Трансформация экосистем
Ecosystem Transformation

ISSN 2619-094X Print
ISSN 2619-0931 Online
www.ecosysttrans.com

Article

Individual variability of dewlap and antlers of the European elk *Alces alces* (L., 1758) on the territory of the Leningrad Province (Russia) according to observations with camera traps mounted nearby artificial salt licks

Nickolay V. Sedikhin[1, 2]

[1] *Zoological Institute, Russian Academy of Sciences, Universitetskaya emb. 1, Saint Petersburg, 199034 Russia*
[2] *Saint Petersburg State Forest Technical University named after S.M. Kirov, Institutsky per. 5-U, Saint Petersburg, 194021 Russia*

sedoi1995@mail.ru

Received: 28.05.2022
Revised: 11.07.2022
Accepted: 15.07.2022
Published online: 29.10.2022

DOI: 10.23859/estr-220528
UDC 599.6/.73: 59.018

Translated by D.M. Martynova

Abstract. Visually identifiable morphological features serve as distinctive signs of individuals and may indicate the state and sex-age structure of populations of large mammals. The development and change of morphological structures may occur under the influence of various factors, including human economic activity. The article proposes a classification of dewlap and antler morphotypes of the population of the European elk (*Alces alces alces* (L., 1758)), living on the territory of the Leningrad Province (North-West of Russia). Frequency of occurrence of observed morphotypes is analyzed and discussed considering the data of long-term observations conducted in 2015–2020 at 20 artificial salt licks located on 11 experimental sites in three districts of the region. Based on the studied material, the following morphotypes of the dewlap are identified: “icicle”, “drop”, and “fold” (halberd, triangular, rounded). In females, the dewlaps of the “icicle” and “drop” type dominate, the “fold” is noted very rarely. In males, on the contrary, the “fold” is most often encountered. The antlers may be palmated, cervine, intermediate, transitional, “spike”, “fork”, and abnormal. Palmate and cervine antlers are found with almost the same frequency of occurrence (about 25%), a lower number of cases is noted for “spikes” and “forks”, as well as for intermediate type of antlers; transitional and abnormal antlers are recorded the least. The analysis of literary sources devoted to the classification and variability of the studied morphological characters has been also carried out.

Keywords: ungulates, morphological features, mineral nutrition, places of concentration, hunting, North-West of Russia

To cite this article. Sedikhin, N.V., 2022. Individual variability of dewlap and antlers of the European elk *Alces alces* (L., 1758) on the territory of the Leningrad Province (Russia) according to observations with camera traps mounted nearby artificial salt licks. *Ecosystem Transformation* **5** (4), 57–70. https://doi.org/10.23859/estr-220528

Introduction

Currently, observations of animals with the help of camera traps have become commonplace, which no longer surprises both specialists and ordinary people. The need to conduct remote observations of various objects with no presence of a man is justified by a reduction in labor costs and an increase in the supply of free time. In addition, the objectivity of observations and conclusions is increased, since it becomes possible to verify independently the obtained digital data.

For most large mammals and birds, only phenotypic and behavioral features can be observed with camera traps. Measuring the weight of animals from photographs and video files is impossible without the development of new methods based on the ratios of body parts. At the same time, the length of the body (or its parts) and the height of the animal can only be fixed relatively (based on the distance between the object of observation and the camera), which is also quite laborious.

There are quite a lot of examples in the literature of observing predatory species, included into Red List, using camera traps, so it becomes possible to assess their abundance and, accordingly, population density in a certain area (Jackson et al., 2005; Kolchin and Tkachenko, 2011; Lukarevsky and Lukarevsky, 2019). While individuals of the Siberian tiger (*Panthera tigris altaica* Temminck, 1844) or Amur leopard (*Panthera pardus orientalis* Schlegel, 1857) may be distinguished by unique spots on their pelage; numerous game animals lack such individual signs. Therefore, observation of such species is often low-value. However, the distinguishing features of an economically significant species of ungulates for Russia, such as the European elk *Alces alces alces* (Linnaeus, 1758), also allow to draw reliable conclusions about its sex, age, hierarchical status, and trophy qualities, as well as to count different individuals in a limited period of time.

Both abiotic and biotic factors affecting animal populations change the physiological processes in the body, the animal behavior, and the population size. The size and weight of elk antlers correlate with age (Kolesnikov and Makarova, 2014), as well as the animal weight (Andreozzi et al., 2015); in turn, this depends on nutritional conditions and the stress level (Glushkov and Kuznetsov, 2015). Predation, anthropogenic and hunting pressure, the activity of blood-sucking insects, endoparasites, and exposure to harsh climatic conditions may be the stress factors for elk, causing energy deficiency. Uncontrolled hunting for the largest individuals in the population may lead to a change in the linear dimensions of the body and morphological structures of the animals. At the same time, the construction of highways, new residential areas and gardeners' non-commercial partnerships, quarrying, and other nature-destroying economic activities contribute to the reduction of habitats of large mammals and the formation of limited areas of terrain, which are most suitable for the existence of micropopulations in unfavorable periods.

In the present paper, the possibility to assess the sex and age composition, quality and condition of elk populations according to visually identifiable morphological features, and zoning of territories based on the identified local characteristics of populations is supported and discussed. First of all, it is necessary to unify the research methodology, to develop a classification of the morphological forms of the studied population, and to establish how elks adhere to the territories of seasonal habitats.

This article presents the results of observations of elks at artificial salt licks in the Leningrad Province, North-west of Russia. The individual variability according to two secondary morphological features, antlers and dewlap (a leathery outgrowth on the ventral side of the body, located in the zone of the lower jaw and neck), is considered. The study aims to identify and to describe visually distinct morphotypes of the studied traits and assess their representation in the studied elk population.

Materials and methods

The materials were obtained using camera traps in artificially created sites for mineral feeding (hereinafter referred to as artificial salt licks) in the Leningrad Province, Russia. We used Bushnell Essential E2 and E3, Bushnell Agressor, Scoutguard, Browning BTC-8F, Wildgame Innovations camera traps. Observations were carried out at 20 artificial salt licks located at 11 sites in three districts of the Leningrad Province (Vsevolozhsk, Tosno, and Luga). Observations was carried out at conditionally non-limited territory; the sites were remote from each other by 10 km or more and belonged to three different regional hunting farms. One to four artificial salt licks were mounted within the boundaries of the site, the distances between them did not exceed 5 km. Most of the primary data was obtained by the author and partially provided by the employees of the hunting farms mentioned above.

When studying the attendance of artificial salt licks by elks, the animal individuality was determined by several main features: (1) the shape and direction of antlers in males, (2) the shape and relative sizes of dewlaps in both sexes, (3) the presence of external damage to tissues and organs, and (4) relative size (applicable to three age groups: calves, yearlings (1.5-year-olds) and adults) (Sedikhin, 2021b). The data on registered yearlings and adult individuals were used to identify morphotypes of dewlaps and antlers.

The shape and relative dimensions of the dewlap were determined subjectively based on materials obtained during the absence of most of the hair cover

(May–July). The photos showing an elk side-on were used as the examples of distinguished forms of the dewlap. The identification of dewlap morphotypes of individuals recorded in the rest of the year was based on experimental data on hair growth of already defined types.

Photos were used as well to determine the types of antlers; the photos were obtained during the final period of antler formation (July–August) and after the antlers were cleaned from skin integuments (September–November). The photos showing an elk "from above" and showing clearly antler's shape, direction and tines, served as examples of the antler shapes.

The occurrence of registered forms of dewlaps and antlers was calculated for each site and each observation period, lasting for 4–12 months during the year. The obtained results were compared with the previously published materials on this topic.

Photoshop CS 2.0 and CorelDraw X 7 version 17.6.0.10.21 programs were applied to outline the examples of the types of antlers and dewlaps. The image was outlined by the body structures; then an outline was traced with the "high quality image" effect.

Results

From 2015 to 2020, from 8 to 186 different individuals were recorded annually in total, depending on the number of observed artificial salt licks. Almost at all observations sites, a certain number of individuals were noted visiting the artificial salt lick every year for several years (Sedikhin, 2021a). According to preliminary estimates, their share was 17–25% of the total number of individuals recorded at observations sites annually, and, most often, they were represented by mature individuals. However, assuming that there may be more elks, in particular yearlings, visiting the same salt licks, the average frequencies of occurrence of dewlap types and antler shapes were calculated separately for each observation period based on the total number of elks recorded for all sites. According to the author's observations, the shapes of the dewlap and antlers in older elk (approximately older than 5 years) did not undergo serious changes for several years. In addition, elks that were observed for several years in a row, as a rule, had characteristic features: (1) males had scars, cuts in the auricles, and injuries; (2) females, the presence of calves and yearlings in the initial period of observation of the next year (April), ulcers from the activity of gnat. These features, together with the shape of the antlers and dewlap, may serve for reliable elk identification. The number of registered elk by sites, sex, and age groups is presented in Table 1.

Dewlap

The following types of dewlaps were subjectively distinguished:

- "Drop" is very short, rounded or slightly elongated (Fig. 1).
- "Icicle" is long, thin, with a leathery "base" (slight expansion at the site of attachment to the neck) or without it (Fig. 2).
- "Fold" is a wide, large, complex-shaped dewlap, usually starting in the area between the lower

Table 1. Distribution of registered European elks by sex and age.

Observation period	Area	Number of observed salt licks	Number of individuals				Total
			Adults		1.5-year-olds		
			Male	Female	Male	Female	
2015	Vsevolozhsk	1	3	3	1	1	8
2016	Vsevolozhsk	1	3	2	0	0	5
	Tosno	2	14	8	2	1	25
2017–2018	Vsevolozhsk	2	7	8	3	6	24
	Luga	2	13	7	2	0	22
	Tosno	2	17	7	2	3	29
2018–2019	Vsevolozhsk	3	12	3	7	3	25
	Luga	5	34	18	7	5	64
	Tosno	2	10	9	4	2	25
2019–2020	Vsevolozhsk	7	22	21	9	6	58
	Luga	8	73	31	13	11	128
2020–2021	Vsevolozhsk	3	11	10	4	4	29
	Luga	4	49	15	12	5	81

jaws and ending at the neck. Divided into three subtypes: “halberd” (Fig. 3 **A**–**C**), “rounded” (Fig. 3 **D**, **E**), and “triangular” (Fig. 3 **F**–**H**).

On average, an icicle-type dewlap was presented in 37 ± 5.3% (hereinafter, mean (*m*) ± standard error (*SE*), *n* = 6) of annually recorded elks, “drop”, in 23 ± 6.3%, “fold”, in 25 ± 1.2% (Table 2). In approximately 10% of elks, dewlap shape was difficult to identify due to their short registration during the period when the elk has a winter coat (October–March). Moreover, the reduction of daylight hours during this period (and the corresponding predominance of night photographs and video recordings in the arrays of received information), as well as a decrease in the activity of vising the salt lick by the elk, reduced the reliability of assigning newly recorded elks to one or another group according to the dewlap shape.

In females, the “icicle” dewlap was most often noted (48 ± 4.7% of all registered females). A “drop” was noted in 37 ± 8.5% of females; the “fold” was very rare (1 ± 0.9%). On the contrary, in males, the “fold” was the most common (41 ± 2.0%). “Icicle” was noted in 30 ± 5.9%, “drop”, in 14 ± 5.0% of recorded males. It was difficult to determine the dewlap shape in 13 ± 6.9% of females and in 15 ± 3.0% of males.

The subtypes of the “fold” dewlap were analyzed only for males, since for entire 5-year observation period only two females were noted with a folded dewlap of the triangular subtype. At the same time, they were recorded two years in a row at the same sites, more than 70 km apart from each other. The “rounded” shape was found in 28 ± 5.3% of males with a folded dewlap shape, “triangular”, in 31 ± 6.9%, and “halberd”, in 42 ± 5.9%.

Antlers

When processing observations data, the author identified the following types of antlers:

1. “Spike” – the antler is represented by one tine (typical for yearlings).
2. “Fork” – the main trunk of the antler is like a “spike”, but ends with two short tines (typical for yearlings).
3. “Cervine” – antlers without palmate thickenings between the main tines, they are characterized by a limited number of elongated (usually up to 5) anterior tines (a_n) (Pocock, 1933, cited by Severtsov, 1951), on which further branching into short tines occurs (or does not occur), sometimes forming thickenings among themselves in different planes, with the predicted absence of thickenings.
4. “Palmated” – antlers with a formed thickening between the anterior tines (a_n) and posterior tines (p_n), subdivided into two forms:
   - “Full” – antlers have thickenings between all the anterior tines;
   - “Double” (“Separated”) – antlers with formed branching and thickening on the anterior tine a_1, as well as with thickenings between the other anterior tines; while without (or with minimal) thickening between a_1 and a_2, capturing the first posterior tin p_1. If the anterior tin a_1 does not have branching, but the other listed properties are present, then the antlers also belong to the “double palmated” type.
5. “Intermediate” – antlers in which the lengths of the anterior tines (a_n) from the edge of the thickening between them visually exceed the thickness of the thickening formed with them by the posterior tines (p_n). This also includes cases when one of the antlers has a kind of palmate thickening, not represented on the second antler.
6. “Transitional” – developed antlers with two and (or) three well-defined tines (most often one anterior and one posterior), characterized by a transitional state from simple antlers (“spike”, “fork”) to antlers of an established form (typical for young males up to 5 years).
7. “Abnormal” is one of the following forms:
   - antlers, initially forming several tines from the rosette, diverging in different directions;
   - antlers, which are one (or two) very short tines;
   - antlers with curved (or sinuous) thin tines;;
   - antlers of the “tulip” type, which are several multidirectional tines (often oppositely directed), diverging to the sides from each other from one site of the antler rod.

The palmated antlers were noted annually in 23 ± 4.7% of elks (Fig. 4), cervine, in 25 ± 4.5% (Fig. 5); on average, 15 ± 2.6% of males were recorded with intermediate antlers (Fig. 5), with transitional antlers, 8 ± 2.1% (Fig. 6). Annually, 18 ± 1.8% of “spike” and “fork” antlers were registered, as well as 5 ± 1.7% of elks with abnormal antlers (Fig. 6). In 7 ± 1.6% of elks, it was difficult to determine the shape of the antlers due to their short registration in the initial period of antler growth (April–May). Palmated antlers were more often noted in Luga and Tosno Districts (31 ± 3.9% and 27 ± 5.5%, respectively) than in Vsevolozhsk (14 ± 4.7%). On the contrary, “spikes” and “forks” were more often recorded in the Vsevolozhsk District (21 ± 4.6%) (Fig. 7).

On the basis of a combination of elk features (dewlap, antlers, scars, ear ruptures, permanent presence), at least 14 males with stable antler shape were identified, observed at 5 different sites for several years annually. In this case, there were no serious changes in the main directions of the antler; however, a slight increase or decrease in the number of anterior tines was possible. Sometimes, as a result, the type of antlers changed to “intermediate”, but a sharp transition from cervine to palmated and vice versa was not observed.

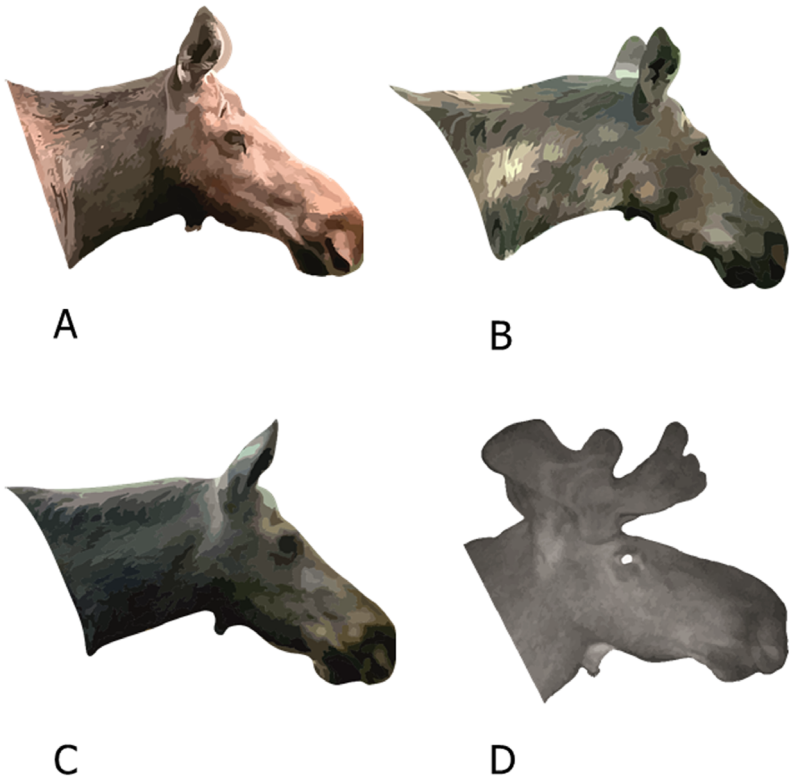

Fig. 1. Variations of the “drop” dewlap indicating the region and date of registration. **A** – Vsevolozhsk District, 12.07.2020; **B** – Tosno District, 09.06.2017; **C –** Vsevolozhsk District, 13.07.2019; **D –** Vsevolozhsk District, 23.06.2018.

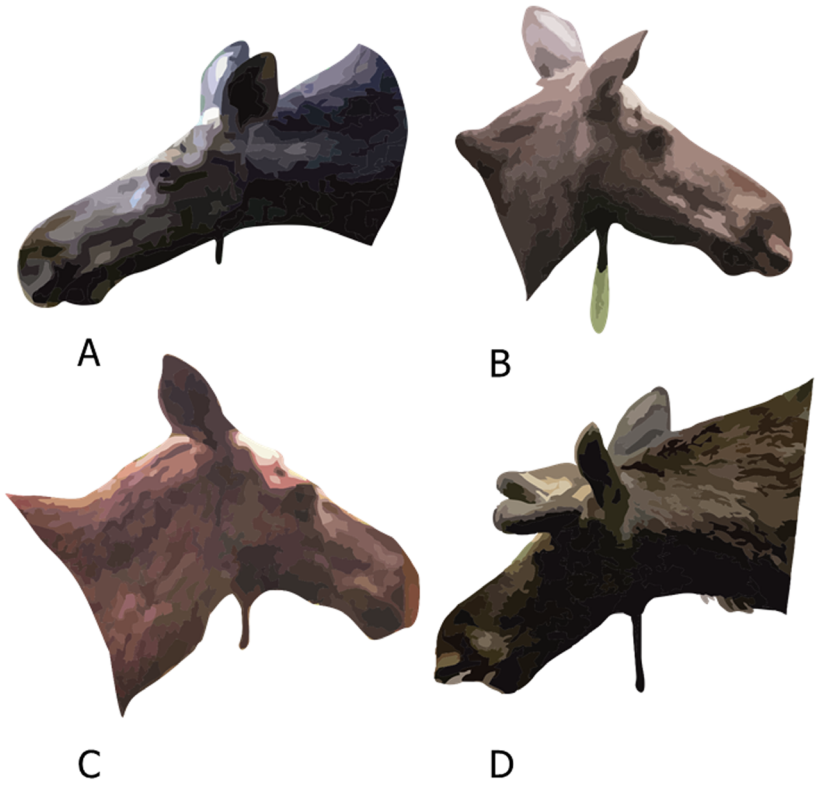

Fig. 2. Variations of the “icicle” dewlap, indicating the region and date of registration. **A** – Vsevolozhsk District, 18.06.2019; **B** – Luga District, 01.06.2020; **C** – Tosno District, 01.06.2017; **D** – Luga District, 11.07.2020.

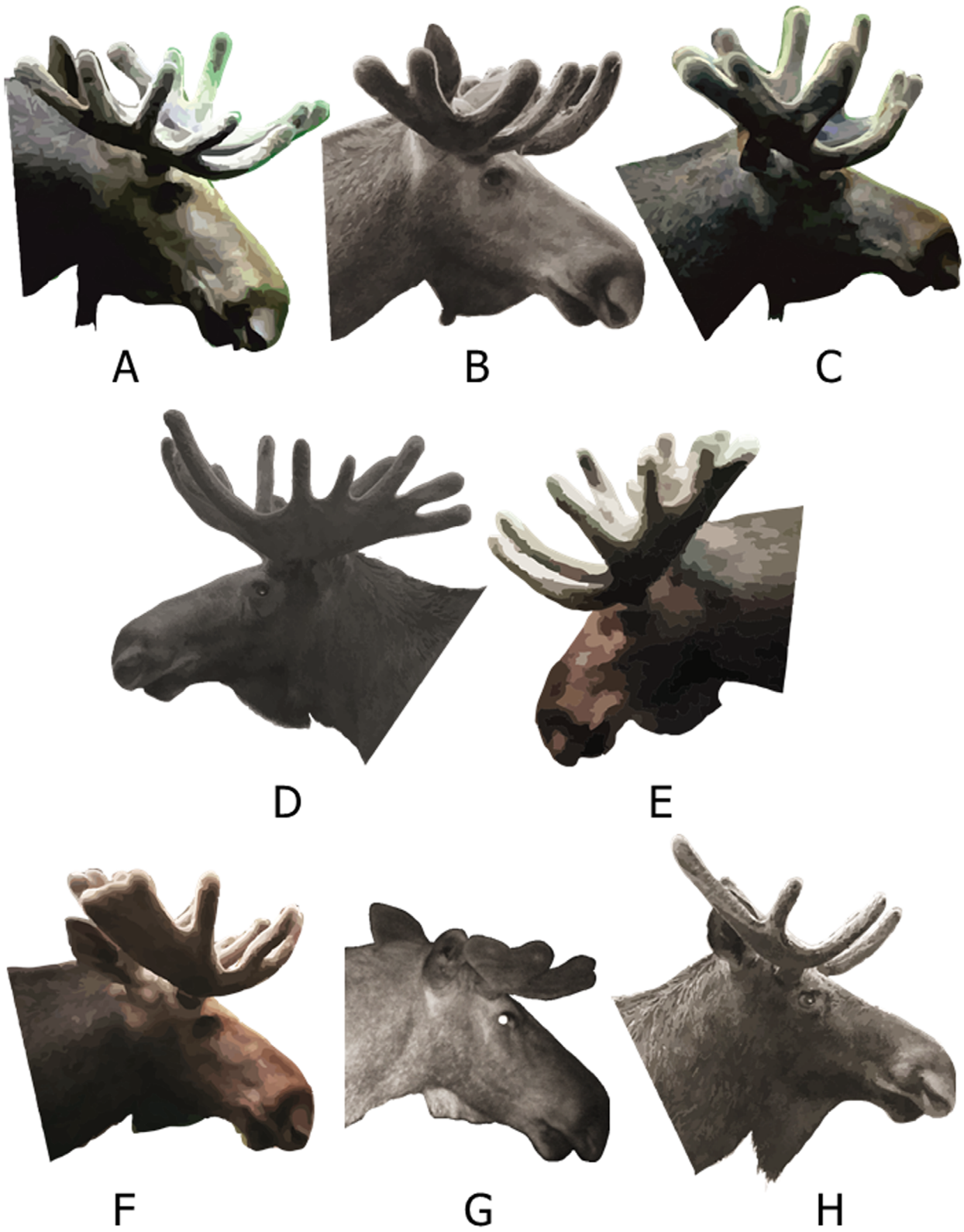

Fig. 3. Variations of the dewlap "fold" indicating the region and date of registration: halberd (**A**–**C)**, rounded (**D** and **E)**, and triangular (**F**–**H)**. **A** – Luga District, 08.07.2019; **B** – Tosno District, 25.06.2018; **C** – Luga District, 13.06.2019; **D** – Tosno District, 30.07.2016; **E** – Luga District, 14.07.2018; **F** – Luga District, 26.06.2020; **G** – Tosno District, 07.06.2017; **H** – Tosno District, 07.08.2016.

Table 2. The number and frequency of occurrence of individuals with different dewlap morphotypes during the study period.

Year	Dewlap morphotype	The number of individuals with a certain morphotype	**Total number of individuals registered**	**Share, %**
2015	Drop	0	8	0.0%
	Icicle	3		37.5%
	Fold	2		25.0%
	Undefined	3		37.5%
2016	Drop	14	30	46.7%
	Icicle	4		13.3%
	Fold	7		23.3%
	Undefined	5		16.7%
2017–2018	Drop	27	75	36.0%
	Icicle	23		30.7%
	Fold	16		21.3%
	Undefined	9		12.0%
2018–2019	Drop	28	114	24.6%
	Icicle	44		38.6%
	Fold	27		23.7%
	Undefined	15		13.1%
2019–2020	Drop	29	186	15.6%
	Icicle	93		50.0%
	Fold	53		28.5%
	Undefined	11		5.9%
2020–2021	Drop	14	110	12.7%
	Icicle	58		52.7%
	Fold	33		30.0%
	Undefined	5		4.6%

Discussion

Dewlap

Little has been published about the dewlap in Russian scientific literature. It is mentioned that the length of a dewlap of the European elk may reach 40 cm (Knorre, 1959; Makridin et al., 1978). The largest size is observed in three- and four-year-old animals (Rudenko and Semashko, 2003). However, this data is given without any information about measurements. It is also noted that the functional and physiological significance of the dewlap is not known still for certain, but there are several assumptions about its functions. The sexual olfactory-optical and thermoregulatory functions are most often mentioned (Filonov, 1983; Timmermann, 1979). The dewlap may also be a rudimentary organ with a high variability in its shapes and sizes (Bubenik, 1973).

A significant contribution to the description of the growth characteristics of dewlap has been made by the North American zoologist H.R. Timmermann when studying the subspecies of the American moose (*A. americanus gigas* Miller, 1899; *A. a. andersoni* Peterson, 1950; *A. a. shirasi* Nelson, 1914; and *A. a. americanus* Clinton, 1822) in central Ontario, Canada (Timmermann, 1979; Timmermann et. al., 1985). According to his conclusions, males are distinguished by a larger dewlap, while its shape changes with age; in general, the variety of dewlap shapes in males is higher than in females. A long thin dewlap can fall off, which was also noted by E.P. Knorre (1959), and the skin outgrowth at its base may increase and

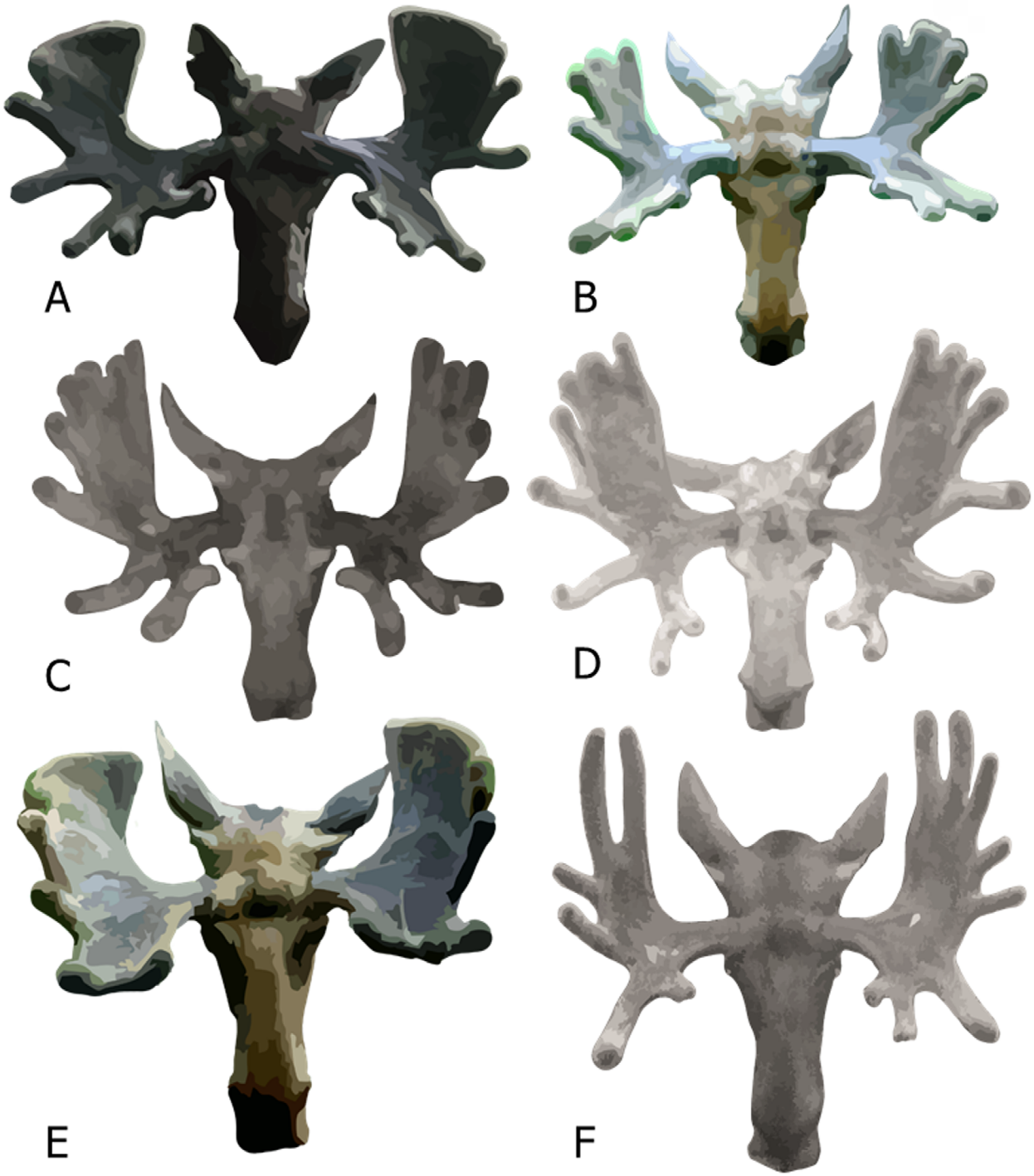

Fig. 4. Palmated branches in antlers at different stages of development, indicating the area and date of registration. **A, B** – **"**double palm", **C**–**F** – "full palm". **A** – Luga District, 13.07.2019; **B** – Luga District, 04.07.2019; **C** – Luga District, 14.07.2019; **D** – Luga District, 05.07.2020; **E** – Luga District, 24.06.2019; **F** – Tosno District, 04.08.2016.

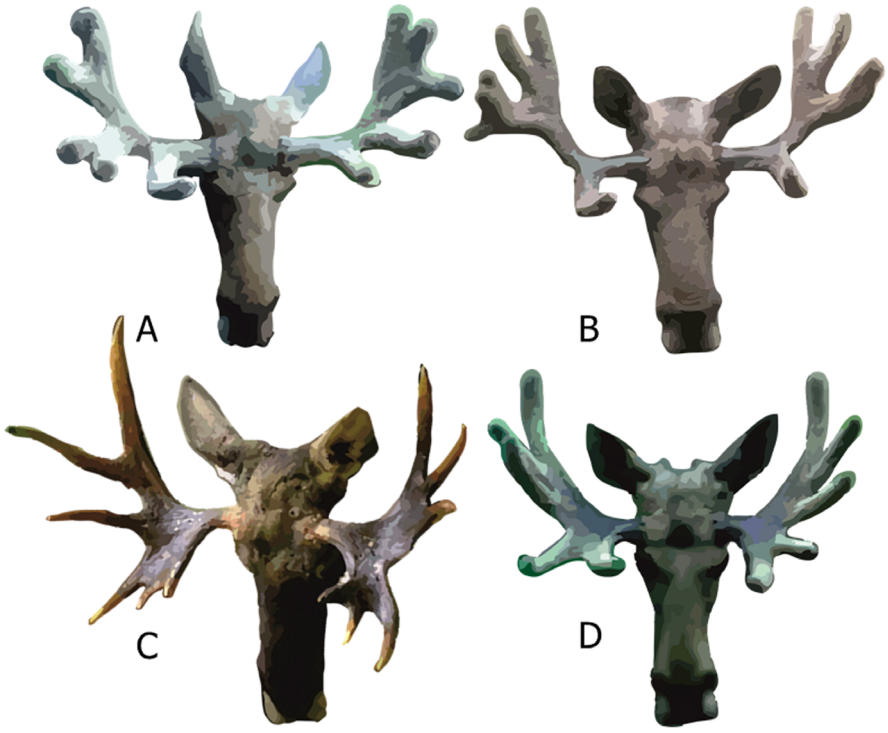

Fig. 5. Developed cervine antlers (**A**, **B)** and intermediate antlers (**C**, **D)** at different stages of development, indicating the area and date of registration. **A** – Luga District, 02.07.2019; **B** – Luga District, 16.06.2020; **C** – Vsevolozhsk District, 19.10.2017; **D** – Luga District, 22.07.2019.

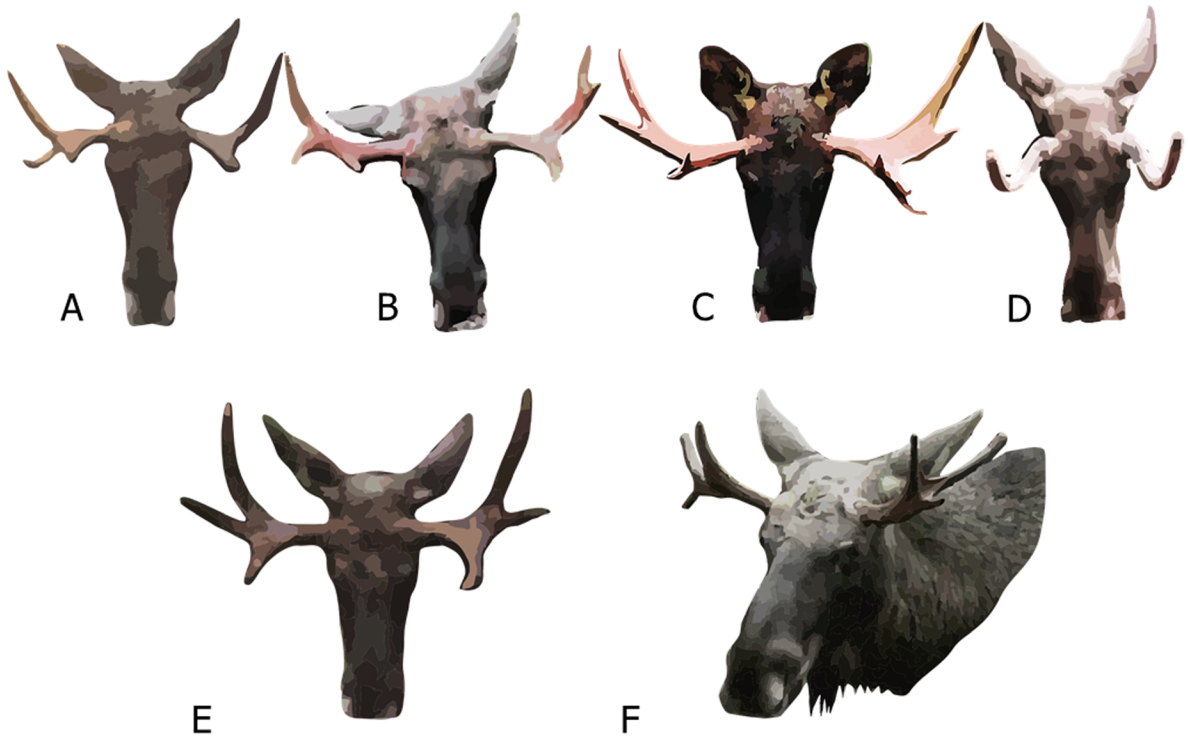

Fig. 6. Antlers of transitional form (**A**–**C**, **E)**, "spike" type antlers (**D**) and abnormal "tulip" type antlers (**F)** showing area and date of registration. **A** – Luga District, 22.10.2020; **B** – Luga District, 16.09.2020; **C** – Luga District, 22.09.2020; **D** – Luga District, 27.08.2018; **E** – Luga District, 13.09.2019; **F** – Luga District, 27.09.2019.

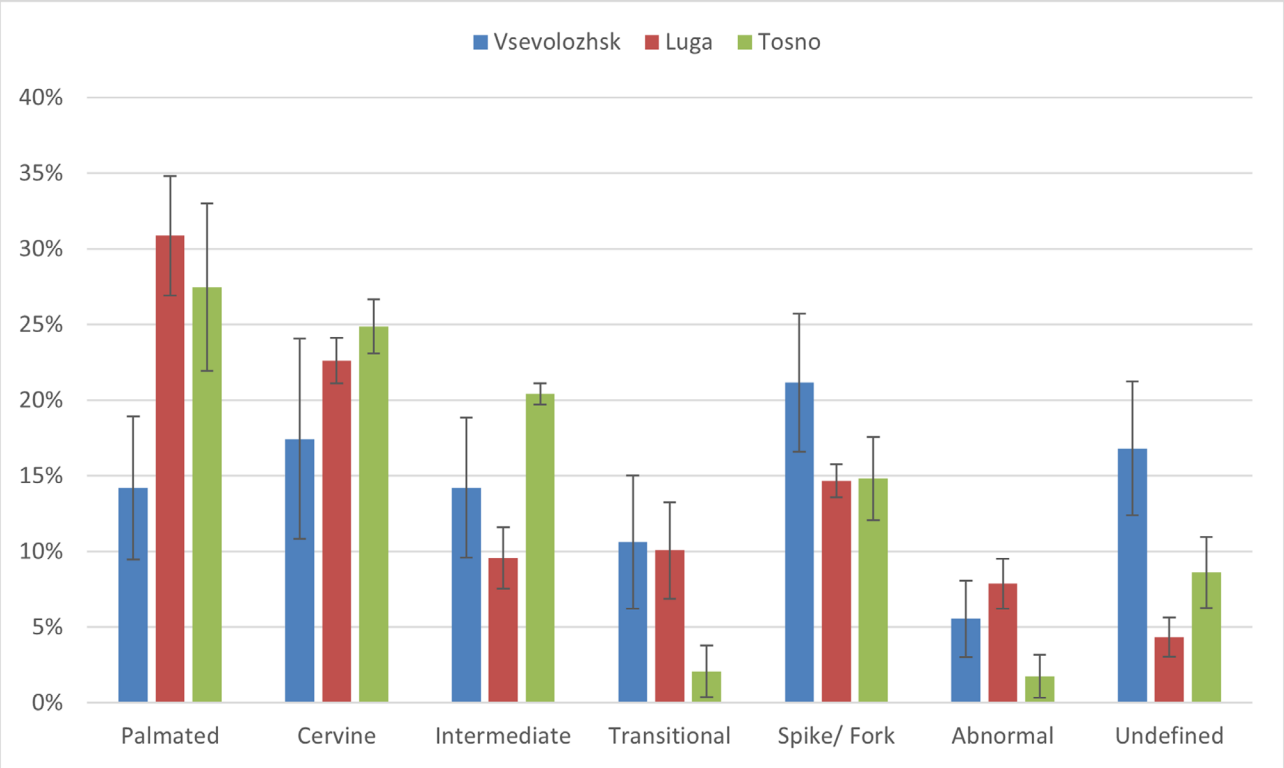

Fig. 7. The average frequency of occurrence of different types of elk antlers in the Leningrad Oblast (Vsevolozhsk, Luga, and Tosno Districts) based on long-term observations at the sites of artificial salt licks. The "whiskers" in the histogram denote the standard error of the mean (*SE*).

become wider and saccular. Most often, the loss of part of the dewlap is associated with frostbite. At the same time, the so-called "terminal scars" from a broken dewlap are much more common in males than in females (Timmermann, 1979).

The longest dewlaps are typical for elks under the 5-year age (Sokolov, 1964; Timmermann et al., 1985). Some sources indicate that the maximum length of the dewlap (38 inches or 96 cm) has been recorded in Manitoba in 1903 (Timmermann et al., 1985), according to other authors, this was in 1897 (McCollough, 2019). However, it is also noted that this dewlap belonged to a female, which questions the reliability of these sources when compared with the results of modern research.

During this study, remote observation methods did not allow us to estimate the absolute dewlap length (in centimeters). However, in relative terms, an adult elk with intermediate antlers (4 left and 4 right tines) had the longest dewlap; it was noted in the Luga District in 2020. The halberd fold with an elongated thin part in the normal position of the body reached the chest line.

Comparing our data and that presented by H.R. Timmermann, we assume that the dewlap of male elks inhabiting the Leningrad Province turns with age from an "icicle" shape into a "fold". At the same time, the "halberd" dewlap is observed in 6–10-year-old elks, "triangular" and "rounded", in the elks older than 10 years. In turn, females either form a long thin dewlap, which then freezes in winter, turning into a "drop", or a short small "drop" dewlap is initially formed, developing after 10 years into a small "fold". It is possible that very few females with the "fold" dewlap have been noted due to the fact that many elks do not live over 10 years. However, the "fold" shape probably varies depending not only on age, but also on the place where the "icicle" dewlap has been cut off. In males, the "fold" dewlap at the base of the "icicle" one can appear already at the age of 3.5 years; after the "icicle" falls off at the base, a triangular fold is formed, not baggy, but more shaped and tightened. Probably, rare cases of a huge "halberd" dewlap and a very long "icicle: dewlap may be due to variable climate of the Leningrad Province. In particular, the dewlap does not always freeze and falls off at a certain age. For example, in the animal rehabilitation center "Veles," which has several mooses under of 6 years age, who were brought there as calves, no dewlap falling was observed at all (personal communication of "Veles" employees).

We believe that the longer and thinner the dewlap, the more likely elk is to lose part of it. Meanwhile, during the observation period, eight males at the age of 1.5 years have been recorded, who had a small "drop" dewlap. When studying elks in the Pechoro-Ilychsky Reserve, dewlap falls off at the age of 1–2 years (Knorre, 1959). This conclusion is doubt-

ful; at the same time, relatively long "icicles" are also found in young-of-the-year, so the possibility of such outcomes should not be completely ruled out. In Fennoscandia, relatively small sizes of dewlaps are also noted (Timmermann et al., 1985); it is possible that the development of the original form may also be genetically determined. Unfortunately, on the basis of the dewlap alone, it is impossible to reliably determine the age of an elk with an accuracy of up to a year. However, knowing the developmental features of dewlap together with other elk characteristics, it is potentially possible to attribute the elk to a certain age category.

Antlers

In the literature, two types of elk antlers are most often mentioned: cervine and palmated. Opinions about the existence of two main types are supported and used by many researchers (Boeskorov, 2001; Bubenik, 1973; Danilkin, 1999; Filonov, 1983; Timofeeva, 1974). It should be noted that there are descriptions of the development of antler characteristics of the elks inhabiting the European part of Russia and former USSR in the Russian literature of the first half of the XX century (Buturlin, 1934; Kulagin, 1932). For example, it is indicated that the "palm" in elk is formed after 5 years, but at the same time there are references to different forms with a narrow (or absent) and wide palm. Specialists agree that elk antlers are highly susceptible to genetic, age, and physiological variability. That is why there are multiple variations in the antler development.

According to later publications, the cervine antlers are characteristic of the European elk (*A. alces alces*), palmated antlers, of the American moose (*A. americanus* Clinton, 1822) (Boeskorov, 2003; Danilkin, 1999; Fil' and Gordienko, 2009). However, there is evidence that a palmate thickening does not develop on the antlers of the Ussuri moose *A. americanus cameloides* Milne-Edwards, 1867 (a subspecies of the American moose), and the number of tines in adults of this species is limited (Boeskorov, 2001; Filonov, 1983; Fil' and Gordienko, 2009; Kulagin, 1932). The living conditions of the European elk and the Ussurian moose are different, but the reasons for the parallel formation of the cervine antlers in these two species are still not clear. A clear difference between the antler shapes in the European elks and American moose is observed when comparing *A. alces alces* with *A. americanus andersoni*. In representatives of the latter species, palmated antlers are a definite feature starting from the 2nd year of life (Child et al., 2010); this is extremely rare case for the European elk. Comparing 1.5-year-old European elks and American subspecies, up to 8 tines can develop in the latter at this age. At the same time, in Lapland, where climate in some terms is similar to that in the northwest of Russia, only one tine is most often recorded in the European elk at the same age (Filonov, 1983).

In addition, many sources testify to the presence of other forms, which are rather an age indicator: "spike" with a single long tine, "fork" or "forks" with two tines (Knorre and Shubin, 1959; Yazan, 1987). A "intermediate" ("medium") shape of the antlers is also mentioned, when the observer finds it difficult to attribute them to the "palmated" or "cervine" group of antlers (Danilkin, 1999; Engan, 2001; Makarova, 2015; Nygrén et al., 2007). Based on these data, similar groups are identified in the present study. It is also noted that antlers of different types ("cervine" and "palmated") can form in the areas with the same conditions (Filonov, 1983) and are present in almost all populations (Danilkin, 1999).

Despite the identification of many subjective forms of antlers, there are still no clear criteria for assigning them to one or another type. The monographs give single quantitative characteristics. For example, E.K. Timofeeva (1974), mentioning a "narrow palm", indicates a width of less than 10 cm, but can this mean that all antlers that have thickenings of more than 10 cm in any place belong to well-developed palmated antlers? In the study of trophy antlers in Norway (Engan, 2001), antlers with a palm width of at least 20 cm were classified as palmated, while narrower antlers were categorized as "intermediate". It is also unclear whether antlers of various shapes can be formed in elks at a mature age for several years in a row under natural conditions if the elks constantly live within the same area. There is evidence of a sharp change in the shape of the antlers when living and feeding conditions change (Knorre and Shubin, 1959), but if the conditions do not change, is it possible to assert that there is some predisposition to a certain shape of the antlers for each elk individual?

According to G.G. Boeskorov (2001), only the antler shape of healthy elks that have reached physiological maturity can be used as a diagnostic feature. However, physiological maturity is usually the age at which an elk reaches adult size and is able to participate in the breeding process. In most cases, this age in males corresponds to 2.5 years. Thus, in order to assess the predominant form of antlers, a part of yearlings, for which the forms "spike", "fork", and "abnormal" are typical, must be omitted from the sample, as well as weak males 2.5–3.5-year-old with similar antlers. It should be noted that in the European population, antlers at this age most often have no more than 2–3 tines (Knorre and Shubin, 1959; Yazan, 1987), while the North American moose population is characterized by antlers with 3–6 tines and with formed thickenings between them (Child et al., 2010). In this study, observations were made for *A. alces alces,* living in the south-boreal and hemi-boreal zones of the taiga of northwestern Russia with a predominance of mixed coniferous forests. Ecological, climatic, and economic conditions here are significantly different from that of Western Siberia and North

America. Taking into account the information about the shapes and sizes of antlers and differences in the karyotype of European elk and American moose, we argue that the antlers of these species are formed differently. At the same time, the palmated ("elk") antlers are presented at older ages in the European elk than in the American moose.

Along with this, one should not ignore the fact of grinding and deterioration of the physiological state of elk, noted by many authors conducting research in the northwest of Russia and of the former USSR (Chervonny et al., 2015; Kulagin, 1932; Timofeeva, 1974; Vereshchagin and Rusakov, 1979). This phenomenon negatively affects the formation of the palmate shape and the size of the antlers in general. According to our data, significantly more elks with "spike" and "fork" antlers, as well as males with an abnormal shape of antlers, are recorded generally in the Vsevolozhsk District (closest to St. Petersburg city). The reduction in the number of elks with palmated antlers may be facilitated by a reduction in habitats and diversity of food supply, high hunting pressure, and participation of younger males in mating. This is noted by various authors when explaining the possible reasons for the deterioration of the physiological state of elk in other parts of the range (Danilkin, 1999; Fil' and Gordienko, 2009; Filonov, 1983). Apparently, these processes continue to this day, so now the annual comprehensive observations of hunting resources are more relevant than ever.

Summarizing the above, we conclude that asserting predominance of the deer-shape antlers in the European population is based on inaccurate identification of morphological forms. As a rule, all elks older than 1.5 years without any palmated thickenings (thickenings between tines exceeding 10-cm width) are classified as elks with cervine antlers. Following this, the ratio of the cervine and palmated antlers recorded in this work would average 3:1. At the same time, the calculation based on the proposed classification leads to a fundamentally different result of 2.3:3.0.

It is also erroneous to classify antlers with 1–2 shaped tines as cervine, since there is no unequivocal answer whether this elk can develop another form of antlers at an older age (5–10 years). In turn, actual observations indicate minor changes in the shape of the antlers over several consecutive years in older elks under constant conditions and at the same observation sites. Unfortunately, at present, there is no model that allows to predict their parameters for the next year based on the size and shape of the antlers of the current year. However, this may be developed if there is a reliable sample providing enough data on the branching of tines, relative sizes, and correlation of antler projections in the same elks for several years in a row. Such modeling of the features of the antler growth, as well as their classification according to meristic signs, may be performed using remote observations and relative measurements. The advantage of this approach is the possibility of obtaining a sufficiently large sample quickly and without any killing or even temporary narcotizing. Subsequent clustering according to the relative parameters of antlers and other morphological features will help to assign elks more accurately to certain age groups with further normalization and rational regulation of the use of this species.

Conclusions

Modern national nature management require methodological development. When using neural networks, the results of observations of elk in the form of photographic material from the places of their concentration may become the basis for developing a method for remotely measuring their abundance, assessing the sex and age ratio, and also analyzing the biodiversity of large mammal populations in general.

The distribution of recorded elks according to the types of antlers and dewlaps proposed in this article may be considered as one of the characteristics of the population state in a limited area, since the proposed forms and types are indirectly oriented to age groups and the physiological state of elks. Based on comparisons with other unique elk characteristics, it is possible to determine more reliably the size and structure of populations, correlate the results with habitat conditions, and also to understand the potential stocks and quality of annual production with the possibility of rational resource management.

Undoubtedly, this classification is still very subjective, so the next step should be to identify similar forms and types based on real morphometric measurements. At the moment, the author is developing approaches for assessing the material, which will increase objectivity in determining the characteristic features of elks and their individual sings.

ORCID

N.V. Sedikhin 0000-0002-1444-4476

References

Andreozzi, H.A., Pekins, P.J., Kantar, L.E., 2015. Analysis of age, body weight and antler spread of bull moose harvested in Maine, 1980–2009. *Alces: A Journal Devoted to the Biology and Management of Moose* **51**, 45–55.

Boeskorov, G.G., 2001. Sistematika i proiskhozhdenie sovremennykh losei [Systematics and origin of modern elks]. Nauka, Novosibirsk, Russia, 120 p. (In Russian).

Bubenik, A.B., 1973. Hypothesis concerning the morphogenesis in moose antlers. *Proceedings of the North American Moose Conference and Workshop* **9**, 195–231.

Buturlin, S.A., 1934. Losi [Elks]. All-Union Cooperative United Publishing House, Moscow – Leningrad, USSR, 67 p. (In Russian).

Chervonnyj, V.V., Gorbacheva, A.A., Sitnikova, G.V., 2015. Sravnitel'nyi analiz morphometricheskikh characteristik rogov losya (*Alces alces* L.) Okskoi i Ladozhskoi populyacii kak pokazatel' promyslovoi nagruzki [Comparative analysis of the morphometric characteristics of elk antlers (*Alces alces* L.) of the Oka and Ladoga populations as an indicator of hunting press]. *Regional'nye geosistemy [Regional geosystems]*, **32** (15 (212)), 125–130. (In Russian).

Child, K., Aitken, D., Rea, R., 2010. Morphometry of moose antlers in central British Columbia. *Alces: A Journal Devoted to the Biology and Management of Moose* **46**, 123–134.

Danilkin, A.A., 1999. Olen'i (Cervidae). Mlekopitayushchie Rossii i sopredel'nykh regionov [Deers (Cervidae). Mammals of Russia and adjacent regions]. GEOS, Moscow, Russia, 552 p. (In Russian).

Engan, J.H., 2001. Changes in the relationship between palmate and cervine antlers in moose (*Alces alces*) in Southeastern Norway. *Alces: A Journal Devoted to the Biology and Management of Moose* **37**, 79–88.

Fil', V.I., Gordienko, V.N., 2009. Los' Kamchatskogo Kraya [Elk of the Kamchatka Territory]. Kamchatpress, Petropavlovsk-Kamchatsky, Russia, 236 p. (In Russian).

Filonov, K.P., 1983. Los' [Elk]. Lesnaya promyshlennost', Moscow, USSR, 246 p. (In Russian).

Glushkov, V.M., Kuznetsov, G.V., 2015. Morphophysiological and behavioral adaptations of elk to wintering. *Izvestiya RAN. Seriya biologicheskaya [Bulletin of Russian Academy of Science. Series Biological]* **42** (4), 371–377. https://doi.org/10.1134/S1062359015040068

Jackson, R., Roe, D., Wangchuk, R., Hunter, D., 2005. Surveying snow leopard populations with emphasis on camera trapping: a handbook. The Snow Leopard Conservancy, Sonoma, California, 73 p.

Kolchin, S.A., Tkachenko, K.N., 2011. Primenenie fotolovushek v izuchenii krupnykh khishchnykh mlekopitayushchikh Yuga Dalnego Vostoka [The use of camera traps in the study of large predatory mammals in the south of the Far East]. *Materialy nauchnoi konferentsii "Distantsionnye metody issledovanii v zoologii" [Proceedings of the scientific conference "Remote methods of research in zoology"]*. Moscow, Russia, 33 p. (In Russian).

Kolesnikov, V.V., Makarova, D.S., 2014. Opredelenie vosrasta samtsov losei evropeiskogo losya (*Alces alces alces* L.) po rogam [Age determination of males of the European elk (*Alces alces alces* L.) by their antlers]. *Vestnik okhotovedeniya [Bulletin of Hunting]* **11** (2), 317–322. (In Russian).

Knorre, E.P., 1959. Ekologiya losya [Ecology of the elk]. *Trudy Pechoro-Ilychskogo gosudarstvennogo zapovednika [Proceedings of the Pechoro-Ilychsky State Reserve]* **7,** 5–122. (In Russian).

Knorre, E.P., Shubin, G.G., 1959. Opredelenie vozrasta losya [Determining the age of the elk]. *Trudy Pechoro-Ilychskogo gosudarstvennogo zapovednika [Proceedings of the Pechoro-Ilychsky State Reserve]* **7,** 123–133. (In Russian).

Kulagin, N.M., 1932. Losi SSSR [Elks of the USSR]. USSR Academy of Sceinces Printing House, Leningrad, USSR, 120 p. (In Russian).

Lukarevsky, V.S., Lukarevsky, S.V., 2019. Otsenka chislennosti dal'nevostochnogo leoparda (*Panthera pardus*) v Rossii [Estimation of the abundance of the Far Eastern leopard (*Panthera pardus*) in Russia]. *Zoologicheskii zhurnal [Russian Journal of Zoology]* **98** (5), 567–577. (In Russian). https://doi.org/10.1134/S0044513419050064

Makarova, D.S., 2015. Sootnoshenie trofeinoi otsenki evropeiskikh i vostochnosibirskikh losei [Correlation between the trophy assessment of European and East Siberian elks]. *Agrarnaya nauka Evropeiskogo Severo-Vostoka [Agricultural Science of European Northeast]* **46** (3), 66–70. (In Russian).

Makridin, V.P., Vereshchagin, N.K., Taryannikov, V.I., Kaletsky, A.A., Sviridov, N.S. et al., 1978. Krupnye khishchniki i kopytnye zveri [Large predators and hoofed animals]. Lesnaya promyshlennost, Moscow, USSR, 295 p. (In Russian).

McCollough, M., 2019. Dangling dewlaps. *Northwoods Sporting Journal.* Web page. URL: https://www.sportingjournal.com/dangling-dewlaps/ (accessed: 08.05.2022).

Nygrén, T., Pusenius, J., Tiilikainen, R., Korpelainen, J., 2007. Moose antler type polymorphism: age and weight dependent phenotypes and phenotype frequencies in space and time. *Annales Zoologici Fennici* **44**, 445–461.

Rudenko, F.A., Semashko, V.Yu., 2003. Los', kaban [Elk, wild boar]. AST, Astrel', Moscow, Russia, 143 p. (In Russian).

Sedikhin, N.V., 2021a. Tsyklichnost' i individual'nost' v solontsevanii losei, *Alces alces* (Linnaeus, 1758), na territorii severo-zapada Rossiiskoi Federatsii [Cyclicity and individuality in the salt licking by moose, *Alces alces* (Linnaeus, 1758), in the North-West of the Russian Federation]. *Trudy Zoologicheskogo institute RAN [Proceedings of Zoological Institute RAS]* **325** (3), 348–363. (In Russian). https://doi.org/10.31610/trudyzin/2021.325.3.348

Sedikhin, N.V., 2021b. The salt licking activity of the European Moose (*Alces alces* Linnaeus, 1758) in the Leningrad region of Russia: temporal and behavioral aspects. *Russian Journal of Theriology* **20** (2), 158–172. http://dx.doi.org/10.15298/rusjtheriol.20.2.05

Severtsov, S.A., 1951. Problemy ekologii zhivotnykh. Neopublikovannye raboty. T. 1 [Problems of animal ecology. Unpublished works. Vol. 1]. USSR Academy of Sciences Publishing House, Moscow, USSR, 172 p. (In Russian).

Sokolov, V.E., 1964. Struktura kozhnogo pokrova i yazyka losya [The structure of the skin and tongue of an elk]. In: Bannikov, A.G. (ed.), *Biologiya i promysel losya. Sb. 1. [Elk biology and hunting. Comp. 1]*. Rossel'khozizdat, Moscow, USSR, 174–195. (In Russian).

Timmermann, H.R., 1979. Morphology and anatomy of the moose (*Alces alces*) bell and its possible functions. *Master of Science in biology thesis.* Lakehead University, Thunder Bay, Ontario, Canada, 90 p.

Timmermann, H.R., Lankester, M.W., Bubenik, A.B., 1985. Morphology of the bell in relation to sex and age of moose (*Alces alces*). *Alces: A Journal Devoted to the Biology and Management of Moose* **21**, 419–446.

Timofeeva, E.K., 1974. Los' (ekologiya, rasprostranenie, hozyaistvennoe znachenie) [Elk (ecology, distribution, economic value)]. Publishing house of Leningrad University, Leningrad, USSR, 167 p. (In Russian).

Vereshchagin, N.K., Rusakov, O.S., 1979. Kopytnye Severo-Zapada SSSR (istoriya, obraz zhisni i hozyaistvennoe ispol'zovanie) [Ungulates of the North-West of the USSR (history, lifestyle and economic use)]. Nauka, Leningrad, USSR, 309 p. (In Russian).

Yazan, Yu.P., 1987. Skol'ko let losyu? [How old is an elk?] *Okhota i okhotnich'e khozyaistvo [Hunting and Game Management]* **8,** 12–13 (In Russian).