NORMAL METABOLIC PROFILES OF LAMB AND ADULT CALIFORNIA BIGHORN SHEEP

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ABSTRACT

Data on 16 serum parameters, together with body weights, are presented for a captive population of 32 California bighorn ewes and lambs collected in the fall and again in winter. The purpose was to establish normal metabolic profiles for comparative nutritional and genetic studies of wild bighorn sheep populations. Estimates of repeatabilities of serum parameters are presented and their relationship to estimates of inbreeding are briefly discussed.

INTRODUCTION

Metabolic profiles have been used to assess nutritional status and health in both domestic and wild species. For example Payne <u>et al.</u> (1970) and Kitchenham and Rowlands (1976) have done extensive work relating health and nutritional status of dairy herds to the concentration of certain serum constituents of representative animals from these herds. Franzmann (1971a, 1971b) and Bottrell <u>et al.</u> (1978) have reported serum constituent levels for both bighorn and thinhorn sheep. Utilization of these profiles, in assessing herd health and nutritional status of wild species, is a recent technique and is currently undergoing intensive study, Hebert (1972; pers. comm., and this study). The practical application of these techniques in developing and monitoring supplemental feeding and stocking rate programs are obvious. No attempt is made here to evaluate the utility of various serum constituents for these purposes. Rather, the intent is to delineate the effects of age and of season on the various serum constituents in order to help establish normal levels for the age classes studied.

Data presented here are the result of a study to identify genetic markers for use in determining inbreeding in natural bighorn sheep populations. Inbreeding, in general, causes a decline in vigour, while specifically it lowers reproductive fitness. Estimates of the sensitivity and levels of inbreeding in bighorn sheep will establish the minimal size for small isolated breeding populations, and aid in determining the most suitable size and genetic composition for re-introductions.

MATERIALS AND METHODS

Data used in this study were obtained from animals in the captive herd of California bighorn sheep (Ovis canadensis californiana) of the cooperative bighorn sheep management project involving the British Columbia Fish and Wildlife Branch, the Okanagan Game Farm, the University of British Columbia, and Simon Fraser University. Animals used in this study included 8 male lambs, 10 female lambs (all born in 1977), and 14 ewes (dams of the lambs), each bled in late September, 1977, and again in December, 1977.

Serum samples were obtained from whole blood taken from the jugular vein by vacuutainers, and were later analysed by a commercial bio-medical laboratory.

The estimates of age Class (C) (male lambs, female lambs, and ewes), Season (S) (September and December) and the interaction between Class and Season (CxS) were used in the following linear model, to obtain estimates of the least-square means of body weight and each serum constituent associated with each effect.

$$Y_{ijk} = U + C_i + S_j + (CxS)_{ij} + C_{ijk}$$

Single degree of freedom contrasts were used to evaluate the effects of Class - lambs (male + female) vs. ewes and male lambs vs. female lambs. Newman-Keul multiple range test was used to evaluate differences in Class x Season interaction. The variance among individuals (V_i) and within individuals (V_w) were estimated by adding individuals within classes (I_{il}/C_i) to the above model. The repeatability coefficients were estimated by $R = V_i/(V_i+V_w)$.

Significance levels reported in this paper are $P \leq 0.05$.

RESULTS AND DISCUSSION

The means and standard deviations for body weight and levels of each serum constituent for each Class, Season and Class by Season cell are given in Table 1. Phosphorus, blood urea nitrogen (BUN), uric acid, and potassium were all lower in the current study, while cholesterol and thyroxin were found to be higher than reported by Bottrell _et al_ (1978). These differences are quite large, in some cases, and likely due to differences in available feed. The lambs in the study, reported by Bottrell, were fed hay with a grain supplement, while those in the current study were on native range with no supplementation. Mean values reported by Franzmann (1971a) and Franzmann and Thorne (1970) agree with the current results for phosphorous, glucose, BUN, and total protein. Calcium levels were higher and cholesterol levels lower in the present study than found by the above authors.

No significant differences were found between male and female lambs for any of the variables studied including weight. Adult ewes did not differ from lambs in serum glucose, cholesterol, total protein, bilirubin, or potassium, but were significantly heavier and differed in all other serum constituents as indicated in Tables 1 and 2.

Seasonal effects are elaborated in Tables 1 and 2, and only bilirubin, sodium, creatinine, triglyceride, and amylase showed no change due to season. Serum mineral levels (calcium, phosphorus, and potassium) declined from September to December. BUN, uric acid, cholesterol, total protein, and globulin also declined. Only serum albumin and thyroxin increased from September to December.

Significant Class x Season interactions were observed for weight, cholesterol, globulin, and creatinine (Table 1). Lambs increased in weight, while ewes lost weight from first to second sampling. It should be noted that no significant change in weight occurred within an age class; rather the weight loss of the ewes was small and not significant, but the combined gain of the lambs and loss of the ewes was a significant differential response. It was noted that many of the ewes were still lactating at the September sampling period which may account for this significant interaction. Cholesterol levels in lambs dropped while

Table 1: Means and standard deviations for body weight and serum constituent levels in California bighorn sheep for age classes and seasons

		Overall Mean	Class: Male Lambs (M)	Class: Female Lambs (F)	Class: Adult ewes (E)	Season: September (S)	Season: December (D)	Class x Season: M in S	F in S	E in S	M in D	F in D	E in D
Number of observations	(1)	64	16	20	28	32	32	8	10	14	8	10	14
Weight (kg)	Mean	36.8	26.3^{a}	24.2^{a}	52.5^{b}	36.5	37.2	25.5^{a}	22.9^{a}	53.8^{b}	27.2^{a}	25.5^{a}	51.3^{b}
	S.D.	(14.1)	(3.1)	(2.8)	(4.4)	(15.4)	(12.9)	(3.7)	(2.9)	(4.7)	(2.4)	(1.9)	(3.8)
Calcium (Ca) mg/dl	Mean	9.44	9.75^{a}	9.90^{a}	8.96^{b}	9.70^{a}	9.19^{b}	10.19	10.22	9.06	9.31	9.57	8.86
	S.D.	(0.70)	(057 1	(0.62)	(0.48)	(0.74)	(0.55)	(0.95)	(0.57)	(0.45)	(0.36)	(0.50)	(0.58)
Phosphorous (P) mg/dl	Mean	4.35	4.84^{a}	4.56^{a}	3.92^{b}	5.05	3.64	5.99	5.24	4.39	3.70	3.87	3.45
	S.D.	(1.24)	(1.45)	(1.32)	(0.91)	(1.21)	(0.81)	(0.99)	(1.36)	(0.83)	(0.74)	(0.90)	(0.78)
Glucose mg/dl	Mean	140.2	130.4	147.7	140.3	143.7	136.6	124.9	145.4	150.4	135.9	146.1	130.2
	S.D.	(39.5)	(29.4)	(44.7)	(40.7)	(41.8)	(37.4)	(35.1)	(45.8)	(42.0)	(23.6)	(45.8)	(36.3)
BUN mg/dl	Mean	27.2	26.1^{a}	25.4^{a}	29.0^{b}	29.1^{a}	25.7^{b}	27.2	26.9	31.6	25.0	24.0	26.4
	S.D.	(4.1)	(3.2)	(2.9)	(4.7)	(3.6)	(3.7)	(3.6)	(2.3)	(2.8)	(2.3)	(2.7)	(4.7)
Uric Acid mg/dl	Mean	0.247	0.244^{a,b}	0.195^{a}	0.286^{b}	0.328^{a}	0.166^{b}	0.337	0.268	0.371	0.150	0.130	0.200
	S.D.	(0.153)	(0.179)	(0.132)	(0.146)	(0.120)	(0.140)	(0.151)	(0.088)	(0.107)	(0.160)	(0.142)	(0.130)
Cholesterol mg/dl	Mean	58.5	59.1	61.9	55.7	64.6^{a}	52.3^{b}	69.4^{a}	69.7^{a}	58.7^{b}	48.8^{b}	54.1^{b}	53.1^{b}
	S.D.	(12.4)	(16.1)	(14.3)	(7.48)	(12.1)	(9.5)	(14.8)	(13.2)	(5.9)	(9.7)	(11.2)	(8.2)
Total protein gm/dl	Mean	6.52	6.54	6.36	6.61	6.84^{a}	6.19^{b}	7.07^{a}	6.80^{a,b}	6.74^{a,b}	6.00^{c}	5.92^{c}	6.49^{b}
	S.D.	(0.55)	(0.66)	(0.58)	(0.46)	(0.43)	(0.47)	(0.37)	(0.40)	(0.46)	(0.36)	(0.36)	(0.44)
Albumin gm/dl	Mean	3.21	3.27^{a}	3.33^{a}	3.09^{b}	2.81^{a}	3.61^{b}	2.91	2.89	2.69	3.62	3.77	3.48
	S.D.	(0.48)	(0.39)	(0.48)	(0.51)	(0.22)	(0.30)	(0.12)	(0.100)	(0.28)	(0.14)	(0.21)	(0.37)
Globulin gm/dl	Mean	3.31	3.27^{a,b}	3.03^{a}	3.53^{b}	4.03^{a}	2.58^{b}	4.16^{a}	3.91^{a}	4.04^{a}	2.36^{b}	2.15^{b}	3.01^{c}
	S.D.	(0.89)	(0.98)	(0.94)	(0.75)	(0.44)	(0.56)	(0.39)	(0.34)	(0.54)	(0.31)	(0.21)	(0.55)
Bilirubin mg/dl	Mean	0.44	0.41	0.48	0.43	0.48	0.41	0.41	0.48	0.51	0.40	0.48	0.36
	S.D.	(0.13)	(0.09)	(0.13)	(0.15)	(0.14)	(0.11)	(0.11)	(0.14)	(0.16)	(0.08)	(0.12)	(0.10)
Sodium (Na) meq/l	Mean	149.7	150.7^{a}	151.8^{a}	147.7^{b}	149.7	150.1	150.3	151.5	147.4	151.2	152.1	147.9
	S.D.	(3.3)	(2.6)	(2.6)	(2.8)	(3.3)	(3.2)	(2.6)	(2.7)	(3.0)	(2.8)	(2.5)	(2.7)
Potassium (K) meq/l	Mean	4.55	4.62	4.38	4.64	4.79^{a}	4.31^{b}	4.97	4.50	4.90	4.27	4.26	4.37
	S.D.	(0.81)	(0.86)	(0.83)	(0.77)	(0.99)	(0.47)	(1.10)	(1.08)	(0.88)	(0.33)	(0.49)	(0.54)
Creatinine mg/dl	Mean	2.01	1.06	1.97	2.12	2.12	1.89	1.86^{a}	1.99^{a}	2.36^{b}	1.86^{a}	1.95^{a}	1.87^{a}
	S.D.	(0.39)	(0.26)	(0.38)	(0.43)	(0.46)	(0.26)	(0.12)	(0.47)	(0.41)	(0.20)	(0.28)	(0.28)
Triglyceride mg/dl	Mean	36.8	45.7^{a}	43.7^{a}	27.1^{b}	35.4	38.19	48.6	40.4	24.4	42.7	46.2	29.9
	S.D.	(20.3)	(29.4)	(19.1)	(7.19)	(24.3)	(15.7)	(37.1)	(22.4)	(7.6)	(21.4)	(15.7)	(5.8)
Amylase (somogyi units)	Mean	45.4	44.3^{a,b}	33.7^{a}	54.1^{b}	45.1	44.8	49.12	33.7	52.4	39.5	33.7	55.7
	S.D.	(25.6)	(27.2)	(20.0)	(35.5)	(29.5)	(21.6)	(33.7)	(22.4)	(30.5)	(19.9)	(18.9)	(20.3)
Thyroxin (T_4) mg/dl	Mean	8.81	10.14^{a}	10.29^{a}	6.93^{b}	7.92^{a}	9.84^{b}	9.05	9.51	5.9	11.22	11.08	8.94
	S.D.	(3.07)	(2.52)	(2.17)	(2.98)	(3.91)	(2.82)	(2.47)	(1.93)	(2.93)	(2.19)	(2.21)	(2.71)

(1) three observations were missing - weight on a ewe in September
- amylase on a female lamb in September
- thyroxin on a ewe in December

Common subscript within an ANOVA category indicates means are not significantly different P≤0.05 (Newman-Keul multiple range test).

Table 2: Summary of analysis of variance and repeatabilities for body weight and serum constituent levels.

Dependent Variable	Units	Class (2 d.f.) Lambs-ewes	Class (2 d.f.) lambs male-ewe	Season (1 d.f.) Sept.-Dec.	Class x Season (2 d.f.)	Repeatability (R)
1. Weight	kg	-27.4*	ns	ns	*(1)	(2)
2. Calcium (Ca)	mg/dl	0.87*	ns	0.51*	ns	0 (3)
3. Phosphorus (P)	mg/dl	0.77*	ns	1.53*	ns	0 (3)
4. Glucose	mg/dl	ns	ns	ns	ns	19
5. BUN	mg/dl	-3.25*	ns	3.48*	ns	32
6. Uric Acid	mg/dl	-0.0690*	ns	0.1630*	ns	21
7. Cholesterol	mg/dl	ns	ns	13.8*	*(1)	9
8. Total protein	gm/dl	ns	ns	0.73*	*(1)	29
9. Albumin	gm/dl	0.22*	ns	-0.79*	ns	29
10. Globulin	gm/dl	-0.39*	ns	1.53*	*(1)	0 (3)
11. Bilirubin	mg/dl	ns	ns	ns	ns	0 (3)
12. Sodium (Na)	meq/l	3.6*	ns	ns	ns	0 (3)
13. Potassium (K)	meq/l	ns	ns	0.49*	ns	24
14. Creatinine	mg/dl	-0.20*	ns	ns	*(1)	0 (3)
15. Triglyceride	mg/dl	17.3*	ns	ns	ns	5
16. Amylase	(somogyi units)	-15.53*	ns	ns	ns	(2)
17. Thyroxin (T_4)	mg/dl	3.29*	ns	-1.96	ns	(2)

* significant $P \leq 0.05$

(1) see Table 1 for multiple range test

(2) not estimated due to missing observation

(3) negative estimate of V_i, assumed R=O

serum cholesterol levels in the ewes remained constant. Serum globulin levels in the lambs dropped drastically from September to December, while the level in ewes dropped over that period but not to the same extent. The creatinine level for ewes was high in September and dropped to a level comparable to that of the lambs in December. The repeatabilities (correlations between repeated samples of the same individual) for serum BUN, total protein, albumin, glucose, uric acid, and potassium (Table 2) were reasonably high. This suggests these constituents may be suitable polygenic markers, because the magnitude of the among individual variance (V_I) indicates that genetic differences do exist for these traits in the population. Further evaluation is required to eliminate the real possibility that several of these parameters are controlled by simple genetic systems, in which case they may be useful as polymorphic markers.

It is also apparent, from this analysis, that approximately 10% of the variation in BUN, total protein, and albumin levels is associated with differences among individuals which has implications on sampling schemes for monitoring nutrient status of populations. No comparisons of these estimates of repeatabilities are available in the literature for this species. However, the repeatabilities are generally consistent with those found in dairy cattle populations (Peterson 1978, Kitchenham and Rowland 1976).

Differences were observed, for most variables, between lambs and adult ewes, while sex of lamb was not important. It follows that metabolic profiles, used for assessing nutritional status, would need to be adjusted for the age effects to obtain realistic estimates for a herd or population. The observed seasonal changes may be due to normal season cycles or to a decline in nutritional status. This will require additional investigation.

LITERATURE CITED

BOTTRELL, A., B. GORDY and R. PETERSON. 1978. Comparison of chromosomes and serum constituents of California and Rocky Mountain bighorn and Dall and Stone thinhorn sheep. Proceedings of the Northern Wild Sheep and Goat Conference, Penticton, B.C.

FRANZMANN, A.W. and E.T. THORNE. 1970. Physiological values in wild bighorn sheep (Ovis canadensis canadensis) at capture, after handling and after captivity. J. Am. Vet. Med. Assoc. 157:647.

FRANZMANN, A.W. 1971a. Comparative physiological values in captive and wild bighorn sheep. J. Wildlife Diseases. 7:105.

FRANZMANN, A.W. 1971b. Physiological values in stone sheep. J. Wildlife Diseases. 7:139.

HEBERT, D.M. 1972. Forage and serum phosphorous values for bighorn sheep. J. Range Manage. 25:4.

KITCHENHAM, B.A., and G.T. ROWLANDS. 1976. Differences in the concentrations of certain blood constituents among cows in dairy herds. J. Agric. Sci. 86:171.

PAYNE, J.M., S.M. DEW, R. MANSTON and M. FAULKS. 1970. The use of a metabolic profile test in dairy herds. Vet. Rec. 87:150.

PETERSON, R.G. and D.E. WALDERN. 1978. Serum constituent levels in dairy cattle as affected by feeding regime, age, lactation, and pregnancy. Estimates of the correlations of the serum constituents between repeated samples of the same animal. (Unpublished).