

TABLE 1. Latitude and elevation of sites where field studies of Bobolinks have been conducted.

Location	Latitude (°N)	Elevation (m)	Source
Douglas Lake, Cheboygan County, Michigan	45°33'	219	O. S. Pettingill, Jr. (pers. comm.)
Sauk City, Dane County, Wisconsin	43°16'	231	Martin (1971)
Lakeport, Madison County, New York	43°10'	113	R. L. Kalinoski (pers. comm.)
Bridgeport, Madison County, New York (Shackelton Point)	43°10'	114	This study
P-Ranch, Harney County, Oregon	42°49'	1,400	Wittenberger (1978)
Brooktondale, Tompkins County, New York (Bald Hill)	42°21'	490	This study

Adult Bobolinks routinely left their territories to forage in patches of winter cress and were observed to carry 1-3 cabbage butterfly larvae to nests known to contain nestlings. Lepidopteran larvae were an important food for Bobolink nestlings in Oregon (Wittenberger 1980). It may be that the density and dispersion of the host plant, in combination with spring weather favorable to first generation cabbage butterflies, produced a unique situation locally, allowing double-broodedness in Bobolinks.

I greatly appreciate the assistance of G. H. Farley, S. C. Moore, T. J. Rawinski, and D. A. Takacs in the field. Temporal continuity of the project could not have been maintained without the cooperation of J. L. Forney, Director of the Cornell Biological Field Station, and F. Liddington, owner of the Bald Hill hayfields. D. K. Dawson, B. G. Murray, Jr., V. Nolan Jr., R. T. Reynolds, P. W. Sherman, C. R. Smith, and J. F. Wittenberger provided pertinent comments on the manuscript. This research was supported by the Cornell University Agricultural Experiment Station, New York State College of Agriculture and Life Sciences.

LITERATURE CITED

BENT, A. C. 1958. Life histories of North American blackbirds, orioles, tanagers and allies. U.S. Natl. Mus. Bull. 211.

CODY, M. L. 1971. Ecological aspects of reproduction. Pp. 461-512 in *Avian biology*, vol. 1 (D. S. Farner and J. R. King, Eds.). New York, Academic Press.

ENGELS, W. L. 1969. Photoperiodically induced testicular recrudescence in the transequatorial migrant *Dolichonyx* relative to natural photoperiods. *Biol. Bull.* 137: 256-264.

KLUJVER, H. N. 1951. The population ecology of the great tit, *Parus m. major*. *Ardea* 39: 1-135.

LACK, D. 1968. Ecological adaptations for breeding in birds. London, Chapman and Hall.

MARTIN, S. G. 1971. Polygyny in the Bobolink: habitat quality and the adaptive complex. Unpublished Ph.D. dissertation. Corvallis, Oregon, Oregon State Univ.

PERRINS, C. M. 1965. Population fluctuations and clutch-size in the great tit, *Parus major*. *J. Anim. Ecol.*, 34(3): 601-647.

WITTENBERGER, J. F. 1978. The breeding biology of an isolated Bobolink population in Oregon. *Condor* 80: 355-371.

———. 1980. Vegetation structure, food supply, and polygyny in Bobolinks (*Dolichonyx oryzivorus*). *Ecology* 61: 140-150.

Received 14 February 1983, accepted 8 July 1983.

Plumage Wettability of Aquatic Birds

SHEILA A. MAHONEY

Department of Biological Sciences, Florida Atlantic University, Boca Raton, Florida 33431 USA

Rijke (1970) investigated the feather structure and wettability of breast feathers of 32 aquatic and terrestrial bird families. He found that the breast feathers of terrestrial families tended to be more water repellent on the surface, whereas the feathers of fully aquatic families tended to have greater resistance to

water penetration through the feather layer. Body feathers and flight feathers would be expected to have different characteristics, however, as a result of differences in structure, feather density, and packing; furthermore, maintenance activities, such as preening, also affect wettability.

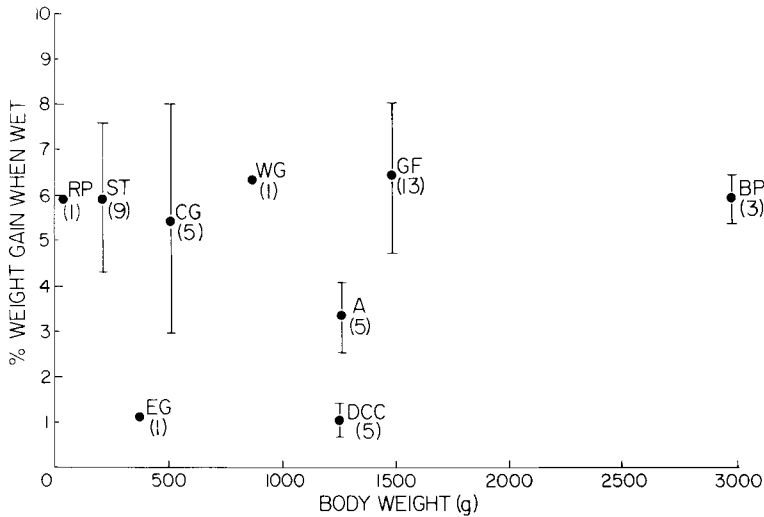


Fig. 1. Plumage wettability of selected aquatic birds. RP = Red Phalarope; ST = Sooty Tern; EG = Eared Grebe; CG = California Gull; WG = Western Gull; A = Anhinga; DCC = Double-crested Cormorant; GF = Great Frigatebird; BP = Brown Pelican. Means are shown plus or minus one standard deviation (vertical lines). Numbers in parentheses are sample sizes.

I define plumage wettability as the percentage gain in body weight that a wet bird experiences. Because it is a whole body measurement, it does not allow one to distinguish between water repellancy and water penetration, as Rijke's model of individual feathers does. Plumage wettability has important energetic consequences for aquatic birds. Wet birds are heavier, and they have increased wing loading and higher energetic costs in flying. Additionally, heat loss from wet birds is greater, because the thermal conductivity of water is 25–30 times that of air.

Because the only data on wettability of the entire body are anecdotal, I examined plumage wettability in a variety of aquatic bird species in order to determine whether or not any general patterns exist among aquatic birds.

I examined plumage wettability in nine aquatic bird species representing seven families; Podicipedidae, Phalaropodidae, Phalacrocoracidae, Anhingidae, Pelicanidae, Fregatidae, and Laridae. All individuals were live, healthy birds. The Double-crested Cormorants (*Phalacrocorax auritus*) and Anhingas (*Anhinga anhinga*) were captured in Florida and held at the Duke University aviary and were 9–12 months old. The Great Frigatebirds (*Fregata minor*) and Sooty Terns (*Sterna fuscata*) were adults caught wild at Midway Atoll, Pacific Ocean. The Eared Grebe (*Podiceps nigricollis*) and California Gulls (*Larus californicus*) were caught wild at Mono Lake, California. The gulls were immatures of 6–8 weeks of age. Joseph Jehl, Jr. generously sampled the Red Phalarope (*Phalaropus fulicaria*) and Western Gull (*Larus occidentalis*) at Hubbs-SeaWorld, San Diego, California. The S.P.C.A. Wild

Bird Care Center in Fort Lauderdale, Florida kindly allowed me to sample captive Brown Pelicans (*Pelecanus occidentalis*).

Plumage wettability was measured by obtaining a bird's dry weight and then submerging the bird in water for several seconds and immediately weighing it again. I held the birds loosely, allowing them to relax their wings while I pushed them completely underwater. Some birds struggled but were unable to open their wings completely. In most cases birds were weighed in a mesh bag, the weight of which was subtracted from the total weight. Anhingas and cormorants were placed on a top-loading balance after a single brisk shake to remove excess surface water. All birds were submerged in fresh water except the terns and frigatebirds, which were submerged in sea water. A series of experiments with the California Gulls, in which fresh water and Mono Lake water (2.5 times the concentration of sea water) were used, indicated that plumage wettability did not differ in the different waters.

Thermal conductance (K) of Anhingas and cormorants was calculated from a rearrangement of the heat balance equation:

$$K = (M - E)/(T_b - T_a),$$

where M is metabolic rate, E is evaporation rate, T_b is body temperature (approximated by cloacal temperature), and T_a is ambient temperature (for details, see Mahoney 1981).

I found no association between body size and plumage wettability (Fig. 1), but there was an asso-

ciation with feeding habits. The six species that are surface feeders gained approximately 6% when wet. Of these, Brown Pelicans also plunge dive but spend most of their time floating on the water surface. Sooty Terns and Great Frigatebirds are unusual among aquatic birds, because they do not normally alight on the water but rather pluck prey from the surface.

The remaining three species (Eared Grebe, Double-crested Cormorant, and Anhinga), which forage by diving and swimming underwater for prolonged periods and to variable depths, had lower plumage wettability. Cormorants and Eared Grebes dive and actively swim underwater to seize prey. Their plumage wettability was only 1% of their body weight. Anhingas were more wettable, gaining 3% of their body weight. Owre (1967) has suggested that Anhingas' greater wettability, as compared to cormorants, decreases their bouyancy and helps them to remain submerged while they swim slowly and stalk prey.

The condition and amount of feathers also affects wettability. The captive cormorants in poor condition gained three times more weight than those in normal plumage (Fig. 2). Anhingas that had molted primaries and rectrices (lost simultaneously in this species) gained two-thirds of the weight that wet anhingas in normal, full plumage gained (Fig. 2). Therefore, primaries and rectrices account for one-third of the plumage wettability of anhingas.

At least some members of all species used in this study could take off in flight when wet. Sooty Terns took off with difficulty, but all became airborne. Of 6 frigatebirds, only 2 (of 4) males could take off from the water when wet and then only with considerable difficulty. Frigatebirds have the lowest wing-loading of all seabirds (Murphy 1936). Magnificent Frigatebird (*Fregata magnificens*) males weigh 10% less than females and have 11% lower wing-loading (Harrington et al. 1972, see also Table 1). Great Frigatebird males are 8% lighter than females, and their wing-loading is presumed to be similar to that of Magnificent Frigatebirds. When wet, wing-loading increases 7% in Great Frigatebird males and 6% in fe-

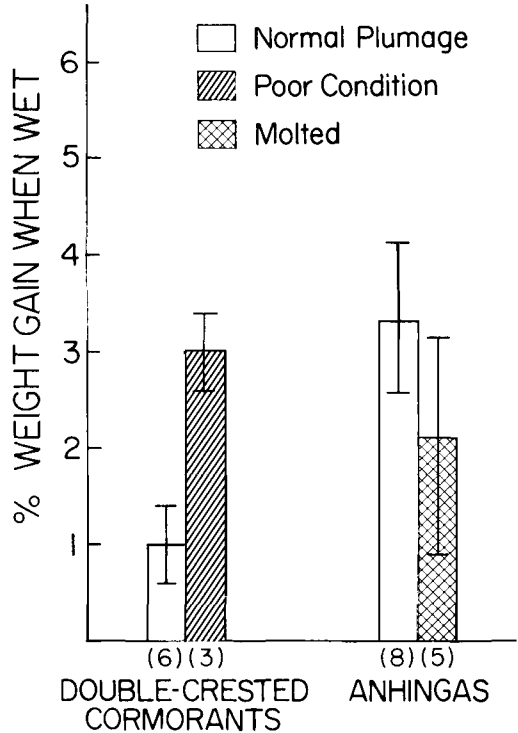


Fig. 2. Plumage wettability of cormorants and Anhingas. Histograms represent means, and vertical lines indicate plus or minus one standard deviation. Numbers in parentheses are sample sizes.

males (Table 1). Only two of the four experimental males and none of the females were able to take off from the water surface when wet, although most birds could fly if they were thrown up in the air.

The effect of plumage wettability on heat loss is shown by changes in whole-body thermal conductance. Anhingas and cormorants are of similar size,

TABLE 1. Wet and dry wing-loading of frigatebirds.*

Species	Dry weight (g)	Wing area (cm ²)	Dry wing-loading (g/cm ²)	Wet weight (g)	Wet wing-loading (g/cm ²)
<i>Fregata magnificens</i>					
Males (n = 5)	1,401 ± 86	3,610 ± 259	0.39	—	—
Females (n = 5)	1,633 ± 143	3,725 ± 203	0.44	—	—
<i>Fregata minor</i>					
Males (n = 4)	1,430 ± 110	3,610 ^b	0.40	1,534 ± 114	0.43
Females (n = 4)	1,596 ± 138	3,725 ^b	0.43	1,684 ± 129	0.45

* Data are expressed as the mean ± one standard deviation where possible.

^b Data from *F. magnificens* (Harrington et al. 1972).

dive for fish, and overlap in habitat and distribution in tropical and subtropical regions. Cormorants, whose plumage is not very wettable (1% gain in body weight), did not experience a significant increase in thermal conductance when wet (3.18 dry vs. 3.60 $W \cdot m^{-2} \cdot ^\circ C^{-1}$ wet). Anhingas, whose plumage is 3 times more wettable than that of cormorants' (3% gain in body weight), underwent a 32% increase in thermal conductance (2.73 dry vs. 3.59 $W \cdot m^{-2} \cdot ^\circ C^{-1}$ wet) and, hence, a 32% greater heat loss when wet (Mahoney 1980, 1981). This consequence of Anhingas' plumage wettability is sufficient to explain why these birds are confined to tropical and subtropical regions (Mahoney 1980, 1981). Cormorants, with low plumage wettability, do not experience increased rates of heat loss when wet and can forage in colder climates, which is reflected by their wider distribution throughout tropical, temperate, and into polar regions (Mahoney 1980, 1981).

Plumage wettability approximated 6% in most of the aquatic bird species examined in this study (body size range from 42 to 2,960 g). Türcek (1966) examined plumage weight in 91 avian species and found that it averaged 6.3% of body weight. If plumage wettability depends upon the amount of plumage, then it too would be expected to be a fixed percentage of body weight. This appears to be the case for the six surface-feeding aquatic taxa examined in this study, whose wettability averaged 6% (the plumage weight of these species is unknown). The plumage wettability of three diving species (1–3%), however, is well below that of the other six aquatic species and presumably is a result of differences in feather weight or structure or plumage organization (density) that act to decrease water penetration into the feathers during diving. Penetration probably depends upon the depth and duration of dive as well, but this could not be examined.

The plumage of all 43 birds used in this study (except some cormorants as noted in the text) appeared to be in normal, healthy condition. I attempted to minimize disturbance to the birds' plumage when handling and dunking them, and I assume that they arranged their feathers "normally" upon submergence. The relatively low variance in the data, despite very small sample sizes in some cases, suggests that the method of handling and weighing was consistent and gave reliable results.

In the two species for which it was calculated, thermal conductance seems to be related to plumage wettability. The distinction between water repellancy and penetration could be more important, however, than differences in plumage wettability. A bird whose plumage was of low penetration and repellance could be wet mainly on the surface feathers, and wettability would not have much effect on thermal conductance (Bernstein and Maxson 1982). Another bird of similar plumage wettability but higher water

penetration, however, would experience an increase in thermal conductance. Anhingas have more wettable plumage than have cormorants, and water probably penetrates deeper into the plumage to produce the observed increase in thermal conductance.

A further cautionary note is that whole-bird plumage wettability obscures regional differences in feather wettability, which could be important for surface-feeding aquatic birds: plumage that is not normally in water may have disproportionately higher wettability (Owre pers. comm.).

Increased weight from wet plumage affected the ability of Sooty Terns and Great Frigatebirds to take off from the water. Although it appears that frigatebirds cannot fly when wing loading exceeds 0.45 (Table 1, wet females), I suggest that the greatest problem for frigatebirds in taking off is not wing loading *per se*, but rather the mechanical difficulties of flapping their long wings (2–2.4-m wing spread) and having short legs with only vestigial webbing, which cannot aid in take-off. Sooty Terns, a much smaller bird, could take off when wet, but did so with some difficulty.

I am grateful to Debbie Crouse, Lincoln Fairchild, Jennifer Granito, Tim Hargrove, and Joseph R. Jehl, Jr., for their help in capturing and wetting birds. Lincoln Fairchild, Joseph R. Jehl, Jr., and Oscar Owre made helpful comments on the manuscript. This work was supported in part by a National Institutes of Health Grant HL-02228 to K. Schmidt-Nielsen, the Herbert and Betty Carnes Fund, the Frank M. Chapman Memorial Fund, and a Research Development Award and Faculty Enhancement Award from Florida Atlantic University.

LITERATURE CITED

- BERNSTEIN, N. P., & S. J. MAXSON. 1982. Absence of wing-spreading behavior in the Antarctic Blue-eyed Shag. *Auk* 99: 588–589.
- HARRINGTON, B. A., R. W. SCHREIBER, & G. WOOLFENDEN. 1972. The distribution of male and female Magnificent Frigatebirds, *Fregata magnificens*, along the Gulf Coast of Florida. *Amer. Birds* 26: 927–931.
- MAHONEY, S. A. 1980. Thermal energetics of Double-crested Cormorants and Anhingas. *Amer. Zool.* 20: 734.
- . 1981. Some aspects of the thermal physiology of Anhingas (*Anhinga anhinga*) and Double-crested Cormorants (*Phalacrocorax auritus*) Pp. 461–470 in *Proceedings of the symposium on birds of the sea and shore, 1979*, Cape Town (J. Cooper, Ed.). African Seabird Group.
- MURPHY, R. C. 1936. *Oceanic birds of South America*, vol. 2. New York, Macmillan Publishing Co.
- OWRE, O. T. 1967. Adaptations for locomotion and

- feeding in the Anhinga and the Double-crested Cormorant. Ornithol. Monogr. No. 6.
- RIJKE, A. M. 1970. The phylogenetic development of water repellancy in water bird feathers. *Ostrich Suppl.* 8: 67-76.
- TÜRCEK, F. J. 1966. On plumage quantity in birds. *Ekologia Polska Series A*, 14(32): 617-634.

Received 18 April 1983, accepted 8 September 1983.

First Record of the Red Phalarope from the Philippines

E. WILLIAM WISCHUSEN,¹ ROBERT S. KENNEDY,^{2,3} AND STEPHEN E. GAST¹

¹The Haribon Society, Room 435, Makati Stock Exchange Building, Ayala Avenue, Makati, Metro Manila Philippines; and ²Department of Zoology, Washington State University, Pullman, Washington 99164-4220 USA

The Red Phalarope (*Phalaropus fulicaria*) is an extremely rare visitor in east and southeast Asia. Étchécopar and Hüe (1978) cite it as a sporadic migrant in China, and King and Dickinson (1975) warn that it "might turn up" in the geographical region of southeast Asia included in their book. There are only two previously documented records of the species south of Japan and China: a specimen from Hsien Shi, Taiwan on 23 February 1968 (Mees 1970), and a sighting of two individuals among a flock of hundreds of Red-necked Phalaropes (*Phalaropus lobatus*) at sea between Santubong and the Turtle Islands, Sarawak in north Borneo on 2-3 October 1968 (Croxall 1969). DuPont (1971) lists the Red-necked Phalarope as the only phalarope known from the Philippines.

On 6 December 1981, Wischusen, Gast, Timothy H. Fisher, and David Simpson found a dead Red Phalarope in a brackish fish pond bordering Tayabas Bay, 4 km east of the municipality of Pagbilao, Quezon Province on the island of Luzon, Philippines. The bird was intact but partially decomposed when found. The preserved specimen is now in the Louisiana State University Museum of Zoology (LSUMZ #105640). Sex could not be determined. It is generally in winter (grey) plumage but a few reddish brown upper tail coverts and abdominal feathers are still present, and the paired 4th and 5th outer rectrices are tipped in cinnamon. Its stomach contained only a small amount of grit and a small gastropod shell.

The bird's presence was probably due to Typhoon "Anding," which originated east of Guam and hit Polillo Island about 100 km northeast of Pagbilao on 24 November 1981 with winds of 240 kph.

Wischusen and Kennedy thank the Marcos Foundation, Bureau of Forest Development, Philippine Airlines, World Wildlife Fund, and National Geographic Society for their generous support. We also thank Edward C. Dickinson for pointing out the two previous records south of Japan and China. This is Contribution No. 7 of the Philippine Eagle Conservation Program. Please address reprint requests to Kennedy.

LITERATURE CITED

- CROXALL, J. P. 1969. Bird notes from Sarawak: September-October 1968. *Sarawak Mus. J.* 17: 391-398.
- DUPONT, J. E. 1971. *Philippine birds*. Greenville, Delaware, Delaware Mus. Nat. Hist.
- ÉTCHÉCOPAR, R. D., & F. HÜE. 1978. *Les oiseaux de Chine de Mongolie et de Corée non passereaux*. Papeete, Tahiti, Les Éditions du Pacifique.
- KING, B. F., & E. C. DICKINSON. 1975. *A field guide to the birds of south-east Asia*. London, Collins.
- MEES, G. F. 1970. Notes on some birds from the island of Formosa (Taiwan). *Zool. Mededelingen* 44(20): 285-304.

Received 17 January 1983, accepted 1 September 1983.

³ Present address: Raptor Information Center, National Wildlife Federation, 1412 16th Street, N.W., Washington, D.C. 20036 USA.