

Serum chemistry of wild, free-ranging mountain lions (*Puma concolor*) in the eastern Sierra Nevada, California, USA

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We report descriptive statistics and reference intervals for serum chemistry from 43 unique mountain lions captured in the eastern Sierra Nevada, California, for ecological or genetic investigations during 1993–2004. We tested for differences between males and females, and winter (when mule deer [*Odocoileus hemionus*] were most abundant in diets) and summer (when smaller prey were more common in diets). Differences in direct bilirubin and total protein occurred between the sexes, whereas seasonal differences occurred in CO₂, A/G ratio, Ca and, again, direct bilirubin. Subjects that were bayed with hounds and captured after short chases exhibited lower levels of creatine kinase than those captured using other methods or that had been pursued long distances. Retrospective comparisons with previously published information also revealed differences in mean levels of Na, cholesterol, and creatine kinase among mountain lions captured after baying with hounds in those independent investigations.

Key words: comparative biochemistry, cougar, geographic variation, mountain lion, puma, *Puma concolor*, reference interval, serum chemistry

There is intense interest, both political and biological, in mountain lion (*Puma concolor*) as a keystone species, highly adaptable predator, and potential threat to human safety (Torres et al. 1996, Bleich and Pierce 2005, Torres 2005, USFWS 2000, 2007). Despite widespread and increasingly detailed research on population genetics, ecology, and the role of mountain lions in ecosystem function, there is a paucity of information on blood parameters (Pierce and Bleich 2003). Such data are limited to few reports in the professional literature that are based on captive individuals (Currier and Russell 1982), wild animals (Currier and Russell 1982, Dunbar et al. 1997, Foster and Cunningham 2009), or combinations of wild and captive animals (Currier and Russell 1982).

Mountain lions are among the most widely distributed mammals in the Western Hemisphere, with an historical range from northern British Columbia to southernmost Argentina and Chile, and occupied suitable habitat from coast to coast in North America (Young and Goldman 1946, Williams 2018). Thus, variation in serum chemistry across the range of the species would not be unexpected (Dunbar et al. 1997), and the value of obtaining data from multiple study areas previously has been emphasized (Dunbar et al. 1997, Pierce and Bleich 2003).

We captured mountain lions from a population occupying a localized and remote area of California, which since has been identified as genetically distinct from other populations of mountain lions in that state (Ernest et al. 2003, Gustafson et al. 2019). Seasonal variation in availability of primary prey (Villepique et al. 2011), the potential for sex-specific differences, and our large sample of wild, free-ranging animals provided an opportunity to examine blood serum chemistry of those cryptic felids occupying a rural and largely pristine region. Moreover, increasing attention to pathogen spillover from domestic cats (*Felis catus*) to mountain lions at the urban-wildland interface (Paul-Murphy et al. 1994, Foley 1997, Bevins et al. 2012, Carver et al. 2016, Kellner et al. 2018) made it especially valuable to document reference intervals in this sparsely populated part of California.

STUDY AREA

Our primary study area, the Round Valley Mule Deer Winter Range (~450 km²; 37°25' N, 118°36' W), was located along the eastern slope of the Sierra Nevada, Mono and Inyo counties, California, a rural area with a mean population density of <2 persons/km² (Duncan 1993). The Sierra Nevada is a massive mountain range reaching elevations in excess of 4,400 m, and extends 640 km in a north-south direction while separating the Great Basin from the San Joaquin and Sacramento valleys to the west (Storer and Usinger 1968). Mule deer (*Odocoileus hemionus*) comprise the primary prey base for mountain lions in the eastern Sierra Nevada (Bleich and Taylor 1998, Pierce et al. 1999, 2000a, 2000b, 2004; Villepique et al. 2011). An endemic subspecies of bighorn sheep (*Ovis canadensis sierrae*), and tule elk (*Cervus elaphus nannodes*)—which are not native to the region—also are occasional prey of mountain lions (McCullough 1969, Johnson et al. 2013, Villepique et al. 2015), as are domestic livestock (Villepique et al. 2011). Mountain lions showed a functional response to the concentration of mule deer on winter range, as evidenced by a marked increase in the frequency of deer remains in lion feces during winter compared to summer, and a corresponding increase of smaller mammals in lion feces during summer (Villepique et al. 2011).

Mountain lions occupy the eastern Sierra Nevada year-round, although some individu-

als migrate with mule deer to summer ranges (Pierce et al. 1999). Density of mule deer during winter (November–April) in Round Valley was much greater than during summer (May–October) because the majority of wintering mule deer disperse northward to higher elevations or through mountain passes to summer ranges west of the Sierra Crest, returning to winter ranges each year during autumn (Kucera 1992, Monteith et al. 2011). The mule deer population in Round Valley during winter declined substantially, from approximately 6,000 (~13/km²) in 1985, reaching its nadir of about 1,000 (~2/km²) in 1991; in 1992, the population began to increase slowly, and trended upward through the remainder of our investigation (Pierce et al. 2012). The mean number of mountain lions occupying the winter range declined from 6.1 in winter 1992–1993 to 0.6 in winter 1998–1999, lagging the decline in the deer population by about 7 years (Pierce et al. 2012, Pierce and Bleich 2014).

METHODS

We captured mountain lions for ecological (Pierce et al. 1999, 2000a, 2000b, 2004, 2012; Villepique et al. 2011, 2015), behavioral (Bleich et al. 1996, Pierce et al. 1998), and genetic (Ernest et al. 2003, Gustafson et al. 2019) investigations from 1991 to 2004, and obtained serological information on lions captured during 1993–2004. Our capture protocol followed then-current guidelines of the California Department of Fish and Game (CDFG; Jessup et al. 1986) and animal care and use protocols of the American Society of Mammalogists (*ad hoc* Committee on Acceptable Field Methods in Mammalogy 1987, Kirkland 1998), and was approved by the Institutional Animal Care and Use Committee at the University of Alaska Fairbanks (Pierce 1999).

We immobilized animals with Telazol® (tiletamine HCl and zolazepam HCl; Fort Dodge Animal Health, Fort Dodge, IA) after they were brought to bay by hounds (Young and Goldman 1946) or captured with foot snares (Logan et al. 1999); one individual was caught accidentally in a leg-hold trap set legally for other species, as described by Andreason et al. (2018). Following immobilization, we restrained each animal with hobbles and covered the eyes with a blindfold, obtained morphometrics and weight, and conducted a thorough physical examination. We fitted each mountain lion with a VHF or GPS telemetry collar (Bleich et al. 2000), and used venipuncture to collect 50 cc of blood from the medial saphenous vein, and transferred samples immediately to appropriate vacutainer tubes for serum chemistry and hematology, as well as for anticipated genetic investigations. Blood samples were transported directly from the field (≤ 4 hr) to Northern Inyo Hospital, Bishop, California, where samples were processed and analyzed upon arrival (Vitros Chemistry System®, Ortho Clinical Diagnostics, Raritan, NJ); funds were not available for processing through a commercial veterinary laboratory. At least one investigator remained with each study animal until it became mobile and departed the capture site.

Ten individuals were represented >1 time among our samples. Thus, we used Mann-Whitney tests to compare variables between males and females, and between winter (November–April) and summer (May–October). If no statistically significant difference ($P > 0.05$) existed between the sexes or between seasons, variables were pooled prior to further analysis. Where differences did occur, we present values for males and females separately and in combination, as well as separately for winter and summer and in combination.

We used Reference Value Advisor (Greffre et al. 2011), an Excel Spreadsheet add-in, to calculate descriptive statistics, analyze each variable for distribution and outliers, and to

calculate reference intervals for this population. Reference Value Advisor used Tukey's Test to flag outliers and confirmed them with the Dixon-Reed Test to evaluate the distance from the outlier to the nearest value, divided by the whole range of values; in the absence of an obvious explanation for outliers, we retained them among data to be analyzed (Greffre 2009). Gaussian distribution was assessed in Reference Value Advisor with the Anderson-Darling Test and, as a result, reference intervals and the 90% CI around the upper and lower reference limits were calculated using the nonparametric method (Greffre et al. 2011). Where sample sizes were inadequate to calculate a reference interval, we present only the mean, *SD*, median, and range of values (Friedrichs et al. 2012).

We also summarized results of previous investigations, and conducted retrospective comparisons between analytes reported here and those reported by earlier researchers. We tested for differences between mean values of sodium, potassium, chloride, creatine kinase, total bilirubin, phosphorous, and cholesterol, for which mean values had been reported by Currier and Russell (1982), Paul-Murphy et al. (1994), or Dunbar et al. (1997). We back-calculated standard deviation (Higgins and Green 2011) from the mean and 95% confidence interval provided by Currier and Russell (1982) and then used Welch's Approximate *t*, which is robust to considerable departures from theoretical assumptions when two-tailed tests are employed and samples are large (Zar 1984), for these comparisons.

RESULTS

We report results for 61 blood samples obtained from 43 (20 male, 23 female) unique mountain lions ≥ 6 months-of-age; descriptive statistics and reference intervals are based on samples ranging in size from 20 to 59 (Table 1). One male and one female were captured with foot snares, one female was accidentally caught in a leg-hold trap, and one female was sampled immediately after being pursued at length and dispatched because of human safety concerns. Blood samples were obtained immediately after the mountain lion was immobilized; in the latter case, however, the sample was obtained immediately following the animal's death. External physical examination and body weight (Roelke 1987, Dunbar et al. 1997), body conformation (our subjective index to body condition), and coat condition (Charlton et al. 1998) indicated that mountain lions included in these analyses were healthy and in good body condition. Further, none exhibited evidence of chronic disease, serious injury, or heavy infestation by external parasites.

Differences (Table 1) occurred between males and females in direct bilirubin ($U_A = 577$, $z = -2.44$, $P = 0.015$) and total protein ($U_A = 556.5$, $z = -2.12$, $P = 0.034$), whereas seasonal differences occurred in CO_2 ($U_A = 190.5$, $z = 3.19$, $P = 0.001$), A/G ratio ($U_A = 201.0$, $z = 3.01$, $P = 0.003$), calcium ($U_A = 266.5$, $z = 1.97$, $P = 0.049$), and again in direct bilirubin ($U_A = 542$, $z = -2.64$, $P = 0.008$). We identified four outliers for creatine kinase, but present results with and without those data. Creatine kinase for animals bayed with hounds ($\bar{x} = 554.3$, range 148–1,545) was far lower than that involving other methods of capture or a long pursuit ($\bar{x} = 13,215.8$, range 3,605–25,967); in the absence of those outliers, no difference existed in creatine kinase by sex or season (Table 1). Retrospective analyses indicated differences in mean values for creatine kinase, Na, and cholesterol among wild, free-ranging mountain lions captured in this investigation when compared to results from other independent reports (Appendix I, Appendix II).

TABLE 1.—Serum chemistry values for mountain lions captured in the eastern Sierra Nevada, Inyo and Mono counties, California, 1993–2004. Reference intervals and the 90% CI around the upper and lower reference limits were calculated using the method of Greffire et al. (2011); where sample sizes were inadequate to calculate a reference interval, we present only the mean, SD, median, and range of values (Friedrichs et al. 2012).

Analyte	<i>n</i>	Mean	SD	Median	Range	Reference Interval	90% CI Lower Limit	90% CI Upper Limit
Sodium (mEq/L)	59	158.3	40.2	153.0	141–461	144–309	141–148	157–461
Potassium (mEq/L)	59	4.55	1.85	4.20	3.6–17.6	3.60–12.95	3.60–3.65	5.20–17.60
Chloride (mEq/L)	59	123.3	27.3	121.0	106–327	108.5–227.0	106–112	126–327
CO ₂ (mEq/L) (Annual) ^a	59	16.4	6.4	16.0	9–59	9.5–42.0	9.0–11.5	21.0–59.0
CO ₂ (Summer)	20	14.2	2.0	14.0	11–18	—	—	—
CO ₂ (Winter)	39	17.6	7.5	17.0	9–59	—	—	—
Glucose (mg/dL)	59	144.9	69.1	130.0	62–431	65–391.5	62.0–74.0	279.0–431.0
Blood Urea Nitrogen (mg/dL)	59	42.3	17.4	45.0	16–74	16.0–74.0	16.0–18.0	70.0–74.0
Creatine Kinase (U/L) ^b	57	1458.7	4208.2	514.5	148–25967	148.0–23072.8	148.0–186.7	3062.2–25967.0
Creatine Kinase ^c	53	554.3	336.9	493.5	148–1545	148.0–1467.3	148.0–180.0	1126.0–1545.0
SGPT (U/L)	59	77.9	54.3	65.0	19–364	30.0–316.0	19.0–45.0	169.0–364.0
GGT (U/L)	57	9.5	4.1	9.0	5–28	5.5–26.7	5.0–6.0	17.0–28.0
Alkaline Phosphatase (U/L)	59	37.3	30.0	28.0	10–187	11.0–144.5	10.0–12.5	81.0–187.0
Total Bilirubin (mg/dL)	58	0.47	0.88	0.30	0.1–6.8	0.10–4.33	0.10–0.10	0.85–6.80
Direct Bilirubin (mg/dL) (♀+♂) ^d	58	0.37	0.88	0.20	0–6.8	0–4.0	0.0–0.0	0.71–6.80
Direct Bilirubin (♀)	30	0.19	0.15	0.20	0–0.6	—	—	—
Direct Bilirubin (♂)	28	0.55	1.24	0.30	0–6.8	—	—	—
Direct Bilirubin (mg/dL) (Annual) ^e	58	0.37	0.88	0.20	0–6.8	0–4.0	0.0–0.0	0.71–6.80
Direct Bilirubin (Summer)	20	0.36	0.23	0.30	0–0.9	—	—	—
Direct Bilirubin (Winter)	38	0.37	1.08	0.20	0–6.8	—	—	—
Indirect Bilirubin (mg/dL)	58	0.07	0.12	0.0	0–0.6	0–0.51	0.0–0.0	0.30–0.60
Total Protein (g/dL) (♀+♂) ^f	59	7.48	1.76	7.30	5.5–20.2	5.75–14.15	5.50–6.40	8.00–20.20
Total Protein (♀)	31	7.13	0.61	7.20	5.5–8.0	—	—	—
Total Protein (♂)	28	7.88	2.44	7.45	6.7–20.2	—	—	—
Albumin (g/dL)	59	4.04	1.40	3.90	3.0–14.3	3.05–9.60	3.0–3.4	4.3–14.30

TABLE 1.—Continued.

Analyte	<i>n</i>	Mean	SD	Median	Range	Reference Interval	90% CI Lower Limit	90% CI Upper Limit
A/G Ratio (Annual) ^g	59	1.20	0.31	1.10	0.80–2.40	0.80–2.40	0.80–0.90	1.70–2.40
A/G Ratio (Summer)	20	3.73	0.27	3.80	3.0–4.0	—	—	—
A/G Ratio (Winter)	39	1.28	0.34	1.20	0.9–2.4	—	—	—
Calcium (mg/dL) (Annual) ^h	59	10.66	1.28	10.50	9.0–18.9	9.05–15.45	9.0–9.40	11.70–18.90
Calcium (Summer)	20	10.32	0.58	10.20	9.0–11.5	—	—	—
Calcium (Winter)	39	10.84	1.49	10.70	9.1–18.9	—	—	—
Phosphorus (mg/dL)	59	6.01	1.99	5.50	3.20–10.80	3.20–10.55	3.20–3.50	9.75–10.80
Triglycerides (mg/dL)	56	37.9	24.3	31.0	9.0–115.0	9.40–110.3	9.0–10.0	89.1–115.0
Cholesterol (mg/dL)	58	150.0	29.6	150.0	59.0–207.0	68.0–205.6	59.0–109.9	196.4–207.0
Creatinine (mg/dL)	56	1.89	0.67	1.75	0.80–3.60	0.84–3.47	0.80–1.00	3.07–3.60

^a Seasonal difference ($U_A = 190.5, z = 3.19, P = 0.001$)

^b Includes 4 outliers (3 ♀, 1 ♂) with exceedingly high CPK (see text for details)

^c Outliers removed from sample

^d Females and males differed ($U_A = 577, z = -2.44, P = 0.015$)

^e Seasonal difference ($U_A = 542, z = -2.64, P = 0.008$)

^f Females and males differed ($U_A = 556.5, z = -2.12, P = 0.034$)

^g Seasonal difference ($U_A = 201.0, z = 3.01, P = 0.003$)

^h Seasonal difference ($U_A = 266.5, z = 1.97, P = 0.049$)

DISCUSSION

Significant differences in direct bilirubin and total protein between males and females reported here may not be biologically meaningful, but are presented for consideration by future investigators. Similarly, significant differences between seasons in direct bilirubin, calcium, CO₂, and A/G ratio may not be biologically meaningful. Nonetheless, these results could have foundations in differences between the sexes in diet or life history strategies (Pierce et al. 2000b, White et al. 2011), and remain open to further inquiry.

Availability of previously published information provided an opportunity to conduct a retrospective comparison of mean values for sodium, potassium, chloride, total bilirubin, phosphorus, cholesterol, and creatine kinase between this investigation and those reported by earlier researchers (Appendix I, Appendix II). Mean level of creatine kinase reported here was nearly identical in value to that for mountain lions bayed by hounds in Florida (Dunbar et al. 1997), but values reported by Currier and Russell (1982) were significantly less than those reported in this investigation or by Dunbar et al. (1997). Further, the mean value for creatine kinase reported by Currier and Russell (1982) did not fall within the reference interval for mountain lions occupying the eastern Sierra Nevada, and may reflect effects of differences in pursuit times (Harlow et al. 1992), ambient conditions (Kozakiewicz et al. 2018), handling protocols (Kock et al. 1987, Zahid et al. 2018), laboratory methods (Duncan et al. 1994), or genetic variation among populations (Yamin et al. 2007, 2008, 2010). Mean values for sodium and cholesterol also differed among the four investigations (Appendix II), and reasons for those differences remain open to further consideration. Mean values for sodium and cholesterol reported by Currier and Russell (1982) or Dunbar et al. (1997) did, however, fall within the reference interval calculated for mountain lions captured in the eastern Sierra Nevada.

Anthropogenic mortality is frequent among mountain lions (Wolfe et al. 2015, Andreasen et al. 2018), and an increase in domestic pets, including house cats, can be expected as human populations expand. This eventuality will lead to greater opportunities for mountain lions to contact humans and their domestic felids (Anderson et al. 2009, Bevins et al. 2012; but, see Carver et al. 2016). Although mountain lions preyed infrequently on domestic cats in the eastern Sierra Nevada (Villepique et al. 2011), we provide baseline reference intervals from a part of California where those iconic carnivores are much less apt to contract pathogens than at the urban-wildland interface, where there is increasing interest in spillover from domestic to wild felids (Foley 1997, Riley et al. 2004, Foley et al. 2013, Carver et al. 2016, Kellner et al. 2016, Kozakiewicz et al. 2018).

As noted by Barnes et al. (2008), baseline data are of importance when investigating the health status of free-ranging wildlife, and health monitoring is necessary to understand and manage threats (Deem et al. 2001). Our results provide reference intervals from a genetically defined population of mountain lions that likely has experienced fewer encounters with domestic cats than at the constantly growing urban-wildland interface, and values reported here can serve as a baseline against which to measure future changes among mountain lions occupying a rural and isolated region of America's most populous state. Indeed, other investigators have reported that prevalence rates of pathogens among mountain lions occupying the eastern Sierra Nevada were among the lowest reported from California (Girard et al. 2012, Foley et al. 2013).

Reference intervals normally are based on values obtained from individual animals.

In this investigation, 5 mountain lions were sampled twice, 3 were sampled 3 times, 1 was sampled 4 times, and 1 was sampled 5 times (median time between repeat captures = 18 months [range 4–38 months]). Thus, population-specific reference values reported here are based on a combination of intra-individual and inter-individual variation (Grefe et al. 2009).

Variation in weather, prey availability and its effect on diet composition, reproductive status, age, and differences in capture methods likely are meaningful representations of variability in the conditions that can affect serum chemistry of individuals (Ellervik and Vaught 2015). Although some mountain lions were sampled more than once and those data were used to calculate the reference values presented, resampling occurred under a variety of ecological settings that likely reflected individual responses to environmental or physiological variability. We acknowledge the potential for “nondemonic intrusion” (i.e., a chance event) that may have affected some individuals (Hurlburt 1984), but consider our use of multiple samples from the same individual to be representative of conditions likely to be encountered by individuals comprising our study population at some point in their lives. Multiple samples from each experimental unit (i.e., the individual mountain lion) can be desirable in that it increases the precision with which properties of each individual are estimated (Hurlburt 1984), and multiple samples from individual mountain lions were included in population-specific reference intervals reported by Currier and Russell (1982) and Dunbar et al. (1997).

The importance of local factors in explaining disease exposure (Carver et al. 2016) and calculations performed ancillary to this investigation support the desirability of obtaining serum chemistry values from mountain lions on local scales that reflect differing ecological settings (Pierce and Bleich 2003), landscape features (Kozakiewicz et al. 2018), or one or more of the numerous stressors currently facing wild felids (Kellner et al. 2018). Rather than assuming that reference values or descriptive statistics from a single location are representative for what historically was the most widely distributed terrestrial mammal in the western hemisphere (Logan and Sweaner 2001), differences among populations are to be expected and do exist (Appendix I, Appendix II). Our results further emphasize the value of detailed sampling at multiple locations and add substantially to the paucity of information on the serum chemistry of wild, free-ranging mountain lions that currently is available.

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**APPENDIX I: MEAN AND STANDARD DEVIATION OF SERUM CHEMISTRY VALUES FOR WILD,
FREE-RANGING MOUNTAIN LIONS INHABITING DISPARATE NORTH AMERICAN ECOSYSTEMS
IN FLORIDA, COLORADO, AND CALIFORNIA, USA**

Analyte	Bleich et al. (this paper)			Currer and Russell (1982)			Paul-Murphy et al. (1994)			Dunbar et al. (1997)		
	<i>n</i>	Mean	SD	<i>n</i>	Mean	SD	<i>n</i>	Mean	SD	<i>n</i>	Mean	SD
Sodium (mEq/L) ^a	59	158.3	40.2	17	144.6	2.42	—	—	—	94	152.6	3.4
Potassium (mEq/L) ^a	59	4.55	1.85	17	4.6	0.32	—	—	—	94	4.6	0.48
Chloride (mEq/L) ^a	59	123.3	27.3	17	114.2	4.84	—	—	—	94	115.5	4.3
CO ₂ (mEq/L) ^b	59	16.4	6.4	—	—	—	19	12.53	1.75	94	14.33	4.00
Glucose (mg/dL) ^b	59	144.9	69.1	—	—	—	19	110.6	37.3	94	154.4	51.0
Blood Urea Nitrogen (mg/dL) ^b	59	42.3	17.4	—	—	—	19	32.9	6.4	94	37.7	14.1
Creatine Kinase (U/L) ^a	52 ^c	554.3 ^c	336.9 ^c	17	108.0	55.75	—	—	—	88	515.1	415.1
SGPT (U/L) ^b	59	77.9	54.3	—	—	—	19	60.2	33.4	94	60.2	35.0
GGT (U/L) ^{a,b}	57	9.5	4.1	—	—	—	—	—	—	80	1.6	1.4
SGOT (U/L) ^{a,d}	—	—	—	17	68.0	22.09	—	—	—	94	73.4	77.8
Alkaline Phosphatase (U/L)	59	37.3	30.0	—	—	—	19	22.6	11.3	94	35.4	38.6
Total Bilirubin (mg/dL)	58	0.47	0.88	17	0.3	0.11	—	—	—	94	0.26	0.61
Direct Bilirubin (mg/dL) ^{a,b,c}	58	0.37	0.88	—	—	—	—	—	—	—	—	—
Indirect Bilirubin (mg/dL) ^{a,b,c}	58	0.07	0.12	—	—	—	—	—	—	—	—	—
Total Protein (g/dL) ^b	59	7.48	1.76	—	—	—	19	6.58	0.67	93	7.37	0.67
Albumin (g/dL) ^b	59	4.04	1.40	—	—	—	19	3.13	0.32	94	3.70	0.36
A/G Ratio ^{a,b,c}	59	1.20	0.31	—	—	—	—	—	—	—	—	—
Calcium (mg/dL) ^b	59	10.66	1.28	—	—	—	19	9.53	0.66	94	9.92	0.66
Phosphorus (mg/dL)	59	6.01	1.99	17	5.6	1.58	—	—	—	94	5.77	1.51
Triglycerides (mg/dL) ^{a,b}	56	37.9	24.3	—	—	—	—	—	—	85	54.9	103.4
Cholesterol (mg/dL)	58	150.0	29.6	17	167	2.41	—	—	—	94	147.9	26.9
Creatinine (mg/dL) ^b	56	1.89	0.67	—	—	—	19	2.05	0.45	94	1.84	0.54

^a Not reported by Paul-Murphy et al. (1994)

^b Not reported by Currer and Russell (1982)

^c Four outliers excluded (see text for explanation)

^d Not reported by Bleich et al. (this paper)

^e Not reported by Dunbar et al. (1997)

APPENDIX II: PAIRWISE COMPARISONS OF SERUM CHEMISTRY VALUES

Results of pairwise comparisons of mean serum chemistry values from populations of free-ranging mountain lions captured in widely disparate ecosystems (at sea level in Florida [Dunbar et al. 1997], exclusively at high elevation in the Rocky Mountains in Colorado [Currier and Russell 1987], and at intermediate elevations in the eastern Sierra Nevada in California [this paper]). A fourth group (Paul-Murphy et al. 1994) included mountain lions captured among a multitude of ecological systems in California. Two-tailed P-values for differences in means were calculated from data in Appendix I using Welch's Approximate t, which is robust to considerable departures from theoretical assumptions when two-tailed tests are employed and samples are large (Zar 1984); significant differences are indicated in bold font.

Analyte	Source	Source		
		Bleich et al. (this paper)	Currier and Russell (1982)	Paul-Murphy et al. (1994)
Sodium ^a (mEq/L)	Currier and Russell (1982)	0.012		
	Paul Murphy et al. (1994)			
	Dunbar et al. (1997)	0.281	<0.001	
Potassium ^a (mEq/L)	Currier and Russell (1982)	0.843		
	Paul Murphy et al. (1994)			
	Dunbar et al. (1997)	0.839	>0.999	
Chloride ^a (mEq/L)	Currier and Russell (1982)	0.095		
	Paul Murphy et al. (1994)			
	Dunbar et al. (1997)	0.143	0.312	
Creatine Kinase ^a (U/L)	Currier and Russell (1982)	<0.001		
	Paul Murphy et al. (1994)			
	Dunbar et al. (1997)	0.544	<0.001	
SGOT ^{a,b} (U/L)	Currier and Russell (1982)			
	Paul Murphy et al. (1994)			
	Dunbar et al. (1997)		0.578	
Total Bilirubin ^a (mg/dL)	Currier and Russell (1982)	0.157		
	Paul Murphy et al. (1994)	0.192		
	Dunbar et al. (1997)	0.114	0.560	0.640
Phosphorus (mg/dL)	Currier and Russell (1982)	0.382		0.898
	Paul Murphy et al. (1994)	0.348	0.898	
	Dunbar et al. (1997)	0.429	0.685	0.722
Cholesterol (mg/dL)	Currier and Russell (1982)	<0.001		0.101
	Paul Murphy et al. (1994)	0.523	0.101	
	Dunbar et al. (1997)	0.661	<0.001	0.340

^a Not reported by Paul-Murphy et al. (1994)

^b Not reported by Bleich et al. (this paper)