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SALT UTILIZATION IN THE HOUSE FINCH

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The House Finch (*Carpodacus mexicanus*) is one of the more common birds of western North America. It occurs widely throughout the arid southwest and occupies some of the barren islands off the Pacific coast of México and southern California. Although it is conspicuously successful in desert and semi-desert habitats, it also occurs widely in mesic areas. In arid regions it is almost always found near surface water.

Because of the widespread occurrence of the House Finch in regions of water scarcity and its adaptability to captivity, it is an attractive species for the study of water economy. Previous publications have dealt with its respiratory water loss (Bartholomew and Dawson, 1953), the effects of temperature on its water requirements (Bartholomew and Cade, 1956), and its ability to use salt water (Bartholomew and Cade, 1958). The present study is intended not only to present additional data to assist in the evaluation of the role of water in the ecology of the House Finch but to supply comparative material to assist in understanding the biology of birds that live in areas where fresh water is scarce.

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MATERIALS AND METHODS

The 18 House Finches used were trapped either on the Los Angeles campus of the University of California or in nearby Rustic Canyon between December, 1960, and March, 1961. They were housed individually in cages measuring 25 x 25 x 48 cm. and kept in a windowless room on a 12-hour photoperiod (lights on from 10 a.m. to 10 p.m.). Air temperature ranged from 24.6° to 25.7° C. and the relative humidity varied between 40 and 50 per cent. The fluid consumption of the birds was measured by the use of graduated cylinders equipped with L-shaped drinking tubes. One drinking device was used to correct for evaporation. The birds were trained to drink from the tubes by placing a watering cup nearby for several days. Mixed bird seed and chick starter were available at all times.

The birds were weighed to the nearest 0.1 gm. daily, immediately after the lights came on, and fluid consumption was recorded at the same time. Minimum water requirements were determined by progressive reduction of the available water until a daily ration was found below which body weight could not be maintained. Levels of activity were measured in arbitrary units by attaching the single transverse perch in each cage to a microswitch in such a manner that each time the bird hopped on the perch the event was indicated on an Esterline-Angus recorder. The birds were allowed four days to adjust to each drinking solution before measurements of activity were made.

Blood samples were collected in heparinized capillary tubes from a small puncture in the vein on the medial surface of the tarsometatarsus. Samples varied in volume from 10 to 25 microliters (µl) and filled half of the tube or less. The empty end of the tube was fused shut and the tube was then centrifuged for two minutes at 7500 rpm to obtain serum for the determination of freezing point depression and chloride concentration.

No attempt was made to obtain urine by catheterization or surgery because of the small size of the birds and because studies on the domestic fowl (Korr, 1939) indicate that such procedures induce excessive excretion of urine. When a urine sample was to be collected, a clean glass plate was placed in the bottom of a cage and examined at least once per minute for droppings. The droppings typically showed a conspicuous component of clear liquid in addition to the uric acid and fecal material. We shall refer to this clear liquid as urine and it was on this that our measurements of osmotic pressure and chloride concentration were made. Samples of the urine were picked up from the glass plate with 10 µl disposable capillary tubes and immediately sealed with plasticine clay. Urine volumes were determined to the nearest 0.1 µl by measuring the length of the sample in the tube.

Osmotic pressure of urine and serum were determined by freezing point depression using a Ramsay microcryoscope (Ramsay and Brown, 1955) and chloride concentrations were measured with an Aminco-Cotlove automatic chloride titrator. These instruments made it possible to determine both freezing point depression and chloride concentration of volumes as small as two µl.

RESULTS

Body weight and drinking.—The weights of the birds after adjustment to captivity but prior to experimentation ranged from 17.9 to 22.1 gm. with a mean of 19.3 gm. The performance of the individually caged birds used in this study (table 1) closely paralleled that of the groups of House Finches measured by Bartholomew and Cade (1958). The birds freely drank all concentrations of sodium chloride tested. *Ad libitum* drinking increased slightly as the salinity increased to 0.15 M NaCl and increased rapidly between 0.15 M and 0.3 M NaCl. Body weight increased on regimens less concentrated than 0.2 M and decreased on regimens more concentrated than 0.2 M NaCl.

TABLE 1

WEIGHT AND AD LIBITUM DRINKING IN THE HOUSE FINCH

		Fluid consumption as per cent body weight per day		Per cent change in body weight per day	
Drinking solution	Days	Mean	No.	Mean	No.
Distilled Water	30	21.2	18	0.06	15
0.10 M NaCl	12	22.7	10	0.13	10
0.15 M NaCl	10	26.2	4	0.30	4
0.20 M NaCl	15	34.9	10	0.00	10
0.25 M NaCl	9	64.6	9	—0.40	9
0.30 M NaCl	6	110.2	8	—3.16	7

Serum and urine.—Neither the chloride concentration nor the osmotic pressure of the serum varied significantly with the amount of NaCl in the drinking solutions (figs. 1, 2). The mean concentrations of the serum chloride ranged from 120 to 142 milliequivalents per liter (mEq/L) and those of the serum osmotic pressures varied between 305 and 390 milliosmols. The variability of both serum chloride and serum osmotic pressure was greatest in birds drinking 0.3 M NaCl which is near the maximum which individuals of this species can tolerate.

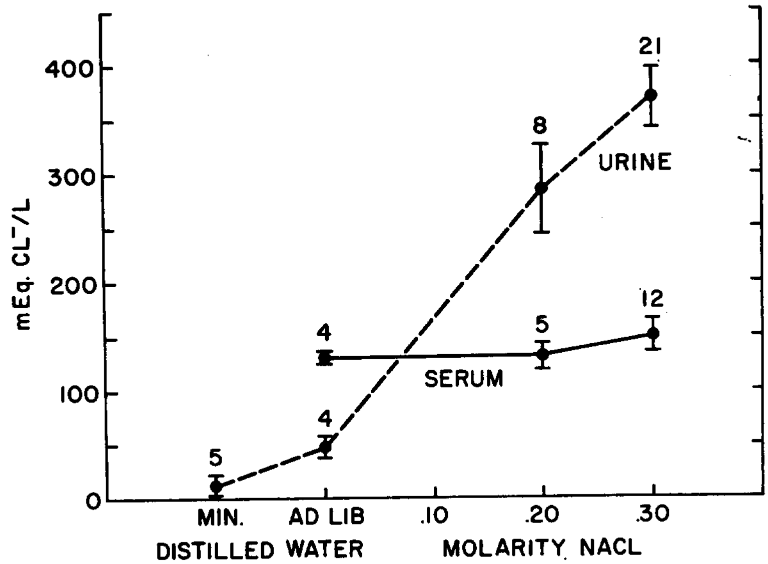

Fig. 1. The effects of *ad libitum* drinking of various solutions and minimum intake of distilled water on mean chloride concentrations of serum and urine of *Carpodacus mexicanus*. The vertical lines include 2 σ_m above and below the mean. The numbers indicate sample size.

Both the concentration of chloride in the urine and the osmotic pressure of the urine increased directly with the molarity of the solution being drunk and reached their maxima (means, 370 mEq/L and 850 milliosmols) in birds drinking 0.3 M NaCl. Birds drinking distilled water *ad libitum* produced urine with chloride concentrations and

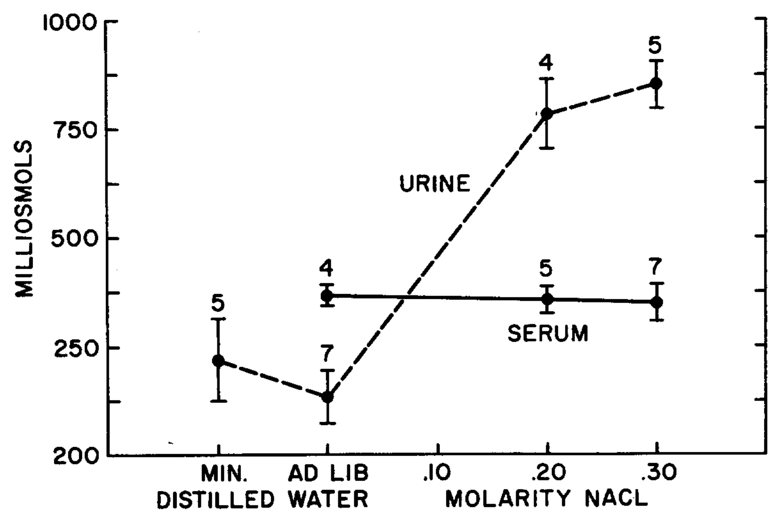

Fig. 2. The effects of *ad libitum* drinking of various solutions and minimum intake of distilled water on mean osmotic pressures of serum and urine of *Carpodacus mexicanus*. Symbols as in figure 1.

osmotic pressures about one third to one half those of the serum. On all *ad libitum* regimens other than distilled water both the chloride concentrations and the osmotic pressures of the urine were greater than that in either the serum or the drinking solution.

Minimum daily water requirements.—The mean daily minimum ration of distilled water on which the House Finches could maintain weight was approximately half the mean *ad libitum* consumption. With increasing salinity of the drinking solutions, however, the minimum ration became a progressively greater proportion of the *ad libitum*

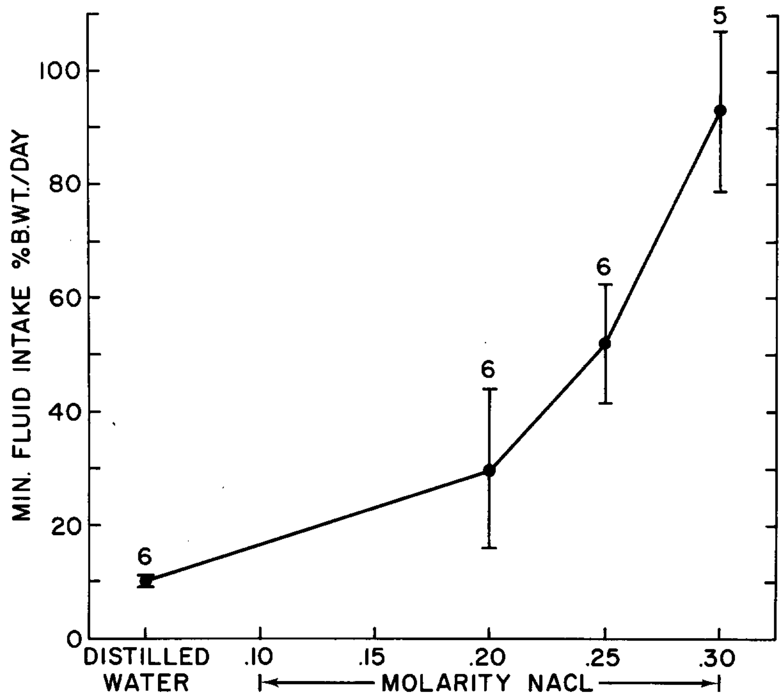

Fig. 3. The effects of various drinking solutions on the mean minimum daily fluid consumption necessary for weight maintenance of *Carpodacus mexicanus*. Symbols as in figure 1.

consumption (fig. 3). Measurements of urine of birds on minimum fluid rations were made only on individuals drinking distilled water and no measurements were made on the serum. The osmotic pressure of the urine of birds on a minimum ration of distilled water was somewhat greater than that of birds on an *ad libitum* regimen while the concentration of urine chloride was less (figs. 1 and 2).

Activity.—The level of general activity of the House Finches was highest on a regimen of distilled water. Activity decreased slightly on 0.25 M NaCl and fell sharply on 0.3 M NaCl (fig. 4).

DISCUSSION

There is insufficient published information about the urine and blood of passerines to allow us to place our information on the House Finch in adequate biological perspective. Insofar as we know the only other fringillid for which comparable data are available is the Savannah Sparrow, *Passerculus sandwichensis* (Poulson and Bartholomew, 1962), and there is a dearth of information on terrestrial birds of other groups although much is known about salt excretion in marine birds. We obtained no evidence which suggests that the House Finch has any extra-renal mechanisms for salt excretion of the sort found in several orders of aquatic birds (see Schmidt-Nielsen, 1960). However, our methods did not allow us to differentiate between the role of the kidney in urine concentration and the possible contributions to urine concentration by the gut and cloaca through water resorption.

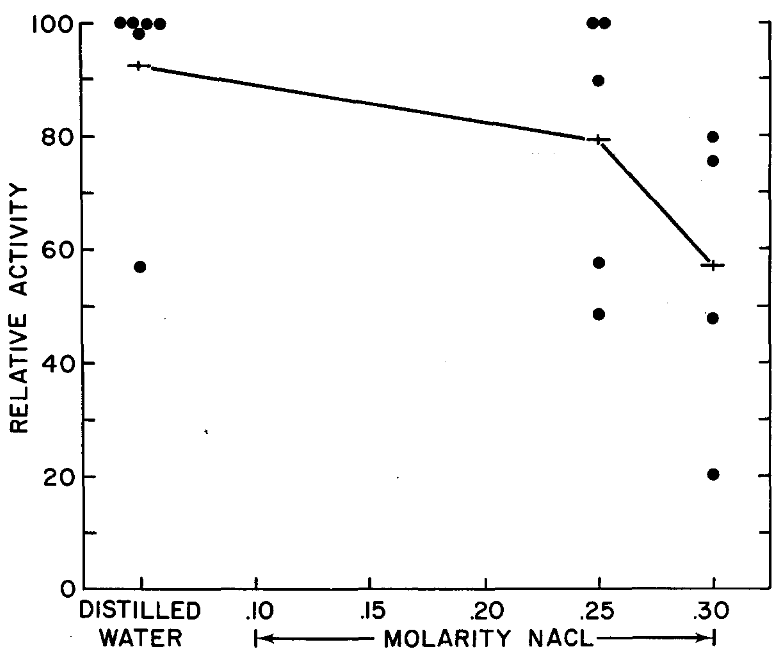

Fig. 4. The effects of *ad libitum* drinking of various solutions on activity of six *Carpodacus mexicanus*. Each individual's maximum activity was assigned a value of 100 regardless of the drinking solution on which it occurred, and that individual's activity on other drinking solutions was expressed as a percentage of its maximum.

Wherever the sites of urine concentration, it is apparent that the House Finch can produce urine with a total osmotic pressure almost twice, and a chloride concentration more than twice, that of the serum (fig. 5). These urine-serum ratios are less than half those of *P. s. beldingi* which only occurs in salt marshes but are similar to those of *P. s. brooksi* which commonly occurs in fresh water marshes (table 2). The mean of the highest concentrations recorded from each of the House Finches tested was 370 mEq/L which is far lower than the chloride concentrations found in the secretions of the nasal glands of any aquatic bird so far investigated (Schmidt-Nielsen, 1960). This concentration is also only about 75 per cent of the chloride concentration of sea water and thus precludes the use of the sea as a water source by the House Finch.

The maximum concentration of NaCl on which House Finches can subsist is 0.3 M (Bartholomew and Cade, 1958). In the present study, those individuals which reduced their activity and drank relatively small quantities of 0.3 M NaCl were able to regulate their serum chloride and serum osmotic pressure well. However, those birds which did not reduce their level of activity and drank relatively large quantities of 0.3 M NaCl could not regulate and died when their serum chloride exceeded 150 mEq/L or their serum osmotic pressure exceeded 390 milliosmols. This response of a voluntary reduction in level of activity with a concomitant reduction in drinking when near the maximum physiological capacity for processing saline solutions is similar to that shown by both *Passerculus sandwichensis beldingi* and *P. s. brooksi* under comparable circumstances.

TABLE 2

URINE-SERUM RATIOS

	Cl-	Freezing point depression
Carpodacus mexicanus	2.4	2.1
Passerculus sandwichensis brooksi	3.3	2.2
Passerculus sandwichensis beldingi	5.5	4.5
Columba livia	1.9[1]	....

[1] Scothorne, 1959.

The observation that the minimum daily water requirements of the House Finch for distilled water is about half its *ad libitum* intake is consistent with observations on other terrestrial birds for which data are available—Savannah Sparrow (Poulson and Bartholomew, 1962), California Quail, *Lophortyx californicus* (Bartholomew and Mac-

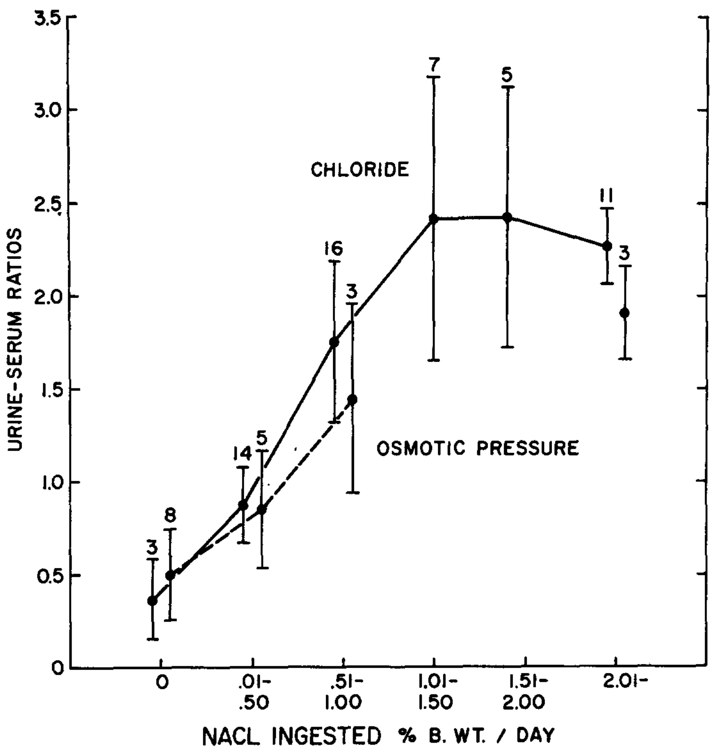

Fig. 5. The relation of salt ingestion to the ratios of chloride concentration and osmotic pressure in urine and serum of *Carpodacus mexicanus*. Symbols as in figure 1.

Millen, 1961), and the Mourning Dove, *Zenaidura macroura* (MacMillen, MS)—and can be interpreted to mean either that the drinking of these birds is adjusted for a level of activity considerably higher than they maintain in captivity or that on a reduced water ration they reduce their activity and their rate of water loss is consequently reduced.

The minimum water requirements of the House Finch like those of *Passerculus sandwichensis brooksi* but unlike those of *P. s. beldingi* become increasingly large percentages of the *ad libitum* consumption with increasing salinity of the drinking solution.

It is of interest that the House Finch's minimum water requirements (mean 10.2 per cent of body weight per day) is approximately the same as their mean pulmocutaneous water loss measured at comparable temperatures and humidities (Bartholomew and Dawson, 1953).

SUMMARY

This study extends information on the water economy of the House Finch to include the effects of the drinking of various concentrations of NaCl on the chloride concentrations and osmotic pressures of the urine and serum, on the minimum daily fluid ration on which weight can be maintained, and on the general level of activity.

Serum osmotic pressures varied between 300 and 390 milliosmols and serum chloride concentrations varied from 120 to 150 milliequivalents per liter (mEq/L). The osmotic pressure and the chloride concentration of the serum were independent of the salinity of the drinking solution, but the variability of each was greatest in birds drinking 0.3 M NaCl which is near the maximum which birds of this species can utilize. Both urine chloride concentration and urine osmotic pressure increased directly with the amount of NaCl ingested. The mean of the highest urine chloride concentrations from each of the individuals measured was 370 mEq/L and the highest urine osmotic pressures averaged 850 milliosmols. For the concentrations of sodium chloride tested the mean level of activity was inversely related to the concentration of sodium chloride in the drinking solution. Only those birds which reduced their activities and drank relatively little were able to survive on a regimen of 0.3 M NaCl.

The minimum daily ration adequate for weight maintenance on a regimen of distilled water was slightly less than half of the *ad libitum* consumption and increased to 85 per cent of *ad libitum* consumption on a regimen of 0.3 M NaCl.

No evidence for extra-renal excretion of salt was obtained. The performance of the House Finch in relation to that of other birds is discussed.

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