SOME CHARACTERISTICS OF ANTLEROGENESIS IN MOOSE - A PRELIMINARY REPORT

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Abstract: The morphological characteristics of 82 cast antlers and 191 antlers from aged moose were studied. Antler Surface Area (ASA) was found to increase in direct proportion to volume as well as to dry weight and dry weight in proportion to volume (P = 0.001 in all cases). The Enclosed Area (EA: the area enclosed by the antler tips) increased faster relative to ASA in antlers having an ASA of 650 cm^2 to 1600 cm^2 (mainly from 2 1/2 to 4 1/2 year old bulls). The development of the brow tines, relative to the ASA slows during this middle period (ASA 500 to as high 1700 cm^2). In the yearlings' antlers, the brow tines have high priority in development. Following this set, until an ASA of 1700 cm^2 is reached (approximately 4 1/2 years), general tine growth (excluding the brow) has obvious priority over palm development. The quotient of ASA over EA when plotted on the burr circumference provides a parameter of antler quality.

The distance between the inner points of the brow tines becomes more narrow (i.e. more defensive) up to about 7 years and probably declines in senior animals.

Moose, following the antlerogenesis pattern of other Odocoileinae, produce their first set of antlers at 6 to 8 months. A coronet is not produced until the second set. In some Odocoileinae the seal profile can be used as an indicator of the animal's condition. In our sample this character showed great variability with age, however, we had no other data on physical condition.

Contribution No. 78-6

It is generally accepted that antlers of large cervids are: (1) an important indicator of physical fitness and neurohormonal status of the individual as well as the overall condition of the population (Beninde 1937, Bubenik 1959, 1966, Chapman 1975, Taber 1958); they are (2) a significant optical and olfactory cue in intraspecific communication (Bubenik 1973b, 1975a,b, Eibel-Eibesfeldt 1970, Hediger 1946, Portmann 1953); and finally, (3) a sophisticated weapon in social conflicts (Beninde 1937, Bubenik 1966, Lorenz 1964, Severtzov 1951). For these reasons, the rate of antler development, the size and shape, as well as the frequency and degree of antler injuries are considered to be basic parameters in managerial operations in countries with high hunting ethics and biologically based game control (Beninde 1937, Boone & Crockett Club 1958, Bubenik 1976, Chapman 1975, CIC 1960, Huxley 1931, Wagenknecht 1969).

In North America, primarily because of different hunting traditions and different views of game and game management, (Clarke 1976, Teer 1976) little attention has been paid to antlers in the management of cervids (Bubenik 1973a, Gasaway 1975, Timmermann 1971, White 1958). In the case of moose, this basic cause for neglect has been compounded by the difficulty in acquiring antlers for study.

Despite these obstacles we decided to study the antlerogenesis and antler morphometry of North Central Ontario moose to determine if some parameters could be of significance in managerial practice. In order to obtain moose heads of all age classes, we started a program to educate moose hunters (Buss 1978). This was enthusiastically responded to and enabled us to get preliminary information regarding the following questions:

(1) Does antlerogenesis in moose follow the same principles as in other

Odocoileinae or that of the Cervinae (Bubenik 1966, Hoffmann 1956, Lehmann 1959, Pocock 1933), e.g. does the first antler cycle occur during the first 6 to 9 months of life or later?

(2) Is the basic plan of antler ramification that of the Cervinae or Odocoileinae; e.g. is the first tine homologous or analogous to the brow tine or brow palm of Cervus species?

(3) How does the subsequent antler casting influence the pedicle length?

(4) Are there characteristics of the seal profile which are indicators of antler quality?

(5) Is antler size and shape related to the maturation status and what are the sociobiological parameters of antler quality?

(6) How do the morphometric parameters behave in relation to each other and the number of antler cycles?

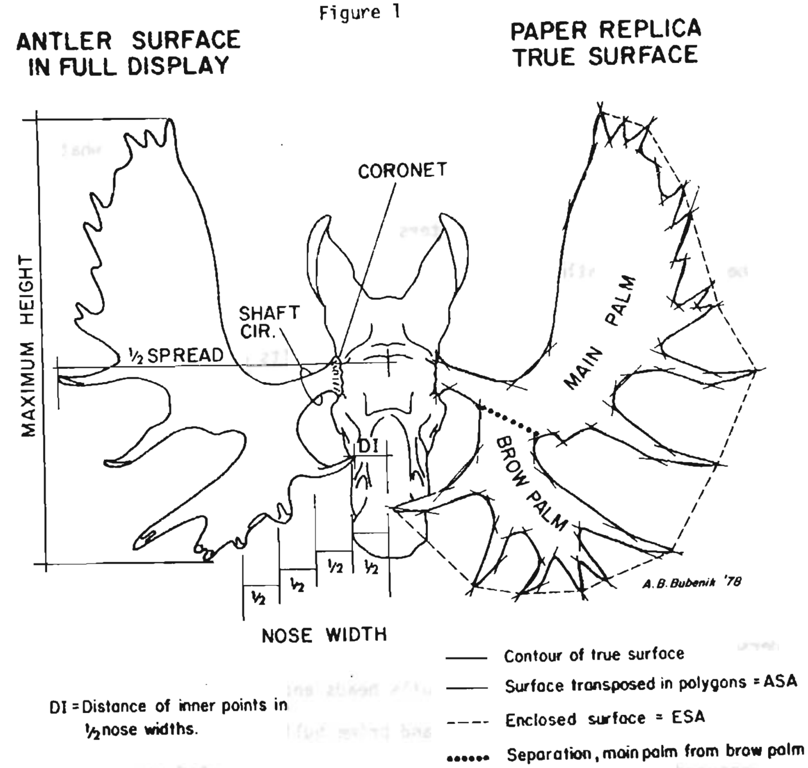
Not all of these questions could be answered satisfactorily from the material available, but the preliminary results are interesting. We hope they may encourage similar studies elsewhere.

METHODS

Our antler collection was made in the North Central Region of Ontario where according to Peterson (1955) the subspecies Alces a. andersoni and A. a. americana should overlap or hybridize. In 1976 and 1977, 48 yearlings, 143 older bulls heads and 19 male calf heads, as well as 82 cast antlers of teen and prime bulls were photographed and measured. The pedicles of the calves were investigated as to the progress of growth and antler cycle. The yearling antlers were checked for a coronet, which is the main indicator of a subsequent antler (Bubenik 1966). From antlers of known age, the following measurements

were recorded: maximum spread (according to the "Boone and Crockett Club" formula), minimum circumference of the beam between the coronet (called "burr" by some authors) and the first bifurcation (a "shaft" in our terminology*), distance between the inner points of the brow palms or tines, and the maximum height of the antler (Fig. 1). Each of the cast antlers was weighed, air dried and in water to establish

Figure 1



*There is not an appropriate English term in the literature for that part of the beam between the coronet and the bifurcation of the first tine. In German it is called "der Schaft". Therefore, we propose the term "shaft".

a weight, volume and the "average specific gravity", i.e. including the air trapped in the cavities of the spongeous core. A sheet of paper was taped on the dorsoventral side of the antlers and the outer contour was traced to get a flat replica of the antler surface. The boundaries of this tracing were transposed to form a polygon (Fig. 1), the x and y coordinates of each vertex were digitized and the area of the polygon calculated by computer. This leads to minor errors within a ±8 percent range, as estimated from the known weight of 1 cm^2 of the paper from which the surface replica was cut.

The computer was used to calculate the Antler Surface Area (ASA), the Brow Surface Area (BSA) and the Enclosed Surface Area (ESA - that area enclosed by the tine tips). The ASA/ESA ratio should serve as an indicator of the point length in relation to palm surface. The main palm area, or MPA (=ASA-BSA), and BSA development were studied since they are characteristic of the butterfly type of North American antlers (Bubenik 1973a). Where possible, the actual age of the bulls was estimated from dentition (in calves and yearlings) and cementum layers in all older animals.

RESULTS

The tips of calf pedicles from November and December were found to be built from mature antler bone of different thicknesses. Some of them were still more or less covered with dried velvet. In only a few cases a small disc of clean antler bone protruded. None of the 19 calves investigated had primary antlers of more than one centimeter length, although longer primary antlers have been recorded in zoos (Bubenik, unpubl., Kramer 1938) and elsewhere (Bromée 1940, Lundblad 1977).

From 27 yearling antlers, two were without a coronet. The majority of yearling antlers had a coronet, a characteristic which first appears on antlers of the second cycle.

In only a few specimens was it possible to investigate the length of the pedicle. From these it could be concluded that with each casting the pedicle becomes substantially shorter and apparently no regrowth follows, as occurs in Cervus species.

The gain in shaft circumference (Fig. 2), number of points (Fig. 3) and maximum antler spread (Fig. 4) develops gradually up into the sixth year of life. Thereafter, the increase is much slower. The shaft seems to reach its optimum circumference between the seventh or eighth year of life, but the spread and number of points does not decline before the age of 12 years. From our material it was not possible to estimate if the gain in spread is achieved by a true growth of points or by enlarging the divergency of palms (compare with Gasaway 1975).

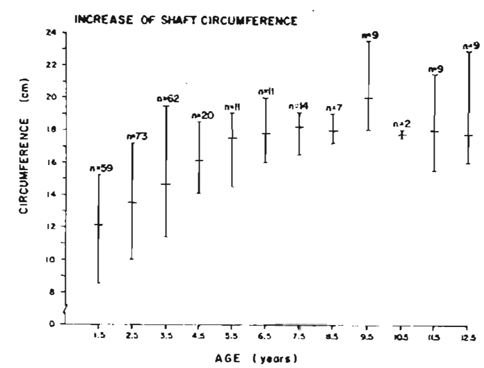


Figure 2

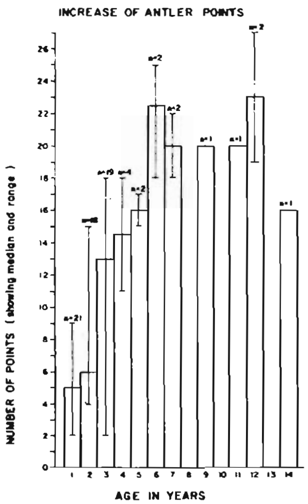


Figure 3

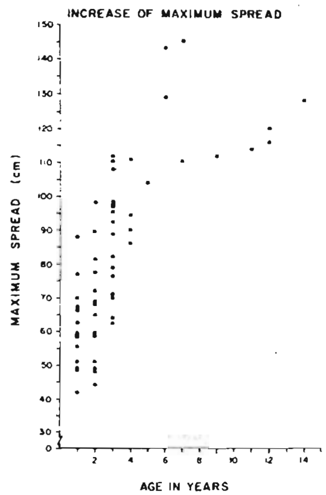


Figure 4

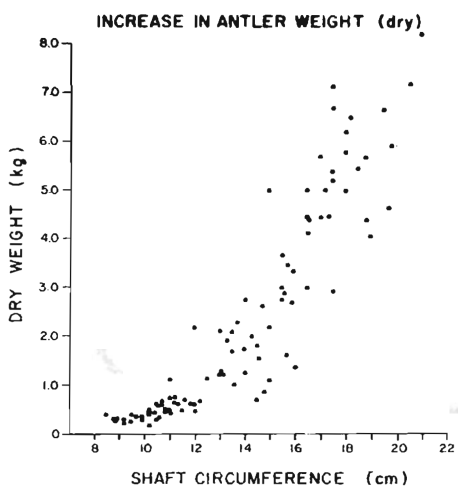
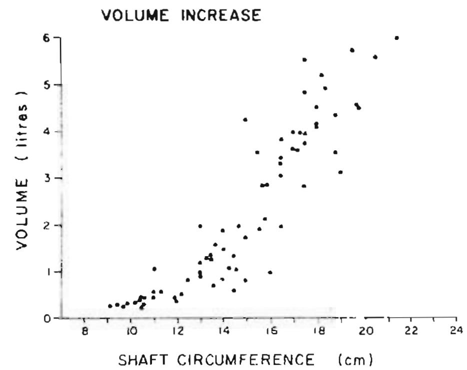


Figure 5



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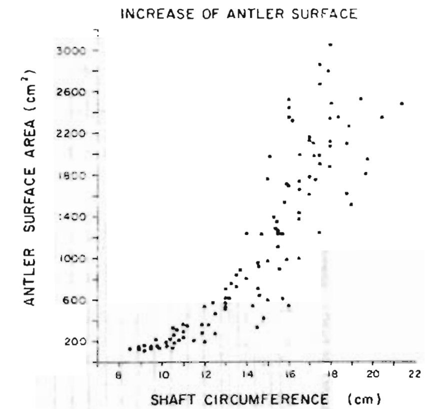

Figure 7

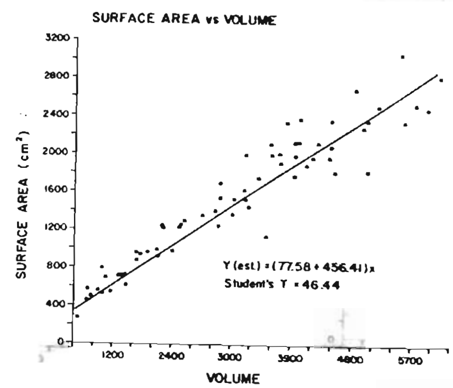

Figure 8

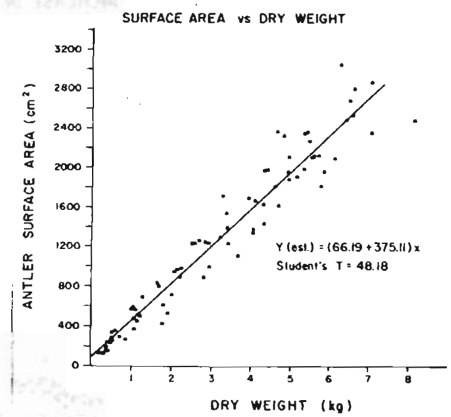

Figure 9

The shaft circumference is obviously related to the weight and volume (Fig. 5, 6) but it is difficult to say if it is linear or parabolic. The same can be said about the relationship of shaft circumference and ASA (Fig. 7).

ASA to volume and to dry weight are linear correlations (Fig. 8, 9). The specific gravity of young animals' antlers was quite variable (1.0 to 1.6). As the antlers increased in volume over 0.75 litres, the variability became restricted primarily to 1.2 to 1.4. The antlers having a specific gravity less than 1.2 were noticeably porous (Fig. 10).

The relationship between ASA and ESA (Fig. 11) shows a similar regression slope in antlers with a surface area up to 650 cm^2 and above 1700 cm^2. In antlers between 650 and 1700 cm^2 the slope is greater. Using the same divisions (650 and 1700 cm^2) when studying the graph of BSA on ASA (Fig. 12), it appears that the growth of the brow portion of the antler slows at this time. The main palm area relative to ASA shows a steady increase (Fig. 13). From these three graphs (11, 12, 13), it is apparent that in the mid-range of size of antlers (650 to 1700 cm^2 or very approximately antlers of 2 1/2 to 4 1/2 year old bulls) tines of the main palm have priority over the brow in development. Putting the quotient ASA/ESA in relation to shaft circumference as a quasi indicator of antler development in cast antlers of unknown age (Fig. 14), we get a high diversity of values.

Comparing this graph with the antlers, we saw that all the cervicorn and poorly palmated antlers appeared on the lower part of the field. At least for the smaller antlers (up to 15 cm shaft circumference), it was possible to visualize a clear dividing line between well-palmed and poorly palmed antlers. If the ability to produce palm between tines is an indicator of condition as was the

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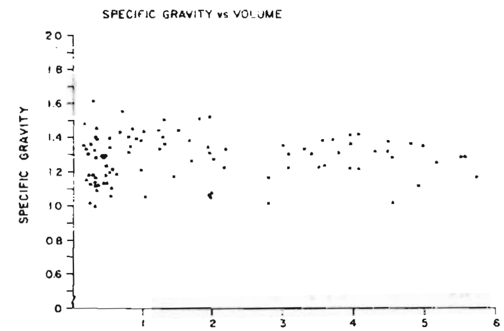

Figure 10 VOLUME (litres)

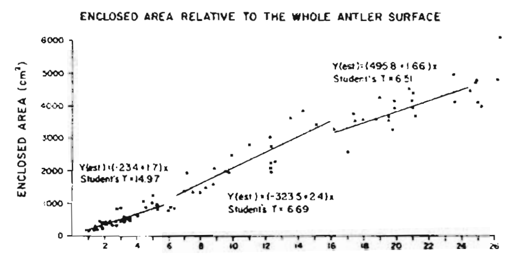

Figure 11 ANTLER SURFACE AREA (in hundreds of cm²)

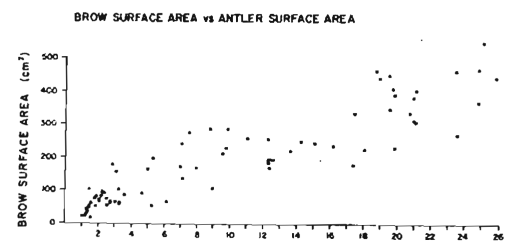

Figure 12 ANTLER SURFACE AREA (in hundreds of cm²)

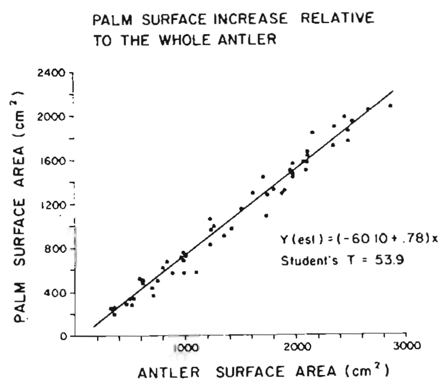

Figure 13

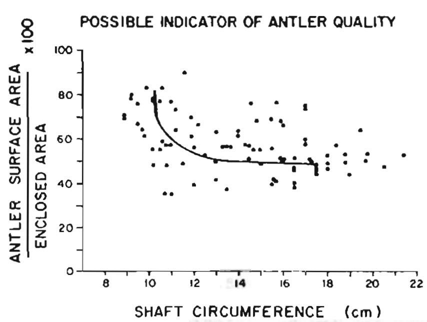

Figure 14

case in Sweden and Norway, (Bromée 1940, Schulz 1931, Swahn 1970, Swahn and Liden 1967), then the ratio of antlers on either side of the line in Fig. 14 could be an indicator of the condition of the young male population. It is our opinion, based on our studies of white-tailed deer (Bubenik and Williams in prep. a,b) and apparent from the work of Bielicki and Charzewski (1977) on humans, that the skeletal growth of young males is more eco-sensitive. Perhaps the same is true of moose and their antlers. Unfortunately, our data did not allow investigation of the change of ASA/ESA with age.

It is our opinion that early stages of antler development have more offensive than defensive features, and the opposite is true for mature males (Bubenik 1966, 1973a,b, 1975b). We consider the architecture of the brow palm as a crucial feature in this regard. The more convergent the "brow" is, the more protective, e.g. defensive value, it should have. Assuming that the function of the "brow" should be the protection of the eyes and the front of the head, we used as an index of offensive or defensive (protective) properties of the "brow", the distance between the inner points of the brow, measured in half-nose widths (Fig. 1). The relatively small number of antlers of higher social classes allowed only graphical evaluation of brow palm architecture (compare also Fig. 15). The highest frequency of divergent brow palms (nose distance > 2) appeared in yearlings and 2 to 3 year old teens, e.g. in 97 percent of the antlers in these age groups. Eighty percent of the defensive brow palms were found in animals over 4 years old.

In some antlers of yearlings and 2 year old bulls we found a uni- or bilaterally developed "tine" (Fig. 16) just above the coronet. It will need further study to decide if this is a true tine or a prong (Bubenik and Munkačević 1965).

FREQUENCY OF AGE CLASSES IN
THE BROW TINE PROTECTION TYPES

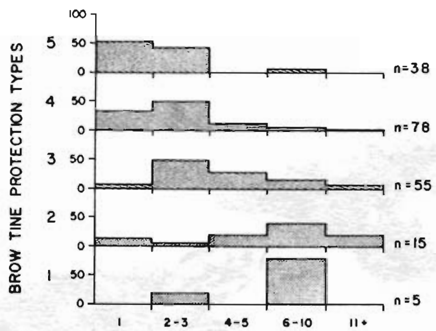

Figure 15

Finally we compared the profile of the seal with the quality of the antlers, rated by their ASA. In red deer Cervus elaphus, (see Bubenik 1966) a convex seal is an indicator of potentially increasing antler mass, a flat one forecasts a stage of stagnancy, and concave seal is an indicator of a decline of antler growth potential. We found in cohorts of 400 cm^2 ASA (Fig. 17) a very diverse pattern of seal profiles with only 43 percent convex and 36 percent concave seals.

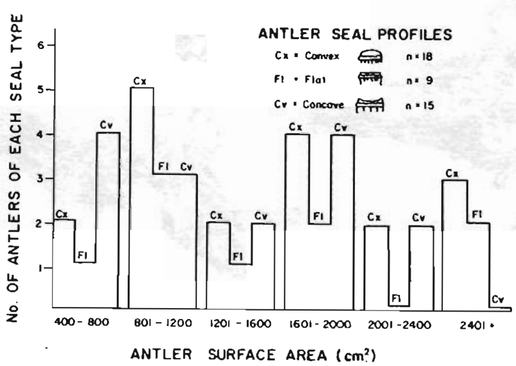

Figure 17

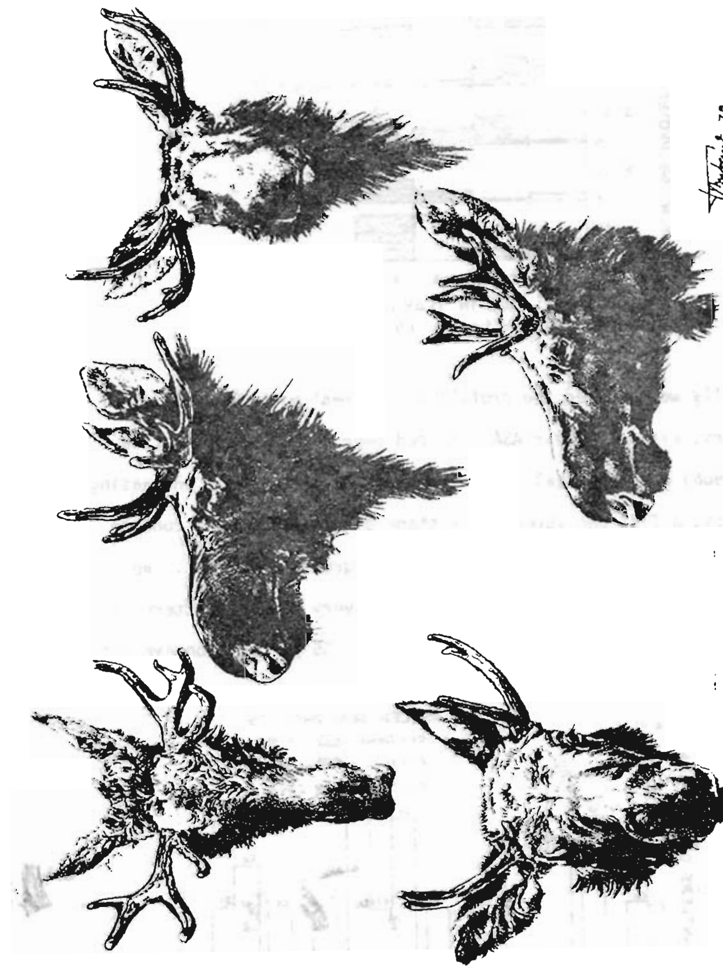

Figure 16 Appearance of the basal tine or prong in the antlers of young moose

CONCLUSIONS

Despite the limited number of calf heads, we believe that antlerogenesis in moose follows that of other Odocoileinae; i.e. in unstrained populations the male calf exhibits the first antler cycle within the first six to eight months of life. It is highly probable that, similar to roe deer and reindeer (Rangifer spp.) (Bubenik 1966, 1975a) as well as in white-tailed deer (Bubenik and Williams, in prep. b), only primary antlers that are several centimeters long will be cast. Antler knobs will be overgrown in the next cycle by velvet and incorporated in the yearling antlers. The fact that 21 percent of the yearling antlers were without a coronet should be considered in these calves as evidence of heavy distress which caused postponment of the first antler cycle.

Another suggestion of distress is seen in the very high diversity of shaft circumferences through age and social classes. A further indicator of distress is the high percentage of concave and flat seals (57 percent) which normally occurs only in antlers of senior bulls. Finally, some large antlers with specific gravity of 1.0 to 1.1 suggest an insufficient supply of calcium (Bubenik 1959, 1978, Magruder et al. 1957).

The occasional appearance of the basal tine in antlers of one and two year old bulls may be an example of a feature which is characteristic of other Odocoileinae. The relatively high frequency of this point in our collection could indicate that this is a tine in regression. If this is true, then it could be probable that a yet unknown primitive species or ancestor of Alcini had this basal tine, and the tine disappeared when the higher one (the brow) developed. A similar evolutionary trend is known in Megaloceros (see Reynolds 1929) and is still in progress

in European red deer, Cervus elaphus hippelaphus (see Bubenik 1966, Lehmann 1959). In such a case the brow tine is only analogous to the brow of Cervinae but could be homologous to the prong of white-tailed deer or bez-tine of some Cervus species (Lehmann 1959).

Finally, there is the progressive shortening of the pedicle, which also is specific for Odocoileinae.

The finding that volume and ASA of palmated antlers correlates so well, could be explained as being due to the relatively constant specific gravity and thickness of palms and points.

It seems to us highly probable that sociobiologically mature antlers are those with well developed and convergent "brow" palms and large main palms. However, more antlers should be evaluated. If this view should be confirmed, it should be respected in the scoring of moose antlers, which in our opinion is not biologically based. The same applied to the sociobiological value of antler spread which is generally smaller in Ontario's taiga moose, despite that the palm width is not much less than in the wide open antlers of tundra moose (Alces alces gigas). In some extraordinarily good antler specimens with palm width over 50 cm, not only were the palms bent nearly 90^0 forward, but also the burr was oriented ventro-apically. Both of these architectural changes could mean a morphological adaptation to the dense cover of the taiga.

The antler spread in relation to age was found to be highly variable, when we consider that our collection is from a relatively small area. Similar variation was found by Gasaway (1975) for moose in Alaska. Gasaway, however, found for different management units different ages for culmination of spread increases (between 6 to 10 years of age).

Unfortunately we do not know anything about the significance of spread as a visual cue or as a constituent of antlers as weapons, or how environmental stress or cover can influence the spread.

The number of collected trophies of known age is too small to generalize our conclusions about antlerogenesis in moose. We cannot say if the great diversity of antler parameters of our collection is only due to distress or is also caused by hydridization of the two subspecies, if they really exist.

ACKNOWLEDGEMENTS

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