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Antler development in reindeer in relation to age and sex

Amund Høymork[1] & Eigil Reimers[1,2]

[1]University of Oslo, Department of biology, Division of general physiology, P.O.Box 1051, Blindern, N-0316 Oslo, Norway (eigil.reimers@bio.uio.no).
[2]The Norwegian School of Veterinary Science, MGA, P.O. Box 8146 Dep., N-0033 Oslo, Norway.

Abstract: Yearling male and adult female reindeer (*Rangifer tarandus tarandus*) are similar in size and shape. If sexual clues are hidden, it can be difficult to distinguish between them. Antlers can be a useful aid in classifying yearling males and adult females, depending on whether specific antler characteristics are identifiable for these two groups. We recorded antler characteristics in a domestic reindeer herd (Vågå) and found considerable overlap in antler height, width and circumference between the different age and sex groups. Total tines and number of tine split-offs are useful for the field biologist when discriminating among adult females, yearling males and 2.5 year-old males. For example, when using the tine split-offs with the suggested classification, 79% of the observed adult females and 76% of the yearling males were classified correctly. The antler height, width and circumference provide other biological differences between groups, but are not easy to use to identify free ranging reindeer. This is due to the great overlap in antler size between the groups and measuring difficulties in a field study situation. Male and female calves have very similar antlers, and only the antler width is possible for sex discrimination, giving 67% accuracy of discriminating between these two groups.

Key words: antler characteristic, classification, Norway, *Rangifer*.

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Introduction

Wild reindeer (*Rangifer tarandus tarandus*) herd composition counts are carried out annually in a number of Norwegian wild reindeer areas during the rutting season (Jordhøy *et al.,* 1996). Counts are based upon body and antler size, and the identification of sex organs. Animals are classified as either calves (c), females (f) or one- (1), two- (2) or three-year and older (3+) males (Jordhøy & Strand, 1997).

In reindeer, both males and females carry antlers. Males have fully-grown antlers just before the rut, shed them during winter and start growing new ones in early spring. As adults, males have the largest antlers of the two sexes and often possess the most branched sets (Nieminen, 1985). Non-pregnant females and young animals cast their antlers from March until the calving season, while pregnant females shed their antlers after calving in May. Females generally start antler growth immediately after shedding (Espmark, 1971). Males develop maximum antler size at 6-7 years of age, whereas females develop their maximum size at 4-5 years of age (Nieminen, 1985). Calves start their antler growth one month after birth (Nieminen, 1985).

The objective of this study was to test the possibility of classifying reindeer sex and age by using visible antler characteristics. For this purpose, it

was only necessary to distinguish between six groups; female calves (FC), male calves (MC), adult females of 1.5 years and older (Fad), yearling males (M1.5), 2.5 year old males (M2.5) and large stags (LS). It is easy to distinguish between calves and adults, and between adult females and large stags. It is difficult to distinguish between male and female calves, between adult females and yearling males, and between small 2.5 year old males and large yearling males. Of course, there are other ways to distinguish between age groups, and especially between the sexes. However, when classifying free ranging individuals, sex and age characteristics other than antlers are frequently difficult to identify.

Material and methods

We examined semi-domestic reindeer belonging to Vågå Tamreinlag in Jotunheimen, central Norway. This herd contained only calves, female adults, yearling males and 2.5 year old males. Antler characteristics were measured in 235 animals from all age and sex groups in December 1996 during Prussian blue treatment with rumen bolus that releases AFCF (ammoniumiron(III)- hexacyanoferrate(II)) to lower radioactivity in the animals. During slaughter in September 1997 we measured 100 yearling males, and during slaughter in December 1997 413 animals from all groups.

Morphometric data

Antler height (length of the main beam on the outside of the antler, from the burr to the outer tip), antler width (maximum obtainable width between the two antlers) and antler circumference (circumference just above the burr or at the first measurable point above the burr) were measured with a tape measure to the nearest 0.5 cm (Fig. 1). Number of tines were counted as all points exceeding 2.0 cm, including the point of the main beam and points on the brow tine (if present). Tine split-offs were counted only in the upper part of the main beam. Only the right antler was measured in 1996. In 1997, both antlers were measured. Tine split-offs were only counted in December 1997.

The upper part of the antler is defined as the antler above the rear tine and the lower part is defined below, including the rear tine (Figure 1). All mean values are presented together with standard error (SE). Not all individuals sampled were investigated for all traits due to broken antlers or antlers gnawed upon. All measured antlers were photographed to provide a photo archive on antler variation.

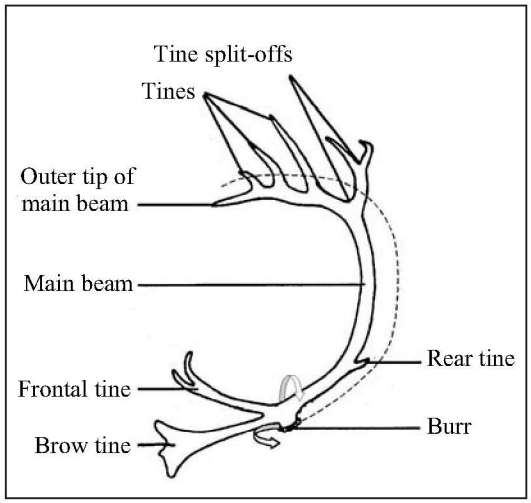

Fig. 1. Reindeer antler nomenclature. Arrows representing measuring points for antler circumference, and dotted line represents the measuring path for antler height. This antler has five split offs. The figure is adapted from Markusson & Folstad (1997).

Statistical analysis

Statistical analysis followed the SAS System (Windows release 6.12). ANOVA was used to compare groups when the data were normally distributed. If they were not, count data (e.g. number of animals with different number of tines) and Fisher's Exact Test (2-tailed) was used, since the only criterion for this test is independent observations. Discriminant Analyses were used to find the best values to separate age and sex groups, by using the Linear Discriminant Function (LDF). This test rounded all measurements of antler characteristics to the nearest whole number. Significance was assigned to a test if $P \leq 0.05$. When comparing data sets with very different variance because of uneven data, transformations were done and outliers were removed if necessary. Transformations used were X2=logX1, X2=log(Xmax-X1+1), X2=log(X1-Xmin+a), a=0.5 (0<a<1) (Hjermann, personal communication). R^2 values are presented together with the analysis to visualise the variation accounted for by the analysis. Relative differences in means are also presented. This is because a large sample size easily shows significant differences in means.

Results

Data from 1996 and 1997 were merged into one data set. Mean, percentiles and the Linear Discriminant Function (LDF) were used for discriminating among groups. Percentile plots show the differences among groups, the range in each

Table 1. Differences in antler characteristics among different semi-domestic reindeer groups presented as the 5, 25, 50, 75 and 95% percentiles (Fig. 2).

Antler Variable	Group	*n*	Percentiles				
			5	25	50	75	95
Right height (cm)	Female calves	62	16.1	23.0	26.0	30.8	34.5
	Male calves	56	16.5	25.0	29.5	33.3	38.0
	Adult females	134	34.7	44.0	50.0	54.0	63.0
	Yearling males	224	50.0	57.9	62.0	68.0	77.9
	2.5 yr. old males	20	73.8	81.8	88.5	92.5	102.5
Width (cm)	Female calves	48	13.0	17.0	20.0	23.0	27.7
	Male calves	45	17.2	21.0	25.0	28.0	34.6
	Adult females	122	28.0	34.0	37.0	43.0	50.0
	Yearling males	180	39.0	44.0	49.0	56.0	64.1
	2.5 yr. old males	13	56.2	60.0	62.0	70.0	87.0
Right circumference (cm)	Female calves	56	4.5	5.0	5.0	5.5	6.0
	Male calves	55	4.9	5.0	5.5	6.0	7.5
	Adult females	136	6.5	7.5	8.0	10.0	12.0
	Yearling males	225	8.0	9.0	11.0	13.0	16.0
	2.5 yr. old males	19	9.5	10.8	11.5	12.0	16.2
Total tines (no)	Female calves	58	2.0	2.0	2.0	2.8	4.2
	Male calves	52	2.0	2.0	2.0	3.0	4.0
	Adult females	126	3.3	6.0	9.0	10.8	13.0
	Yearling males	204	6.0	8.0	9.5	12.0	15.0
	2.5 yr. old males	17	11.4	13.0	15.0	18.0	20.2

Table 2. Measurements for best reindeer classification according to the Linear Discriminant Function (LDF). The test rounds all values to whole numbers. The percentages (%) are the possibilities of an individual measured to a group to actually belong to that group. *n* is the number of individuals from all groups that classify in the suggested classification area.

Group	Right Height (cm)			Width (cm)			Right Circumference (cm)			Total Tines (no)			Tine Split-offs (no)		
	LDF	%	*n*	LDF	%	*n*	LDF	%	*n*	LDF	%	*n*	LDF	%	*n*
Female calves	≤27	60	62	≤22	67	49	≤5	58	60						
Male calves	28-38	46	68	23-31	18	57	6-7	35	78						
Adult females	39-56	67	147	32-44	60	136	8-9	53	135	6-9	38	156	<2	79	42
Yearling males	57-75	87	181	45-58	82	124	10-11	64	106	10-12	64	105	>2	76	49
2.5 yr. old males	≥76	47	38	≥59	29	42	≥12	10	112	≥13	22	59			

group and the outermost limits of the groups (Fig. 2; Table 1). The Linear Discriminant Function found, for each antler character, the best separating points between the groups (Table 2). This made it possible to calculate the probability of an individual measured to a group, to actually belong to that group (Table 2). Used together with the percentiles and the statistical analysis, the LDF revealed antler characteristics which were useful for reindeer classification.

Discrimination between female and male calves

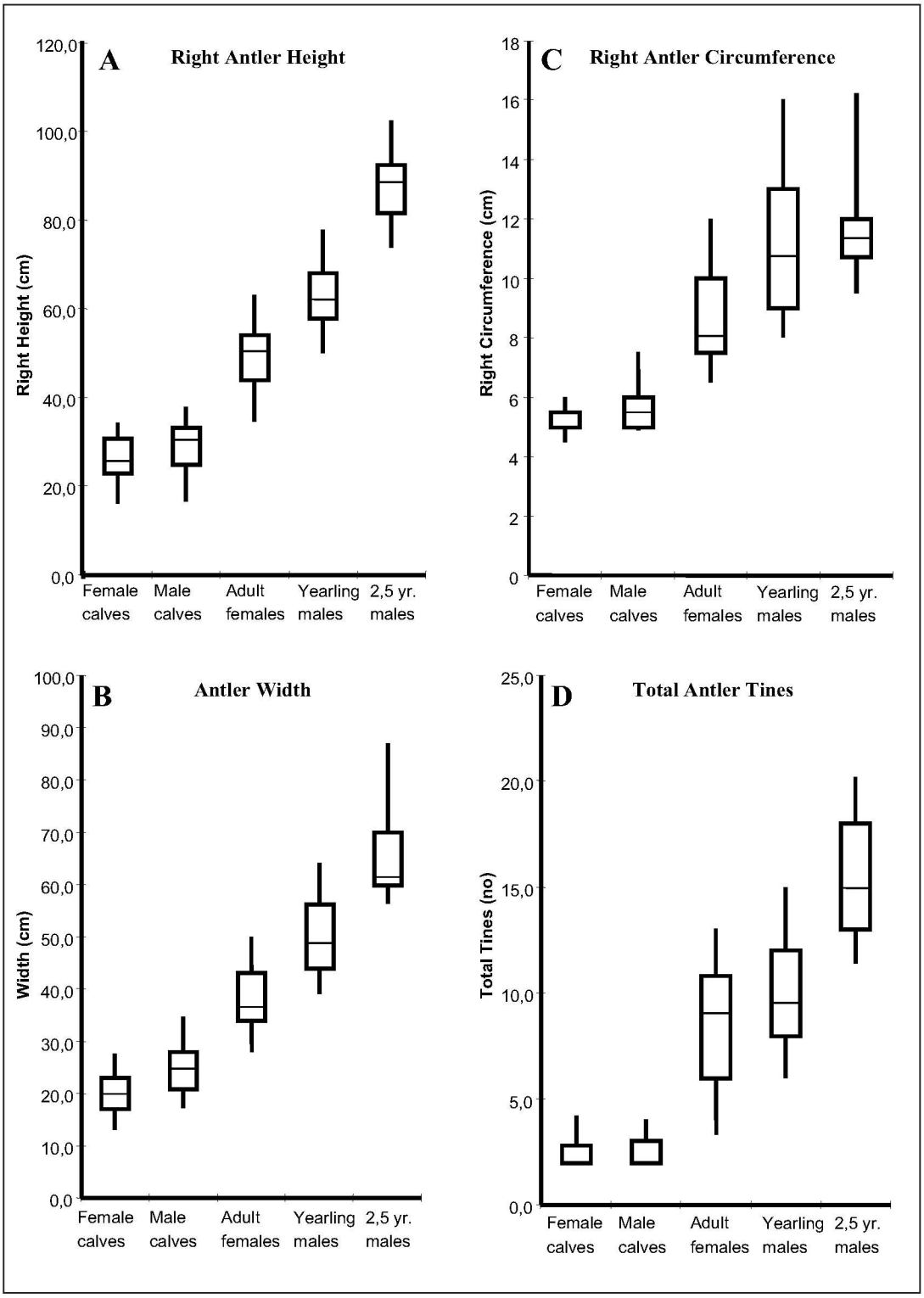

Fig. 2. Differences in antler characteristics among different semi-domestic reindeer groups. The boxes represent 50% of the data and the lines 90% of the data. From bottom up are the 5, 25, 50 (line in the box), 75 and 95% percentiles (Table 1).

Table 3. ANOVA analysis of the differences between a) male calves (MC) and female calves (FC), b) adult females (Fad) and yearling males (M1.5), and c) yearling males (M1.5) and 2.5 year-old males (M2.5). Values are mean ± standard errors, sample size (*n*), significance level (*P*), coefficient of determination (R^2) and the relative differences between the means (Diff). Not all individuals sampled were investigated for all traits due to broken or gnawed antlers.

a) Differences between female calves (FC) and male calves (MC).

Antler Variable	FC	MC	*n*	P	R^2	Diff (%)
Right height (cm)	26.0±0.8	28.5±0.8	118	0.0362	0.04	10.0
Left height (cm)	27.5±0.9	28.0±0.9	95	0.7324	0.00	1.8
Width (cm)	20.3±0.7	25.0±0.7	93	0.0001	0.20	23.2
Right circumference (cm)	5.2±0.1	5.6±0.1	111	0.0031	0.08	7.7
Left circumference (cm)	5.1±0.1	5.6±0.1	101	0.0003	0.13	9.8
Total tines (no)*	2.5±0.1	2.4±0.1	110	0.6230	-	4.2

b) Differences between adult females (Fad) and yearling males (M1.5).

Antler Variable	Fad	M1.5	*n*	P	R^2	Diff (%)
Right height (cm)	49.2±0.7	63.1±0.6	358	0.0001	0.39	28.3
Left height (cm)	48.9±1.0	61.9±0.6	222	0.0001	0.42	26.6
Width (cm)	38.5±0.7	50.3±0.6	302	0.0001	0.38	30.6
Right circumference (cm)	8.5±0.1	11.1±0.2	361	0.0001	0.24	30.6
Left circumference (cm)	8.4±0.2	12.2±0.2	235	0.0001	0.42	45.2
Total tines (no)	8.4±0.3	9.9±0.2	330	0.0001	0.05	17.9
Tine split-offs (no)	1.5±0.2	2.9±0.2	144	0.0001	0.20	93.3

c) Differences between yearling males (M1.5) and 2.5 year old males (M2.5).

Antler Variable	M1.5	M2.5	*n*	P	R^2	Diff (%)
Right height (cm)	63.1±0.6	87.2±2.0	244	0.0001	0.36	38.2
Width (cm)	50.3±0.6	66.8±2.3	193	0.0001	0.20	32.8
Right circumference (cm)	11.1±0.2	11.8±0.5	244	0.3717	0.00	6.3
Total tines (no)	9.9±0.2	15.4±0.8	221	0.0001	0.20	55.6

*Data were not normally distributed, thus count data and Fisher's exact test (2-tail) was used.

is best using the antler width variable. Males were 4.7±1.0 cm wider than females (Table 3a). The LDF indicates female when lower than 22 cm, and male when higher than 23 cm (Table 2), giving 67% accuracy of discriminating between these two groups. The variables right antler height, right antler circumference and total antler tines overlapped too much between the two sex groups to be used in calf discrimination (Fig. 2A, C and D; Table 1; Table 3a).

Significant differences in means between adult females and yearling males were found for all variables tested (Figure 3; Table 3b). The right antler height in males was 13.9±0.9 cm higher than the average female antler (Table 3b). The LDF indicates female when lower than 56 cm, and male when higher than 57 cm (Table 2), giving 88% accuracy of discriminating between these two groups. A similar relationship existed for left antler height (Table 3b).

Male width was 11.8±0.9 cm wider than females (Table 3b). The LDF indicates females when narrower than 44 cm and males when wider than 45 cm (Table 2), giving 77% accuracy of discriminating between these two groups.

The males had 2.6±0.2 cm thicker antlers than the females (Table 3b). The LDF indicates females when thinner than 9 cm and males when thicker

Fig. 3. Typical examples of adult female and yearling male antlers. Note the difference in tine split-offs.

than 10 cm (Table 2), giving 66% accuracy of discriminating between these two groups. A similar relationship existed for the left circumference (Table 3b).

A small difference in means was found when comparing the total tine variable. Males had 1.5±0.4 tines more than the females (Table 3b). The LDF indicates female when less than 9 tines and male when more than 10 tines (Table 2), giving 55% accuracy of discriminating between these two groups.

Males had 1.4±0.3 more tine split-offs than the females (Table 3b). The minimum values were similar, but the female maximum value excluded females when tine split-off was over 5. The LDF indicated females when less than 2 tine split-offs, with an accuracy of 79%, and males when more than 2 tine split-offs, with an accuracy of 76% (Table 2). Thirty seven percent of the animals had 2 tine split-offs and were therefor not classifiable. From the other 63%, 77% of the animals were classified in their correct group (Fig. 3).

A paired *t*-test was performed to check if the females had more tines in the lower part and males more tines in the upper part of the antler. A random sample of 20 males and 20 females were chosen from the picture archive to test this. Females had more tines in the lower part (4.7±0.5) than in the upper part (3.8±0.3) of the antler (n=20, P=0.0482). No such difference was found for males (n=20, P=0.12).

Differences between yearling males and 2.5 year-old males were found in the variables right height, width and total number of tines (Table 3c). The 2.5 year-old males were 24.1±2.1 cm higher than the yearling males (Table 3c). The LDF indicates yearling male when lower than 75 cm and 2.5 year old male when taller than 76 cm (Table 2), giving 87% accuracy of discriminating between these two groups.

The 2.5 year-old males were 16.5±2.4 cm wider than the yearling males (Table 3c). The LDF indicates yearling males when narrower than 58 cm and 2.5 year old males when wider than 59 cm (Table 2), giving 84% accuracy of discriminating between these two groups.

The 2.5 year-old males had 5.5±0.8 more tines than the yearling males (Table 3c). The LDF indicates yearling males when less than 12 tines and 2.5 year old males when more than 13 tines (Table 2), giving 83% accuracy of discriminating between these two groups. Antler circumference was not useful for discriminating between yearling males and 2.5 year old males (Fig. 2C; Table 1; Table 3c).

Discussion

Sex and age classification of reindeer in the field offers a challenge, even when using specific antler characteristics. Obviously, a field worker can not estimate the antler circumference. It is sufficiently hard to estimate the antler height and width. However, this could be done by using the reindeer ear, measuring 11-12 cm (Reimers, unpubl.), and from that, extrapolating an estimate for the antler characters. On the other hand, it should be possible to count the antler tines and tine split-offs quite accurately.

For antler classification, it is important to look at the variation within each group. Minimum and maximum values give the non-overlapping areas between the groups, but as is indicated with the percentiles in Fig. 2, leave most animals unclassifiable. Enlarging the classification area gives poorer accuracy, but includes more animals. To find the best separating point between groups we used the Linear Discriminant Function. This gave us the largest percentages of being right when separating between whole groups, but the accuracy just around the separating point was low and not often more than 50%.

The most recognisable of all groups investigated is the 2.5 year-old males. These have relatively large antlers with only minor overlap with yearling males, and even less overlap with the adult females. If the antler is 76 cm or taller, wider than 59 cm and has more than 13 tines, the animal classify as 2.5 year-old male.

The other easily recognisable group is the calves. Most calves have small and distinctive straight, tine-less antlers, which are not usually confused with adults. Antlers of female and male calves are very similar and hence difficult to discriminate between. The most useful character in calf classification would be the antler width. The male antlers are wider than the females'. The width has to be wider than 23.0 cm to classify as male, and narrower than 22.0 cm to classify as female, giving an accuracy of 67% for calf sex discrimination. Although male calves have slightly higher and thicker antlers than female calves, the similarities between the two sexes are too strong to use antler height or thickness for sex discrimination.

The two most important groups to discriminate between are adult females and yearling males. Inaccurate classification of these groups will lead to miscalculation of the herd's reproductive capability, which in turn may affect management.

Adult females and yearling males are similar in body size and shape. The male antlers were larger than the female antlers, both in height, width and circumference and in number of tines and tine split-offs. Female antlers are shorter than 56 cm, narrower than 44 cm, thinner than 9 cm and with less than 9 tines, while male antlers are taller than 57 cm, wider than 45 cm, thicker than 10 cm and with more than 10 tines. However, tine split-offs are easier to use, and indicate a female when under two and a male when over two tine split-offs. The partitioning of antler tines in the lower and upper part of the antler was not possible to use for sex discrimination purposes.

When defining classification schemes such as this, there will always be animals that do not conform to their classification group. However, even though most of the antler variables are shown to be positively correlated (Høymork, 1998), it is unlikely that multiple characteristics for an individual will simultaneously measure outside their categories. Comparing more than one variable for each individual will therefore ensure a better classification success. Nevertheless, the classification clues given by this work can ensure better probabilities than 50% of classifying correctly for most of the antler characters.

A problem when measuring antlers is the herd-specific differences. Differences occur in both body weight and antler size among different herds (Jordhøy & Strand, 1997). Cervids with better access to nutrients are known to have larger antlers (Suttie & Kay, 1983; Ullrey, 1983), suggesting that antler size differences are due to differences in food quantity and/or quality. In female reindeer, calcium content and density of the skeleton have been shown to decrease during antler development, suggesting that minerals used in the production of antlers are of limited availability (Baksi & Newbrey, 1989).

Without using defined antler characteristics, field workers have few other obvious classification clues (Jordhøy & Strand, 1997). The male penis and the female's dark area in her tail region are distinctive and successful clues for sex discrimination. However, these characteristics are often difficult to see, especially if the animals are lying down, facing towards the observer, walking in high vegetation or clumped together, making classification mostly subjective. The present study has found antler characteristics that discriminate between yearling males and adult females, and between yearling males and 2.5 year old males, providing field scientists with more objective methods for classifying free ranging reindeer. For example, by using the tine split-offs with the suggested classification, 79% of the observed adult females and 76% of the yearling males will be classified correctly. This antler characteristic is easy to record and readily usable in the

field. The total antler tine characteristic is useful for discriminating between yearling males and 2.5 year-old males. This measurement gives correct classification in 83% of the cases, and is also easy to record in the field. However, the other antler characteristics presented in this work are not applicable for the field scientist. For example, estimation of antler height or width from extrapolating from the length of the reindeer ear is difficult, and uncertainties remain when observing free ranging animals. Nevertheless, such measurements may be used to identify area differences in antler characteristics or to sex and age determine shed antlers.

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