The Condor 87:520–527

ADAPTATIONS OF MIGRATORY SHOREBIRDS TO HIGHLY SALINE AND ALKALINE LAKES: WILSON'S PHALAROPE AND AMERICAN AVOCET

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ABSTRACT.—Wilson's Phalaropes (*Phalaropus tricolor*) and American Avocets (*Recurvirostra americana*) occur in large numbers at hypersaline and alkaline lakes. Comparing birds from three lakes of different salinity and alkalinity in the Great Basin of western North America, we found no evidence of salt-loading: blood hematocrit, pH, osmolality, and sodium concentration were not elevated; stomach osmolality and sodium concentration were only slightly higher than the body fluids of the birds' hypo-osmotic prey (brine shrimp and brine flies); salt glands were not enlarged and averaged a relatively low percentage of body weight (0.02%). Through a combination of behavioral and anatomical adaptations, phalaropes and avocets evidently are able to rid their prey of most adherent lake water and thereby largely avoid the problems of salt-loading and the ingestion of harmful ions. Both species occupy hypersaline habitats for long periods and probably derive most of their water needs from the body fluids of their prey. Their use of fresh water is sporadic and may not be required for osmoregulatory balance.

Alkaline and hypersaline lakes, despite being harsh physical environments, are prime habitats for a few species of resident (e.g., flamingos) and a somewhat larger number of migratory waterbirds. Mono Lake, California, a large hypersaline (2½ × the concentration of sea water) and alkaline (pH ≈ 10) lake at the eastern base of the Sierra Nevada, attracts large numbers of a few of these species each year. Approximately 45,000 California Gulls (*Larus californicus*) nest there; in summer and in fall, tens of thousands of Wilson's (*Phalaropus tricolor*) and Red-necked (*P. lobatus*) phalaropes stop over on their southward migration (Jehl 1981), and hundreds of thousands of Eared Grebes (*Podiceps nigricollis*) stage there (Storer and Jehl 1985). American Avocets (*Recurvirostra americana*) are also common at hypersaline lakes, although at Mono Lake only a few pairs breed and flocks of several hundred occur in autumn.

Hypersaline lakes are attractive to these birds because they typically lack fish, which allows the few invertebrates that can occupy them to attain great abundances. These, in turn, serve as food for the birds. At Mono Lake, brine shrimp (*Artemia* sp.) and brine flies (*Ephydra hians*) become super-abundant at some seasons. Birds feeding on these invertebrates, either by pecking them from the surface of the water or by catching them while driving, might be expected to ingest large amounts of lake water and thereby incur deleterious salt loads. Yet, our previous studies of California Gulls (Mahoney and Jehl 1985a) and Eared Grebes (Mahoney and Jehl 1985b) at Mono Lake, where salinities have varied from 72 to 90 ppt (2,160–2,700 mOsm/kg) in 1982–1984, have shown that this is not the case. These species seem to have no special anatomical or physiological adaptations for dealing with high salt loads. Instead, they largely avoid osmoregulatory problems behaviorally, by ridding their food of adherent lake water before swallowing it.

Gulls and grebes differ markedly in their use of fresh water. Gulls visit freshwater streams to drink and bathe several times each day, whereas grebes, although they may remain continuously at Mono Lake for as long as six months (Jehl, unpubl. data), never visit fresh water. Wilson's Phalaropes and American Avocets (Fig. 1) have intermediate patterns of water use; both visit fresh water regularly, though probably not daily.

If phalaropes and avocets ingest large quantities of Mono Lake water and its attendant osmotic and ionic load, they could be expected to show changes in blood chemistry, hydration state, and salt gland size. In order to determine how great a salt load these birds incur while feeding at the lake, we made the following measurements: blood pH and hematocrit; serum osmolality, sodium, and potassium; composition and osmolality of stomach contents, prey body fluids, and lake water; body water content; and salt gland weights. We then compared these values from Mono Lake birds to those of phalaropes and avocets at two other Great Basin lakes to see if salt loads varied with diet or lake water composition.

METHODS

In 1982, 1983, and 1984, we collected a total of 26 Wilson's Phalaropes and three American Avocets for physiological studies at Mono Lake. We also collected three Wilson's Phalaropes at Lake Abert, Oregon, in 1983, and three Wilson's Phalaropes and three American Avocets at Great Salt Lake, Utah, in 1984. In most cases, we immediately withdrew by cardiac puncture 1–2 cc of blood into ammonium-heparinized syringes. Hematocrits were taken from this sample, and the remaining blood was centrifuged in serum separator tubes for 3 min at 5,000 rpm. We later determined serum osmolality (±2%) with a Wescor vapor pressure osmometer; sodium and potassium concentrations (±1%) were determined with an IL443 flame photometer. We measured blood pH of one phalarope immediately after the blood was drawn using a Chemtrix portable pH meter, but pH was not determined for other phalaropes because of the difficulty in obtaining sufficient volumes of blood from these small birds. No blood pH measurements were obtained from avocets.

We determined the stomach (gizzard) contents of all specimens, and measured the osmolality and the sodium and potassium concentrations of the contents, as described above, as well as those of body fluids of prey species and of the water from each lake.

Salt glands were removed from some specimens and were weighed to the nearest milligram. If both glands could be removed, we used the mean weight in our calculations. We also examined the oral cavity of these species to seek possible anatomical structures that might be used to strain excess water from the prey.

All statistical comparisons are based on Student's *t*-test, and analysis of variance: $P < 0.05$ indicates significant differences.

RESULTS

LAKE WATER ANALYSIS

Mono Lake, an alkaline lake, had a pH of 10.83 in 1983 and 10.64 in 1984. Great Salt Lake and Lake Abert are sodium chloride lakes with pH's $\approx$ 8.0. The salinity of the three lakes varied somewhat from year to year, depending upon fresh water run-off from the spring melt of snow in adjacent mountains. Osmolality of Mono Lake was 2,314 mOsm/kg in 1983 and, owing to heavy snowfall and spring run-off, dropped to 2,160 mOsm/kg in 1984. Great Salt Lake experienced similar conditions in 1984 and had salinities from ca. 4,500 mOsm/kg mid-lake to ca. 1,200 mOsm/kg around the periphery. Lake Abert's salinity was 757 mOsm/kg in 1983.

TABLE 1. Blood characteristics of Wilson's Phalaropes and American Avocets (mean ± 1 SD).

	Phalaropes[a]	Avocets[b]
Serum osmolality (mOsm/kg)	324 ± 18 (16)	324 ± 7 (4)
Hematocrit (% RBC)	39 ± 7 (22)	33 ± 6 (6)
Serum sodium (meq/l)	140 ± 0.5 (9)	–
Serum potassium (meq/l)	5.5 ± 0.5 (2)	–
Blood pH	7.49 (1)	–

[a] Values for birds from Mono Lake (1982–1983) did not differ significantly and were pooled.

[b] Values for birds from Mono Lake and Great Salt Lake did not differ significantly and were pooled.

BLOOD ANALYSIS

Despite obtaining blood samples from phalaropes in different years and at different lakes, and from avocets at different lakes, we found no differences in blood characteristics between samples from different species or different localities: serum osmolalities were identical and hematocrits were similar ($0.05 < P < 0.10$; Table 1).

STOMACH CONTENTS

Wilson's Phalaropes spear their prey at or near the surface of the water. Stomachs of the birds we sampled contained from 100% brine shrimp to 100% brine flies (adults, larvae, and pupae). In contrast, avocets sweep the water surface for adult brine flies or probe in the saturated mud for fly larvae; those we sampled had fed only on adult flies.

Brine shrimp and all stages of brine flies are hypo-osmotic regulators that maintain body fluid concentrations well below those of their aquatic medium (Table 2). Osmolalities of phalarope and avocet stomach contents were equal to or slightly higher than that of their prey, but were well below osmolalities of the lakes in which they had been feeding (Fig. 2). At Mono Lake, phalaropes that had eaten brine shrimp had higher stomach content osmolalities than those that had eaten brine flies ($P < 0.001$), which are more dilute (cf. Table 2). One bird that had fed on 50% flies and shrimp had an intermediate value, and five that had fed on undeterminable prey or on a mixture of shrimp and flies had values similar to those that had fed only on shrimp. Two phalaropes

TABLE 2. Body fluid values of Mono Lake invertebrates.

Invertebrate species	Osmolality (mOsm/kg)	Sodium (meq/l)	Potassium (meq/l)	pH	Body water (% body weight)
Brine shrimp					
Adults	—	—	—	—	85[d]
1982	555[a]	170	20	7.44	—
1983	518[a]	200	26	—	—
Brine fly					
Adults	472[b]	—	—	—	78[d]
Pupae	352	—	—	—	—
Larvae	345	160[c]	—	—	87[d]

[a] Data are from samples that were blotted dry and mashed, and include not only hemolymph, but also perhaps a small amount of adhering lake water.
[b] Very dry sample, which may overestimate osmolality.
[c] Herbst (1981).
[d] D. Herbst, pers. comm.

collected in late July, 1984, had higher stomach osmolalities (579 and 730 mOsm/kg), despite having eaten only brine shrimp. These were heavy birds that were collected when the phalaropes were hyperphagic and are not shown in Figure 2.

Three phalaropes from Lake Abert had fed on flies and shrimp in relatively dilute water (757 mOsm/kg); their stomach osmolalities were similar to those of phalaropes feeding on flies at Mono Lake.

At Mono Lake, the osmolalities of avocet stomach contents were higher than those of phalaropes that were feeding on the same prey, brine flies ($P < 0.01$), and were similar to the higher osmolalities of phalaropes feeding on shrimp (Fig. 2). At Great Salt Lake, however, values for avocets and phalaropes, both of which had fed on flies, were similar and not significantly different from avocets at Mono Lake. Phalaropes that fed on brine flies at Great Salt Lake had higher stomach osmolalities than phalaropes feeding on the same prey at Mono Lake ($P < 0.0005$), even though the Great Salt Lake phalaropes were collected on a mudflat where lake water concentration was low (ca. 1,200 mOsm/kg), owing to an influx of fresh water into the lake in 1983–1984. We suspect that these birds were resting after having fed farther out on the lake, where salinities were much greater (ca. 3,600–4,500 mOsm/kg).

Sodium concentrations in the birds' stomachs were about one-half those of the major prey species (Table 3, cf. Table 2). Although avocets from Great Salt Lake had slightly more concentrated stomach sodium than those from Mono Lake, the difference was not significant for these small sample sizes, and values from both locations were pooled. Stomach potassium was similar in phalaropes and avocets and slightly higher than in the body fluids of their invertebrate prey.

SALT GLANDS

Salt glands of Wilson's Phalaropes and American Avocets collected at lakes of greatly differing salinities did not differ in relative size, in most cases (Table 4), and averaged 0.02% of body weight. Salt glands of phalaropes that had just arrived at Mono Lake in mid-June, presumably after a direct flight from the freshwater breeding grounds, were no smaller than those of birds that had resided at Mono Lake

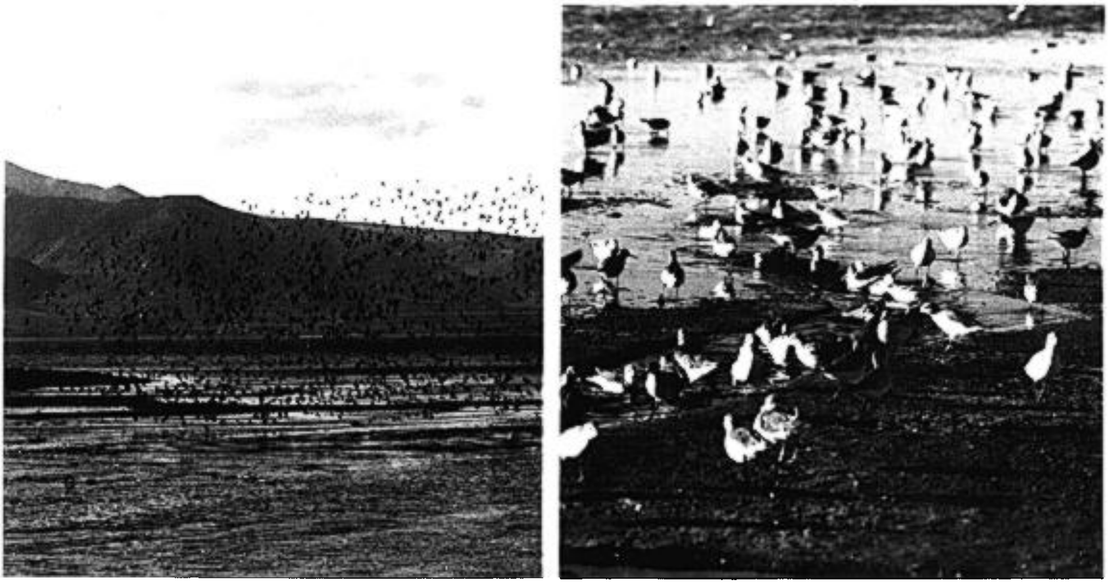

FIGURE 1. In late July, large flocks of Wilson's Phalaropes come ashore at dawn and in the late afternoon to drink and bathe at the mouths of freshwater creeks.

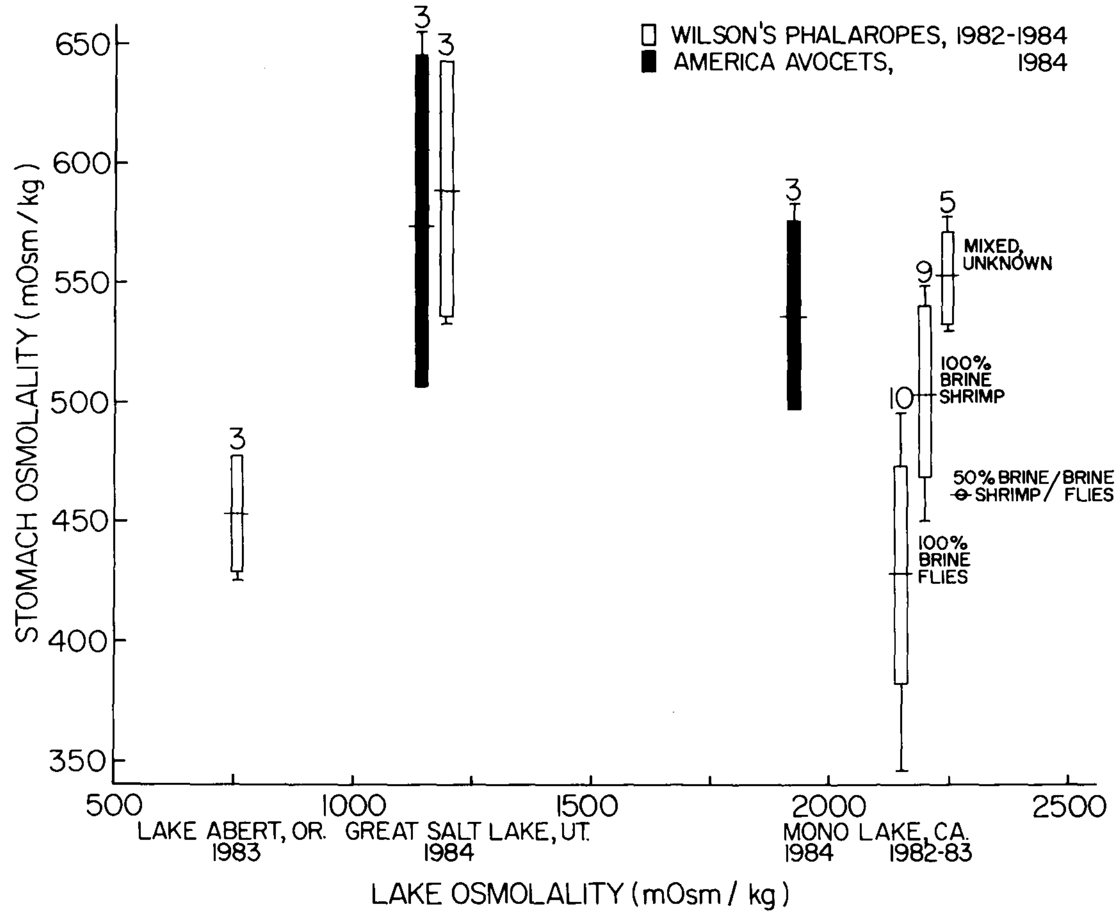

FIGURE 2. Osmolality of stomach contents of Wilson's Phalaropes and American Avocets at three alkaline or saline lakes. Horizontal lines are mean; box is ±1 SD; vertical line is range.

for several weeks. Salt glands of 12 phalaropes we sampled in late July and August, 1984, however, were significantly larger ($P < 0.05$; Table 4), and some of these birds were also considerably heavier (Fig. 3).

An analysis of variance of phalaropes using a two-level nested design with unequal sample sizes produced no differences among Mono Lake, Great Salt Lake, and Lake Abert salt gland weights. Differences were indicated, however, among sets of data from different collection dates (at just above $P = 0.05$). A finer comparison using an a posteriori test, the "sum of squares simultaneous test procedure," indicated a significant difference at $P = 0.05$ between the 16 July–18 August 1984 collections and the other four sets of data. Similarly, a subdivision of the sum of squares for data from different collection dates indicated that the data from the July–August collection dates differed significantly at $P < 0.05$ from those on the other four collection dates.

TABLE 3. Sodium and potassium concentration (mean ± 1 SD) of Wilson's Phalarope and American Avocet stomach contents, Mono Lake and Great Salt Lake, 1984.

	Phalarope		Avocet	
	Sodium (meq/l)	Potassium (meq/l)	Sodium (meq/l)	Potassium (meq/l)
Mono Lake	116	34	101 ± 21	41 ± 6
(*n*)	(1)	(1)	(3)	(3)
Great Salt Lake	105 ± 14	34 ± 7	123 ± 4	37 ± 1
(*n*)	(3)	(3)	(3)	(3)
Pooled	108 ± 13	34 ± 6	112 ± 8	39 ± 4
(*n*)	(4)	(4)	(6)	(6)

TABLE 4. Weights of salt glands (mean ± 1 SD) of Wilson's Phalaropes and American Avocets from three alkaline or saline lakes.

	Phalarope					Avocet	
	Mono Lake			Great Salt Lake	Lake Abert	Mono Lake	Great Salt Lake
	June/July 1983	June 1984	July 16–Aug. 18 1984	July 1984	July 1983	June/July 1984	July 1984
Sample size (*n*)	6	4	12	3	1	3	3
Body weight (g)	62–77	63–70	61–115	40–58	63	305–365	300–310
Mean salt gland weight (mg)	11 ± 2	11 ± 2	14 ± 3	11 ± 2	8	58 ± 20	71 ± 15
(range)[a]	(8–13)	(9–13)	(9–17)	10–13		(38–78)	(60–88)
Lake concentration (mOsm/kg)	2,395	1,914	1,914	1,150	757	1,914	1,150

[a] Based on weight of a single gland per individual or, when possible, the mean weight of both glands.

ORAL CAVITY

The long tongue of Wilson's Phalarope fits into a depression in the roof of the mouth and fills much of the oral cavity, except near the tip of the bill. It is flat and fleshy at the basal third, and smooth, cornified, and concave at the distal two-thirds. On the anterior surface of the palate is a row of minute bumps that gradually increase in size posteriorly and form two slightly offset rows (in a modified herringbone pattern) near the base of the bill. At the rear, these expand to cover most of the palate as a series of fleshy projections (Fig. 4).

The tongue of the avocet is short, broad, and smooth, and occupies much less of the mouth (Table 5). The posterior portion of the palate bears a series of small, hard papillae that project posterioventrally; each is ca. 0.50 mm high and 1.0 mm in total length (Fig. 4; see also Olson and Feduccia 1980:62, fig. 35). The papillae, whose number is evidently variable, are arranged in three groups: one group outlines a shallow depression in the palate that generally conforms to the shape of the tongue; other smaller papillae are located medially in this depression and border the internal choana; a third group is situated at the corners of the mouth. Additional papillae are present farther back in the mouth and throat.

DISCUSSION

Blood characteristics of Wilson's Phalaropes and American Avocets inhabiting lakes of greatly different salinities and alkalinities are

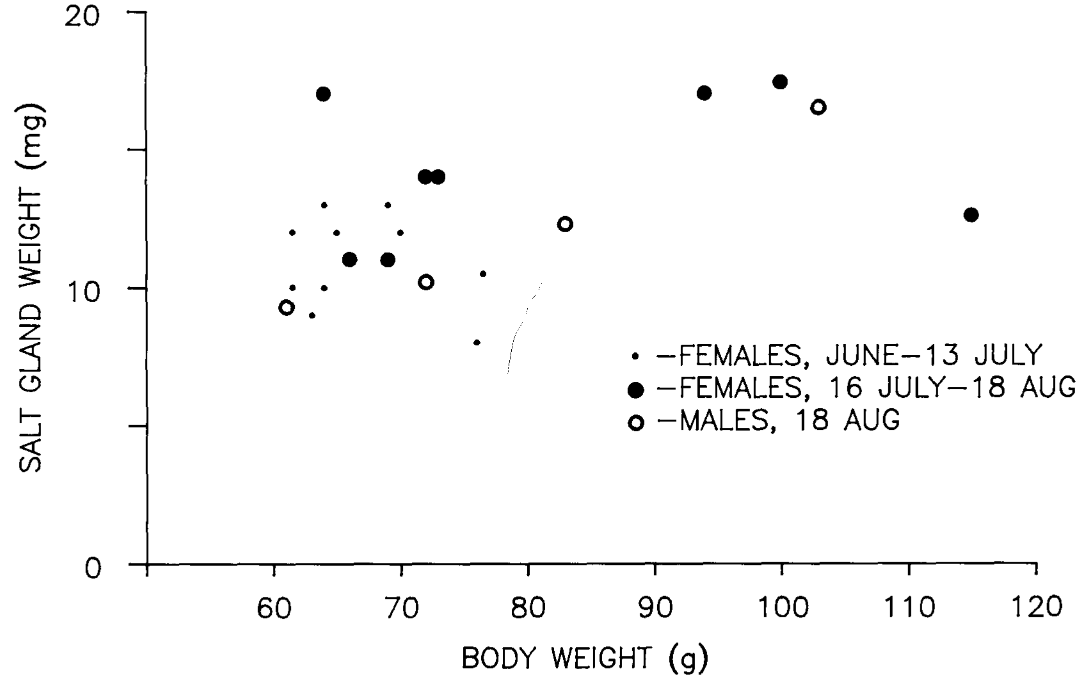

FIGURE 3. Salt gland weight and body weight of Wilson's Phalaropes at Mono Lake, California in 1984. Salt gland weights are the mean weight of the pair of glands.

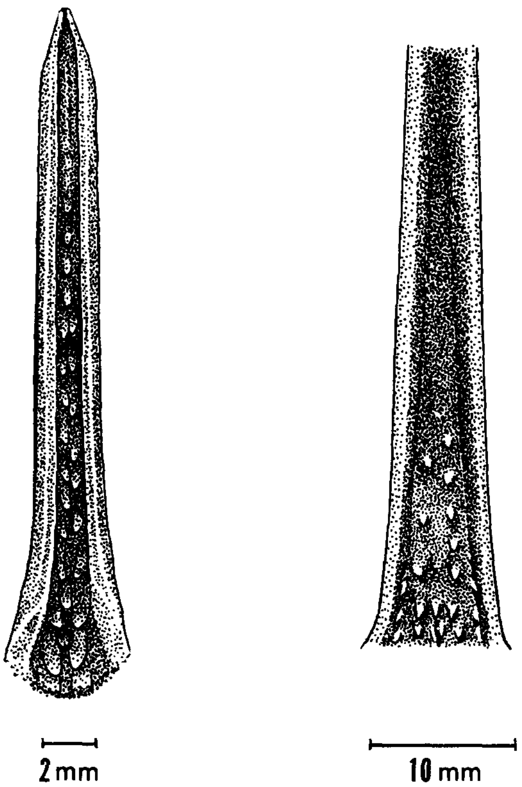

FIGURE 4. Ventral view of the palates of Wilson's Phalarope (left) and American Avocet (right). See text for explanation.

similar and are within the range typical for birds (Skadhauge 1981:table 4). The single pH value from a phalarope, 7.49, is similar to that of domestic Pekin Ducks (*Anas platyrhynchos* var. *domesticus*; Grubb et al. 1978). We previously showed that the body water content of Wilson's Phalaropes does not differ from that of other marine birds (Mahoney and Jehl 1984). Blood chemistry and state of hydration, therefore, indicate no evidence of salt-loading.

Average osmolalities of stomach contents of phalaropes and avocets from different saline and alkaline lakes fall within a narrow range (ca. 429–589 mOsm/kg), only slightly greater than body fluid osmolalities of their prey (brine shrimp, 518–555 mOsm/kg; brine flies, 345–472 mOsm/kg). The lower sodium and higher potassium in the birds' stomachs, compared to the body fluids of their prey, is similar to our findings in grebes (Mahoney and Jehl 1985b) and is probably due to dilution of stomach contents by proventricular secretions that are high in potassium. We conclude that avocets and phalaropes, like the species we had studied earlier, ingest very little lake water and incur only a small salt load (avian blood serum osmolality is ca. 320 mOsm/kg) when feeding on brine shrimp and brine flies, whose body water content is approximately 80–90%.

TABLE 5. Dimensions (mm) of tongues of Wilson's Phalaropes and American Avocets.

	Phalaropes		Avocets	
	Adult	Adult	Adult	Juvenile
Sample size (*n*)	1	1	1	1
Exposed culmen	36.5	28.9	90.5	79.2
Length of tongue	26.5	24.3	28.5	25.9
Width at base	2.0	1.0	6.2	5.4
Thickness at base	1.0	0.9	1.2	1.4

Although phalaropes and avocets can fly to fresh water sources to dilute their salt intake, most of the birds we studied were collected while they were feeding. Therefore, it is unlikely that their stomach contents had been diluted. Previously (Mahoney and Jehl 1985a), we found that California Gulls that had just finished drinking had only slightly lower stomach osmolalities than those that had not.

Like other marine birds, avocets and phalaropes have salt glands, which excrete excess sodium chloride. In some species, these glands undergo rapid hypertrophy when birds move to saline waters, and the degree of hypertrophy is usually a function of the degree of salinity (for review, see Peaker and Linzell 1975; but also see Mahoney and Jehl 1985b). In charadriiform birds, in particular, the size of the salt gland may vary considerably with environmental conditions (Staaland 1967). We found no evidence, however, of extreme hypertrophy that could be associated either with different salinities at the three lakes or, in the case of phalaropes, with the length of time they had resided at Mono Lake. Salt glands of most birds in our study, including the "fat" phalaropes sampled in late July and August, 1984 (cf. Fig. 3), averaged 0.02% body weight, which is low for charadriiform birds; the range for 22 species of this order is 0.01–0.09% (Staaland 1967).

Individual phalaropes may remain at Mono Lake for five to six weeks. In the first portion of their sojourn, they molt heavily and replace nearly all of their body plumage. In the latter portion, they become hyperphagic, add fat for a non-stop migration to South America, and may nearly double their weight (Jehl 1981, unpubl. data). During the molt period, when they use fresh water sporadically at most, the salt glands showed no hypertrophy. In the two weeks or so before emigrating, however, the birds begin to visit fresh water sources every morning and evening. We infer that the great volume of food that is ingested in this hyperphagic period places a temporary osmotic stress on the birds, which is alleviated by drinking fresh water. The hypertrophied salt glands of the 12 birds collected in late July and August, 1984, just before the major emigration, support this hypothesis (Fig. 3).

THE MECHANISM AND EFFICIENCY OF FEEDING

Some filter-feeding birds (e.g., avocets, flamingos, certain dabbling ducks) have obvious anatomical specializations such as bill lamellae and thick tongues for separating tiny prey from the aquatic medium. Other waterbirds (e.g., Eared Grebe; Mahoney and Jehl 1985b) seem to have no special adaptations, but employ a large tongue to squeeze off excess water. Still others (e.g., California Gull; Mahoney and Jehl 1985a) rely on behavioral methods, including head-shaking.

The physiological data reviewed above show that phalaropes and avocets ingest very little lake water while feeding and support the idea that these birds have at least a capacity for primitive filter-feeding (Olson and Feduccia 1980). We infer that both species have subtle anatomical adaptations that enhance straining, and speculate as to how they may operate. The long, attenuated bill of the phalarope allows it to pick prey cleanly from the water surface, and the bill shape enhances rapid runoff of water. When food is brought into the mouth, other adherent water can be removed by compression between the tongue, which nearly fills the cavity, and the palate. Whether the palatal ridges, which are sculptured in the form of a baffle, promote futher lateral drainage, in addition to directing food into the gullet, remains to be determined.

The avocet mouth, with a smaller tongue but harder and more prominent palatal papillae, is somewhat different. Although the papillae certainly assist in retaining slippery prey, they may have a second function. We postulate that food is pressed against the palate by the tongue, but that the papillae, which lie in a small depression, prevent the tongue from making a tight contact. Any fluid that might be present would presumably be extruded laterally, perhaps to drain via papillae in the corners of the mouth. The structural complex seems analogous to the filtering system of baleen whales, except that the strainers are inside the mouth rather than on the borders.

Judged by the osmolality of stomach contents, the filtering system of the phalaropes is more efficient at extruding water than is that of the avocets: mean stomach osmolalities of phalaropes feeding on brine flies was ca. 425 mOsm/kg vs. 525 mOsm/kg for avocets at Mono Lake.

Our results suggest that, although phalaropes and avocets visit freshwater sources sporadically, they may not require fresh water for drinking except, perhaps, when phalaropes are hyperphagic. Bathing to remove salts caked on the plumage may also prompt visits to freshwater sources. Our finding that hypersaline environments do not appear to be physiologically stressful habitats for phalaropes and avocets is not surprising when one considers the natural history of species that occur abundantly in hypersaline situations. Wilson's Phalarope, for example, winters mainly in the altiplano of Bolivia, Chile, and Argentina, at shallow lakes whose salinities range up to 292 ppt (ca. 8,700 mOsm/kg; Hurlbert et al. 1984). These authors also reported hundreds of thousands of phalaropes at a lake whose salinity was 94 ppt (ca. 2,800 mOsm/kg). All of the lakes have freshwater seeps or springs, but whether they were used was not determined.

We conclude that the ability of birds to inhabit challenging hypersaline and alkaline habitats depends upon (i) the hypo-osmolality of their invertebrate prey, which under most conditions probably provide most or all of the fluid they need, and (ii) behavioral and, perhaps, anatomical adaptations for reducing the intake of ions that would have to be excreted. Our findings are similar to those of Purdue and Haines (1977) for the Snowy Plover (*Charadrius alexandrinus*), another species typical of these habitats.

ACKNOWLEDGMENTS

Our research at Mono Lake was supported by the Los Angeles Department of Water and Power, under a cooperative agreement with the U.S. Fish and Wildlife Service. Additional support was provided by Sevylor Boats, Kawasaki Motors of America, Hubbs Research Institute, and Florida Atlantic University. For support and advice on our research at Great Salt Lake and Lake Abert, we thank F. Conte, K. Boula, B. and C. Otani, S. Denny, and D. Paul. M. Boss kindly performed analysis of variance on the data. We thank W. deGraw and an anonymous reviewer for their helpful comments on an earlier version of the manuscript.

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RECENT PUBLICATIONS

Roger Tory Peterson at the Smithsonian.—Richard L. Zusi. 1984. Smithsonian Institution/Mill Pond Press, Inc., Venice, FL. 72 p. Paper cover. $9.95. Source: Smithsonian Institution Press, P.O. Box 1579, Washington, DC 20013; include $1.50 for postage. To mark the 50th anniversary of Peterson's original *Field Guide,* an exhibition was mounted in the National Museum of Natural History during the middle of 1984. It presented well-chosen examples of his artwork from throughout his career, along with a few memorabilia and photographs. Included among the paintings and drawings were early unpublished work, illustrations for books and magazine articles, National Wildlife Federation stamps, limited edition prints, and, of course, some field guide plates. All this is shown in the exhibition catalog, this booklet, together with a brief overview of Peterson's career. The layout is pleasing and the color printing is fine. Admirers and students of bird art will welcome this generous selection at a modest cost.

A natural history of Digges Sound.—A. J. Gaston, D. K. Cairns, R. D. Elliott, and D. G. Noble. 1985. Report Series No. 46,Canadian Wildlife Service. 61 p. Paper cover. Canada $8.00, other countries $9.60. Catalogue No. CW 65-8/46E. Source: Printing and Publishing Supply and Services Canada, Ottawa, Canada K1A 0S9. Digges Sound, situated at the northwestern tip of the Ungava Peninsula, has long been known for its huge colonies of Thick-billed Murres (*Uria lomvia*). Based on four seasons of fieldwork, this report is broader than previous ornithological studies there. It treats the terrestrial and marine environments, the murres and other seabirds, and their predators (ravens, fulls, falcons, and foxes). Analysis of the food web discloses an anomalous situation, with a greater species diversity at lower trophic levels and a lower diversity at higher trophic levels. The findings will be of interest to those who study the ecology of arctic seabird communities. Illustrations, references, appendices of data.

Transactions of the Forty-eighth Federal-Provincial Wildlife Conference.—1984. Canadian Wildlife Service. 291 p. Paper cover. No price given. Catalogue No. CW 69-3/48E. Source: Minister of Supply and Services [Ottawa, Canada]. The latest annual in this series, this volume follows the customary plan for reports on the Conference. The theme, "Team-work in wildlife management," was examined in the keynote address, case studies, and workshops. These exercises showed that management recommendations, however well founded, do not succeed unless they are communicated clearly and tied to the sense of a shared goal. Although these conferences are predominantly by and for Canadians, their messages transcend political boundaries.

Birds of the Cayman Islands.—Patricia Bradley, with photographs by Yves-Jacques Rey-Millet. 1985. Published by P. E. Bradley, George Town, Grand Cayman, Cayman Islands, B.W.I. 246 p. Hard cover. $25.00. The three small Cayman Islands are situated at the extreme northwestern end of the Caribbean island chain. Their avifauna is derived from Cuba, to the north, and Jamaica, to the southeast. This guide describes all 181 species of birds recorded there: breeding birds (45 species), extinct forms, resident and transient winter migrants, and all rare, casual, and accidental species with reliable records. The introduction describes the islands and their major habitats. The species accounts (one-half to one page each) are organized as to field characters, range, Cayman habitat, habits, and status. Close-up photographs of the breeding birds are grouped together in 72 color plates in the middle of the book. Lastly, the book gives directions to good birding areas, accompanied by detailed maps. This sturdy and complete pocket-size guide will be invaluable for resident and transient birders in the Caymans. Selected references, index.