ufności dla średniego zagęszczenia wahał się w zakresie ±0,50 (±36,6% średniej). Liczebność populacji łosia na terenie Puszczy Augustowskiej (1120 km^2) wynosiła w 2020 r. 1344 osobniki.

Moratorium na odstrzał łosia spowodowało, że w latach 2001-2020 na terenie Puszczy Augustowskiej nastąpił wzrost liczebności populacji: z 211 do 1344 osobników. Roczne tempo wzrostu liczebności reprezentujące roczny przyrost zrealizowany populacji wyniosło 10,2% i było trzykrotnie niższe niż roczny przyrost zrealizowany oceniany na terenie Puszczy Augustowskiej w latach 1998-2001 (30,6%). W innych regionach Polski, jak również na terenie Szwecji i Norwegii omawiany wskaźnik był również znacznie wyższy i wahał się od 22,9 do 31,0% liczebności populacji ocenionej na przełomie zimy i wiosny. Nie wydaje się, aby wzrost zagęszczenia populacji powodował spadek reprodukcji lub zwiększoną śmiertelność zwierząt, gdyż brak jest istotnych różnic pomiędzy strukturą płciowo-wiekową łosi ocenianą w latach 1999-2000 i 2019-2020 (chi-kwadrat = 0,2658, df=2, p=0,875) (tab. 2).

Wykazane na badanym terenie różnice dotyczące wysokości rocznego przyrostu zrealizowanego populacji mogły być spowodowane konkurencją pokarmową pomiędzy łosiami w stosunku do zimowej bazy pokarmowej ograniczonej przez grodzenia odnowień leśnych. Jest możliwe, że spowodowało to emigrację części łosi z terenu badań na przełomie jesieni i zimy, co wpłynęło na zaniżenie liczebności wykazanej na początku kolejnego sezonu łowieckiego. Gdyby przyrost zrealizowany w latach 2001-2020 był podobny do przyrostu, jaki na terenie badań wykazano w latach 1999-2000 (~30%), to emigracją mogło być objęte ok. 20% liczebności populacji ocenionej na początku sezonu łowieckiego. Innym czynnikiem wpływającym na niski roczny przyrost zrealizowany mogła być wysoka śmiertelność łosi spowodowana dużym natężeniem ruchu samochodowego. Wykonanie jesienią odstrzału populacji wynoszącego 20% liczebności inwentaryzowanej na początku sezonu polowań pozwoliłoby ocenić wartość rocznego przyrostu zrealizowanego populacji łosia w Puszczy Augustowskiej.

Głównym celem gospodarki łowieckiej łosiem w Puszczy Augustowskiej jest regulacja zagęszczenia populacji do poziomu, który istotnie ograniczy grodzenia odnowień leśnych oraz spowoduje spadek liczby wypadków samochodowych powodowanych przez ten gatunek. Wykonanie tego zadania jest możliwe, jeśli planowanie pozyskania łosi będzie oparte na wiarygodnej liczebności i wysokości rocznego przyrostu zrealizowanego populacji.