SHORT COMMUNICATIONS

CUTANEOUS WATER LOSS IN SMALL BIRDS

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In recent years evaporative water loss (EWL) in birds has undergone extensive study. Although some investigators have assumed that because of the lack of sweat glands, all evaporation occurs in the respiratory tract, others have recognized the potential importance of avian skin as a site for evaporation. To date significant cutaneous evaporation has been reported in pigeons, *Columba livia* (Smith 1969; Smith and Suthers 1969), and Painted Quail, *Excalfactoria chinensis* (Bernstein 1969, 1970, 1971).

This report provides data on both cutaneous and respiratory evaporation in four species of small birds native to mesic and xeric habitats. The results indicate that evaporation from the skin in all four species at thermoneutrality constitutes a major proportion of total EWL. Hence, with the documentation of cutaneous EWL in rodents (Tennent 1945; Chew 1955; Stupfel and Geloso 1959) and in reptiles (Chew and Dammann 1960; Bentley and Schmidt-Nielsen 1966; Dawson et al. 1966; and others), it can now be stated that the skin represents a major pathway for water loss in non-sweating representatives of all three classes of terrestrial vertebrates.

METHODS AND MATERIALS

The species investigated include the mesophilic Painted Quail, and the Village Weaver (*Ploceus cucullatus*) of mesic and xeric habitats. The xerophilic Budgerigar (*Melopsittacus undulatus*) and Zebra Finch (*Poephila castanotis*) were also studied. Painted Quail were hand-reared to adulthood, while the remaining birds were purchased as adults from commercial breeders. All experimental animals represented domesticated stock several generations removed from the native habitat. Birds were maintained in cages in a windowless room on a 16-hr-light, 8-hr-dark photoperiod (Painted Quail and Village Weaver), or in outdoor aviaries (Budgerigars and Zebra Finches). Food and vitamin-supplemented water were available ad libitum.

Simultaneous measurements of cutaneous and respiratory EWL were performed on each bird only once, except the Village Weaver which was measured twice. The methods were similar to those described previously (Bernstein 1971). A postabsorptive bird was enclosed in a Plexiglas chamber ($7 \times 7 \times 30$ cm) that was divided in half by a partition containing a hole through which the head protruded. A close-fitting dental dam collar, stretched across the hole, prevented airflow between compartments. A Plexiglas pillory, affixed about the neck behind the collar and fastened to the partition, prevented the bird from withdrawing its head from the forward compartment. The bird rested on a half-inch-mesh hardware cloth platform above a pool of mineral oil 1 cm deep. Excreta voided during the experiment fell through the platform and were covered by the oil. Data were rejected if excreta adhered to the platform, walls, or pericloacal feathers.

Separate streams of dry air were directed into each compartment at a rate of 1000 cc/min. This was adequate to assure an ambient water vapor pressure of less than 4 mm Hg in each compartment, as determined from EWL data by equation (3) of Lasiewski et al. (1966). The experiment was started after the bird was permitted to equilibrate in the dark for 60 min at 30°C (± 0.5°C), a thermally neutral temperature. Excurrent air from the head and body compartments was directed through parallel, preweighed drying columns (Drierite), and the weight increment of each column over a precisely measured time (approximately 30 min) was determined. These values were taken as estimates of respiratory and cutaneous EWL, respectively. However, because of the possibility of evaporation from the skin of head and neck, values for respiratory evaporation may represent a slight overestimate, while those for cutaneous evaporation may be correspondingly low.

Plexiglas adsorbs water from humid air and, when exposed to dry air, gives up the adsorbed water slowly. To test whether water on the inside surfaces of the Plexiglas chamber contributed to the water vapor appearing in the downstream air, control experiments were performed using the empty chamber. Under the same conditions utilized for experiments with birds, there was a negligible flow of water vapor through the system.

RESULTS AND DISCUSSION

Cutaneous EWL ranged between 2.1 and 5.6 mg H_2O $(g \times hr)^{-1}$ and accounted for the loss of 44.7–62.9 per cent of the total evaporation in the four species (table 1). These values suggest that cutaneous EWL may play an important role in avian thermoregulation. Indeed, the dissipation of a major portion of metabolic heat via cutaneous evaporation in Painted Quail hatchlings contributes in large measure to their inability to regulate body temperature at ambient tem-

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TABLE 1. Cutaneous and respiratory evaporative water loss in four species of birds at 30°C.

		Body wt. (g)		Evaporative water loss [mg H_2O (g × hr)$^{-1}$]						
				Total		Respiratory		Cutaneous		
Species[a]	*n*	$\bar{x}$	range	$\bar{x}$	range	$\bar{x}$	range	$\bar{x}$	range	% of total
Poephila castanotis†	3	12.5	11.8–13.2	8.9	8.1–9.7	3.3	2.8–3.7	5.6	4.6–6.1	62.9
Melopsittacus undulatus†	3	31.6	24.2–39.5	9.0	8.3–9.5	3.7	3.3–4.2	5.3	5.0–5.4	58.9
Excalfactoria chinensis‡	6	42.3	33.6–48.0	4.7	3.3–5.9	2.6	1.6–3.5	2.1	1.7–2.6	44.7
Ploceus cucullatus §*	1	42.6		6.7		3.3		3.4		50.8

[a] Species are native to † xeric, ‡ mesic, or § both xeric and mesic habitats. *Values are means of two measurements.

peratures below brooding levels (Bernstein 1969, 1970, 1971). Moreover, during exposure to temperatures of 40 and 42°C, cutaneous EWL accounted for about half of the total evaporation in Painted Quail, dissipating a large proportion of the body heat (Bernstein 1969, 1970).

Comparison with available data on other species indicates that the range of the cutaneous component of total EWL among birds may be far greater than that observed in the present study. Schmidt-Nielsen et al. (1969) recorded a low rate of evaporation from the leg skin of the Ostrich (*Struthio camelus*) at 40° C. They calculated that a similar rate of evaporation originating from the entire integument would account for less than 2 per cent of total EWL. In contrast, 74 per cent of total EWL in pigeons occurred from the skin at 35°C, as estimated from figures 19 and 20 of Smith (1969).

The occurrence of cutaneous EWL at substantial rates in five avian species, over a 24-fold range of body weights from Zebra Finch to Pigeon, and representing xeric and mesic habitats, suggests the occurrence of cutaneous evaporation in a larger variety of birds. Further work will be necessary to verify this and to clarify the factors involved in the control of cutaneous evaporation rates.

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