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IMMUNOGLOBULIN RESPONSE OF THE ROCKY MOUNTAIN BIGHORN SHEEP

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Abstract: The effects of individual variation, season and parasite activity on the levels of the four major immunoglobulins, IgM, IgA, IgG_1 and IgG_2, were analyzed in four adult Rocky Mountain bighorn ewes. Individual variation was significant for all immunoglobulin classes. Seasonal effects were detected in the levels of IgG_1. The fecal count of *Protostrongylus* larvae was inversely related to IgG_2 concentrations and the fecal *Nematodirus* count was inversely related to IgA. *Muellerius* and coccidia did not demonstrate significant relationships with circulating levels of any of the immunoglobulin classes.

INTRODUCTION

The structural characteristics of ruminant immunoglobulins have been intensively studied, but little is known about their response in disease states. Several reports on the levels of circulating immunoglobulins in domestic animals have appeared.[6,7] However, they were confined to the quantitation of IgM and total IgG, possibly due to the technical difficulties encountered in the preparation of highly specific anti-immunoglobulin sera required for single radial immunodiffusion.

Recently, an immunoelectrophoretic technique was reported which permits the quantitation of IgM, IgG_1 and IgG_2 and the semiquantitative analysis of IgA.[4] This method was used, in a preliminary study with four animals, to assess the possible influence of season, parasite activity and individual variability on the circulating levels of all four immunoglobulin classes in captive Rocky Mountain bighorn sheep.

METHODS

Four adult Rocky Mountain bighorn ewes *(Ovis canadensis)*, captured in the East Kootenay region of British Columbia, were available for this study. Two of these animals (Nos. 1 and 2) were taken from overstocked ranges south of Kootenay National Park just prior to a period of significant mortalities due to respiratory disease. The remaining two animals (Nos. 3 and 4) were captured on the Morrisey-Wigwam range where serious disease losses have not been reported recently. Animal No. 1 was studied for 2 years and No. 2, 3 and 4 were examined for a single year.

Immunoglobulin levels were determined for serum samples collected at two week to one month intervals using quantitative immunoelectrophoresis.[4] Purified reference immunoglobulins, used for calculating concentrations, were measured assuming the following absorption characteristics:[1]

$$0.1 \times E \begin{matrix} 0.5 \text{ cm} \\ 280 \text{ nm} \end{matrix} = 139\ \mu g/ml$$

Since a standard IgA preparation of satisfactory purity was not obtained, only relative rather than absolute changes of this immunoglobulin were measured.

Fecal parasite counts were conducted using a modified zinc flotation method[2] on single fecal samples as described previously.[5]

Analysis of covariance was conducted according to Harvey.[3] Main effects were fit for individuals and seasons (January to June and July to December). Fecal parasite counts of *Muellerius, Protostrongylus, Nematodirus* and coccidia, quantitatively the major parasites present, were treated as covariables.

RESULTS AND DISCUSSION

Overall least squares means and individual arithmetic mean levels of IgM, IgG_1 and IgG_2 for each of the captive bighorn sheep are summarized in Table 1. Concentrations of IgM were only slightly less than those reported for man[10] but were approximately one-third of levels reported for cattle.[6] Total IgG levels (the sum of IgG_1 and IgG_2) were intermediate between values of 1290 mg/100 ml reported for cattle by Penhale and Christie[7] and 2640 mg/100 ml reported by Klaus, Bennett and Jones.[6] These differences may reflect either true species characteristics or the use of different Ig standards.

An examination of the correlation matrix in the least squares analysis disclosed that the levels of each of the immunoglobulin classes tended to be independent. The balance of increased immunoglobulin synthesis, following antigenic stimulation, and increased catabolism due to increased circulating levels did not appear to be uniform for all immunoglobulin classes.

Multiple regression techniques revealed significant individual effects for all immunoglobulin classes following the removal of variation due to season and parasite activity (Table 2). This was most marked in the mean concentration of IgG_2 exhibited by Animal No. 3, which was less than half of that found in the other bighorn ewes. The exact basis of these individual differences is not known. Since the animals were maintained on the same ration under similar conditions of management, environmental variables would not appear to be of major importance. Possibly the variation was due to differences in genetic regulation; however, further studies may reveal other influences such as age and early pathologic history.

Seasonal effects were significant only for the levels of IgG_1 in the animals studied (Table 2). Levels from January to June were significantly higher than during the rest of the year. This difference may be related to a shift in the relative rates of production and catabolism of IgG_1 although other factors such as changes in the distribution of body water may contribute to the observed effect.

Significant inverse relationships were detected between levels of IgA and fecal counts of *Nematodirus* and between IgG_2 and *Protostrongylus* (Table 2). Other correlations between circulating immunoglobulins and parasite activity were not apparent at the levels of infection experienced by the experimental animals (Table 3). The cause and effect nature

Table 1. Mean immunoglobulin levels (± SE) of captive bighorn sheep. All values are given in mg/100 ml.[1]

Animal No.	Year	IgM	IgG_1	IgG_2
No. 1	1968-69	62 ± 5(9)	1551 ± 239(9)	495 ± 39(9)
	1969-70	84 ± 8(10)	1347 ± 16(10)	487 ± 41(10)
No. 2	1968-69	67 ± 11(14)	1906 ± 128(14)	515 ± 20(14)
No. 3	1969-70	99 ± 12(12)	1529 ± 251(12)	189 ± 7(12)
No. 4	1969-70	142 ± 19(10)	1901 ± 74(10)	587 ± 38(10)
Overall least squares means		94(55)	1703(55)	433(55)

[1] Number of values contributing to the means shown in parentheses.

Table 2. Analysis of the influence of individual variation, season and parasite activity on immunoglobulin levels of captive bighorn sheep.

Source of variation	df	F values			
		IgA	IgM	IgG_1	IgG_2
Main effects:					
Individuals	3	6.882[2]	10.233[2]	6.337[2]	49.153[2]
Seasons	1	1.047	0.325	9.269	3.899
Covariables:					
Muellerius	1	0.003	0.940	3.675	0.333
Protostrongylus	1	0.805	1.541	0.165	7.025[1]
Nematodirus	1	6.059[1]	0.312	0.228	0.437
Coccidia	1	0.011	0.318	0.817	4.341
Residual:	47				

[1] $P < .05$
[2] $P < .01$

Table 3. Parasite counts in fecal material collected from captive bighorn sheep. Values are expressel as the number of parasites per gram of air-dried feces.[1]

Parasite Species	Mean ± SE	Range
Muellerius	40.04 ± 12.01	0-600
Protostrongylus	836.36 ± 151.417	24-5,900
Nematodirus	15.57 ± 4.710	0-186
Coccidia	59.21 ± 16.321	0-1419

[1] Number of observations contributing to each mean = 55.

of the significant relationships is not known. Although an antibody response, reflected in immunoglobulin levels, may be responsible for controlling parasite activity, it is also possible that the parasite may exert an effect on the host which results in immunoglobulin depression. Recent studies have shown that parasites may have a marked effect on nitrogen balance and on immunologic responsiveness,[9] both of which may depress circulating immunoglobulins.

This study was based on four captive bighorn ewes and, therefore, conclusions must be considered of a tentative nature. However, the results encourage the use of immunoglobulin quantitation in further study of the host-parasite relationship.

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