THE EFFECT OF WATER DEPRIVATION AT 32.2°C ON THE NEUROSECRETORY CONTENT OF THE *PARS NERVOSA* OF THE WHITE-CROWNED SPARROW, *ZONOTRICHIA LEUCOPHRYS GAMBELII*

by

Thomas Roger Van Devender

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STATEMENT BY AUTHOR

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SIGNED: Thomas R. Van Devender

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

Robert B. Chiasson
Professor of Zoology

8/14/69
Date

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ABSTRACT

The neurosecretory content of the pars nervosa of several avian species may be reduced by inducing osmotic stress through water deprivation or by the administration of a hypertonic saline solution.

The neurosecretory material in the pars nervosa has been shown to be affected differently in birds inhabiting arid environments compared to those inhabiting moist environments. The White-crowned Sparrow displays a neurohypophysial neurosecretory reaction similar to that of other moist environment birds. Laboratory conditions in the present study included a heat stress coupled with an osmotic stress which has not been attempted previously with a moist environment bird.

INTRODUCTION

Studies of the hypothalamic-hypophysial system of birds have led to the conclusion that an ecological adaptation of neurosecretory mechanisms occurs in response to moist and arid environments. Oksche, Laws, Kamemoto, and Farner (1959) concluded that osmotic stress resulted in a marked reduction of the aldehyde-fuchsin positive neurosecretory content of the pars nervosa of the White-crowned Sparrow, Zonotrichia leucophrys gambelii. The Zebra Finch, Taeniopygia castanotis, had very little reduction in neurosecretory material when subjected to osmotic stress (Oksche et al., 1963).

Uemura (1964) obtained no reduction of neurosecretory material in the pars nervosa of the Grass Parakeet, Melopsittacus undulatus. Matsui (1964) obtained a rapid depletion of the neurosecretory content of the pars nervosa of the European Tree Sparrow, Passer montanus saturatus, when deprived of water. It is clear that of the four species studied those living in an arid habitat (Zebra Finch and Grass Parakeet) deplete the neurosecretory material of the pars nervosa much more slowly than do forms living in a moist habitat (White-crowned Sparrow and European Tree Sparrow).

Kripalani, Ghosh, and Rahman (1967) studied three ploceid species of the genus Lonchura each of which lives in an ecologically different habitat and shows corresponding differences in the neurosecretory mechanisms. Lonchura malacca living in a moist environment had severe depletion of neurosecretory material in the pars nervosa after three days of dehydration. L. malabrica, which lives in an arid habitat similar to that of the Zebra Finch and Grass Parakeet, had very little reduction in the neurosecretory content of the pars nervosa following three days dehydration.

The first study to contradict this concept was that of Poore (1969) who showed that the "arid-adapted" Black-throated Sparrow, Amphispiza bilineata, had a significant decrease of neurosecretory material in the pars nervosa only one day following water deprivation. Poore subjected his birds to both heat (32.2°C) and osmotic (water deprivation) stress. Although Oksche et al. (1959) had recorded ambient temperatures during their study, they made no effort to control the temperature. The present study was initiated in order to compare the response of a "moist-adapted" bird (White-crowned Sparrow) with the response reported by Poore for the Black-throated Sparrow.

MATERIALS AND METHODS

Fifty-three White-crowned Sparrows used in this study were collected in mist nets near Continental, Pima County, Arizona between 25 January and 1 March 1969. The birds were held in an outdoor aviary for at least a week prior to the experiments and were provided with food and water ad libitum. The birds were fed Kaytee Birdseed prepared by Knauf and Tesch Company of Chilton, Wisconsin, which had a moisture content of 11.5 percent as determined by use of an Ohaus Moisture Determination Balance. Pairs of birds were held in 24 inch square wire cages in a Scherer Controlled Temperature Chamber set at 32°C during the experiment. Water and food were available ad libitum. The birds were maintained on a 13 hour photoperiod (0630-1930) which closely approximates the natural photoperiod from mid-February to early March. The relative humidity was monitored with an Abbeon Relative Humidity Indicator and remained between 40-50 percent.

The birds were acclimated at 32.2°C for one week prior to the dehydration experiments. Eleven birds were sacrificed at the end of the dark period and used as controls. The water was removed from the cages of the remaining birds at the end of the dark period with the

exception of the 48-hour dehydrated birds. The latter group was deprived of water at the peak of the light period. Birds were deprived of water for periods of 6 hours (n=8), 12 hours (n=8), 24 hours (n=11), 48 hours (n=10), and 72 hours (n=5). Twenty of the 72 hour dehydrated birds died before the completion of the experiment.

The birds were sacrificed by decapitation and all of the skull except for a small portion of the basisphenoid was removed. Less than two minutes after death, the brain and some adhering tissue were placed in Bouin's solution for fixation. The attached portion of the basisphenoid was decalcified with Pereny's fluid (Humason, 1962) before the tissue was embedded in parafin. All sections were cut at 10 microns and stained with aldehyde-thionin (Ezrin, 1963). Mallory's triple stain was used as a counterstain (Humason, 1962).

RESULTS

Dehydration of the White-crowned Sparrow at 32.2°C resulted in a reduction of the aldehyde-thionin positive neurosecretory material present in the pars nervosa. Figure 1 presents a graphical representation of the depletion of aldehyde-thionin positive material from the pars nervosa of the White-crowned Sparrow using color intensity as a measure of relative depletion. An arbitrary scale of color intensity ranging from 3.0 in an undepleted control pars nervosa to a 1.0 in a 72-hour depleted state (Figures 2, 3, and 4) is used here. An undepleted pars nervosa with a value of 3.0 is characterized as stained heavily with a deep navy blue stain and no light areas present. A depleted pars nervosa with a value of 1.0 is devoid of navy blue stain and is usually much lighter than the surrounding background.

The control group of birds with no dehydration had an undepleted pars nervosa in all but one animal. The mean of the group was 2.9. At six hours dehydration one individual showed a decrease in the amount of neurosecretory material in the pars nervosa. At 12 hours dehydration, all individuals showed a depletion of aldehyde-thionin

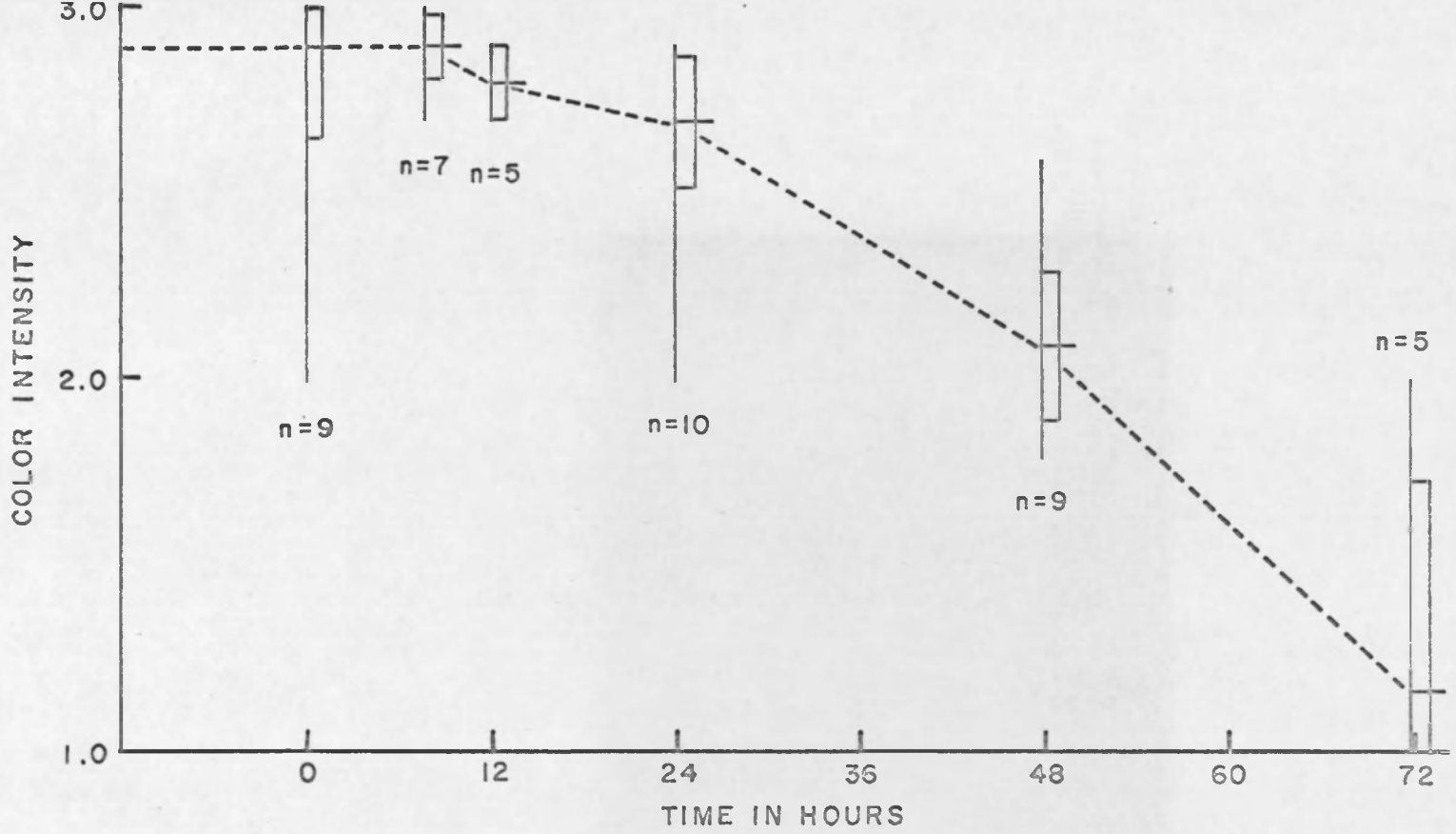

Figure 1. Depletion of neurosecretory material from the pars nervosa using color intensity as an index of depletion.

Vertical lines are observed ranges. Rectangles are 95 percent confidence intervals for the mean. Crosslines are at the mean. Rectangles are abbreviated above and below 3.0 and 1.0 as there is no case in which the true mean would fall in these areas.

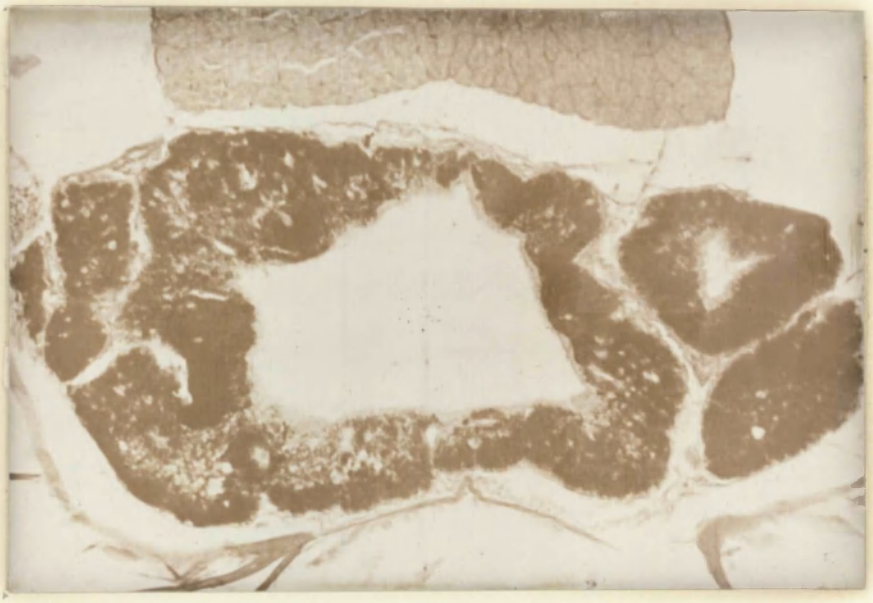

Figure 2. Pars nervosa.

No dehydration. Color intensity of 3.0.

Figure 3. Pars nervosa.

Two days dehydration. Color intensity of 2.0.

Figure 4. Pars nervosa.

Three days dehydration. Color intensity of 1.0.

positive material in the pars nervosa but the mean of 2.8 again indicates little overall depletion.

At 24 hours dehydration, the pars nervosa of the White-crowned Sparrow with a mean of 2.7 is slightly more depleted than at 12 hours. The range of 2.0-2.9 suggests great individual variation in the extent of depletion of neurosecretory material from the pars nervosa. Kawashima et al. (1964) found a great reduction of neurosecretory material from the pars nervosa of the White-crowned Sparrow dehydrated for 24 hours at 25°C. His birds were collected from a wintering population at Snake River Canyon, Washington. Based on Kawashima's Figure 6b, a depletion value of 1.3-1.4 was assigned to the state of depletion of his White-crowned Sparrows which represents a marked difference in the results obtained in my study with Arizona birds dehydrated at 32.2°C for 24 hours.

In the present study birds dehydrated for 48 hours had a mean of 2.1 indicating that about one-half of the neurosecretory material of the pars nervosa is depleted. The range of 1.8-2.6 again shows considerable variation in individual ability to retain neurosecretory material in the pars nervosa. At 72 hours dehydration, the pars nervosa had a mean of 1.26 which represents almost total depletion. This result is almost identical to those

obtained with Passer montanus (Matsui, 1964), Lonchura malacca (Kripalani et al., 1967) and Amphispiza bilineata (Poore, 1969).

The survival rates of White-crowned Sparrows deprived of water at 32.2°C is presented in Figure 5. The five birds surviving at 72 hours were sacrificed for histological examination of the pars nervosa but it is doubtful if any birds would have survived more than 80 hours. MacMillen and Snelling (1966) found that White-crowned Sparrows survived a maximum of seven days when dehydrated at 20-24°C. At 32.2°C the survival rate corresponds closely to the depletion of neurosecretory material from the pars nervosa. Figure 6 presents a scatter diagram and regression line of the correlation of survival rate with the depletion of neurosecretory from the pars nervosa. An r-value of .95 shows a highly significant correlation at the .01 level.

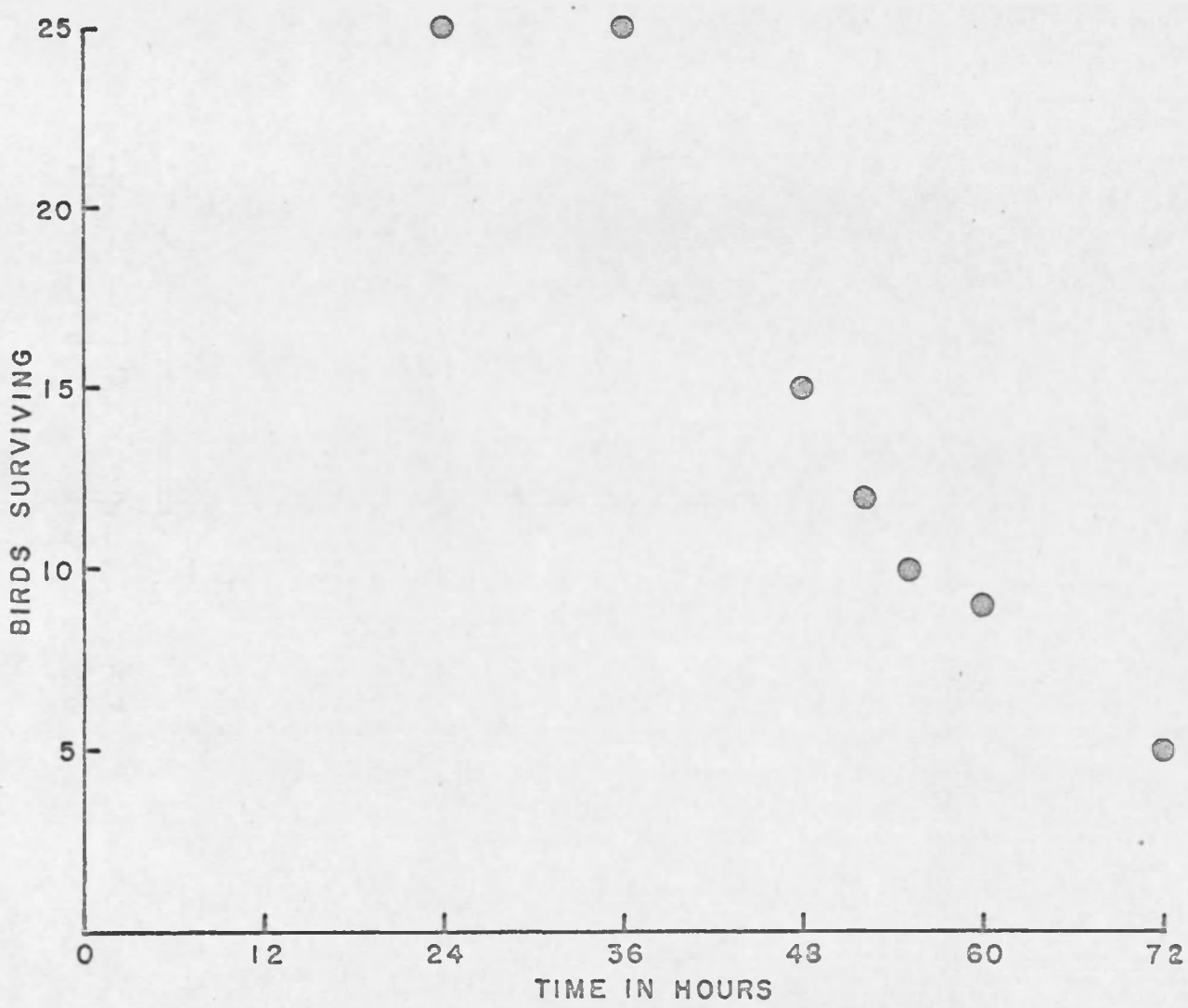

Figure 5. Survival rate at 32.2°C with water deprivation.

Five birds remaining at 72 hours were sacrificed.

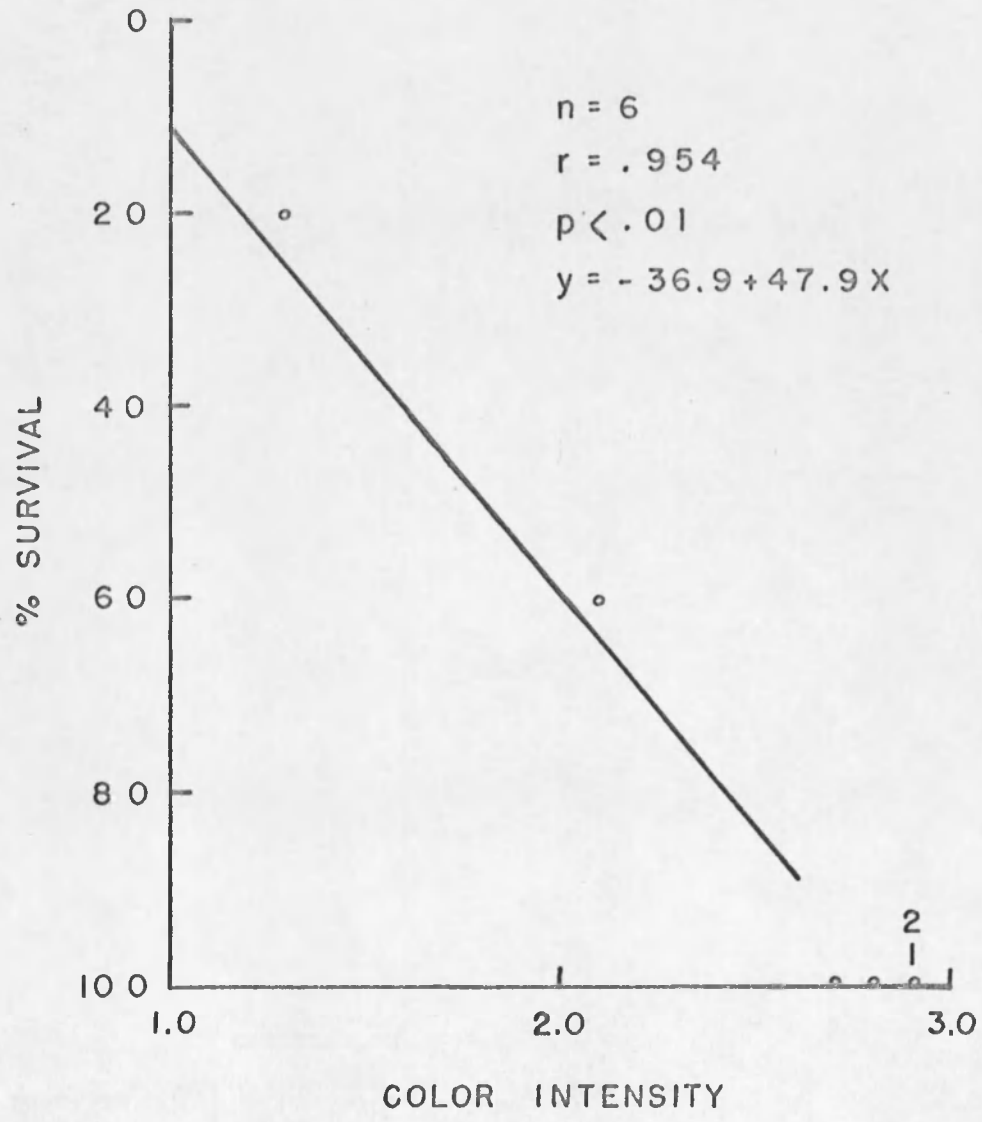

Figure 6. Scatter diagram and regression line of the correlation between survival rate and depletion of neurosecretory material from the pars nervosa.

DISCUSSION

Munsick, Sawyer and Van Dyke (1960) have shown that substances physiologically similar to arginine vasotocin and oxytocin are present in the pars nervosa of the Domestic Fowl, Gallus gallus. Arginine vasotoctin is thought to be the antidiuretic hormone comparable to arginine vasopressin in mammals. This material is thought but not proven to be the neurosecretory material in the pars nervosa which stains positively with aldehyde-fuchsin or aldehyde-thionin. The amount of neurosecretory material present in the pars nervosa is dependent on photoperiod, sex hormones, and osmotic stress.

Aldehyde-thionin positive neurosecretory material began its decrease in the pars nervosa by 24 hours after water deprivation and was essentially depleted by 72 hours of dehydration. These results agree with those of Oksche et al. (1959), Matsui (1964), Kripalani et al. (1967), and Poore (1969). It has been suggested that there is an ecological adaptation of neurosecretory mechanisms in response to moist or arid environments (Kripalani et al., 1967). Evidence supporting this was found in birds from arid environments which showed little if any depletion of neurosecretory material from the pars nervosa when exposed

to conditions of osmotic stress (Oksche et al., 1963; Uemura, 1964; and Kripalani et al., 1967). Amphispiza bilineata is a desert-dwelling bird which showed a reduction of neurosecretory material with water deprivation at 32.2°C comparable to that of moist environment birds (Poore, 1969).

In comparing the results of Kawashima et al. (1964) on the White-crowned Sparrow with the results obtained in the present investigation, several differences are seen. The experiments of Kawashima and associates were performed at 20-24°C as compared to 32.2°C in the present study. Heat stress may cause an increased activation of the hypothalamic-hypophysial system with an increased production of neurosecretory material and an apparently slower depletion of this material from the pars nervosa during osmotic stress. If the differences between the results of my study and that of Kawashima's group represent geographical differences in the same species, then the neurosecretory mechanisms as an ecological adaptation cannot be a species specific character. This would be an ecotypical response that may or may not be present depending on the moisture and temperature control mechanisms which have evolved in a particular species.

The data obtained on the survival of White-crowned Sparrows when dehydrated at 32.2°C indicates that the birds

do not survive well at higher temperatures without water. At the time Arizona temperatures begin to increase, the White-crowned Sparrow migrates north to Canada and Alaska where more favorable ambient temperatures are available.

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