WATER CONSUMPTION OF HOUSE FINCHES

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Few data are available on the water requirements of wild birds, and only a few species which occur in the desert have been studied quantitatively in this respect. The House Finch (*Carpodacus mexicanus*) was selected for study partly because of its small size, hardiness in captivity, and availability, but primarily because its distribution in the desert is clearly related to the presence of surface water.

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METHODS

All of the experimental birds were trapped on the campus of the University of California, Los Angeles. They were housed in cages made of fish net of half-inch bar supported by a wire frame measuring 12×12×18 inches. The netting prevented the injury and feather abrasion which result when birds are held in small wire cages.

Water consumption.—The amount of water drunk was measured with graduated cylinders equipped with "L"-shaped glass drinking tubes (see Bartholomew and Dawson, 1954). The inverted cylinders were mounted on ringstands with the drinking tubes extending into the cages. Spillage due to jiggling of the drinking devices was avoided by arranging the drinking tubes so that they did not touch the cage and by shielding them with an arch of hardware cloth. One drinking device was used to determine evaporation. In each experiment the freshly captured birds were housed individually and given 24 to 36 hours to learn to use the drinking devices and to adjust to captivity. Food consisting of mixed bird seed was continually available. Except for the disturbances incidental to feeding and measuring water consumption, the birds were left completely alone.

During June and July, 18 House Finches were exposed for periods of 3 days to each of three different ambient temperatures. Temperatures were controlled either by a constant temperature cabinet equipped with lights, blower, heater, and refrigeration unit or by a similarly equipped constant temperature room. The photoperiod was controlled by automatic switches to approximate the day length normal in southern California for the season. Temperature and humidity were monitored by a recording hydrothermograph.

Water deprivation.—Two experiments were performed to determine the effects of water deprivation in the absence of temperature stress. Eight birds, captured in April, 1956, were housed in two cages with food and water available for the first 24 hours. The water was then removed and they were maintained on a diet of mixed bird seed for 48 hours after which water was again made available for four days to allow the birds to recover. After the period of recovery, water was again removed and the birds were maintained for seven days on a diet of bird seed and succulent vegetable food such as apples, celery tops, and lettuce. The birds were weighed at regular intervals throughout the experiments.

RESULTS

Water consumption.—Water consumption increased directly with increasing ambient temperature. The mean rate of water consumption was twice as great at 39° as at 20°C., but increased only about 40 per cent between 6 and 20°C. (fig. 1). At the two lower temperatures the birds were under no apparent stress, but at the highest temperature they appeared hyperactive, and some individuals panted almost continually. The mean water consumption at the highest temperature was over 40 per cent of the body

weight per day, and at this temperature three different birds drank more than 100 per cent of their body weight within single 24-hour periods. The body weights of the birds did not change significantly in the course of the experiments.

Water deprivation.—The results of the experiments are summarized in figures 2 and 3. In the absence of drinking water, the birds were unable to maintain their weight. After 48 hours they showed a mean loss of approximately 15.5 per cent of initial body weight. No changes in behavior were apparent during the period of water deprivation. As soon

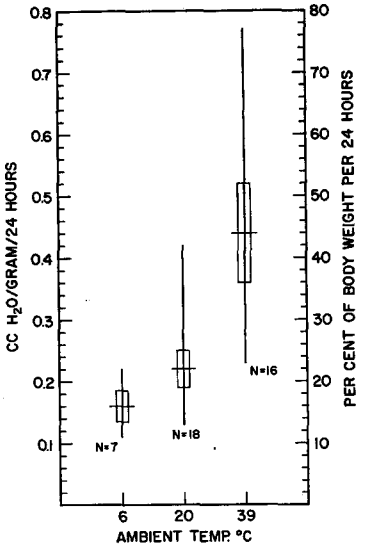

Fig. 1. The relation of water consumption of *Carpodacus mexicanus* to ambient temperature. The vertical lines indicate the range; the horizontal lines indicate the mean (M); the rectangles indicate the interval $M + 2\sigma_M$ to $M - 2\sigma_M$; and N indicates the number of birds used. The humidity mixing ratio (grams of H_2O/kilogram of dry air) at 6° C. was 4.36–5.01; at 20° C. it was 13.75–14.20 and at 39° C. it was 16.94–19.74.

as water was made available, the birds immediately began to drink. After 15 minutes the water was removed, and the birds were weighed. The mean increase in weight after drinking was 2.1 gm. or 12 per cent of the mean weight before drinking. Water was again made available, but the birds showed only slight interest in it. After 30 minutes, the water was removed, and the birds were weighed a second time. All but one had lost a little weight since the previous weighing, presumably as a result of defecation. Twenty-four hours later, with water continually available, the mean weight of the birds was above the starting level, all but one bird having regained or surpassed its initial body weight.

With succulent food available, but without water, caged House Finches were able to maintain a relatively constant body weight, after a slight initial drop, for at least a week (fig. 3). When water was made available on the last day of the experiment there was only a slight increase in body weight. This contrasts sharply with the more acute

experiment in which the birds had been maintained for 48 hours on dry food before water was offered.

In the course of the experiments on water deprivation, the behavior of the birds appeared normal, and none died. After the experiment with succulent food, autopsy showed some subcutaneous fat in the region of the feather tracts.

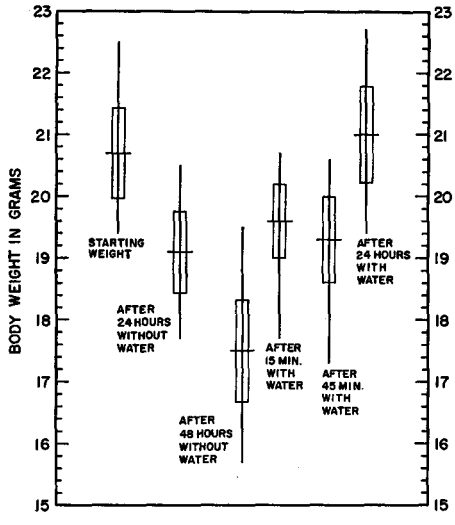

Fig. 2. Body weight in *Carpodacus mexicanus* during water deprivation. Ambient temperature 20–22 C.; relative humidity 54–68 per cent. Eight birds were used; symbolism same as in figure 1.

DISCUSSION

Ecology of House Finches in the desert.—House Finches are widely distributed in western North America and occur locally in all the major deserts where surface water is present (Salt, 1952). They often occur near springs, tanks, watering troughs for stock, and ranch houses which are surrounded by many miles of totally dry desert. Although primarily gramnivorous (Beal, 1904:34), House Finches eat various fruits, including cactus (Grinnell and Miller, 1944:454). Our data indicate that even at moderate temperatures House Finches need water equivalent to 20 per cent of body weight per day but that this requirement can be satisfied entirely by succulent plant food for days at a time. In the deserts of California succulent plant foods are most abundant during the latter part of the rainy season in late winter and spring. It seems probable that in this period when temperatures are still relatively moderate House Finches may occupy some desert areas without regard to the availability of surface water. As the season advances, however, high temperatures prevail, and succulent food becomes less abundant. Under these conditions House Finches, because of their large daily water requirements (as much as 100 per cent of body weight per day in hot weather), must have surface water not only within their daily cruising range (Grinnell and Miller, 1944) but within access for repeated drinks throughout the day. It is a matter of common observation that in hot weather House Finches remain in the immediate vicinity of water and bathe repeatedly. This repeated wetting of the feathers presumably facilitates temperature regula-

tion by evaporative cooling. It is probable that the populations of House Finches which occur on the coastal islands of California and northwestern Mexico can be almost independent of surface water throughout the year, for these islands which have little surface water are characterized by mild temperatures, high humidity, and an abundance of succulent vegetation.

Our laboratory data strongly support and help to explain the suggested habitat requirements of House Finches which Grinnell and Miller (1944:454) have proposed on the basis of field experience.

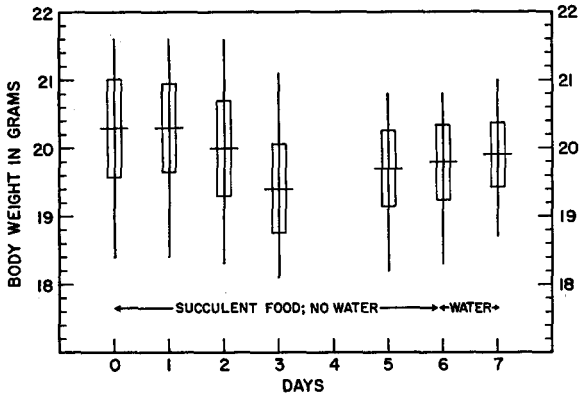

Fig. 3. Body weight in *Carpodacus mexicanus* during water deprivation but with succulent food available. Ambient temperature 20–22° C.; relative humidity, 56–68 per cent. Eight birds were used; symbolism same as in figure 1.

Water consumption and body size.—We have drawn from the literature and from our own unpublished data what little information is available on the water consumption of wild birds (fig. 4). Despite the differences in water content of the food which the various species eat and despite the different experimental conditions under which the data were obtained, an obvious correlation of water consumption with body weight is apparent, that is, the smaller the bird, the more water it drinks relative to its weight.

Weight-relative water consumption shows a curve which is strikingly similar to the curve for weight-relative respiratory water loss (Bartholomew and Dawson, 1953). Both desert and non-desert forms fall on the same curves. This strongly suggests that most desert birds, unlike many desert mammals, have not evolved special mechanisms for water conservation. Instead they appear merely to depend, as do most non-desert vertebrates, on drinking or on succulent food.

Factors affecting occupation of deserts.—The apparent lack of adaptive differences in water consumption between many desert and non-desert species offers an insight into the factors which have allowed the successful invasion of deserts by birds the major distributions of which are not in desert regions. Miller (1951) indicates that of the 274 species of birds which breed in California and about which adequate information is available only 17 show primary affinity for the desert scrub habitat and that an additional 23 species occupy the desert scrub as a part of their total distributions. Thus, about 60 per cent of the desert scrub avifauna consists of species which cannot be characterized as primarily desert birds. The ecological conclusions that we have drawn from data on water consumption and water loss are consistent with this distributional analysis. Thus, any bird which can satisfy its other habitat requirements in the desert is a candi-

date for establishment there because its physiology is apt to be as effective, from the standpoint of water economy, as that of most birds already occupying the desert.

A critical comparison may be made between the extremely eurytopic English Sparraw (*Passer domesticus*), originally from the cool moist British Isles, and the more stenotopic House Finch. One might expect the English Sparrow to enter accessible desert areas wherever surface water is available since its water economy would probably be

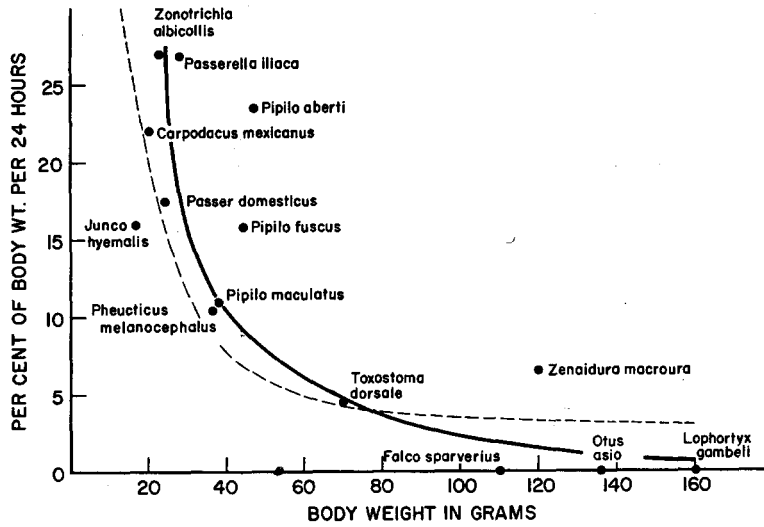

Fig. 4. The relation of water consumption, expressed as per cent of body weight per 24 hours, to body size at ambient temperatures of 20–23° C. The wide line is fitted by eye to the points shown. The thin, broken line shows respiratory water loss (taken from Bartholomew and Dawson, 1953) plotted on the same scale. The sources for the data on water consumption are as follows: *Zonotrichia albicollis, Passer domesticus,* and *Junco hyemalis* recalculated from Seibert (1949); *Pipilo aberti* and *Pipilo fuscus* from Dawson (1954); *Zenaidura macroura* from Bartholomew and Dawson (1954); and *Passerella iliaca, Pipilo maculatus, Pheucticus melanocephalus, Toxostoma dorsale, Otus asio,* and *Lophortyx gambeli* from Bartholomew and Dawson (unpublished data), and *Falco sparverius* from Cade (unpublished data).

comparable to that of most other species of passerines already occupying the desert. It has apparently done so repeatedly in the oases of the Old World and also very recently in the deserts of southwestern United States. As Grinnell (1919) has pointed out, it is widespread in areas of human occupance throughout the desert regions and has successfully invaded Death Valley, California, which is probably the most extreme desert area in North America. The English Sparrow, introduced from the cool moist British Isles, thus is apparently able to occupy the New World deserts in exactly the same way as the House Finch, the evolution of which has presumably been closely tied to the xeric regions of western North America.

In severe deserts, where permanent surface water is absent for hundreds of square miles, birds are extremely scarce. Because of the high levels of water loss and water consumption in small birds, it appears unlikely that any herbivorous species smaller than the Gambel Quail (*Lophortyx gambeli*) can maintain itself without drinking water or eating succulent food. It seems possible that carnivorous birds such as hawks, owls, cap-

rimulgids, and insectivorous passerines might occupy waterless deserts by subsisting on the water in their food. It is of interest that those passerine birds, with the possible exception of the Black-throated Sparrow (*Amphispiza bilineata*), showing primary affinity for the desert scrub habitat (Miller, 1951) are largely insectivorous and thus are assured of water as long as they can find food. Other cases in point are offered by the American Kestrel (*Falco sparverius*) and the Screech Owl (*Otus asio*) which we have kept in captivity for several months without water. Whether or not the water available in animal food is sufficient to meet the demands of evaporative cooling at high ambient temperatures even for the larger raptors remains unknown.

Unfortunately the most critical species with regard to water economy of North American desert birds are yet to be studied. Such forms as the Black-throated Sparrow, the Rock Wren (*Salpinctes obsoletus*), and the Verdin (*Auriparus flaviceps*), which are small and do not appear to be water-dependent, remain completely unknown from the standpoint of water economy.

Despite the incompleteness of our present knowledge, it seems reasonable to hypothesize (1) that most desert birds have not evolved the special physiological mechanisms of water conservation comparable to those shown by many desert rodents, and (2) that the smaller the bird the more acute is its need for surface water, or failing that, a succulent diet.

SUMMARY

During June and July, 1955, 18 House Finches (*Carpodacus mexicanus*), captured on the campus of the University of California, Los Angeles, were exposed for periods of three days to each of three different ambient temperatures, and their water consumption was measured. The weights of these birds did not change significantly in the course of the experiments. Water consumption increased directly with ambient temperature and approximated 16 per cent of body weight per day at 6°, 22 per cent at 20°, and 44 per cent at 39°C.

Eight birds caught in April, 1956, and maintained on a diet of dry seeds without water lost about 15 per cent of their initial body weights in 48 hours at 20°C., but they made up their losses within 24 hours when water was again made available. At the same temperature but with succulent food available, these birds were able to maintain their body weights during a 7-day period without water.

Our data on water consumption of the House Finch help explain its pattern of distribution in the desert and supplement the analyses of its habitat requirements based on field observations.

The relative water consumption of those wild birds which have been studied decreases directly with increasing body size and shows a curve similar to that of respiratory water loss relative to weight. It is suggested that most desert birds have not evolved special mechanisms of water conservation and that the smaller the bird the more acute is its need for surface water, or failing that, a succulent diet.

LITERATURE CITED

Bartholomew, G. A., and Dawson, W. R.

1953. Respiratory water loss in some birds of southwestern United States. Physiol. Zool., 26:162–166.

1954. Body temperature and water requirements in the mourning dove, *Zenaidura macroura marginella*. Ecology, 35:181–187.

Beal, F. E. L.

1904. Some common birds in their relation to agriculture. U. S. Dept. Agr. Farmers' Bull No. 54 (revised):2–48.

Dawson, W. R.
1954. Temperature regulation and water requirements of the brown and Abert towhees, *Pipilo fuscus* and *Pipilo aberti*. Univ. Calif. Publ. Zool., 59:81–124.
Grinnell, J.
1919. The English sparrow has arrived in Death Valley: an experiment in nature. Amer. Nat., 53:468–473.
Grinnell, J., and Miller, A. H.
1944. The distribution of the birds of California. Pac. Coast Avif., 27:1–608.
Miller, A. H.
1951. An analysis of the distribution of the birds of California. Univ. Calif. Publ. Zool., 50:531–644.
Salt, G. W.
1952. The relation of metabolism to climate and distribution in three finches of the genus *Carpodacus*. Ecol. Monogr., 22:121–152.
Seibert, H. C.
1949. Differences between migrant and non-migrant birds in food and water intake at various temperatures and photoperiods. Auk, 66:128–153.

Department of Zoology, University of California, Los Angeles, June 19, 1956.