EFFECTS OF WATER DEPRIVATION AND SODIUM CHLORIDE ON THE BLOOD AND URINE OF THE MOURNING DOVE

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MOURNING Doves, *Zenaidura macroura,* are among the most widespread and successful birds in the arid parts of western North America and, although they have been relatively thoroughly studied, it has yet to be shown that they have any unusual physiological adaptations to the arid desert environment. For example, they require drinking water and have relatively little capacity for processing saline solutions. On a seed diet they lose weight if they drink less than about three per cent of their body weight of water per day or if they drink solutions of NaCl more concentrated than 0.19 molar (Bartholomew and MacMillen, 1960; MacMillen, 1962). In the present study we have undertaken to extend knowledge of the water economy of this species to include information on electrolyte and osmotic concentrations of plasma and urine.

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METHODS

Capture and maintenance.—The 25 doves used were trapped in Rustic Canyon, Los Angeles County, California, between November, 1963, and March, 1965. They were housed separately in small cages with wire mesh bottoms in a windowless room in which the lights were on from 1100 to 2300 hours. They were fed mixed bird seed with a free water content of nine per cent as determined by drying to a constant weight at 100° C. Room temperature varied from 20° to 24° C and the relative humidity varied between 30 and 50 per cent.

Administration of NaCl.—Sodium chloride was given to the birds in their drinking water or by stomach tube. The drinking solutions were provided in graduated cylinders equipped with L-shaped drinking tubes. One tube was used as a control to correct for evaporation.

To administer predetermined amounts of NaCl, 5 ml of a solution of the desired concentration was introduced into the stomach from a 10 ml syringe through a polyethylene tube with an outside diameter of 1.5 mm. The NaCl solution was colored with a dye, Fast Green FCF, so that urine which had passed through the kidneys could be differentiated from fluid which had been voided after passing directly along the digestive tract. Care was taken to introduce the NaCl directly into the stomach and not into the crop.

Blood and urine collection.—Blood samples were taken from the brachial vein with a heparinized 1 ml syringe fitted with a heparinized number 24 hypodermic needle. The area where the brachial vein passes near the surface proximal to the bird's wrist was swabbed with a solution of Zephiran chloride. The needle was inserted into the vein, directed away from the heart, and about 0.5 ml of blood was withdrawn. The blood was chilled and centrifuged for two minutes at 7,000 rpm. The plasma was then withdrawn, sealed into a melting-point capillary tube and frozen for later analysis.

TABLE 1

MEANS AND STANDARD ERRORS OF VARIOUS CONCENTRATIONS IN THE PLASMAS OF TWELVE MOURNING DOVES IN RELATION TO DRINKING

Item	*Quantity of water drunk* Ad libitum	*Three per cent body weight/day*	*None*
mOs/l	372.3 ± 3.9	374.4 ± 4.7	410.8 ± 3.2
Na^+ mEq/l	175.6 ± 10.6	178.1 ± 11.7	189.6 ± 8.8
Cl^- mEq/l	135.9 ± 1.9	147.2 ± 2.3	141.5 ± 3.3
Per cent change body weight/day	—	—	3.7 ± 0.8

After the doves had been kept for seven days on a given drinking regimen the urine voided for a 24-hour period was collected. Shallow trays, made from 1.25 cm wire mesh and covered with a thin sheet of polyethylene which formed depressions between the wires, were filled with mineral oil and placed beneath the cages. The urine and feces dropped into the oil through the bottom of the cage and settled into the depressions in the polyethylene. The urine, if separate from the solid material, rounded up into a sphere which was withdrawn with a pipette. The urine collected over the 24-hour period was pooled for analysis.

To collect serial samples of urine when NaCl was administered by stomach tube, the birds were placed in cages with opaque sides and tops, and wire mesh floors. As the excreta were produced they fell through the floors of the cages onto a roll of waxed paper which served as a conveyer belt on which the urine could be drawn from beneath the cages and picked up in a pipette without disturbing the birds. Samples were collected within 10 seconds of their appearance on the waxed paper. The time of voiding and color of the sample were recorded. The sample was sealed in the pipette, numbered, and frozen for subsequent analysis. The NaCl was administered sometime between 1100 and 1300 hours and the urine samples were collected for approximately six hours thereafter.

Methods of analysis.—Osmotic concentrations of plasma and urine were measured by freezing point depression using a Fiske Osmometer adapted for 0.2 ml samples. Prior to measurements the urine was centrifuged briefly to separate the uric acid crystals from the fluid. Chloride concentrations of urine and plasma were measured with an Aminco-Cotlove Automatic Chloride Titrator. Sodium concentrations of plasma were measured with a Beckman DU Spectrophotometer with a flame attachment.

RESULTS

Water deprivation.—With food available in excess, 12 birds were treated as follows: (1) water *ad libitum* for nine days, (2) minimum water necessary for weight maintenance for eight days, and (3) water withheld completely for four days (Table 1). In the plasma of these birds after water deprivation the osmotic concentration increased significantly; the Na^+ increased slightly, but Cl^- did not change. The excreta of these birds were too dry for us to obtain samples of urine.

Three of the birds which had been without water for four days and had a mean weight of 87.4 g were given water *ad libitum* for 30 minutes (Table

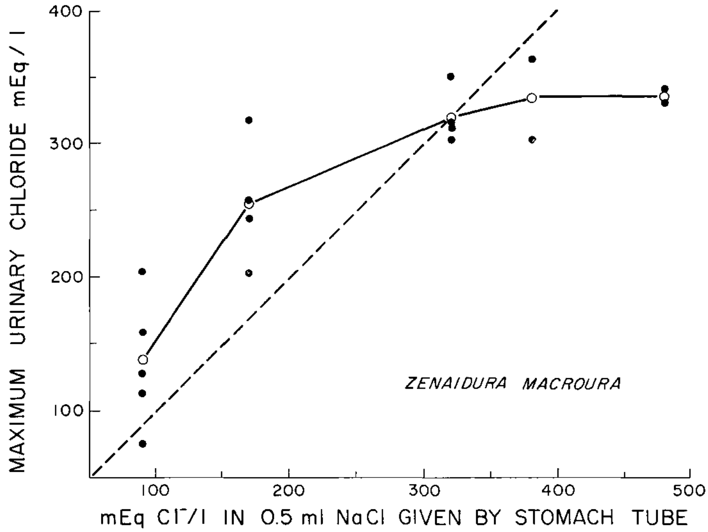

Figure 1. Maximum concentration of urinary chloride in relation to dose of NaCl administered by stomach tube. Shaded circles indicate maxima of different individuals. Unshaded circles show the means. For points above the dashed line the chloride in the urine is more concentrated than that in the dose.

2). They drank an average of 11.7 ml of water in that time and their plasmas were conspicuously diluted as shown by the decreases in osmolality and Cl^- concentration.

Effects of drinking NaCl.—Only three of the six birds tested drank 0.2 M NaCl, but all eight of the birds tested drank 0.1 M NaCl freely (Table 3). The 0.1 M NaCl had no significant effect on the osmotic concentration of the plasma or the urine, but it caused a six-fold increase in the Cl^- in the urine. The drinking of 0.2 M NaCl elevated the Cl^- concentration of both plasma and urine, elevated the osmotic concentration of the plasma, but not of the urine, and had no apparent effect on the Na^+ concentration in the plasma.

Effects of NaCl by stomach tube.—In eight birds tested, chloride concentrations of the serially collected urine samples began to increase within

TABLE 2

EFFECTS OF 30 MINUTES OF *AD LIBITUM* DRINKING ON THE MEAN PLASMA CONCENTRATIONS OF THREE DEHYDRATED MOURNING DOVES

Item	*Before drinking*	*After drinking*
mOs/l	397.8	357.4
Cl^- mEq/l	139.8	118.6

TABLE 3

EFFECTS OF DRINKING NaCl ON THE OSMOTIC CONCENTRATIONS AND THE CONCENTRATIONS OF Na^+ AND Cl^- OF THE PLASMA AND URINE OF MOURNING DOVES

Item	*Drinking solution*		
	Ad libitum *tap water*	*0.1 M NaCl*	*0.2 M NaCl*
Number of birds	12	8	6
Number of days	7	7	6
Plasma (M ± SE)			
mOs/l	372.3 ± 3.9	368.9 ± 4.5	408.5 ± 3.6
Na^+ mEq/l	175.6 ± 10.6	—	179.8 ± 6.7
Cl^- mEq/l	135.9 ± 1.9	—	167.5 ± 8.7
Urine (M ± SE)			
mOs/l	512.0 ± 65.0	528.0 ± 149.0	544.0 ± 49.0
Cl^- mEq/l	22.9 ± 2.9	137.2 ± 17.0	189.4 ± 26.5

30 to 60 minutes after the administration of the salt load by stomach tube. The peak concentration was reached between two and five hours after administration. Thereafter the Cl^- in the urine decreased at a variable rate but did not return to normal for at least two hours. The maximum Cl^- concentration in the urine increased as the Cl^- concentration in the 5 ml doses increased up to 320 mEq/liter. More concentrated doses did not cause a further increase in the concentration of Cl^- in the urine. The maximum concentration observed in the urine was 363 mEq/l and all of the birds tested produced concentrations in excess of 300 mEq/l (Figure 1). The mean of the maxima of the eight birds was 327 mEq/l.

DISCUSSION

Mourning Doves are unable to maintain their weight when drinking solutions of NaCl more concentrated than 0.19 M (Bartholomew and MacMillen, 1960), but at least for short periods of time they can produce urine with a Cl^- concentration 50 per cent higher than that in 0.19 M NaCl. However, when the birds were drinking NaCl, the mean concentration of the Cl^- in their urine over a 24-hour period was 189 mEq/l, which is close to the maximum concentration of Cl^- that they can drink without losing weight.

The Red Crossbill (*Loxia curvirostra*) resembles the Mourning Dove in that it cannot drink NaCl more concentrated than 0.2 M and still maintain its body weight (Dawson *et al.*, 1965). Similarly the Red Crossbill can produce ionic concentrations (in this case Na^+) in its urine greater than those which it can drink and still hold its weight. In contrast to the situation which we found in the Mourning Dove, Dawson *et al.* found that the urinary concentrations of Na^+ in the crossbill averaged higher in the drinking experiments than in the experiments in which salt was introduced

TABLE 4
MEAN MAXIMUM URINARY CHLORIDE CONCENTRATIONS OF VARIOUS LAND BIRDS

Species	*Number of birds*	*mEq/l*	*Method of salt loading*	*Source*
Columba livia	4	298	Intravenous	Scothorne, 1959
Zenaidura macroura	8	327	Stomach tube	Present study
Carpodacus mexicanus	21	370	Drinking	Poulson and Bartholomew, 1962*a*
Amphispiza bilineata	7	527	Stomach tube	Smyth and Bartholomew, 1966
Passerculus sandwichensis beldingi	5	960	Drinking	Poulson and Bartholomew, 1962*b*
Passerculus s. brooksi	16	527	Drinking	Poulson and Bartholomew, 1962*b*
Salpinctes obsoletus	4	372	Stomach tube	Smyth and Bartholomew, 1966

directly into the stomach or the veins. In view of the lack of information about the relation between Na^+ and Cl^- in the functioning of the avian kidney, further discussion seems pointless.

The Cl^- concentrating capacity of the Mourning Dove is slightly less than that of the House Finch, *Carpodacus mexicanus*, and the Rock Wren, *Salpinctes obsoletus*, much less than that of the Black-throated Sparrow, *Amphispiza bilineata*, and that of the Savannah Sparrow, *Passerculus sandwichensis*, but greater than that of the domestic pigeon, *Columba livia* (Table 4).

SUMMARY

In Mourning Doves deprived of water for four days, the concentration of Na^+ and Cl^- in the plasma increased while body weight decreased. When the dehydrated birds were allowed to drink, the osmotic concentration fell to below normal values within 30 minutes.

When the birds drank 0.2 M NaCl, the osmotic concentration of plasma and urine increased, as did the Cl^- concentration of plasma and urine.

The maximum Cl^- concentration in the urine following administration of NaCl by stomach tube averaged 335 mEq/l which is greater than the birds could maintain while drinking salt solutions, and exceeds the concentration of NaCl they can tolerate in their drinking water.

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