Diving by wintering Black Ducks: an assessment of atypical foraging

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Introduction

The American Black Duck *Anas rubripes* usually feeds by tipping up or dabbling although it has also been reported to dive in deeper water (Kutz 1940; Kear & Johnsgard 1968), especially during winter when shallow water freezes. Bourget & Chapdelaine (1975) argued that diving is inefficient for surface feeding ducks but they did not quantify the success of this foraging technique. We compared several aspects of diving and tipping up by Black Ducks to determine if the success of these foraging techniques differed, and if so, to examine the factors that contributed to the difference.

Study area

We observed Black Ducks foraging at two sites in the vicinity of Ottawa, Ontario. These sites (A & B) were only 30 km apart and therefore experienced the same overall conditions of temperature and windspeed (Brodsky 1982). None of the ducks was marked. However, because numbers remained nearly constant throughout the study and because ducks were never observed arriving or departing from the study sites (nor were there other open water sites supporting wintering ducks nearby), we assumed that the same individuals remained at each site throughout the study. In January, all of the typical shallow water feeding habitat of Black Ducks had frozen at Site A on the Rideau River. These 10 ducks were then restricted in their foraging efforts to a 0.28 ha patch of deep (2.0–3.8 m) water with strong currents which remained open throughout the study period. The birds foraged exclusively by diving, an atypical feeding method for dabbling ducks. At Site B, a creek carrying warmed tertiary wastes from a sewage treatment plant prevented an area of approximately 6.25 ha of shallow water from freezing and allowed the 185 ducks to forage by tipping up throughout the winter. As part of another study involving these two populations we quantified food availability at both sites (Brodsky & Weatherhead 1984). At Site A the principal food source was *Cladophora* sp., while ducks at Site B fed primarily on *Myriophyllum* sp. Both of these plants are submerged rooted aquatics. We estimated their initial densities as 11.6 dry g/m^2 for *Cladophora* and 13.1 dry g/m^2 for *Myriophyllum*. Although food density was similar at the two sites, the energy value of the food at Site B was considerably higher (*Cladophora* 8.8 kj/dry g; *Myriophyllum* 13.4 kj/dry g; Cummins & Wuycheck 1971).

Methods

We observed foraging activity at Site A on 16 days between 28 December 1981 and 16 March 1982 for a total of 18 hours and at Site B on 10 days between 26 January and 24 February 1982 for a total of 20 hours. Foraging was monitored using a spotting scope for at least 2 hours each day between 0800 hr and 1600 hr EST. We measured the depth of water where the ducks were foraging, and the air temperature [T(a)] and the wind speed (W) at the end of each observation period. Temperatures and wind speed were measured at ground level with a hot wire anemometer and were converted to windchill values [T(c)] using the following formula from the Environment Canada Weather Office: $T(c) = 33-[(0.227\,W + 0.45 - 0.0118\,\sqrt{W})\,(33 - T(a))]$. Although windchill temperatures do not apply directly to waterfowl, heat loss in waterfowl increases with wind speed (Harvey 1971) and windchill temperatures therefore provide an index of the combined effects of wind speed and air temperature.

We recorded the duration of foraging bouts: the time from when a duck began to forage until it switched to another activity. Foraging rates were calculated as the total number of foraging attempts in a 60 s interval during a bout. We recorded the duration of each of 10 consecutive foraging attempts (dives or tip-ups) using randomly selected individuals. During these observations, we recorded the duration of the intervals between every tip-up and between every other dive. Using the first two individuals monitored in an observation period (10

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foraging attempts each), we also recorded the number of attempts in which a duck surfaced with vegetation hanging from its bill. This provided a crude measure of foraging success although ducks may have swallowed food under water.

Results

We performed student t-tests to determine if the measures characterizing diving differed significantly from those for tipping up (Table 1). We recorded more tip ups than dives in a 60 s period because of the longer mean time per dive and the longer mean pause time between dives. Upon surfacing, ducks that were tipping swallowed the food in their bill and immediately tipped up again while those that were diving surfaced, swallowed and then rested before diving again.

In addition to the differences recorded in mean foraging and pause time, the duration of dives and subsequent pauses were more variable than the duration of tip ups and subsequent pauses respectively ($F = 3.86$, d.f. = 198, 1372, $p<0.01$ for foraging times; $F = 7.80$, d.f. = 398, 618, $p<0.01$ for pause times). Since the foraging variables measured for tipping up were relatively constant, they were apparently not greatly influenced by windchill temperatures which varied considerably during the sampling period (–30°C to 0°C). The consistency of foraging times may reflect the uniformity of water depths measured at Site B (0.40–0.45 m). To determine whether the greater variability in foraging parameters for diving at Site A could be explained by environmental variability we analyzed diving relative to variation in water depth and windchill temperature. Ducks were observed to dive in 3 discrete areas within the 0.28 ha patch of open water at Site A (Table 2) which differed considerably in water depth. Dive times were significantly longer in deeper water while pause times did not vary significantly (Table 2).

Windchill temperatures recorded while ducks were diving ranged from –25 to –6°C. Linear regression analysis indicated that windchill temperature did not influence mean dive time ($r = -0.24$, $N = 18$, $p>0.20$) (Fig. 1). As the windchill temperature decreased, however, the mean pause time increased (Fig. 2). Mean pause time was independent of mean dive time ($r = 0.16$, $N = 18$, $p>0.25$).

If we assume that a foraging attempt was successful when a duck surfaced with food

Table 1. Diving vs. tipping up: a comparison of foraging methods used by two groups of wintering Black Ducks in Ottawa, Canada.

	Diving (Site A)			Tipping up (Site B)			Student's	p
	X+S.D.	Range	N	X+S.D.	Range	N	t	
Duration of foraging bout in minutes	13.2±5.5	7–20	26	48.1±14.0	30–65	20	11.6	<0.001
Duration of foraging attempt in seconds	7.6±2.7	5–15	1375	5.5±0.7	4–7	200	27.9	<0.001
Number of foraging attempts per minute	4.0±2.1	2–8	315	10.1±1.4	9–13	200	41.2	<0.001
Duration of pause in seconds	7.9±3.9	4–21	621	1.0±0.5	1–12	400	96.9	<0.001

Table 2. Duration of dives and pauses by Black Ducks at different water depths. Dives were significantly longer in deeper water (ANOVA, $F=192.6$, d.f.=2, 1372, $p<0.01$). Pauses did not vary significantly (ANOVA, $F=2.3$, d.f.=2, 618, $p>0.05$).

	Dive duration (in seconds)		Pause duration (in seconds)	
Water depth	X + S.D.	N	X + S.D.	N
2.0 m	5.45 ± 0.10	325	7.64 ± 0.72	147
2.7 m	7.63 ± 0.16	535	7.82 ± 0.63	240
3.8 m	9.67 ± 0.14	515	7.36 ± 0.55	234

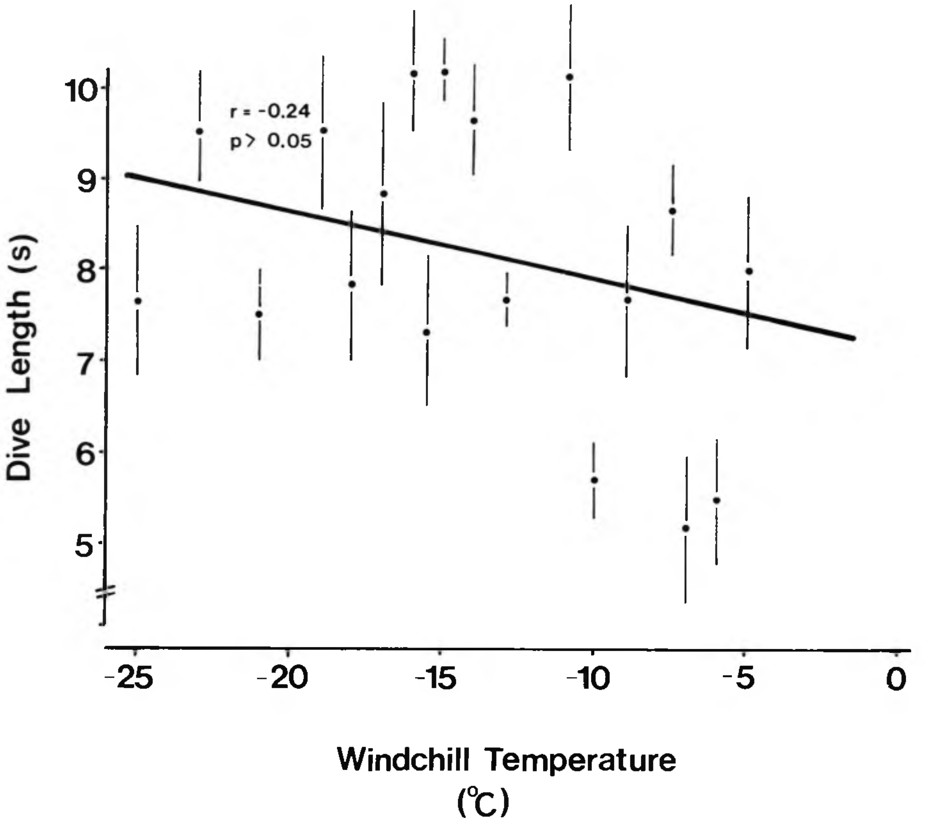

Figure 1. Changes in dive duration at different windchill temperatures. Dots indicate the mean dive duration recorded at a particular windchill. Vertical lines represent one standard deviation. Regression calculated from means.

visible in its bill, then for ducks tipping up, 138 of the 200 (69%) foraging attempts were successful but only 135 of 320 (42%) dives were successful, indicating a highly significant difference between foraging techniques (x^2 = 34.41, d.f. = 1, $p<0.001$). This does not account for variability in the amount of food obtained or for foraging attempts in which the food obtained was too minimal for us to see. Nonetheless, it provides the best measure of the relative success by ducks using the different foraging techniques. Combining the apparent difference in foraging success with the differences in foraging rate and the duration of foraging bouts indicates that based on the rate of food intake, diving was much less efficient than tipping up.

Discussion

The poorer foraging efficiency realized by diving Black Ducks when compared to those tipping up is not surprising since this species is not well adapted to diving. Black Ducks lack the relatively small wings, short bodies, wide feet and short tails characteristic of diving species. Also, the infrequent use of diving may mean that a lack of experience of diving contributes to the lower efficiency achieved.

The increase in dive times recorded in deeper water at Site A is presumably a simple consequence of the greater time required to swim deeper, search for food and resurface. Dow (1964) reported a similar relationship between dive times and

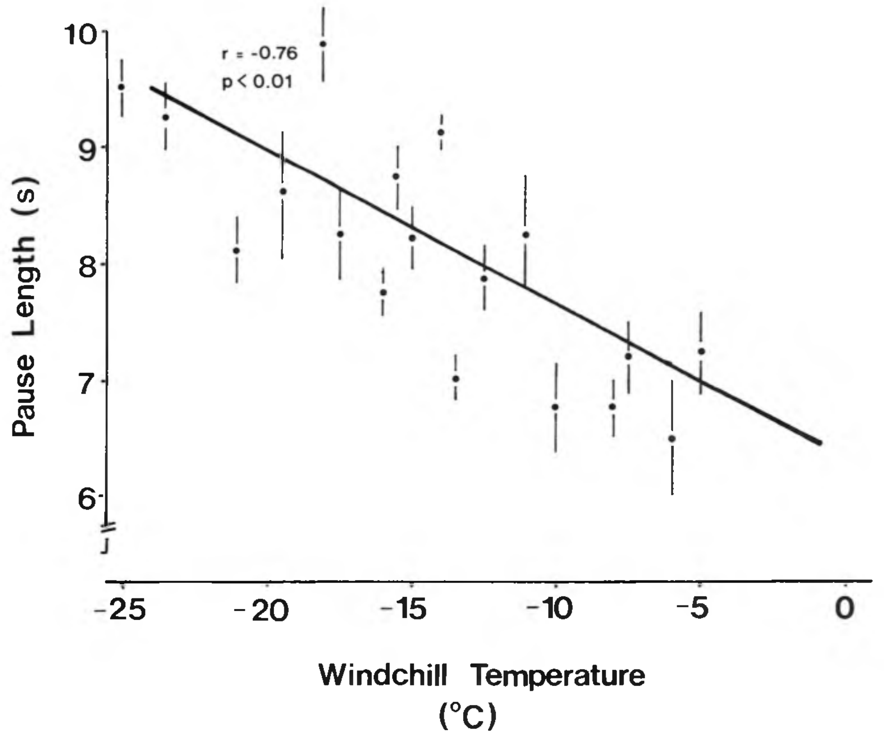

Figure 2. Changes in pause duration at different windchill temperatures. Dots indicate the mean pause duration recorded at a particular windchill. Vertical lines represent one standard deviation. Regression calculated from means.

water depth for seven species of diving birds including four species of ducks. The dive times we measured for Black Ducks were much shorter, however, than those measured by Dow (1964) for ducks that normally forage by diving. For example, the mean dive time of the Common Goldeneye *Bucephala clangula* was 24 s and for the Red-breasted Merganser *Mergus serrator* 42 s in 1–2 m of water. In this study the mean dive time for Black Ducks in 2.0 m of water was 5.5 s. This is similar to the range of 4–6 s recorded for Mallard *Anas platyrhynchos* in 1–2 m of water (Szijj 1965, cited in Bourget & Chapdelaine 1975) and 6.5 s in 0.6–1.5 m of water reported for Northern Pintail *Anas acuta* by Miller (1983). The substantial differences in dive times between ducks that normally dive and dabbling ducks which dive facultatively are a consequence of both morphological and physiological differences which enable diving ducks to remain submerged longer (Dow 1964) and the longer time taken by piscivorous diving birds to secure their prey.

The longer pauses we observed following dives relative to tip ups is similar to that reported by Miller (1983) for Northern Pintail. This difference presumably reflects the greater energetic cost of diving relative to tipping up and the consequent longer rest period required between dives. In spite of a dive being energetically more costly to a Black Duck than a tip up, much of the variation in pause duration between dives was explained by windchill rather than dive duration. This differs from results reported for diving birds (Dow 1964; Morrison *et al.* 1978) in which pause durations were positively correlated with dive durations. That pause durations were longer when windchill temperatures decreased suggests that diving became energetically more costly with respect to maintenance costs for Black Ducks in colder weather, thereby requiring longer recovery periods between dives. The consequent decreased diving rate in cold weather further reduces the foraging effectiveness of diving Black Ducks relative to those that were tipping up.

By virtually every basis of comparison, we judged diving to be an inferior foraging technique to tipping up for wintering Black Ducks. Nonetheless, 8 of the original 10 ducks at Site A survived a winter, for which local weather records showed the coldest January in 50 years, by diving for food that was of poorer quality than that available to the ducks tipping up. Ten birds are too small a sample from which to estimate rates of survival. However, the fact that birds survived the conditions at Site A indicates that some Black Ducks can survive a harsh winter even when forced to feed by diving.

Given the fact of the ducks' survival one might argue that it is inappropriate to talk of diving as an inefficient foraging method for wintering Black Ducks. The results of this study could be interpreted as showing only that i) Black Ducks are opportunistic foragers that can readily adapt to different feeding conditions and ii) they choose wintering sites with enough food available so that they can survive even if forced to feed by diving. However, to conclude that diving is as good as tipping up because both allow survival in a harsh winter is to confuse survival with fitness. In a related study (Brodsky & Weatherhead 1984) we found that the ducks that foraged by diving initiated courtship later in the spring and devoted less time to courtship than the ducks that foraged by tipping up. If these effects result in a delayed initiation of breeding and subsequent lower reproductive success (Sayler & Afton 1981), then diving would truly be a less efficient method of foraging than tipping up for wintering Black Ducks.

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Summary

Two wintering populations of Black Ducks *Anas rubripes* differed in the foraging technique they employed (tipping up vs. diving). Our results indicated that tipping up, the natural foraging technique for dabbling ducks, was far superior to diving. This superiority resulted from an apparent higher rate of success, a higher foraging rate, longer foraging bouts and lower foraging costs, particularly in colder weather, for tipping up. In spite of the apparent inefficiency of diving by a dabbling duck, 8 of the 10 ducks in the diving group survived the winter. This suggests that Black Ducks select wintering sites which provide a margin of energy large enough to allow such flexibility in foraging behaviour.

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