SHORT COMMUNICATIONS

WATER DEPRIVATION AND USE OF SODIUM CHLORIDE SOLUTIONS BY VESPER SPARROWS (*POOECETES GRAMINEUS*)

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The Vesper Sparrow (*Pooecetes gramineus*) is a widespread species found in both moist and dry habitats in North America. Our study is concerned with the water economy of *P. g. confinus* (Phillips et al. 1964) whose elevational breeding distribution extends from approximately 4,000 ft (Grinnell and Miller 1944) to 12,000 ft (Bailey 1904, 1928). In both Arizona and Sonora, México, which are part of the wintering grounds for *P. g. confinus*, the birds normally forage in dry, grassy, or weedy areas that are often some distance from surface water. We have observed individuals drinking at stock ponds, but also have recorded birds 10–15 miles from known water sources. That some individuals of this race breed in very moist situations and winter in arid regions raised questions concerning water requirements and salt tolerances.

MATERIALS AND METHODS

The 45 Vesper Sparrows used in this investigation were netted in the vicinity of Tucson, Arizona, in late February and early March of 1968. The birds were held in outside aviaries for one or more weeks before being transferred to individual cages (22 × 22 × 37 cm). The cages were located in a windowless chamber in which temperature was controlled between 20 and 21° C. Water vapor pressure during the experiments ranged from 3.8 to 14.8 mm Hg (20–70 per cent relative humidity).

Twelve birds were used in each test to determine the ability of the Vesper Sparrow to survive water deprivation and to utilize various solutions of NaCl. Tests with no fluid, and with 0.2 M and 0.25 M solutions were run for 21 days. Those with 0.1 M, 0.3 M, and 0.4 M solutions were terminated at 16, 16, and 8 days, respectively. The study was conducted February–May 1968.

The use and placement of "L" drinking tubes were similar to those described by Smyth and Bartholomew (1966). Distilled water was given to the birds for 3–5 days between experiments. The body weight of the birds (to the nearest 0.1 gm) and the fluid levels in the drinking devices (to the nearest 0.2 ml) were determined daily, 10:00–12:00, shortly before the beginning of the photoperiod (12 hr L and 12 hr D). A commercial finch seed mixture combined with commercial chick starter mash was supplied ad libitum. Chaff and excess seeds were allowed to accumulate on the cage bottoms to act as a secondary food source, an absorbant, and a soft base. One drinking device was used to correct for evaporation.

Simultaneous measurements of perch activity and fecal water loss were made for watered and unwatered birds following procedures described by Smyth and Bartholomew (1966). Activity measurements for the two groups of four birds each were recorded continuously for 48 hr. The birds in the unwatered group were taken from a sample of 11 which had completed 21 days testing without water. Data on defecation rate and moisture content of feces were obtained during the initial 2 hr of each of two consecutive photoperiods.

RESULTS

Fluid Consumption. When allowed ad libitum consumption of 0.1 M NaCl solution, the test birds consumed a mean of 19.7 per cent of their body weight daily. There was a reduction in consumption of the 0.2 M solution and a marked increase on the 0.25 and 0.3 M concentrations (table 1). Of the groups of 12 birds drinking the 0.25, 0.3, and 0.4 M solutions, two, three, and five died. Test birds were incapable of utilizing the 0.4 M solution for any length of time and showed a mean reduction in fluid intake as compared to the 0.3 M test. One of the 12 test birds refused to drink the 0.3 M solution, and it was excluded from the analysis.

Body weights of the test birds fluctuated widely during the experiments (fig. 1). Although two test birds died while consuming the 0.25 M solution, the mean body weight was stable throughout the experiment. Precipitous weight loss was observed in the birds drinking the 0.4 M solutions, and most of the

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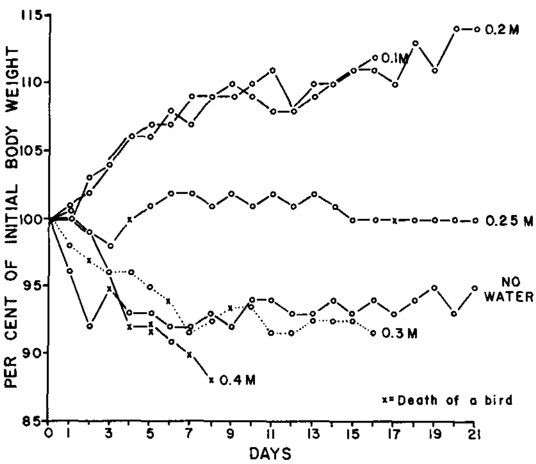

FIGURE 1. Mean per cent of initial body weights of Vesper Sparrows during consumption of varying molar solutions of NaCl and during water deprivation.

experimental birds died before losing 10 per cent of their mean body weight.

Water Requirements. Vesper Sparrows were able to survive water deprivation on a diet of seeds and chicken starter mash containing 7 per cent moisture (as determined by drying to constant weight at 100° C). The test birds had previously been used in salinity experiments. Initial weight loss of the water-deprived birds was greater than in any of the salinity tests (fig. 1). The lightest (19.6 gm) test bird died on day 3, causing part of the upswing in the curve. Relative weights of other water-deprived birds dropped as low as did those of birds that died during saline tests, but none died. Water-deprived birds were still 1.4 gm (5 per cent) below their initial weight on day 21.

Activity (perch hops/hr) comparisons between four watered and four unwatered birds, using Student's t test, showed no statistically significant difference. Mean activity values for watered and unwatered birds $\pm$ 1 SD were 5.5 $\pm$ 7.1 ($n = 4$) and 5.6 $\pm$ 6.4 ($n = 4$), respectively.

Water content of excrement voided by birds supplied with distilled water for drinking and by those deprived of it averaged 82 and 63 per cent, respectively. Defecation rate was 3.7 times per hour for birds receiving water and 3.0 for the unwatered sample.

DISCUSSION

Data on weight-relative ad libitum consumption of 0.1 M NaCl solution for the Vesper Sparrow at 21° C conforms with the general relationship between size and ad libitum consumption for avian species in the absence of temperature stress (discussed by Bartholomew and Cade 1963). Ad libitum water consumption exceeded slightly that lost through evaporation at moderate temperatures (predicted from Bartholomew and Cade 1963:508).

The overall response of the Vesper Sparrow to increasingly more concentrated solutions of NaCl agrees closely with the Pattern A of Bartholomew and Cade (1963:518). Generally, mean fluid consumption increased with increasing saline concentrations until the test birds were placed on the 0.4 M NaCl solution. At this concentration, there was a slight decrease in consumption.

The ability of the Vesper Sparrow to exist solely on a diet of dry seeds, and the inablity to survive on saline solutions much more concentrated than its body fluids is similar to that reported for the Budgerygah, *Melopsittacus undulatus* (Cade and Dybas 1962); the Zebra Finch, *Taeniopygia castanotis* (Lee 1964); the Stark's Lark, *Spizocorys starki*, and Grey-backed Finch-lark, *Eremopterix verticalis* (Willoughby 1968); and the Sage Sparrow, *Amphispiza belli* (Moldenhauer and Wiens 1970). This general pattern may be more widespread than is presently indicated from other water requirement studies, for at least two other North American fringillids cannot maintain body weight on salt solutions greater than 0.3 M NaCl but can exist on a diet of dry seeds (Ohmart, unpubl. data). It appears that the physiological capability of processing solutions containing NaCl concentrations equal to sea water, in the absence of salt-secreting glands, appears to be a less common adaptation than that of surviving solely on air dry seeds in the absence of free water and temperature stress.

Reduction in motor activity is one method by which pulmocutaneous water loss can be reduced when water is limited or absent. In the two species whose activity was monitored during the initial 4 days of water deprivation, the Black-throated Sparrow, *Amphispiza bilineata* (Smyth and Bartholomew 1966), and the Sage Sparrow (Moldenhauer and Wiens 1970) did not reduce their activity. Activity of Brewer's Sparrows, *Spizella breweri*, after 21 days of water deprivation was reduced, compared with that of watered birds (Ohmart and Smith 1970). Many birds may increase their activity following water deprivation and then reduce their activity if they are capable of existing on a dry diet of seeds. The investigator should be cognizant of this difference and design his experiment to answer the relevant question. It is not clear in previous studies (Poulson and Bartholomew 1962a, b) how soon activity measurements were taken after water withdrawal.

The slight differences in perch hops/hr between watered and unwatered Vesper Sparrows may not be a valid criterion of differences in activity. Vesper

TABLE 1. Weights and fluid consumption for Vesper Sparrows utilizing various saline solutions and during dehydration.

Solution (M NaCl)	n	$\bar{x}$ body wt. (g) Initial	Terminal	Fluid consumption (% body wt.) $\bar{x}$	SD	Range
0.1	12	24.9	27.7	19.7	15.6	9.6– 48.2
0.2	12	22.6	25.8	13.7	6.4	7.6– 29.9
0.25	12	25.9	25.8	39.1	37.8	11.7–130.5
0.3	11	25.1	23.0	56.9	48.3	10.9–156.2
0.4	12	25.3	22.2	38.5	19.7	16.2– 83.7
No fluid	11	25.5	24.1			

Sparrow movements were confined largely to the floor of the cage, rather than to actual perching. Thus, perch hop values may be misleading and valid data on activity in the Vesper Sparrow are probably lacking. Unwatered Vesper Sparrows did reduce water loss by drying their feces, but from defecation rates, the food intake appeared to remain nearly the same for the two groups.

Direct comparison of mean weight loss curves during water deprivation tests between Brewer's Sparrows (Ohmart and Smith 1970[a]) and Vesper Sparrows (present study) is possible because all experimental conditions were identical. The fact that the water vapor pressure was identical in the two tests is highly important. The size difference is also important in that the smaller the bird, the greater is its weight-relative evaporative water loss (Bartholomew and Cade 1963). In the smaller Brewer's Sparrow (11–12 gm), the initial weight loss was less and weight recovery was made by day 13 of the 21-day test. The Vesper Sparrow (23–26 gm) initially lost more weight and did not recover the loss at the termination of the 21-day test. Thus, using stability of body weight as the primary criterion, the small Brewer's Sparrow is much better adapted in water economics than the Vesper Sparrow.

The low water requirement of the Vesper Sparrow supports the conclusions drawn from our field observations, and those of G. M. Sutton who, according to Berger (1968:876), states that the Vesper Sparrow "does not, apparently, depend upon a regular water supply either for drinking or for bathing." Bailey (1928) reported animal material making up 33 per cent of this species' diet. It appears, therefore, that in the absence of extreme temperature stress, metabolic and preformed water together permit independence from free water.

SUMMARY

When allowed ad libitum consumption of 0.1 M solution of NaCl, 12 Vesper Sparrows consumed a mean 19.7 per cent of their body weight (25 gm) daily. Of the 12 test birds consuming 0.25 M solution, two died but the remaining birds were able to maintain their mean body weight. Consumption of solution concentrations of 0.3 and 0.4 M NaCl resulted in precipitous weight loss and/or deaths.

Vesper Sparrows were capable of surviving solely on a seed and commercial mash diet containing 7 per cent moisture for a 21-day test period at temperatures of 20–21° C, and water vapor pressure of 12.0 to 14.8 mm Hg. The unwatered birds reduced fecal water loss, but apparently did not reduce their food intake. Low water requirements, combined with a diet of insects and seeds, apparently allow the Vesper Sparrow to exist without free water, at least in the absence of temperature stress.

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[a] Water economy values given by Smith and Ohmart (1969) and Ohmart and Smith (1970) are in error. The means require slight changes but the ranges and confidence intervals require substantial modification because of incorrect analysis. The raw data are no longer available for recalculation of values for the 1969 paper. Sample size, mean, range, and one standard deviation for distilled water through increasing salinities in figure 1 (Ohmart and Smith 1970) are 11, 32.7, 4.1–109.1, 30.6; 11, 27.5, 5.9–81.9, 23.0; 14, 28.0, 13.0–57.0, 15.5; 13, 26.4, 9.3–103.8, 25.0; 15, 30.2, 9.8–116.6, 32.1; 14, 30.3, 10.8–58.8, 17.6; 12, 18.1, 2.4–41.7, 11.4; 15, 28.2, 2.7–72.2, 23.7; and 18, 13.0, 1.4–58.5, 15.0, respectively. These values for figure 4 are 12, 29.3, 12.7–75.9, 16.8; 12, 35.0, 14.7–57.1, 16.0; 12, 38.7, 24.6–57.0, 10.5; 10, 61.9, 22.8–115.7, 31.9; 12, 47.9, 27.5–63.5, 12.8; 9, 109.3, 37.3–162.5, 53.7; and 11, 131.6, 82.4–178.7, 28.3. These changes are mathematical in nature and do not affect the validity of the biological information.