

Discussion on the Main Reasons for a Large Number of Père David's Deer (*Elaphurus davidianus*) with Abnormal Antler Shedding

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Abstract [Objectives] This study was conducted to find out the causes of abnormal antler shedding in Père David's deer (*Elaphurus davidianus*). [Methods] Abnormally-shed antlers were compared with normally-shed antlers in terms of light condition, antler development and bone nutritional status during the abnormal shedding season in the growth area of Père David's deer. [Results] Abnormally-shed antlers had no significant differences in the development of shed antlers, or even in the overall composition of antlers, from those of normal Père David's deer. [Conclusions] Insufficient light was the main cause of abnormal antler shedding in Père David's deer.

Key words *Elaphurus davidianus*; Antler shedding; Development; Composition

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Père David's deer (*Elaphurus davidianus*) are one of the rare protected animals unique to China, and their normal antler shedding time is in late autumn, but the phenomenon of abnormal antler shedding (from June to August) has been recorded for a long time^[1-2], so that sporadic abnormal antler shedding has almost been regarded as a normal phenomenon. Since 2014, the phenomenon of Père David's deer's abnormal antler shedding in the Père David's deer reserve in Shishou City, Hubei Province has intensified. In the summer of 2017, abnormal antler shedding was observed in 27 Père David's deer, reaching the peak of abnormal antler shedding for many years.

Père David's deer's antler shedding is mainly regulated by hormones, especially sex hormones and the nutrition in the growth and development of antlers^[3-4]. From the perspective of sex hormones, Père David's deer are a short-day wild animal, which gradually enters the period of sexual activity and sex hormone activity with the shortening of sunshine. In terms of the nutritional regulation of antlers, only the male deer with the most balanced nutritional status can grow out a pair of huge antlers, and a large amount of calcium and protein are deposited in the antlers. If the protein secretion is insufficient or the calcium deposition is insufficient, antlers will change and fall off easily.

In addition, from the time and appearance of antler shedding, Père David's deer's antlers grow very fast, and it takes only four months to become mature antlers. The abnormal shedding

time is generally July, when the antlers are fully developed and no longer grow. From the morphological point of view, antlers have fallen off, which also shows that they have become mature antlers, which makes abnormally-fallen antlers directly comparable to normally-fallen antlers.

In order to find out the causes of Père David's deer's abnormal antler shedding, the comparison between abnormal antler shedding and normal antler shedding was made from light condition, antler development (bifurcation and thickness) and bone nutrition (ratio of calcium to collagen) in the abnormal horn shedding season in Père David's deer's growing area.

Experimental Materials

The normally- and abnormally-shed antlers were taken from the nature reserve. Other observations and data were also conducted or obtained within the Père David's deer nature reserve.

Experimental Methods

Relation between light and proportion of abnormal antler shedding in Père David's deer

The proportion of abnormal antler shedding in Père David's deer from June to August 2018 (the period of abnormal antler shedding) was calculated in the experiment. Meanwhile, according to the historical data of China Weather News and the meteorological data from Shishou Meteorological Bureau, the weather situation was statistically analyzed. Generally, there is still strong sunlight in cloudy summer weather, so sunny, cloudy, cloudy-to-sunny, and sunny-to-cloudy weather were all considered as strong sunlight weather conditions for statistics, and the proportion of strong sunlight weather was calculated. And the proportion of strong light was analyzed with the proportion of abnormal antler

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shedding.

Determination of the nutritional status of deer antlers

Deer antlers are also formed by alternating deposition of calcium and protein, and only with an appropriate ratio of hydroxyapatite type calcium to bone collagen can well-developed and dense deer antlers be formed. If the ash content is high, it indicates insufficient collagen deposition, while conversely, it indicates insufficient calcium deposition. When the nutrition of antlers is abnormal, there will be significant abnormalities in their density, ash ratio, *etc.* In the experiment, the development status, density, bone ash content and other data of abnormally- and normally-shed antlers were detected.

Determination of the nutritional status of deer herd

The nutritional status of individuals and the herd was judged by a 10-grade evaluation method. The evaluation criteria were as follows (no individuals below grade 5 were observed): grade 5 (55 points), individuals are unable to walk normally, and they often lie or stand on the ground, and are unable to exercise and feed alone; grade 6 (65 points), individuals can stand and walk, but their movements are slow and their reactions are slow, and most of them are isolated Père David's deer and their movements cannot keep up with the herd; grade 7 (75 points), individuals are moderately fat in the body, healthy in physique, and move relatively fast with the herd, but in the latter half of the herd when running; grade 8 (85 points), individuals are relatively strong in physique, moderate to fat in the body, and move very fast, and in the first half of the herd when running; grade 9 (95 points), individuals are strong in physique, good in body fat, and show glossy fur, upright ears, lively eyes, and agile gait; and grade 10 (105 points), individuals are strong in physique and has excessive body fat, and the cross-shaped section of the back and waist is relatively wide and flat, and the muscles on both sides of the spine are plump. Based on this, the health and nutrition scores of male deer normal and abnormal in antler shedding were evaluated, and then the average score was calculated according to the statistical quantity.

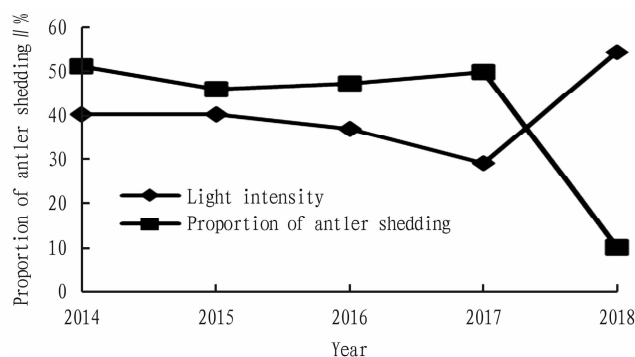
Experimental Results

Relation between light and proportion of abnormal antler shedding in Père David's deer

According to the statistical results, there was a significant deviation between the situation of antler shedding in Père David's deer and the intensity of light. That is, the more sufficient the light from June to August, the milder the abnormal antler shedding in Père David's deer, and conversely, insufficient light would result in a significant increase in the proportion of antler shedding. In the summer of 2018, there was no rain, resulting in the lowest value of antler shedding in Père David's deer in years (Fig. 1).

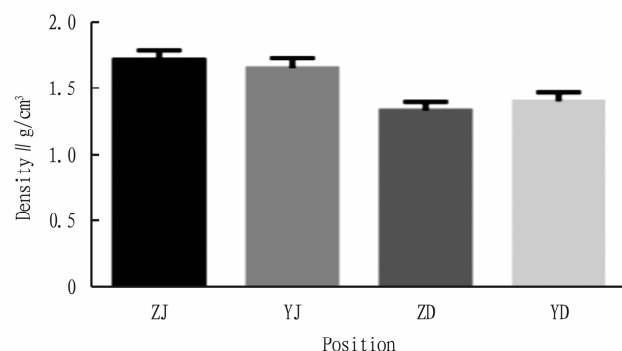
Determination of density and ash content of deer antlers

The densities at the base and top of abnormally-shed antlers and normal antlers were measured in this study, as shown in Fig. 2.



The light intensity is based on the proportion of sunny and cloudy days from June to August of the current year to the total number of days, and the proportion of antler shedding is the proportion of deer with antler shedding to the total deer population. The proportion shown in the figure is magnified ten times.

Fig. 1 Relational graph between light intensity and antler shedding in Père David's deer



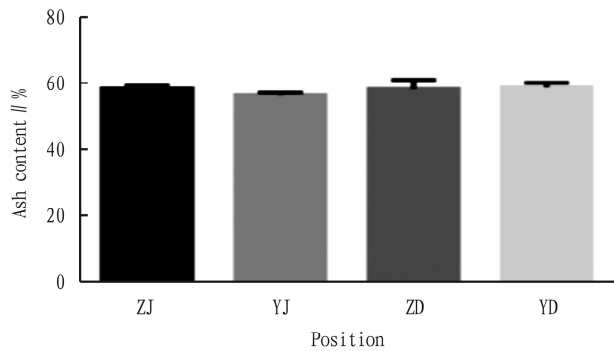
ZJ represents the density at the base of normal antlers; ZD represents the density at the top of normal antlers; YJ represents the density at the base of abnormally-shed antlers, and YD represents the density at the top of abnormally-shed antlers.

Fig. 2 Density difference between normally- and abnormally-shed antlers of Père David's deer

From the above figure, it can be seen that the density at the base of antlers was greater than that at the top of antlers, whether normal or abnormal, and the density differences between individual antlers were not significant. In this study, we found that one of the normal antlers was severely weathered and had an exceptionally low density, which was excluded at the time.

From the comparison between the normal and abnormal antler groups, the density at the base of normal antlers was slightly higher than that of abnormally-shed antlers, while for the density at the top of antlers, the density at the top of normal antlers was slightly lower than that of abnormally-shed antlers due to the long weathering time. Overall, there was only a slight difference between the two sets of data, and there was no statistically significant difference.

About 1 g of sample was taken from each group of deer antlers, respectively. The samples were incinerated in a crucible to determine the ash content. The specific situation was shown in Fig. 3. There was almost no difference in the ash content between the two groups of deer antlers, and there was no statistical difference.



ZJ represents the ash content at the base of normal antlers; ZD represents the ash content at the top of normal antlers; YJ represents the ash content at the base of abnormally-shed antlers; and YD represents the ash content at the top of abnormally-shed antlers.

Fig. 3 Ash content in normally- and abnormally-shed antlers of Père David's deer

Determination of antler development

During antler sampling, we observed the developmental morphological characteristics of abnormally and normally-shed antlers. We also measured the weights of entire antlers, as well as morphological indicators such as the length of the main stem, length of the posterior branch, circumference of the antler base, width of the antler, angle between the posterior branch and the main stem, number of branches, and number of small thorns. However, it is difficult to compare male deer's age, weight, nutrition and other information accurately, and judgment could only be made according to observation. Generally speaking, abnormally-shed antlers had the same structure, bifurcation and length, which were basically consistent with those of normal antlers.

Evaluation on the nutritional status of deer herd

The staff in the Père David's deer nature reserve in Shishou City conducted statistics on the time of abnormal antler shedding in Père David's deer and their own condition, as shown in Table 1.

Table 1 Evaluation on the nutritional status of Père David's deer with normal and abnormal antler shedding in Shishou City

	2014	2015	2016	2017	2018
Normal	87	92	90	89	89
Abnormal	88	90	90	90	88

From this table, it can be seen that the overall health of Père David's deer was good, and basically no Père David's deer showed poor health and nutrition conditions after abnormal antler shedding. In actual observation, the mental state and sports vitality of Père David's deer were good after antler shedding.

Conclusions and Discussion

Père David's deer are a unique and rare protected animal in China, which mainly exists in three Père David's deer nature

reserves^[5-7]. The phenomenon of off-season antler shedding in Père David's deer has a long history, and a small number of Père David's deer can be observed to lose their antlers in advance every year. Generally, the proportion of Père David's deer with abnormal antler shedding is below 3%, but in recent years, the proportion of abnormal antler shedding has gradually approached or even exceeded 5%. In this regard, our previous research mainly focused on Père David's deer's health situation, the change of local conditions and domestication and the change of food types, but the results have not been great. Therefore, we no longer explain it from the pathological point of view, but start from the physiological factors of the formation and shedding of antler. The growth and shedding of antlers are regulated by sex hormones and restricted by the nutrition of antlers, so we decided to start looking for reasons from the main factors affecting sex hormones and nutrition.

From the results of this study, there were no significant differences in the overall health, the development of shed antlers and even the general composition of antlers between Père David's deer with abnormal and normal antler shedding. Thus, we locked the main reason in whether the light condition was sufficient. It happened that there was almost no rain in the whole summer of 2018, and the light was very sufficient. The results showed that after the whole summer had passed, and the proportion of Père David's deer with abnormal antler shedding reached the lowest value on record without any other changes, which just proves that insufficient light conditions are the main reason for abnormal antler shedding in Père David's deer.

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