

Reference Values for Total RBC, Hematocrit, Hemoglobin, and Total WBC in Male Elk Deer (*Cervus Canadensis*) Reared in Korea

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(Accepted: May 2, 2006)

Abstract : Normal reference values for hematological parameters were evaluated using 85 male Elk deer reared in Korea. The reference interval estimated were 6.01-9.93 ($\times 10^6/\text{mm}^3$) for the red blood cell count, 10.90-19.70 (g/dl) for the hemoglobin concentration, 43.10-76.40 (%) for the hematocrit value, and 2.60-7.68 ($\times 10^6/\text{mm}^3$) for the total white blood cell count. Our estimates were compared with previously reported values for these parameters in Korea and other countries.

Key words : Reference values, Hematology, *Cervus Canadensis*.

Introduction

Koreans have been utilizing deer products for a long time, and deer now occupy an important position among Korean livestock, after cattle, swine, and poultry, with the number of head increasing to 156,076 in 2001 (6). The majority (30.7% at 47,876 head) of the Korean deer population consists of *Cervus Canadensis* (6), commonly called Elk. Nonetheless, health criteria for this species has not yet been clearly established. Although some studies have analyzed the blood components of deer, they have only presented the mean and standard deviation (SD), or minimum and maximum (3,4,10). For clinical purposes, reference values or a reference interval would be more useful in providing criteria for health in a population (8). However, until now, there has been no study on the reference range for the blood components of deer reared in Korea. Accordingly, the present study analyzed certain blood components of healthy male Elk deer, born and raised in Korea, to establish normal reference values for the total red blood cells (RBC), hematocrit (Hct), hemoglobin (Hb), and total white blood cells (WBC).

Materials and Methods

Selection of animals

Nineteen deer farms from the Republic of Korea participated in this study. A veterinarian examined the animals and

selected 85 male Elks in good physical condition. All animals included were aged from 1 to 9 years (mean \pm SD 4.8 \pm 2.1; median 4).

Blood sampling and analysis

Blood sampling was performed during March and April, 2001. Blood sample was obtained from the jugular vein under immobilization using a combination of xylazine, ketamine, and acepromazine. After anticoagulant treatment with EDTA, the total RBC ($\times 10^6/\text{mm}^3$) and total WBC ($\times 10^3/\text{mm}^3$) counts, Hb concentration (g/dl), and Hct value (%) were estimated using a blood counter (HEMAVET[®] 850, CDC Technologies INC., Oxford, Connecticut).

Determination of reference values

The data were first sorted, then trimmed based on deleting the highest and lowest 2.5% of the values. The remaining 95% of the values for the population were then used to determine the minimum and maximum of the reference range for normal values (13). Reference ranges were calculated for two age groups: one was for the whole study population aged from 1 to 9 years and the other was for 60 deer of 3-5 years old.

Meta-analysis

Previous publications (papers in journals or abstracts from conferences) on hematological values for Korean Elk were used for a meta-analysis. Information was searched, in December 2001, in PubMed (<http://www.pubmed.gov>) and in Korea education & research information service (<http://riss4u.net>)

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for following terms: Elk, hematology, and Korea. The relevance of the articles with our study object was judged with their title, abstract, and key words. Related articles were additionally searched from bibliography part of the previously detected publications. Finally, four studies published from 1976 to 1998 were found and all of those were combined for meta-analysis according to following equation (9):

$$Mean_{meta} = \sum \frac{1}{V_i} Mean_i,$$

where, $Mean_{meta}$ was the result of meta-analysis, V_i and $Mean_i$ were the variance and mean, respectively, observed in each study included in the meta-analysis. Since one study (4) did not report variances of their estimations, these were replaced by imputations from mean and variances observed in three other studies.

Blood were taken from the jugular vein (3,11) or the capillaries (4,12) in these studies. One study (11) reported on hematological values from both the jugular vein and the antler capillaries. Yet, only values from the jugular vein were considered in the meta-analysis.

Statistical analysis

Values included in reference ranges (normal values) were compared for two age groups using Student's t-test. In addition, mean and SD of values within reference ranges were compared with those resulted from meta-analysis by Student's t-test. All calculations for the present study were performed with EXCEL®.

Results

Estimation of normal reference values

The reference ranges estimated for male Elk deer aged from 1 to 9 years age were 6.01-9.93 ($\times 10^6/\text{mm}^3$) for the total RBC count, 10.90-19.70 (g/dl) for the Hb concentration, 43.10-76.40 (%) for the Hct value, and 2.60-7.68 ($\times 10^6/\text{mm}^3$) for the total WBC count. Those observed for deer aged from 3 to 5 years were comparable to findings in 1-9 years-old deer. Their reference ranges were 5.87-10.37 ($\times 10^6/\text{mm}^3$), 10.51-19.82 (g/dl), 40.57-76.70 (%), 2.09-6.23 ($\times 10^6/\text{mm}^3$) for total RBC count, Hb concentration, Hct value, and total WBC count, respectively. Normal values were not significantly different according to age group ($p > 0.05$ for total WBC, Hb, total RBC, and Hct) (Table 1).

Meta-analysis

The results of the meta-analysis based on results from previous studies of Korean deer are presented in Table 1. Mean and SD were 6.90×5.22 ($\times 10^6/\text{mm}^3$) for total RBC count, 15.27×10.90 (g/dl) for Hb concentration, 36.15×22.05 (%) for Hct value, and 4.62×3.70 ($\times 10^6/\text{mm}^3$) for total WBC count. Any significant difference was not observed from reference values estimated ($P > 0.05$ for all of four parameters).

Discussion

Many environmental factors, including the sex and age of the animals and sampling season, can influence the hematological values of animals (5). To control any possible variations due

Table 1. Reported values, reference ranges and meta-analysis results for hematological parameters in male Elk deer reared in Korea

Classification	Component	RBC ($\times 10^6/\text{mm}^3$)	Hb (g/dl)	Hct (%)	WBC ($\times 10^3/\text{mm}^3$)
Previous publications (mean \pm SD)					
First author, Year					
	Song ¹² , 1976	6.71 \pm 0.30	10.20 \pm 0.43	30.00 \pm 1.95	3.60 \pm 0.45
	Lim <i>et al.</i> ⁴ , 1976	7.15, na	13.9, na	41.00, na	8.90, na
	Shin <i>et al.</i> ¹¹ , 1994	9.99 \pm 1.26	15.9 \pm 1.91	47.50 \pm 3.46	3.40 \pm 0.84
	Geum <i>et al.</i> ³ , 1998	6.71 \pm 0.98	12.15 \pm 1.06	34.23 \pm 2.69	33.17 \pm 0.69
Our findings					
Meta-analysis					
	Mean \pm SD	6.90 \pm 5.22	15.27 \pm 10.90	36.15 \pm 22.05	4.62 \pm 3.70
	95% confidence interval	1.78 - 12.02	4.59 - 25.95	14.54 - 57.76	0.99 - 8.25
Whole population (aged 1-9 years)					
	Reference range	6.01 - 9.93	10.90 - 19.70	43.10 - 76.40	2.60 - 7.68
	Mean \pm SD	7.97 \pm 0.98	15.30 \pm 2.20	59.75 \pm 8.33	5.14 \pm 2.17
Aged 3-5 years					
	Reference range	5.87 - 10.37	10.51 - 19.82	40.57 - 76.70	2.09 - 6.23
	Mean \pm SD	8.12 \pm 1.13	15.17 \pm 2.33	58.64 \pm 9.03	4.16 \pm 1.04

na: did not appear in original publication; student's t-test: normal values for aged 1-9 years *versus* 3-5 years, non significant ($p > 0.05$); normal values of the two age groups *versus* meta-analysis results, non significant ($p > 0.05$)

to sex, species, or season associated with the reproductive period, the blood sampling in the present study was performed during less than two months using only male animals from the same species. On the other hand, we cannot neglect variations observed among studies because blood sampling and its analysis were done with specific manner in each study. Therefore for the meta-analysis, the present study employed a kind of random-effect model that can include both of within-study sampling error and between-studies variation (9). If there is a significant heterogeneity among the studies included, random effect model would give somewhat wide confidence intervals, as observed in the present study (Table 1).

Although the blood in the capillaries is known to have a lower total RBC count and lower hemoglobin concentration, yet higher total WBC count than in venous blood (1), four studies included in our meta-analysis showed no significant differences between the hematological values from the jugular vein and the antler capillaries. Studies on Elk conducted in other countries have reported a variation in the total RBC count from 6.9 to $11.0 \times 10^6/\text{mm}^3$, Hb concentration from 17.0 to 20.9 g/dl, Hct value from 53.3 to 67.6% , and total WBC count from 4.0 to $8.6 \times 10^3/\text{mm}^3$ (2,7,14). As such, these hematological values are higher than those reported in Korean studies, including the present study. This difference may be due to differences in environment, measuring or individual factors, and so on. It can also be a phenomenon appeared by enumerating published results without adjusting for the factors cited-above.

Current study established reference values for some hematological parameters of 85 healthy male Elk reared in Korea. Further studies to establish reference ranges for other deer species as well as female Elk need to be conducted to provide useful information for clinicians.

References

1. Bouda J, Davalos-Flores JL, Nunez-Ochoa L, Paasch-Martinez L, Quiroz-Rocha GF. Blood acid-base and serum electrolyte values in red deer (*Cervus Elaphus*). *Can J Vet Res* 2000; 64: 222-225.
2. Follis TB. Reproduction and hematology of the cacje elk herd. *Utah: Wild Resour Publ.* 1972: 72-78.
3. Geum CH, Jang JS, Lee HB. Hematological and blood chemical values for Elk raised in Korea. *Kor J Vet Clin Med* 1998; 15: 162-170.
4. Lim YJ, Lee SS, Kim MC. Hematologic status in deer (Wapiti, Elk, Continental). *Kor J Vet Sci* 1976; 16: 221-222.
5. Maede Y, Yamanaka Y, Sasaki A, Suzuki H, Ohtaishi M. Hematology in sika deer (*Cervus nippon yesoensis* Heude, 1884). *Jpn J Vet Sci* 1990; 52: 35-41.
6. Ministry of Agriculture and Forest. Annual Report of Ministry of Agriculture and Forests, Korea. Kwacheon, 2001: 124-125.
7. Pedersen RJ, Pedersen AA. Blood chemistry and hematology of elk. *J Wild Manage* 1975; 39: 617-620.
8. Petrie A, Watson P. Statistics for veterinary and animal science. Oxford: Blackwell Science Ltd. 1999: 24.
9. Pettiti DB. Meta-analysis, decision analysis, and cost-effectiveness analysis in medicine. 2nd ed. New York: Oxford University Press. 1994: 119-141.
10. Shin KH, Lim SS, Chung HS, Baek IB. Analysis of the composition of biochemical components in unossified antlers. *Kor J Pharmacogn* 1999; 30: 314-319.
11. Shin NS, Kwon SW, Han DH, Lee HS. Hematological and serum chemical values in Pere David's Deer and Wapiti. *Kor J Vet Clin Med* 1994; 22: 133-140.
12. Song HC. Hematology of deer (Elk). *Kor J Vet Sci* 1976; 46: 221.
13. Swinscow TDV, Campbell MJ. Statistics at square one. London: BMJ books. 2001: 35-45.
14. Vaughn HW, Knight RR, Frank FW. A study of reproduction, disease and physiological blood and serum values in Idaho elk. *J Wild Dis* 1973; 9: 296-301.

한국에서 사육되는 수컷 엘크 사슴(*Cervus Canadenis*)의 적혈구수, 적혈구 용적율, 헤모글로빈 및 총백혈구 수에 대한 참고범위

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요 약: 수컷 엘크 사슴 85두에서 채혈하여 한국에서 사육되는 엘크사슴의 혈액화학치에 대한 정상범위를 설정하였다. 적혈구수에 대한 참고범위는 $6.01-9.93 (\times 10^6/\text{mm}^3)$ 이었으며, 헤모글로빈농도에 대하여는 $10.90-19.70$ (g/dl), 적혈구용적은 $43.10-76.40$ (%), 총백혈구수에 대하여는 $2.60-7.68 (\times 10^6/\text{mm}^3)$ 으로 산정되었다. 위의 네가지 혈액화학치에 관하여 한국 및 외국에서 기 발표된 자료와 비교하면서 본 연구에서 설정된 참고범위의 값들의 타당성을 검증하였다.

주요어: 참고범위, 혈액학, 엘크 사슴.