ANIMAL SCIENCE AND GENETICS
Published by the Polish Society of Animal Production
vol. 19 (2023), no 4, 69-79
DOI: 10.5604/01.3001.0054.3016
Research Article ***Open Access***

Characteristics of the moose population in central-eastern Poland

Katarzyna Dziki-Michalska[1], Maciej Wójcik[2], Katarzyna Tajchman[1], Justyna Batkowska[3#]

[1]Department of Animal Ethology and Wildlife Management, University of Life Sciences in Lublin, 13 Akademicka St., 20-950 Lublin, Poland
[2]Regional Directorate of the State Forests in Lublin, 4 Czechowska St. 20-950 Lublin, Poland
[3]Institute of Biological Basis of Animal Production, University of Life Sciences in Lublin, 13 Akademicka St., 20-950 Lublin, Poland; [#]e-mail: justyna.batkowska@up.lublin.pl

SUMMARY

The study aimed to analyse the spatial structure of moose (*Alces alces*) in central-eastern Poland, taking into account sex structure and preferences regarding the composition of social groups. The density of animals in forest and swamp areas was analysed. Moose were shown to strongly prefer forest areas. Females moving with fawns and single females and males were most often observed. Statistical analysis confirmed that the biotope preference of this species does not depend on the type of social group in which the animals migrate. In the territory of the Regional Directorate of State Forests in Lublin, the moose density per 1000 ha of forest and swamp averaged 5.9 individuals. Reproductive success and the number of young born were typical of the species. In 73% of cases, they moved in three dominant types of social groups, i.e. a hind with fawns, solitary stags and solitary hinds. The animals were found mainly in forest areas (65.1%). It should be remembered that in European forests it is very rarely possible to maintain *Cervidae* populations at a level that guarantees the absence of foraging effects on forest regeneration and the maintenance of its sustainability. Therefore, continuous monitoring of the species' population size is recommended.

KEY WORDS: *Alces alces*, population size, overdensity, social groups

INTRODUCTION

There has recently been a noticeable increase in the number of moose (*Alces alces*) in Poland. A moratorium, i.e. year-round protection for the species, has been in force since 2001 by Regulation of the Minister of the Environment on the establishment of a list of game species and the specification of hunting periods for these animals (Journal of Laws 2001 No. 43, item 488).

Corresponding author e-mail: justyna.batkowska@up.lublin.pl
Received: 5.12.2023 Received in revised form: 10.12.2023
Accepted: 11.12.2023 Published online: 14.12.2023

Discussions of the possible abolition of full-year protection and the resumption of moose hunting have been taking place in Poland for a long time, due to the increasing damage they cause to forests and crops every year, for which the State Treasury is responsible. The largest numbers of these animals in Poland are currently found in the Warmińsko-Mazurskie, Lubelskie, Mazowieckie and Podlaskie Voivodeships (www.stat.gov.pl). According to the Central Statistical Office, the number of moose in Poland increased from 2 000 in 2000 to 30 213 in March 2022. In the Lublin Voivodeship alone, the number of *Alces alces* more than tripled from 2012 to 2022 (from 2 155 to 6 666 individuals) (www.stat.gov.pl). In addition, the presence of this species has been recorded in Poland in places where it had not been observed consistently for several years, such as the Lubuskie Voivodeship (Panek and Budny, 2015).

The factors that contribute to a rapid increase in population size are mainly climate change, low predation pressure after World War II, and modern forest management practices that favour herbivores (Sommer and Nadachowski, 2006; Van Ballenberghe, 2006). There is no denying that the recovery of the Polish population of Eurasian moose is a positive development in terms of biodiversity. However, the potential consequences associated with the rapid numerical growth of Poland's largest deer representative should not be overlooked. In 2021 alone, the provincial boards and the State Forests paid compensation of PLN 14 713 400 (www.stat.gov.pl) for damage caused by game animals under year-round protection. Sokół (2009) showed that an adult moose eats about 50 kg of vegetation per day in summer and 12 kg in winter, but according to other researchers, the nutritional needs of this species are lower (Dzięciołowski and Pielowski, 1993). With high deer population densities, forest degradation is inevitable (Husheer and Tanentzap, 2023; Persson, 2003). Another negative effect of the increase in the moose population is the increasing frequency of road collisions involving moose, with the intensive development of road infrastructure contributing to the number of collisions. Moose also play an important role in the spread of parasitosis among wild and breeding ruminant species (Filip et al., 2017).

The study aimed to analyse the spatial distribution of moose in the Regional Directorate of State Forests in Lublin (RDSF in Lublin), taking into account their sexual structure and habitat preferences, as well as the composition of the social groups in which the animals moved. The study also included an analysis of the density of the species in forest and swamp areas of the Lublin Region.

MATERIAL AND METHODS

Research area

The study was carried out in the territory of the RDSF in Lublin, which covers the whole Lubelskie Voivodeship and part of the Podkarpackie and Mazowieckie Voivodeships. The RDSF manages 426 000 ha of land, of which 408 700 ha is forest land. Owing to geographic, climatic and soil diversity, the RDSF in Lublin includes habitat types characteristic of lowland and upland areas, with lowland habitats accounting for 92.5% and upland habitats for 7.5%. Pine habitats occupy 46.9% of the forested area, and deciduous habitats account for 45.6%. The share of pine and larch in stands is as high as 68.3%, while oak, sycamore, hornbeam, maple and ash constitute 14.1% (RDSF in Lublin 2023).

According to the March 2022 inventory, there were 6 500 moose, 14 000 red deer, 800 fallow deer, 65 000 European roe deer, and 2,000 wild boars on the territory of the Lublin RDSF. As the

wildlife population continues to grow, so does the amount of damage they cause to forests. The species causing the most damage were red deer (36%) and roe deer (24%), but moose and beavers are responsible for nearly 40% of the damage (RDSF in Lublin, 2023).

There are eight Game Management Regions (GMR) within the RDSF in Lublin, with total area ranging from 569 716 ha to 181 460 ha and forested area ranging from 114 276 ha to 66 434 ha. Only one of the GMRs is typically forested – Janów Forests, with forest cover exceeding 40% (Table 1).

Table 1.
Total area and forest cover of Game Management Regions of RDSF in Lublin

Game Management Region	Total area (ha)	Forest area (ha)	Forest cover (%)
Sandomierz Forest (Polish: Puszcza Sandomierska)	181 460	66 434	36.6
Janów Forests	247 752	114 276	46
Roztocze and Solska Forest (Polish: Puszcza Solska)	290 655	98 438	34
Chełm	569 716	102 306	17.96
Lublin	328 987	55 730	16.94
Łęczna-Włodawa Lakeland	252 890	95 949	38
Pulawy-Lubartów	398 246	93 168	24
Podlasie	338 141	93 562	27.67

Field observations

The analysis was conducted on information published in the Long-term Hunting Management Plan for the period from 1 April 2017 to 31 March 2027 for eight GMRs in the Lublin Region, i.e. the density of moose in relation to the total area as well as the forest and swamp area (Table 2). The ratio of males to females, which illustrates the sexual structure of the species in the Lublin Voivodeship, was analysed as well (Table 3). Survey data obtained from observation cards distributed in the Chełm, Parczew, Sobibór and Włodawa Districts were also analysed. observation cards were filled in by foresters and forest supervisors of the respective forest districts. The observation cards were completed when a moose was observed in the forest district.

The questionnaire required the input of information relevant to the analysis and consisted of several parts:

- part A – the name of the forest district, the number of the GMR and hunting district, and the date of the observation
- Part B – information on the observation of a solitary animal, i.e. its sex, estimated age, and the time of the observation
- part C – information on the observation of a group of animals, i.e. the composition of the group, including the number of animals of each sex, and the time of the observation

– part D – the antler type of stags observed (if such an observation was made)
– Parts E, F, G, and H – the type of area the observation was made in and how it was made (in a forest, in a forest cultivation, in a field, from a drive, during a driven hunt), the number of hours spent in the hunt by the observer, the name of the observer, and any comments.

In three forest districts (Chełm, Parczew, and Sobibór), observations were carried out during a full hunting season, while in the Włodawa Forest District they were carried out during the last five marketing years. The location of observations in all forest districts was analysed first. Observation cards that lacked information on the location of the sighting were excluded from the analysis. Among 323 observation cards, the location of the observation was recorded in 212. Then the structure of the social groups in which the animals moved was analysed. Observation cards on which animals were noted without identifying their sex and age were also excluded. Among 323 observation cards, 273 contained complete information regarding the sex and age structure of the animals.

Subsequently, habitat preferences were investigated for the various social groups observed in the study hunting area. To test whether there was a statistical relationship between the social group and the habitat chosen by the moose, Kendall's tau correlation coefficient was determined. One vector was the number of observations made (in the context of the social groups), and the other was the number of observations in the areas specified (field, forest cultivation, or forest). The null hypothesis (H0) and the alternative hypothesis (H1) were established:

H0: Biotope preference does not depend on the type of social group.
H1: Biotope preference depends on the type of social group.

Calculations were made using the Statistica 13.1 package at a significance level of $\alpha = 0.05$.

The density of the species was analysed in the context of the total area of the GMR as well as the forest and swamp area. Data on the number of hinds and fawns observed was also collated to verify the percentage of twin pregnancies as well as the number of fawns per hind in the study areas.

RESULTS

The density of moose per 1000 ha of total area as well as of forest and swamp area was lowest in the Sandomierz Forest (0.17 and 0.45 individuals, respectively) and highest in the Łęczyńsko-Włodawskie Lakeland (3.75 and 9.87 individuals, respectively). On average, the density of the species in the RDSF in Lublin per 1000 ha of total area as well as in forest and swamp area was 1.65 and 5.90 individuals, respectively (Table 2). In three GMRs (Sandomierz Forest, Janów Forests, and Roztocze and Solska Forest), the density did not exceed 5 individuals/1000 ha of forest and swamp area, while in the remaining regions it did not exceed 10 individuals/100 ha of forest and swamp area.

Table 2.
Moose density per 1000 ha of total area and forest and swamp area in particular Game Management Regions of the RDSF in Lublin

Game Management Region	Number of moose/1000 ha total area	Number of moose/1000 ha forest and swamp area
Sandomierz Forest (Polish: Puszcza Sandomierska)	0.17	0.45
Janów Forests	1.82	3.92
Roztocze and Solska Forest (Polish: Puszcza Solska)	1.1	3.24
Chełm	0.97	5.39
Lublin	1.45	8.58
Łęczna-Włodawa Lakeland	3.75	9.87
Pulawy-Lubartów	2.16	9.22
Podlasie	1.82	6.58
Average	1.65	5.9

Subsequently, the data published in the Hunting Plans were detailed in the context of analysis of the moose sexual structure in the RDSF in Lublin, which averaged 1:1.13 in favour of females; in the Sandomierz Forest GMR alone it was 1:2.33. The situation in the Janów Forests was not assessed due to a lack of data in the published reports (Table 3).

Table 3.
Sexual structure of moose population in Game Management Regions of the RDSF in Lublin

Game Management Region	Male-to-female ratio
Sandomierz Forest (Polish: Puszcza Sandomierska)	1:2.33
Janów Forests	No data
Roztocze and Solska Forest (Polish: Puszcza Solska)	1:1.14
Chełm	1:1.13
Lublin	1:1.34
Łęczna-Włodawa Lakeland	1:1.21
Pulawy-Lubartów	1:1.12
Podlasie	1:1.18
Average	1:1.13

Moose living in the study area were most often observed in the forest area (65.1%), and least often in cultivated fields (13.2%). A reversal of the trend was observed only in the Chełm District, where as many as 20.5% of all observations took place in crop fields (Table 4).

Table 4
Number of observations per biotope for forest districts

Forest Districts	Observation area						Total
	Forest	%	Forest cultivation	%	Field	%	
Chełm	32	72.7	3	6.8	9	20.5	44
Parczew	28	75.7	7	18.9	2	5.4	37
Sobibór	21	70.0	6	20.0	3	10.0	30
Włodawa	57	56.4	30	29.7	14	13.9	101
Total	138	65.1	46	21.7	28	13.2	212

Twelve different structures were identified in the analysis of social group preferences: a hind with fawns (one or more), a solitary stag (including five single young stags with an antler form with simple beams), a single female, a bachelor group (comprising a minimum of two stags of different ages), a family group (comprising an older stag, a hind, and one or several fawns), a herd (a female group, which includes a minimum of two hinds with or without fawns), a herd with an older stag (a stag with an antlers in a variety of forms), a hind with older stags, solitary hinds, a hind with a stag, a hind with stags (stags with antlers in a variety of forms), and a family group with a yearling stag. As many as 73% of all animals observed moved in one of the three dominant types of social groups, i.e. a hind with fawns, single stags, and single hinds. The 10 remaining groups accounted for only 27% of all structures (Table 5).

Table 5.
Social groups observed in the study area

No.	Type of social group	Number of observations	%
1	**Hind with fawns**	87	31.89
2	**Solitary stags**	76	27.83
3	**Solitary hinds**	37	13.55
4	**Bachelor group**	21	7.69
5	**Family group**	12	4.39
6	**Herd**	12	4.39
7	**Herd with older stag**	7	2.56
8	**Hind with stag**	10	3.66
9	**Solitary fawn**	5	1.83
10	**Hind with older stags**	2	0.74
11	**Hind with stags**	2	0.74
12	**Family group with yearling stag**	2	0.74

Subsequently, habitat preference was analysed for the various social groups observed in the hunting districts to see if there was a relationship between the social group and the habitat chosen by the moose. Most of the social groups observed lived in forest areas: 42 hinds with fawns, 26 solitary stags, and 17 solitary hinds, while considerably fewer lived in forest cultivations and the fewest in fields (Table 6). However, the results of the statistical analysis ($\chi^2 = 29.3466$; $p = 0.08$) indicate that there are no grounds to reject H0 in favour of H1, and we therefore conclude that biotope preference does not depend on the type of social group.

Table 6.
Distribution of observations in each biotope according to the social structure of the group

Type of social group	Observation area		
	Forest	Forest cultivation	Field
Hind with fawns	42	12	4
Solitary stags	26	10	8
Solitary hinds	17	9	3
Bachelor group	8	3	0
Family group	6	1	0
Herd	6	1	2
Herd with older stag	2	0	3
Hind with stag	4	2	2
Solitary fawn	0	2	0
Hind with older stags	-	-	-
Hind with stags	2	0	0
Family group with yearling stag	2	0	0

Based on the number of females observed and the fawns following them, it was determined that 31.44% of the hinds had no young (Table 7). There were therefore 0.73 fawns per hind, while the proportion of twins was 12.9% of all observed females with juveniles.

Table 7.
Number of moose hinds and fawns observed in the study area of the forest districts

Forest Districts	Number of observations			
	Female	Fawns	Hind without fawns	Hind with twins
Chełm	39	38	8	9
Parczew	42	28	19	5
Sobibór	32	21	6	1
Włodawa	81	55	28	10
Total	194	142	61	25

DISCUSSION

The moose is a forest animal, which chooses extensive and humid forests rich in willow bushes as its habitats (Sæther r et al., 2004; Sokół, 2009; Chmielewski and Maślanko, 2014). Studies have confirmed that it prefers older woodlands and peatlands (Nikula et al., 2004). For protection, it chooses dense, closed forest complexes (Van Beest et al., 2012; Melin et al., 2016). However, there is some annual flexibility in the choice of foraging areas, with cultivated fields and young woodlands used as foraging areas mainly at night, while during the day moose are usually found in older woodlands, which provide cover as well as protection from adverse weather conditions and predators (Dussault et al., 2004; Godvik et al., 2009; Bjørneraas et al., 2011). Foraging choice may also vary depending on the availability of food in the area (Zweifel-Schielly et al., 2009).

This kind of behavioural divergence is typical of herbivores and helps them to cope with changes in the availability of food resources (Hanley, 1997). Moose also find their way well in areas subject to synurbation (Khoyetskyy, 2011), owing to the high plasticity of the species' behaviour and the constant habituation process (Dziki-Michalska et al., 2019). The species is not affected by hunting pressure, nor does it have significant natural enemies. At the same time, encounters between moose and humans are becoming more frequent (Bobek et al., 2013), which leads to reduced fearfulness and thus contributes to the ongoing process of synurbanisation (Hansen and Aanes, 2015).

The analysis identified 12 types of social groups in which the animals were observed. As many as 45 variants of social groups were observed in a study conducted by Nasiadka (2015) in Kampinos National Park. However, despite this large number of types of sex-age groups, three that were most frequently observed were singled out: hinds with fawns, solitary stags, and solitary hinds. This preference is confirmed by our observations. The statistical analysis indicated that the choice of foraging site is not determined by the type/group to which the animals belong. Irrespective of the diversity of groups, the preferred biotope is forest. Nevertheless, both the choice of foraging area and the wide variety of social structures confirm the high plasticity of these animals' behaviour.

The results of research carried out in Estonia (Tõnisson and Randveer, 2003) indicate that the optimum density of moose should be five animals per 1000 ha of forest and swamp area. With regard to the ecology of the species, the number of animals per 1000 ha of total area should be in the range of 7–8 individuals. The Strategy for the Protection and Management of the Moose Population in Poland (Ratkiewicz, 2011) outlines the standards for country. The results of the study do not exceed the recommendations indicated in that document (from 1.2 to 10 individuals/1000 ha of forest and swamp area). It should be remembered that overcrowding is not only dangerous for purely environmental reasons, but also harms the animal population in a given area. First, it intensifies competition between individuals (Szukiel, 1972; Pedersen and Pedersen, 2021), which forces them to migrate in search of optimal biotopes, and moreover, it is conducive to the spread of pathogens (Dzięciołowski and Pielowski, 1993).

A skewed sexual structure is a factor that directly affects the reproductive success of the moose. Many authors suggest that the sexual structure of the moose population should be at a level of 1:1 (Gębczyńska and Raczyński, 1989; Peterson, 1955; Nasiadka et al., 2015; Sæther et al. 2003). In the present study, these ratios were exceeded in all GMRs, especially in Sandomierz Forest. It should be emphasized that this imbalance leads to increased reproductive success, which directly

translates into a rapid increase in the numbers of these animals, especially as the percentage of twin pregnancies in moose is not low. The study showed that 12.9% of hinds had given birth to twins. This result is similar to those reported by Gębczynska and Raczynski (1989). Nasiadka (2015), on the other hand, indicated a 20% twin pregnancy rate in Kampinos National Park. There were 0.73 fawns per hind, which is not a high rate in comparison with previous studies by other authors (Gębczyńska and Raczyński, 1989). However, the value obtained in the present study was the same as that reported by Nasiadka (2015).

In conclusion, the average density of moose in central-eastern Poland per 1000 ha of total area and forest and marsh area was 1.65 and 5.90 individuals, respectively. However, in some GMRs it was much higher. The sexual structure of moose was at an appropriate level (on average 1:1.13). In 73% of cases, the animals moved in three dominant types of social groups, i.e. a hind with fawns, solitary stags, and solitary hinds. The animals were mainly observed in forest areas (65.1%). It should be remembered that in European forests it is very rarely possible to maintain *Cervidae* populations at a level that guarantees the absence of foraging effects on forest regeneration and the maintenance of its sustainability (Szukiel, 1991). Therefore, continuous monitoring of the species' population size is recommended. Information from direct observations is very valuable. As Ericsson and Wallin (1999) point out, data collected from foresters and wildlife managers can be considered one of the most reliable sources of information on population structure and moose numbers. It is important to remember that rationally conducted hunting management makes it possible to maintain the animal population while protecting and minimizing the damage it causes (Dziki-Michalska et al., 2019).

REFERENCES

1. Bjørneraas K., Solberg E.J., Herfindal I., Van Moorter B., Rolandsen C.M., Tremblay J.P., Skarpe C., Sæther B.E., Eriksen R., Astrup R. (2011). Moose *Alces alces* habitat use at multiple temporal scales in a human-altered landscape. Journal of Wildlife Management, 17(1): 44-54, doi: https://doi.org/10.2981/10-073.
2. Bobek B., Merta D., Furtek J., Wojciuch-Płoskonka M., Kopeć K., Maślanka J., Ziobrowski M. (2013). Ocena dynamiki liczebności i zagęszczenia populacji dzikich kopytnych przy użyciu różnych metod w czterech regionach Polski. Studia i Materiały Centrum Edukacji Przyrodniczo-Leśnej w Rogowie, 36(3): 88-101.
3. Chmielewski T.J., Maślanko W. (2014). Struktura ekologiczna krajobrazu a przestrzenne rozmieszczenie i warunki migracji łosia europejskiego na Polesiu Zachodnim. Sylwan, 158 (1): 49−60.
4. Dussault C., Ouellet J.P, Courtois R., Huot J., Breton L., Larochelle J. (2004). Behavioural responses of moose to thermal conditions in the boreal forest. Ecoscience, 11: 321–28, doi: https://doi.org/10.1080/11956860.2004.11682839.
5. Dzięciołowski R., Pielowski Z. (1993). Łoś. Warsaw, Poland, Anton, 208 pp.
6. Dziki-Michalska K., Tajchman K., Budzyńska M. (2019). Increase in the moose (*Alces alces* L. 1758) population size in Poland: causes and consequences. Annals of Warsaw University of Life Sciences – SGGW Animal Science, 58(3): 203-214, doi: 10.22630/AAS.2019.58.3.20.

7. Ericsson G., Wallin K. (1999). Hunter observations as an index of moose *Alces alces* population parameters. Wildlife Biology, 5: 177−185, doi: https://doi.org/10.2981/wlb.1999.022.
8. Filip K.J., Demiaszkiewicz A.W., Pyziel A.M. (2017). Rola łosi (*Alces alces*) w rozprzestrzenianiu parazytoz. Życie Weterynaryjne, 92(5): 359-363.
9. Gębczyńska Z., Raczyński J. (1989). Distribution, population structure, and social organization of moose in the Biebrza Valley, Poland. Acta Theriologica, 34 (13): 195−217.
10. Godvik I.M.R., Loe L.E., Vik J.O., Veiberg V., Langvatn R., Mysterud A. (2009). Temporal scales, trade-offs, and functional responses in red deer habitat selection. Ecology, 90: 699–710, doi: http://www.jstor.org/stable/27651033.
11. Hanley T.A. (1997). A nutritional view of understanding and complexity in the problem of diet selection by deer (*Cervidae*). Oikos, 79: 209–218, doi: https://doi.org/10.2307/3546006.
12. Hansen B.B., Aanes R. (2015). Habituation to humans in a predator-free wild ungulate. Polar Biology, 38:145–151, doi: https://doi.org/10.1007/s00300-014-1572-0.
13. Husheer S.W., Tanentzap A.J. (2023). Hunting of sika deer over six decades does not restore forest regeneration. Journal of Applied Ecology, 00: 1-11. doi: 10.1111/1365-2664.14544
14. Khoyetskyy, P. (2011). Stan populacji łosia na Ukrainie. Leśne Prace Badawcze (Forest Research Papers), 72(3): 285–288. doi: 10.2478/v10111-011-0028-3.
15. Melin M., Matala J., Mehtätalo L., Pusenius J., Packalen P. (2016). Ecological dimensions of airborne laser scanning — Analysing the role of forest structure in moose habitat use within a year. Remote Sensing of Environment, 173: 238–247, doi: https://doi.org/10.1016/j.rse.2015.07.025.
16. Nasiadka P., Skubis J., Wajdzik M. (2015). Bezpośrednie obserwacje zwierzyny, jako element monitorowania dużych kopytnych na przykładzie łosi (*Alces alces* L.) w Kampinoskim Parku Narodowym. Sylwan, 159(7): 565−578.
17. Nikula A., Heikkinen S., Helle E. (2004). Habitat selection of adult moose *Alces alces* at two spatial scales in central Finland. Journal of Wildlife Management, 10(2): 121-135, doi: https://doi.org/10.2981/wlb.2004.017.
18. Panek M., Budny M. (2015). Sytuacja zwierząt łownych w Polsce 2015. Biuletyn Stacji Badawczej Polskiego Związku Łowieckiego w Czempiniu w Czempiniu, 16-17.
19. Pedersen S., Pedersen H. Chr. (2021). Exploitative competition between mountain hare and moose-qualitative effects on hare winter forage? Animals, 11(9): 2693. doi: 10.3390/ani11092638
20. Persson I.L. (2003). Moose Population Density and Habitat Productivity as Drivers of Ecosystem Processes in Northern Boreal Forests. Doctoral thesis, Swedish University of Agricultural Sciences, Umeå, ISBN 91-576-6506-0.
21. Peterson R.L. (1955). North American Moose. Toronto, Canada, University Toronto Press, 324 pp., doi: https://doi.org/10.3138/9781487578213.
22. Ratkiewicz M. (2011). Editor. Strategia ochrony i gospodarowania populacją łosia w Polsce. Białystok, Poland, Narodowy Fundusz Ochrony Środowiska i Gospodarki Wodnej, 69 pp.
23. Sæther B.E., Solberg E.J., Heim M. (2003). Effects of altering sex ratio structure on the demography of an isolated moose population. The Journal of Wildlife Management 67(3): 455-466. https://doi.org/10.2307/3802703

24. Saether B.E., Solberg E.J., Heim M., Stacy J.E., Jakobsen K.S., Olstad R. (2004). Offspring sex ratio in moose *Alces alces* in relation to paternal age: an experiment. Wildlife Biology, 10(1): 51-57, doi: https://doi.org/10.2981/wlb.2004.009.
25. Sokół J. (2009). Jeleniowate na wolności i w chowie fermowym, jako atrakcja dla turystów. Ekonomia i Zarządzanie, 1: 107-119.
26. Sommer R.S, Nadachowski A. (2006). Glacial refugia of mammals in Europe: evidence from fossil records. Mammal Review, 36(4): 251-265, https://doi.org/10.1111/j.1365-2907.2006.00093.x.
27. Szukiel E. (1972). Spałowanie drzew przez zwierzynę jako problem ekologiczny. Wiadomości Ekologiczne, 18(4): 339-359.
28. Szukiel E. (1991). Ochrona drzewostanów przed zwierzyną. PWRiL, Poznań. 1-177 pp.
29. Tõnisson J., Randveer T. (2003). Monitoring of moose-forest interactions in Estonia as a tool for game management decisions. Alces: A Journal Devoted to the Biology and Management of Moose, 39:255-261.
30. Zweifel-Schielly B., Kreuzer M., Ewald K.C., Suter W. (2009). Habitat selection by an alpine ungulate: the significance of forage characteristics varies with scale and season. Ecography 32: 103–113, doi: https://doi.org/10.1111/j.1600-0587.2008.05178.x.
31. Van Beest, F.M., Moorter, B.V., Milner, J.M. (2012). Temperature-mediated habitat use and selection by a heat-sensitive northern ungulate. Animal Behaviour, 84(3): 723–735, doi: https://doi.org/10.1016/j.anbehav.2012.06.032.
32. Van Ballenberghe V. (2006). Predator control, politics, and wildlife conservation in Alaska. Alces, 42: 1-11.