Weather-dependent Foraging of Great Blue Herons (*Ardea herodias*)

R. Russell Bovino[1] and Edward H. Burtt, Jr.[2,3]
[1]*Northshore Drive, Concord, Tennessee 37922 USA and* [2]*Department of Psychology, University of Tennessee, Knoxville, Tennessee 37916 USA*

Weather has been shown to affect the foraging behavior and success of several avian species. For example, changes in winter weather significantly affect foraging "niches" of woodland birds of temperate North America (Grubb 1975, 1978). Dives for fish by Ospreys (*Pandion haliaetus*) are significantly less frequent and significantly less successful when the sun is occluded or the water's surface is rippled than when the sun shines or the water is smooth (Grubb 1977a, 1977b). Meyerriecks (1960) and Kushlan (1976, 1978) describe the foraging behavior of Great Blue Herons (*Ardea herodias*), but foraging success and its dependence on weather and water conditions is unstudied. Here we report the effect of temperature, cloud cover, and wind on the frequency and success of foraging by Great Blue Herons.

On 43 occasions between 2 December 1976 and 5 April 1977, we watched herons foraging in a shallow inlet of Fort Louden Lake, Concord, Knox County, Tennessee. Observation times varied from 0630 to 0900. At the start of each session, we recorded the temperature, sky conditions, and form of precipitation, if any. During March and April, we recorded wind conditions according to the Beaufort force scale and classified the water's surface as either smooth or rippled.

Herons foraged solitarily along the inlet's uninhabited southern shore, arriving soon after sunrise and departing 30–90 min later. Ages and individual identities of the herons were unknown. When foraging, they used the upright stand-and-wait posture (Kushlan 1976) under all weather conditions. A strike was considered successful if a fish was visible in the heron's bill when the bird raised its head from the water or if the heron straightened its neck and swallowed after the strike.

Foraging was not significantly affected by temperature, except that no foraging occurred while the inlet was frozen from 3 January to 2 February 1977. Strikes were more frequent when skies were overcast than when the sun shone (Table 1; $\chi^2 = 5.83$, df = 1, $0.01 < P < 0.02$) or when rain (Table 1; $\chi^2 = 13.93$, df = 1, $P < 0.005$) or snow (Table 1; $\chi^2 = 10.18$, df = 1, $P < 0.005$) was falling. Successful strikes were also more frequent when skies were overcast than when the sun shone (Table 1; $\chi^2 = 5.20$, df = 1, $0.01 < P < 0.02$) or when rain (Table 1; $\chi^2 = 14.33$, df = 1, $P < 0.005$) or snow (Table 1; $\chi^2 = 12.54$, df = 1, $P < 0.005$) was falling.

Reflectance from the water's surface may reduce the heron's ability to see fish. On bright, sunny days, reflectance could be blinding, thereby accounting for the increased intervals between successive strikes and between successive successful strikes by herons foraging under sunny skies as compared with herons foraging under overcast skies.

Reflectance that interferes with vision can be reduced by dark patches near the eyes (Ficken et al. 1971, Burtt in press) or intraocular polaroid filters (Pumphrey 1961). Great Blue Herons have dark plumage and skin surrounding the eye, but a polarizing filter has not been documented among herons, although homing pigeons (*Columba livia*) seem to possess one (Kreithen and Keeton 1974). Furthermore, herons occasionally behave as if to reduce glare off the water by tilting the head so as to move the glare patch out of or to one side of the visual field (Krebs and Partridge 1973), a behavioral pattern we never saw.

Table 1. The effect of weather on the number of strikes and successful strikes by foraging Great Blue Herons.

	Clear	Overcast	Rain	Snow
Min of observation	2,005	570	700	145
Total strikes	469	170	129	19
Strikes/min	0.23	0.30	0.18	0.13
Total successful strikes	194	77	46	4
Successful strikes/min	0.10	0.14	0.07	0.03
% successful strikes	41	45	36	21

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[3] Present address, address for reprints: Department of Zoology, Ohio Wesleyan University, Delaware, Ohio 43015 USA.

TABLE 2. Effect of wind and rippling of the water's surface on foraging behavior under clear skies.

	Calm (Beaufort number ≤ 1)[a]	Windy (Beaufort number ≥ 2)[b]
Min of observation	340	655
Total strikes	147	184
Strikes/min	0.43	0.28
Total successful strikes	73	53
Successful strikes/min	0.21	0.08
% successful strikes	50	29

[a] Beaufort number 1: Direction of wind shown by smoke drift, but not by wind vanes; water unrippled (0.4–1.5 m/s).

[b] Beaufort number 2: Wind felt on face, leaves rustle, ordinary vane moved by wind, water rippled (1.6–3.3 m/s).

Strikes were more frequent (Table 2; $\chi^2 = 10.81$, df = 1, $P < 0.005$), successful strikes were more frequent (Table 2; $\chi^2 = 28.11$, df = 1, $P < 0.005$), and herons were more successful (Table 2; $\chi^2 = 14.23$, df = 1, $P < 0.005$) when winds were calm and the water unrippled. Because of local topography, Grubb (1977b) was able to separate the effect of wind from the effect of rippling. Whereas the foraging success of Ospreys in his studies was not significantly affected by wind alone, foraging success was significantly reduced when wind rippled the water's surface. Presumably fish are less visible beneath a rippled surface (a factor that may explain the reduced success of herons foraging in rain); hence ripples reduce the foraging success of Ospreys and may be the cause of reduced foraging success by Great Blue Herons foraging on windy mornings.

Herons forage more successfully when skies are overcast than when the sun is shining. Why? Perhaps fish are more active on overcast days. Alternatively, dark herons such as the Great Blue may be less conspicuous when seen against a gray sky than when seen against a bright sky. Mock (pers. comm.) found that under a bright sky fish avoid dark herons more than white herons, evidence that indirectly supports the second hypothesis.

Unlike herons, Ospreys forage most successfully under sunny conditions (Grubb 1977a, 1977b). Specular reflectance may account for the difference between fish-eating species as well as for the heron's greater success on overcast days. A Great Blue Heron must strike within reach; hence, it searches a small area only 0.5–1.0 m from its eyes. Specular reflectance off the water could obliterate the entire search area, or the possibility of specular reflectance might necessitate the choice of a less favorable foraging site. An Osprey foraging well above the water can see a large area and strike anywhere within that area. This means that, except when ripples create local specular reflectance in all directions, the Osprey can see some area within striking distance that has minimal specular reflectance. On sunny days there is more direct sunlight penetrating the water so that the Osprey (not blinded by specular reflectance as is the heron) can pick up the specular reflectance from the fish themselves, thus making the Osprey most efficient on sunny days.

Cloud cover, wind that ripples the water, and precipitation affect the foraging success of Great Blue Herons. Together with the results of Grubb (1975, 1977a, 1977b, 1978), Dunn (1973), and Ueoka and Koplin (1973), our results suggest that weather affects the survival of avian species not only directly, through storm-related deaths, but also indirectly, through the impact of weather on foraging success.

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Parental Behavior of a Replacement Male Dark-eyed Junco

THOMAS A. ALLAN[1]
Department of Forestry, Michigan Technological University, Houghton, Michigan 49931 USA

While studying the breeding biology of the Dark-eyed Junco (*Junco hyemalis*) in the jack pine (*Pinus banksiana*) forests of Baraga County, Michigan, I observed the pair formation and parental behavior of a male Dark-eyed Junco that replaced the resident male of a territory after it was killed. I describe here the parental behavior of the male junco to the nestling of its new mate and the sexual behavior of the female junco toward her replacement mate.

On the morning of 27 June 1977 one of three eggs hatched in the junco nest under observation (the remaining two eggs were infertile and were later removed). On that same morning the male holding that territory was found dead in a partially opened mist net nearby. During the 6 h of observation that day, the female brooded the nestling regularly that morning and was observed in the company of a new unbanded male that afternoon. On the next day the new male occasionally followed the female to a tree adjacent to the nest site. The female left the nestling unattended for longer periods of time as she spent increasing amounts of time with the male. Four copulation attempts were observed during 8 h of observation that day. On the second day after hatching, I observed the male in the nest area often and saw it following the female to the nest area as she delivered food to the nestling. Six copulations were observed during 6 h of observation. Such copulatory behavior by the female stands in contrast to the view that sexual behavior in parent birds is usually suspended during the nestling stage (Emlen 1955). On the following day inclement weather appeared to be responsible for an increase in nest attentiveness by the female and a decrease in the feeding rate of the nestling, as I saw the female feed the nestling only twice during 6 h of observation. The male was seen regularly in the area, and two copulations were observed that day, but the male made no effort to feed the nestling. On the fourth day of the male's presence, he began to feed the nestling, contributing 5 of 6 feedings observed during 4 h that day. The male continued to perform more than half of the observed feedings for the following 5 days that the nestling remained in the nest. This is contrary to the normal junco parental behavior that I observed at other nests, where the female assumed a greater proportion of the feeding responsibility as the young increased in age and less time was spent in brooding (Allan 1978). The female in the present case engaged in unusually long brooding periods as the nestling increased in age, leaving the nest when the male returned to feed the nestling and often returning without food. Both parents actively defended the nest with alarm calls and distraction displays when the nest was disturbed. The nestling left the nest 9 days after hatching, and both parents were last observed feeding the nestling when it was 14 days old.

Such behavior by the male junco can be considered maladaptive, as he increases his parental investment by the raising of an unrelated young (Trivers 1972) with no opportunity to increase his fitness. Barash (1977) stated that species that require considerable care for their young should evolve mechanisms that

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[1] Present address: Route 1, Box 85B, Calumet, Michigan 49913 USA.