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Red Deer Stags Rank Position, Body Weight and Antler Growth

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Bartoš L., Perner V. & Losos S., 1988: Red deer stags rank position, body weight and antler growth. Acta theriol., 33, 14: 209—217 [With 1 Table & 2 Figs.].

Fifteen red deer stags *Cervus elaphus* Linnaeus, 1758 were observed during the period of antler growth in the Game Reserve. Dominance/subordinance relationships were checked in 19 observation sessions and on average every 2nd or 3rd day it was recorded in which social company every stag was living. A mean relative dominance index (mRDI) was calculated for each stag for the period between his antlers casting and cleaning. The relative body weight was estimated from video-recordings. Antlers cast in the following season were weighed and measured. The value of mRDIs, body weight and antler characteristics were adjusted for age and then used for further analysis. mRDI was significantly correlated with body weight. mRDI showed significant correlations with several antler characteristics while body weight showed similar but non-significant trends. When body weight was controlled by partial correlation, mRDI correlated with antler length, number of tines, number of points on the royal, bez tine, third point of the royal, and length of all the royal points. On the other hand, when mRDI was controlled by partial correlation, there was still no significant correlation between body weight and antl r characteristics. In conclusion, it is suggested that high rank position of a stag during the velvet period stimulated growth of the newly developing antlers, under certain circumstances regardless of the stag's body weight.

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1. INTRODUCTION

In our previous studies we have already suggested the existence of a relationship between the social rank position of red deer stags during the period of antler growth (velvet period) and the final antler size. High ranking stags produced heavier, longer and more branched antlers (Bartoš & Hyánek, 1982; Bartoš *et al.*, 1987). These results seemed to be, however, not consistent with the conclusions of some other authors who argued that antler size is related to individual differences in body size and weight (Huxley, 1926; 1931; Hyvärinen *et al.*, 1977; Clutton-Brock *et al.*, 1979; Appleby, 1982). Some studies show that rank position may be correlated with body weight in red deer (Clutton-Brock *et al.*, 1979; Appleby, 1982) as well as in other large ruminants (Schein & Fohrman, 1955; Reinhardt, 1973; Sambraus, 1978). On the other hand, there are also studies not showing such a correlation (Suttie, 1980; Lott,

1979; Eccles & Shackleton, 1986). In the previous study, there were some indications that under certain circumstances body weight did not have a major influence on the relationship between rank position and antler development. For example, the alpha stag was not usually the oldest and heaviest animal (Bartoš, 1986 a) *etc.* The stags that were studied were between 2 and 5 years of age during which age-span there exists a close correlation between age and body weight (Kay, 1981; Bubenik, 1984) and also between age and rank position (Appleby, 1980; Bartoš & Hyánek, 1982). In our earlier study (Bartoš *et al.*, 1987) the effect of age was statistically controlled. Nevertheless, the lack of data on the body weight of the observed stags has remained the weakest point of the conclusions. That is why we repeated the observation with information on body weight included.

2. METHODS

The study was performed in the main paddock (1.26 square km) of the Game Reserve in Žehušice, Central Bohemia, Czechoslovakia. The subjects were 15 stags of the "white" red deer *(Cervus elaphus)* herd (Bartoš, 1982). The stags were known individually since birth, so that their ages were known exactly. The stags were 2, 3, 4, 6 or 7 years old, there being three stags of each age.

Observations were made in 1985 during the period between the date of the first stag's antler casting (9th March) and the date of the last stag's antler cleaning (13th August). In this time the bachelor group tends to disintegrate (Bartoš & Perner, 1985). Hence, during this period on every second or third day on average (63 times in total) a record was made of how many groups of stags there were that day and which individuals were in each group. Stags were considered to belong to the same group if they were within 200 m each other. A stag wandering alone was treated as a "group" of 1 member.

Social relationships between the stags were always checked in the largest group present, during 19 different observation sessions of (mean±S.E.) 29.88±3.58 minutes each. The observations were made during artificial feeding (carried out throughout the year) by an observer seated on a tractor at a distance of approximately 20 m from the deer without any apparent disturbance of the deer. On 4 of the occasions, the interactions between the stags were videorecorded (SONY SL-F1E with camera HVC-4000P), giving a total recorded time of 4 hrs 24 minutes. During the observations food was always deposited in one place to induce competition among the stags. All animals encountered each other regularly. When one animal moved away when approached or attacked by another, this was taken as an indicator of subordinance. The rank order was based on the encounters of single stags with each animal of the group. This method allowed us to assess gradually the social relationships among the stags living within the paddock which was further used in dominance index construction (see below).

In a previous study we followed the distribution of all stags in social groups during the period between antler casting and cleaning. Their relative rank position (an average rank position calculated from individual positions within groups in which a stag was seen to be during the days of observation) differed from their general rank within the whole bachelor group living in the paddock. The relative

rank position also showed a closer correlation with fullgrown antlers than did the general rank position (Bartoš, 1987). That is why we used a measure called Relative Dominance Index (RDI — Bartoš & Perner, 1985) for a single observation of a social group. That is, the rank of a stag within a given group (where the alpha position=1, *etc.*) was divided by the number of stags in the group. Thus the RDI was equal to 1 for both the stag of the lowest rank in any group and for a stag alone. The RDI could be easily calculated only when the stags of the given group displayed a linear hierarchy. If there were one or more triangular relationships, the hierarchy was first estimated according to Clutton-Brock *et al.* (1982, Appendix 10, p. 317). The values were ranked. The order represented the rank position of a stag and RDI could be then calculated. A mean RDI (mRDI) was calculated for each individual, *i.e.* a mean value of all RDIs obtained between the individual's dates of antler casting and cleaning. The mRDI was based on average on 37.33±3.80 RDIs per stag.

It was not possible to obtain actual live body weight for the studied animals. However, the videorecords could be used for this purpose. To find a method to estimate the body weight, we used photographs of 11 farmed red deer. The deer

Table 1

Relationship between mean Relative Dominance Index (mRDI), relative body weight and antler characteristics.

Antler characteristic	Correlation between:		Partial correlation between:	
	mRDI and antler characteristic	body weight and antler characteristic	mRDI and antler characteristic with body weight controlled	body weight and antler characteristic with mRDI controlled
Antler weigth	—0.44	0.28	—0.36	0.08
Antler length	—0.58*	0.30	—0.58*	—0.31
Lower circumference	—0.07	0.23	0.19	0.29
Upper circumference	—0.32	0.15	—0.34	—0.18
Number of tines	—0.24	—0.11	—0.54*	—0.51
Number of points of the royal (tines)	—0.36	—0.10	—0.72**	—0.68**
Brow tine	—0.26	0.17	—0.22	—0.07
Bez tine	0.56*	—0.23	0.64*	0.43
Trez tine	—0.37	0.29	—0.23	—0.00
First point of the royal (top tine)	—0.40	0.17	—0.44	—0.26
Second point of the royal (top tine)	—0.45	0.23	—0.46	—0.25
Third point of the royal (top tine)	—0.74**	0.48	—0.68**	—0.28
Length of all royal points (tops)	—0.59*	0.26	—0.66**	—0.44
Total antler length	0.36	—0.52	—0.10	—0.41
Diameter of seal (pedicle attachment point)	—0.46	0.51	—0.11	0.27
Diameter of coronet	—0.32	0.39	—0.01	0.24

* $p<0.05$; ** $p<0.01$.

stood without restraint about 30 cm in front of a board with a scale grid on it and photographed with a camera held at about the level of the deer's heart. The photographed deer were then weighed. (The photographs were kindly given to us by Dr. R.N.B. Kay, the Rowett Research Institute, Aberdeen, Scotland). Methods normally used for estimation of the body weight of farm animals in Czechoslovakia from their dimensions were estimated and satisfactory results obtained using the equation:

$$m = 49.18 \times h \times d - 63.51$$

where m — estimated body weight in kg, h — thorax depth in cm (the vertical distance between withers and chest, see Fig. 1), d — straight body length in cm (measured from caudal point of pelvis at a right angle to the line of the thorax depth, see Fig. 1). Fig. 2 shows the relationship between the selected body dimensions and the measured body weight.

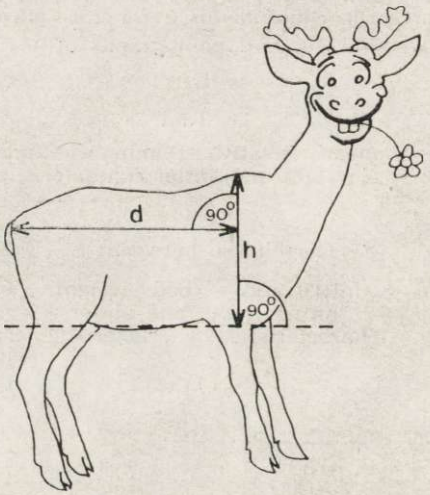

Fig. 1. A sketch showing the measurement of the stags.

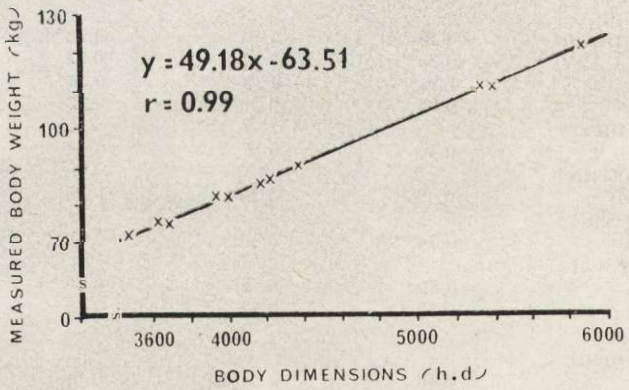

Fig. 2. Relationship between the selected body dimensions and the measured body weight.

For the stags under study, their body weight was estimated as follows. In the videorecords, all the situations in which two stags were standing side-on to the camera and the same distance from it were identified, 134 such sequences were found. Each stag was involved on average 14.7 times. The distance of the pairs of stags from the camera was not constant in all cases. Hence the body weight was used in a relative form. For each pair of stags, the body weight was estimated separately. The percentage of one stag's value relative to the other of the pair was calculated. If several measurements were available for the same pair of stags, the arithmetical mean of the values was taken for the final calculation. The stag who was involved in the greatest number of pair comparisons (n=43) was taken as a final reference animal. Therefore his estimated body weight was taken as 100 and all the other stags' estimated values were related to this.

Antlers cast the following season were used for measurements. The terminology of antler characteristics has been adopted from Bubenik (1982) and/or Whitehead (1982). Where the two authors differed, the term of Bubenik was adopted and the one of Whitehead added in parentheses. Almost the same antler characteristics were used as in the previous study (Bartoš *et al.*, 1987): Antler weight and length, lower — measured between brow and trez tines — and upper — measured between trez tine and royal — circumferences, number of tines, number of points of the royal (number of tops), length of brow, bez, and trez tines, length of the 3 longest terminal points called first, second and third points of the royal (top tine), total antler length (after Bubenik, 1982), diameter of seal (diameter of pedicle attachment point), and diameter of coronet.

The values of mRDIs, relative body weight, and antler characteristics were adjusted for age by the least square analysis and residual correlation coefficients were calculated according to Harvey (1967).

3. RESULTS

The stags did not develop a stable linear social hierarchy as in the previous seasons. During the observations, 3 changes in rank position were noticed and 5 to 6 triangular relations within the whole bachelor group developed (see Fig. 2 in Bartoš, 1988). At any one time, about 56 per cent of the stags were involved in triangular relationships with other members of the group.

Least-squares analysis of variance showed a non-significant relationship of age to mRDIs, but a significant relationship to relative body weight ($p<0.01$) as well as to all antler characteristics ($p<0.001$) but one (bez tine, $p=0.09$).

The mRDI was significantly correlated with relative body weight ($r=-0.79$, $p<0.01$). Residual correlation coefficients between mRDI and antler characteristics, relative body weight, and antler characteristics and partial correlation coefficients between mRDI and antler characteristics with relative body weight controlled and between relative body weight and antler characteristics with mRDI controlled are presented in Table 1.

mRDI showed statistically significant correlation with 4 antler char-

acteristics, while relative body weight did not show any, though similar but non-significant trends were apparent. When relative body weight was controlled, mRDI showed significant correlation with 6 antler characteristics. On the other hand, when mRDI was statistically controlled, relative body weight showed significant correlation with only one antler characteristic.

4. DISCUSSION

The red deer stags did not show as close a correlation between their rank position during the period of antler growth and attained antler size as was found in previous seasons with the same study group (Bartoš *et al.*, 1987). The reason for this may be found in the structure of the social hierarchy. In the previous seasons, the hierarchy within the bachelor group of stags had been linear and stable all year round (Bartoš, 1985). During the present study period, the social hierarchy was not so stable and it was not linear, showing numerous triangular relationships. It has been shown already that the linearity of the hierarchy may be the principal factor affecting physiological response to rank position such as antler casting (Bartoš, 1988).

In the present study there was found a close correlation between body weight of a stag and his rank position, which is in good agreement with many authors (Clutton-Brock *et al.*, 1979; Appleby, 1982; Suttie, 1980). In red deer calves, body weight determined markedly their subsequent rank (Suttie, 1983). However, the body weight of older animals itself may also be most likely modulated by rank-related behaviour. This seems to be indicated in the study of Sundby & Velle (1983) who found a relationship between growth rate and testosterone secretion in bulls. The same may apply to deer. Suttie (1985) found in farmed red deer stags that it was not dominance rank which altered but the ranking of body weight. He concluded that this might indicate that dominance in adult stags influenced body weight rather than vice versa.

No significant correlation was found between body weight of a stag and the size of his antlers in the present study. This is contrary to results of many authors (Huxley, 1926; 1931; Hyvärinen *et al.*, 1977; Clutton-Brock *et al.*, 1979; Appleby, 1982). However, it has already been observed elsewhere that live weight need not correlate with antler size in red deer stags (Suttie, 1980). The difference in results between the afore mentioned studies may lie in the living conditions. Huxley (1926; 1931), Clutton-Brock *et al.* (1979) and Appleby (1982) studied large populations which were relatively unlimited with regard to space in comparison with Suttie s (1985) farmed red deer and the present study group in

rather small paddocks. Suttie (1980) found increased aggression among stags under the space restricted living conditions, which may also be the case in the deer herd under study (Bartoš, 1986 b). It has been already suggested that aggression may be of basic importance for expression of the feedback relationship between hormones and the control of antler growth and rank position of a stag (Bartoš, 1986a). When we eliminated the possible influence of body weight in the analysis in the present study by partial correlation, the relationships between rank position and antler size became markedly more pronounced. But when we eliminated the possible influence of rank position, the relationship between body weight and antler size did not increase consistently. The only case of significant correlation (body weight with the number of points of the royal) may be supposed to be accidental since in fact it shows the reverse of the expected correlation.

Rank correlated significantly with both antler dimensions and body weight. Body weight showed similar trends in relation to antlers thought non-significant. Hence the present results cannot be regarded as a base to abandon the existence of the relationship between body weight and antler size, documented by so many different authors. However, we can conclude, in agreement with our previous studies (Bartoš & Hyánek, 1982; Bartoš *et al.*, 1987), that these results suggest a rather significant stimulative effect of the high rank position of a stag during the velvet period on the antler growth (at least under certain circumstances), regardless of his body weight. We can also conclude that those studies showing a relationship between body weight and antler size of stags in social groups, should always be analyzed also from the point of view of the stag's rank position during the time of antler growth. Otherwise, a false relationship due to lack of the third and perhaps very important factor may be indicated.

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RANGA SOCJALNA, CIĘŻAR CIAŁA I ROZWÓJ POROŻA U JELENI

Streszczenie

Piętnaście byków jeleni *Cervus elaphus* Linnaeus, 1758 obserwowano w okresie wzrostu poroża i rejestrowano relacje dominowania i subordynacji między nimi. Dla każdego osobnika wyliczono średni wskaźnik względnej dominacji (mRDI). Względna masa ciała szacowana była przy pomocy rejestracji video (Ryc. 1 i 2). Poroża (po zrzuceniu) były ważone i mierzone. Wskaźnik względnej dominacji korelował z masą ciała i kilkoma cechami poroża (Tabela 1). Jednak gdy przez częściową korelację wyłączono wpływ zmienności ciężaru ciała, wówczas wskaźnik dominacji był wysoko skorelowany z sześcioma charakterystykami poroża (Tabela 1), natomiast przy wyłączonym wpływie wskaźnika mRDI nie uzyskano istotnej korelacji między masą ciała a cechami poroża. Autorzy sugerują, że wysoka pozycja socjalna byka stymuluje lepszy wzrost kształtowanego poroża, do pewnego stopnia niezależnie od ciężaru ciała osobnika.