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The Raccoon (*Procyon lotor*) on St. Catherines Island, Georgia. 1. Biochemical Parameters of Urine and Blood Serum

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ABSTRACT

Biochemical parameters of urine and blood serum were measured for 24 raccoons trapped during winter on St. Catherines Island, Georgia. Serum urea nitrogen and cholesterol concentrations were significantly higher in juvenile raccoons than in adults, and urine creatinine concentrations were significantly higher in adults. The incidences of proteinuria, ketonuria, bilirubinuria, urobilinogenuria, and hemoglobinuria are reported.

INTRODUCTION

The raccoon can be used as an indicator species for the monitoring of environmental zoonoses and pollutants (Bigler et al., 1975a; Hoff et al., 1977). In the Southeastern United States, raccoons are exposed to at least 13 pathogens known to cause disease in man (Bigler et al., 1975a), and their serum is routinely examined for evidence of St. Louis Encephalitis, Venezuelan Equine Encephalitis, and Eastern Equine Encephalomyelitis (Bigler et al., 1975b).

There are few baseline studies of normal raccoon blood parameters. The morphology and number of blood elements of captive raccoons in Canada were reported (Kennedy, 1935). Total serum protein was shown to vary with seasons of the year in a population of estuarine raccoons (Doyle, Hoff and Bigler, 1975). Carotenoids were found by Hardin (1976) in the blood of all raccoons sampled from St. Catherines Island, Georgia. The distribution of acid-soluble phosphorus in blood cells of raccoons was described by Rapoport and Guest (1941). Various whole blood, blood serum, and urine values were reported for a euthanized sample of free-ranging raccoons in Florida (Hoff et al., 1974). We evaluate urine and blood serum constituents in free-ranging raccoons from St. Catherines Island, Georgia.

A sample of 10 living raccoons was taken from St. Catherines Island to the Southeastern Cooperative Wildlife Disease Study (Dr. Frank Hayes) in Athens, Georgia, in March 1977. Results of these studies will be available later.

The opinions expressed in this paper are those of the authors and do not necessarily represent those of Fairleigh Dickinson University, the American Museum of Natural History, or the New Jersey State Department of Health.

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METHODS AND MATERIALS

All raccoons were captured between January 31 and February 26, 1977, in the northern third of St. Catherines Island, Liberty County, Georgia, in live traps baited with canned cat food. Twenty-four hours after baiting the trap, the raccoon, while still in the trap, was placed for 24 hours over a tray lined with aluminum foil to collect urine, which was filtered and frozen until assayed. Within six hours after the collection of the urine, the raccoon was anesthetized with Ketamine Hydrochloride (Bigler and Hoff, 1974) and 10 ml. of blood was collected by cardiac puncture. After clotting occurred, the serum was separated by centrifugation and was stored frozen until assayed. No food or water was given the raccoons during handling procedures. While still under anesthesia, data on sexual characteristics (Sanderson, 1961), body measurements, weight, and dentition class (Grau, Sanderson and Rogers, 1970) were gathered. The serum was assayed for glucose (Hoffman, 1937), urea nitrogen (Marsh, Fingerhut and Miller, 1965), uric acid (Hawk, Oser and Summerson, 1947), creatinine (Hawk, Oser and Summerson, 1947), total protein (Failing, Buckley and Zak, 1963; Weichselbaum, 1946), albumin (Rutstein, Ingenito and Reynolds, 1954), cholesterol (Block, Jarret and Levine, 1965), and triglycerides (Kessler and Lederer, 1965). Sodium and potassium concentrations in the serum were measured by flame photometer. Urine was assayed for total protein, creatinine, and urea nitrogen. Chemical reagent strips were used to test for urine pH and for the presence of glucose, ketone bodies, bilirubin, urobilinogen, and blood in the urine. Creatinine clearance was calculated from the formula

$$\frac{\text{Urinary Creatinine}}{\text{Serum Creatinine}} \times \frac{\text{Urine Volume Excreted}}{\text{Minute}}$$

(Faulkner and King, 1976).

RESULTS

The sample consisted of 24 raccoons (12 adult males, five juvenile males, three adult females, and four juvenile females). Age was determined by dentition, weight, body measurements, and sexual characteristics. In this sample, no significant sex-related differences were noted in biochemical parameters of either the serum or the urine. For this reason, males and females were grouped for further analysis.

Both serum cholesterol and urea nitrogen were higher in juveniles than in adults, $p<0.01$, table 1. No statistically significant differences were noted in serum glucose, uric acid, creatinine, total protein, albumin, globulins, triglycerides, sodium, or potassium. Serum total protein and globulins were higher in adults than in juveniles but only attained the 90 percent confidence level.

Urinary excretion of creatinine was higher in adults than in juveniles, $p<0.05$, table 2. Whereas urinary total protein, urea nitrogen, and creatinine clearance appeared to be higher in adults than in juveniles, these differences did not attain statistical significance. Urine total protein and creatinine clearance only attained the 90 percent confidence level. Employing chemical reagent strips, we found that 92 percent of the raccoons exhibited hemoglobinuria, 96 percent excreted urobilinogen, all showed proteinuria, 88 percent evidenced bilirubinuria and 33 percent showed ketonuria. Glucosuria was not detected. A pH of 5.0, 5.5, 6.0, and 7.0 was found in 21, 25, 46, and 8 percent of the raccoons, respectively.

Regression analysis showed significant correlations between concentrations of serum urea

TABLE 1
Blood Serum Chemical Values for 15 Adult and 9 Juvenile Raccoons from St. Catherines Island, Georgia

Determination	Age	Mean ± Standard Error of the Mean
Glucose (mg/dl)	Juvenile	96.0 ± 9.17
	Adult	82.3 ± 6.16
Urea Nitrogen (mg/dl)	Juvenile	38.8 ± 5.03[a]
	Adult	19.0 ± 1.92
Uric Acid (mg/dl	Juvenile	2.21 ± 0.14
	Adult	2.40 ± 0.10
Creatinine (mg/dl)	Juvenile	0.39 ± 0.03
	Adult	0.41 ± 0.02
Total Protein (mg/dl)	Juvenile	8.80 ± 0.34
	Adult	9.43 ± 0.19
Albumin (g%)	Juvenile	1.94 ± 0.07
	Adult	1.96 ± 0.06
Globulins (g%)	Juvenile	6.86 ± 0.29
	Adult	7.47 ± 0.17
Cholesterol (mg/dl)	Juvenile	270.4 ± 11.86[a]
	Adult	185.5 ± 14.65
Triglycerides (mg/dl)	Juvenile	73.1 ± 17.65
	Adult	54.1 ± 6.19
Sodium (mMol/l)	Juvenile	146.0 ± 1.63
	Adult	145.7 ± 0.82
Potassium (mMol/l)	Juvenile	4.53 ± 0.15
	Adult	4.41 ± 0.11

[a]$p<0.01$ employing the two tailed students "t" test to compare means of juveniles and adults.

nitrogen and serum cholesterol ($r = 0.53$, $p<0.01$), serum urea nitrogen and urine urea nitrogen ($r = -0.54$, $p<0.01$), serum uric acid and urine urea nitrogen ($r = 0.55$, $p<0.01$), serum globulins and serum glucose ($r = 0.47$, $p<0.05$), serum total protein and serum glucose ($r = 0.43$, $p<0.05$), and as might be expected, between concentrations of serum total protein and both serum albumin ($r = 0.54$, $p<0.01$), and serum globulins ($r = 0.97$, $p<0.01$).

DISCUSSION

The serum concentrations of glucose, uric acid, and total protein in both adult and juvenile raccoons are in agreement with the results reported by Hoff et al. (1974). The serum cholesterol concentration of our juveniles also agrees with the data reported by them, but for adults, our values are significantly lower. The serum urea nitrogen concentration of adults is also in agreement, but that of our juveniles is significantly higher. The increased serum total protein concentration noted in the adult appears to be due to the increase in serum concentration of globulins, since the albumin concentration was the same for both adult and juvenile.

Results of our study agree with those of Hoff et al. (1974) in the absence of glucosuria and the presence of proteinuria in the study populations. However, our raccoons did evidence hemoglobinuria, ketonuria, urobilinogenuria, and bilirubinuria, and showed a greater variation in urine pH.

The significant elevation of serum cholesterol in the juvenile as compared to the adult has been noted in other species such as the rat (Lenz and Fleischman, 1969).

Creatinine clearance in the adult was approximately twice that in the juvenile although the difference only attained the 90 percent confidence level. This would seem to agree with the data, table 2, indicating a significant higher urinary creatinine concentration in the adult. Since creatinine is eliminated from the serum

TABLE 2
Urine Chemical Values for 15 Adult and 9 Juvenile Raccoons from St. Catherines Island, Georgia

Determination	Age	Mean ± Standard Error of the Mean
Total Protein (mg/day)	Juvenile	77.5 ± 22.8
	Adult	150.2 ± 27.7
Creatinine (mg/day)	Juvenile	39.2 ± 9.3[a]
	Adult	76.3 ± 12.7
Urea Nitrogen (mg/day)	Juvenile	358.2 ± 124.6
	Adult	589.2 ± 143.1
Creatinine Clearance (ml blood per minute)	Juvenile	7.41 ± 2.22
	Adult	13.28 ± 2.11
Urine Volume Excreted (ml/day)	Juvenile	16.7 ± 3.1
	Adult	28.0 ± 7.7

[a]$p<0.05$ employing two tailed students "t" test to compare means of juveniles and adults.

primarily by glomerular filtration, the creatinine clearance is a measure of the glomerular filtration rate. The larger adult kidney might be expected to give a larger clearance rate than the juvenile kidney. Creatinine clearance is often related to a standard body surface area (Faulkner and King, 1976). Since a standard surface area for a raccoon has not been established, a correction for surface area could not be applied.

Urinary total protein excretion was higher in the adult than in the juvenile although the difference attained only the 90 percent confidence level. Hoff et al. (1974) raised the possibility that the presence of protein in the urine might be due to the trauma of trapping, handling, and anesthetizing the raccoons. Since anesthesia was not administered in the present study until after urine collection was completed, anesthesia can be ruled out as a reason for the presence of urinary protein in the raccoon. Similarly, even "trap-happy" raccoons that had been captured many times, among them raccoon #696 with 88 previous captures, were excreting protein in the urine. The trauma of trapping and handling seems not to be the reason for the presence of urinary protein. Total urinary protein excretion in the adult was approximately twice as great as in the juvenile. It is interesting to note that urinary creatinine excretion, urea nitrogen excretion, and creatinine clearance are increased in the adult raccoon as compared to the juvenile in approximately the same proportion as the urinary total protein. This could indicate that serum protein is leaked through the kidney and is excreted in the urine. The amount of these nitrogenous products excreted in the urine may be a function of the urine volume because the adult raccoon excretes approximately twice as much urine as the juvenile, although the difference was not statistically significant. It seems that the presence of protein in the urine of raccoons is normal although the reason for the excretion of protein is not known. Proteinuria is significantly less marked in dogs, rats, and in humans (Renkin and Gilmore, 1973). Urinary protein may not be derived exclusively from the glomerular filtrate (Renkin and Gilmore, 1973).

The population density at the time of sampling was moderate relative to high and low values since 1973. The effects of density on biochemical values would be interesting to study.

Our sample of 24 raccoons was collected in winter. Since the dietary habits of raccoons vary at different times of the year and the amount of food available varies with season and year, it would be valuable to continue studies in which a population is sampled over an extended time period. The basic data we have obtained may be useful in various comparisons as other studies on the ecological role of the raccoon on St. Catherines Island continue.

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