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Wetland Salinity and Salt Gland Size in the Redhead *Aythya americana*

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Numerous investigators have shown experimentally that nasal or supraorbital salt glands exist in nonmarine waterfowl and have the ability to enlarge or atrophy in response to changes in the salt content of the drinking water (Scothorne 1959, Ellis et al. 1963, Cooch 1964, Benson and Phillips 1964, Schmidt-Nielsen and Kim 1964). Little information is available, however, about the extent to which such relationships occur in free-ranging populations (Anderson and Warner 1969).

The presence of an extrarenal, salt-elimination mechanism and its adaptability to changing salinity regimens are especially important to the Redhead (*Aythya americana*), which must adjust to marked changes in wetland salinity during its yearly activity cycle. Principal breeding grounds are the freshwater pothole region of the northern United States and adjacent Canadian provinces and the alkaline marshes of the western states. The wintering area for the majority of the Redhead population is the central and lower Texas coast (Bellrose 1976), where salinities normally range from 5 to 35 ppt chlorides. Drought and poor water circulation often result in hypersaline conditions in the coastal bays, causing salinities to reach or surpass 60 ppt. This is particularly true of Laguna Madre, which traditionally hosts the bulk of the wintering population (Weller 1964).

Anderson and Warner (1969) have suggested that the differential state of gland development in migrating Lesser Scaup (*Aythya affinis*) may have some practical application by indicating whether fresh- or saltwater wintering areas were used.

During studies of the ecology of wintering Redheads (Cornelius 1977), I removed and weighed salt glands from various waterfowl species to determine whether or not correlations exist between gland size and the severity of and/or length of exposure to saltwater environments.

Salt glands were obtained from 279 Redheads in Texas. Variation of gland weight according to wetland salinity was analyzed from 212 Redheads taken by hunters in midwinter, 1975–1976, from four bays on the central Texas coast (St. Charles, Copano, Aransas, Corpus Christi). Variation of gland weight during the entire winter season within a single bay was examined from 67 specimens either collected or confiscated as illegal kills in Laguna Madre between 1972 and 1975. Gland weights of 74 Redheads shot by hunters in October 1975 at freshwater habitats in Manitoba (Delta Marsh) and Minnesota (Thief Lake) were compared with gland weights of birds taken from the saline wetlands of Texas. In addition, salt glands were examined from 143 specimens of 11 other waterfowl species frequenting the Texas coastal zone. This series represented three seasons, 1973–1976.

Glands were either excised within 1 day after collection, or the carcass was frozen and glands removed within 3 weeks. ANOVA and Student's t-test of significance were conducted for mean gland weights. Unless otherwise noted, all standard error ranges and tests of significance are presented at the 99% confidence interval.

Unfortunately, an analysis of salt-gland weight variation relative to total body weight was not possible, because the majority of the specimens received from hunters were eviscerated or were only the heads. Data on bay salinities were taken from Texas Parks and Wildlife Department fish survey records.

Salt gland weights of Redheads varied greatly by collection locale (Table 1). Gross gland weights were 2.5–4.5 times greater than mean values from Manitoba and Minnesota. Highly significant variation existed in the mean salt gland weight as a function of habitat salinity of birds collected from the Texas coast in midwinter 1975–1976. The salinities of St. Charles and Copano bays were similar, and the mean gland weights of Redheads collected in the respective bays were nearly identical. A marked increase in gland size, however, was observed in the study material from Aransas and Corpus Christi bays, where salinities ranged 8–17 ppt higher.

Redhead salt glands for each wintering month were available from the Laguna Madre series (Fig. 1) and suggested an upward trend in gland weight from October through March. The mean gland weight of 41 birds collected during fall and early winter (October, November, December) was 1,440 ± 81 mg,

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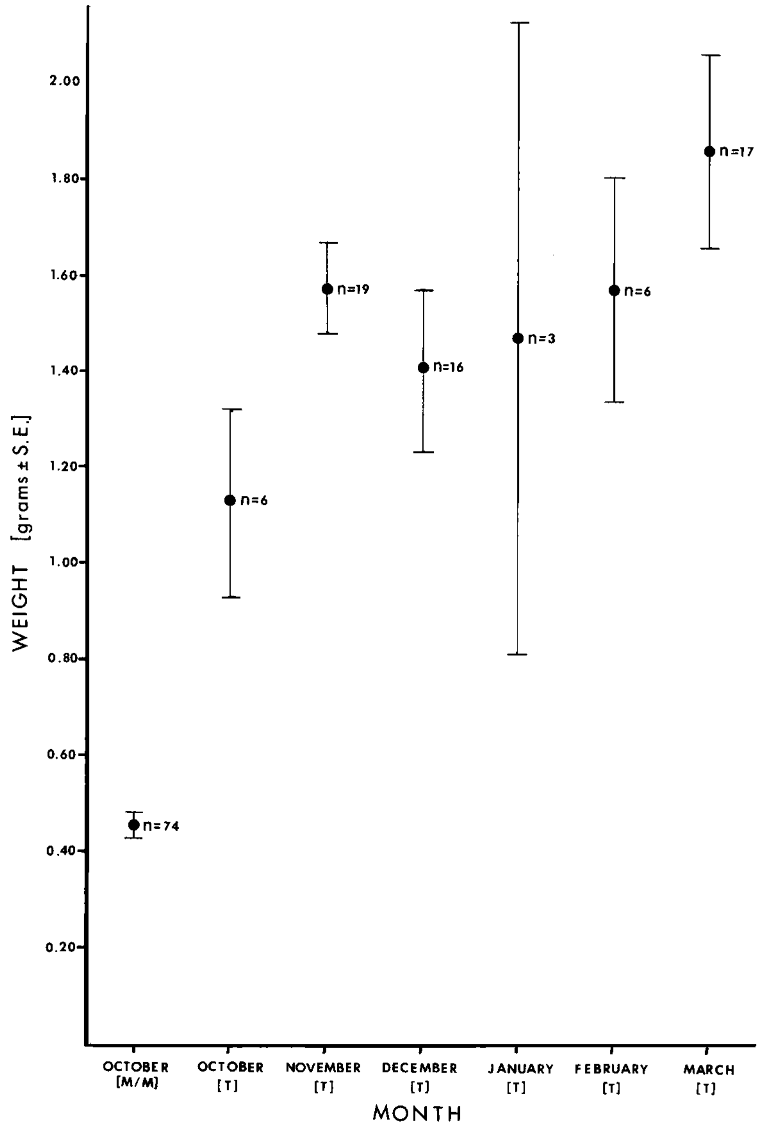

Fig. 1. Temporal analysis of mean salt-gland weights (±SE at 99% confidence interval) of 67 Redheads collected in Laguna Madre, Texas (T) during the 1972–1975 wintering seasons and 74 Redheads collected in Minnesota and Manitoba (M/M) during October 1975.

significantly less than the mean gland weight of 1,746 ± 197 mg for 26 Redheads taken during midwinter and early spring (January, February, March).

Several assumptions are necessary before these data may be interpreted as evidence for a continual increase in gland size throughout the wintering period. The waterfowl were not collected with an analysis of salt gland size and wetland salinity relationships in mind. Instead, the study material resulted from an unrelated investigation or was made available by local wildlife agents. This absence of a systematic design to the data collection procedure may have biased the analysis in some undetermined manner. Three separate wintering seasons were represented, and, although the mean annual salinity of Laguna Madre did not change appreciably during this period, the constancy of salinity between collection locales was unknown. Furthermore, the Redheads examined may not have represented discrete populations that remained in Laguna Madre throughout the winter. Intra- and interbay movements, although uncommon during 1973–1975, do

TABLE 1. Salt-gland weights of Redheads collected in Manitoba, Minnesota, and on the central and lower Texas coast.

Site	n	Mean ± SE (mg)	Coefficient of variation (%)	Salinity[a] (%)
Texas				
St. Charles (1975–1976)	64	1,110 ± 66	24	15
Copano (1975–1976)	22	1,115 ± 187	40	13
Aransas (1975–1976)	121	1,540 ± 52	19	22
Corpus Christi (1975–1976)	5	2,050 ± 333	18	31
Laguna Madre (1972–1975)	67	1,559 ± 40	11	
Manitoba/Minnesota				
Delta Marsh/Thief Lake (1975)	74	451 ± 22	21	

[a] December 1975–January 1976.

occur (Cornelius 1977). The majority of the December and January collections may have been composed of recent arrivals from less saline bays, thus accounting for the observed decrease in mean gland weights. Nevertheless, it seems evident that Redhead salt glands have the ability to quadruple in size during the bird's 6-month stay on saltwater wintering areas. The increase in gland size from the freshwater-adapted state is abrupt at the onset of saltwater use and continues at a slower rate thereafter.

As in Redheads, gland weights from Mottled Ducks (*Anas fulvigula*), Pintails (*A. acuta*), Gadwalls (*A. strepera*), American Wigeons (*A. americana*), Northern Shovelers (*A. clypeata*), and Lesser Scaups showed a positive relationship to the salinity of the collection habitat (Table 2). In all species except Lesser Scaup,

TABLE 2. Salt gland weights of various waterfowl species collected from wetland habitats of different salinity regimes on the central and lower Texas coast in 1974–1975 and 1975–1976.

Species	Area	Habitat salinity (ppt)	n	$\bar{x}$ ± SE (mg)	CV (%)
Mottled Duck	Cameron County	0	3	140 ± 16	10
	St. Charles Bay	10–15	5	336 ± 57	38
Pintail	St. Charles Bay	10–15	29	404 ± 43	29
	Laguna Madre	30–35	18	517 ± 85	36
Gadwall	Kleberg County	0	10	171 ± 45	42
	St. Charles Bay	10–15	17	569 ± 93	34
American Wigeon	Cameron County	0	3	325 ± 157	43
	St. Charles Bay	10–15	15	757 ± 102	27
	Laguna Madre	30–35	3	941 ± 228	21
Northern Shoveler	Copano Bay	10–15	2	160 ± 48	21
	Laguna Madre	30–35	2	190 ± 69	26
Lesser Scaup	St. Charles Bay	10–15	17	728 ± 102	29
	Laguna Madre	30–35	2	1,055 ± 288	20
Green-winged Teal (*Anas crecca*)	Copano Bay	10–15	11	110 ± 24	37
Canvasback (*Aythya valisineria*)	Laguna Madre	30–35	1	710	
Bufflehead (*Bucephala albeola*)	St. Charles Bay	10–15	1	300	
Common Goldeneye (*B. clangula*)	St. Charles Bay	10–15	1	410	
Ruddy Duck (*Oxyura jamaicensis*)	St. Charles Bay	10–15	1	150	

TABLE 3. Salt-gland weight variation by sex for various waterfowl species collected in Texas, Minnesota, and Manitoba during the fall and winter of 1975–1976.

Species	Male $\bar{x} \pm$ SE (mg)	Male n	Female $\bar{x} \pm$ SE (mg)	Female n
Mottled Duck[a]	358 ± 191	3	305 ± 68	2
Pintail	404 ± 47	25	340 ± 148	4
Gadwall	504 ± 126	17	333 ± 111	10
American Wigeon[a]	753 ± 197	6	759 ± 165	9
Green-winged Teal[a]	113 ± 28	9	120 ± 58	2
Lesser Scaup	774 ± 114	13	573 ± 178	4
Redhead (Texas)	472 ± 29	29	432 ± 29	41
Redhead (Minnesota/Manitoba)	1,423 ± 61	138	1,277 ± 81	74

[a] Differences in weight not significant.

waterfowl collected on freshwater ponds or low-salinity, estuarine bays possessed significantly smaller glands ($P < 0.05$) than birds of the same species examined from estuarine or marine habitats. Salt-gland weights of small numbers of six other waterfowl species collected from a single wetland habitat are presented in Table 2 for comparison.

Salt glands of males were significantly larger than those of females in Pintails, Gadwalls, Lesser Scaups, and Redheads (Table 3). Redhead males exhibited larger glands than did females in both the Minnesota/Manitoba and Texas series.

In general, the morphological responses of salt glands in free-ranging waterfowl to differences in habitat salinity and length of exposure time appear to be similar to results obtained in previously reported laboratory studies of artificially induced salt loading. The practical application of these relationships to waterfowl management seems limited, however. The extrarenal mechanism governing the maintenance of proper water balance in ducks responds quickly to changes in saltwater exposure. Fletcher et al. (1967) and Holmes and Stewart (1969) found that glands of ducklings transferred to hypertonic saline exhibited an 80% increase in weight during the first day of adaptation. Within 5 days, gland weight had approximately doubled, and it continued to increase slowly thereafter. Conversely, ducks adapted to a marine habitat show a marked and immediate reduction in salt-gland size when only freshwater is ingested (McArthur and Gorman 1978).

Waterfowl that make regular use of freshwater ponds while wintering on the Texas coast will probably have salt glands that are appreciably smaller than those of individuals of the same species that remain continuously on the saline bays. Therefore, use of the correlation between salt-gland weight and wetland salinity as an aid in evaluating the extent of local movement on the wintering ground is probably not valid. Furthermore, its usefulness as a natural tag on a population to identify wintering or breeding grounds broadly seems very limited until the rate of reduction in gland size during spring migration and the osmoregulatory influence of the salt content of the various wetland breeding areas are investigated.

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Occurrences of the Asiatic Marbled Murrelet [*Brachyramphus marmoratus perdix* (Pallas)] in North America

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The Marbled Murrelet [*Brachyramphus marmoratus* (Gmelin)] is a small alcid that Udvardy (1963: 90) considered to have a disjunct subboreal distribution during its presumed breeding season in the North Pacific Ocean. He portrayed this range with a gap bracing the Aleutian islands, with subspecific differences on opposite sides of the gap—*B. m. marmoratus* (Gmelin) of the northeastern and *B. m. perdix* (Pallas) of the northwestern Pacific Ocean. This gap may not actually exist, as Udvardy described it, because *B. m. marmoratus* is suspected of breeding along the Aleutian chain west at least to Adak Island (Nelson 1887, Byrd et al. 1974), and observations of the species (not necessarily breeding) have been made during its presumed breeding season (Sealy 1974, 1975; see also Simons 1980) even farther west to Attu Island (Murie 1959, Kessel and Gibson 1978). All specimens from the northern Bering Sea in summer [St. Lawrence Island (Bédard 1966), the Diomede Islands (Kozlova 1957), and Idlidlya Island, on the northern coast of the Chukotski Peninsula (Bent 1919)] have been referred to *marmoratus*. Thus, the breeding distribution of *marmoratus* probably extends north as well as west of the Alaska Peninsula, but, to date, only a few birds have been noted in this area (see Nelson 1883, Gabrielson and Lincoln 1959, Bartonek and Gibson 1972). There have been no published reports of *perdix* from North American waters. The most northern record of *perdix* in the Bering Sea is from Litke Strait, on the eastern coast of Kamchatka (Dement'ev and Gladkow 1968), but the closest Asian locality (where *perdix* has been collected) to North American waters is the Commander Islands (Hartert 1920), where *perdix* may breed (Taczanowski 1893; see also Kuzyakin 1963). Thus, the known breeding ranges of the two subspecies of the Marbled Murrelet appear to be geographically separated only by Near Strait, a distance of approximately 500 km.

Whether the subspecies are, in fact, separated year-round is not known. Nominate *marmoratus* ranges regularly in summer and winter along the Aleutian chain and Alaska Peninsula to southeastern Alaska and south along British Columbia to central California (Binford et al. 1975, Ainley 1976), with movements in some winters to southern California (Sealy 1975). *B. m. perdix* ranges in summer along the west and north coast of the Sea of Okhotsk, south to Sakhalin and the eastern coast of the Kamchatka Peninsula (Kozlova 1957, Vaurie 1959), but occasionally south to western Korea (Austin 1948). Movements in winter shift its range south to include the coasts of Japan, Korea, and northern China (Vaurie 1959).

On 11 November 1979, a bird, unidentified by the hunter who shot it at Point Columet, Lake of Two Mountains, near Oka, Québec, was obtained at a bag check by M. Fontaine and turned over to Alison (see David and Gosselin 1980). The frozen specimen was shipped later to Sealy for identification and study. The bird was a Marbled Murrelet [National Museum of Canada (NMC) no. 69,845], which we have referred, on the basis of body measurements (Table 1), to the larger subspecies *B. m. perdix*. Photographs of the bird in the flesh were reproduced by DeBenedictis (1980: 137), who reported it only as a Marbled Murrelet.

This bird was shot as it flew over a freshwater lake.