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Stomach flushing: sampling the diet of Red-cockaded Woodpeckers.—Stomach flushing is one of several non-destructive methods recommended by Rosenberg and Cooper (1990) to ascertain diets of wild birds. Brensing (1977) and Jenni et al. (1990) described the method and documented its lack of effects on the short term survival of passerines. Moody (1970) reported some mortality during use of the procedure on nestlings. He did not study the effects of the procedure on subsequent survival. Here I describe a similar technique I used on adult Red-cockaded Woodpeckers (*Picoides borealis*) in the Apalachicola National Forest in northern Florida. I also describe tests of whether flushing affected the fledging rates and survival of nestlings.

Methods.—To flush the stomach and esophagus of a Red-cockaded Woodpecker, I used a plastic tube of 4 mm outside diameter attached to a 12 cc syringe filled with sterile 0.9% solution of sodium chloride. The tube was moistened with the saline solution for lubrication and inserted into the bird approximately 9 cm. No force was required. Special care must be taken to align the tube properly at the point where the esophagus enters the body cavity to insure easy insertion. Once the tube entered the stomach it slid to the bottom, stopping just above the entrance to the gizzard. The bird was then inverted over a plastic cup so that, as fluid was forced into its stomach, the excess fluid plus the stomach contents flowed into the cup. The process was completed in less than two minutes.

Thirty adult woodpeckers were flushed between August 1993 and May 1994. An additional 21 adult birds were flushed between June 1994 and December 1994. Approximately four birds were flushed per month. Each bird was captured as it went to roost for the night. To avoid stress-related mortality, flushing was not attempted on nights when the dry-bulb temperature was expected to fall below 4°C. Although no birds appeared to be harmed by the process, the first ten were checked for evidence of weakness or mortality in the first days after they were flushed. In each case the flushed bird was still present one week later. Because adult Red-cockaded Woodpeckers are highly territorial and often remain in the same territory for their adult lives, mortality rates of flushed and non-flushed individuals could be estimated by subsequent monitoring. Direct calculation of adult mortality rates is difficult because some movement among sites occurs. The criterion I used was a comparison of the rates at which flushed and non-flushed birds disappeared from their social groups, as measured by an annual census of banded birds. This census was conducted at the end of the nesting season in a sample population of 160 of the approximately 500 social groups on the Apalachicola Ranger District of the Apalachicola National Forest.

The same technique used to flush adults was used on nestlings. They were pulled from their nests with a noose at 5–8 days of age (Jackson, 1982). Each nestling was banded and weighed prior to being flushed. Only the largest nestling in each nest was flushed. In the non-flushed control group, nestlings were pulled, weighed and banded but not flushed. In 1993, 21 nestlings were flushed; in 1994 an additional 22 nestlings were flushed.

Mortality rates of nestlings were determined by visiting each social group 30 days after hatching and observing each group until all birds had been identified by their unique color bands. If color bands were not seen on the first visit, additional visits were made until all birds had been identified. One juvenile bird had to be eliminated from the analysis for 1994 because only one of the two nestmates fledged. That juvenile's color bands were not seen prior to its disappearance. In the analysis of nestling mortality rates, data for each year were analyzed separately and jointly.

Results.—Adult Red-cockaded Woodpeckers were not affected by the flushing process. Surprisingly, flushed birds showed even higher retention rates (83%) than did non-flushed birds (71%) (Table 1), but these differences were not significant (χ^2 = 2.0, P = 0.16 N = 30, 161). In the 1994–1995 season, 81% of the flushed adult birds remained in their groups through the 1995 nesting season compared to 73% for the non-flushed birds (χ^2 = .62, P = 0.43 N = 21, 211). Although there were differences in the retention rates of males and females, these differences were ignored in the analysis, because in most cases flushed birds had higher retention rates than did non-flushed birds.

Stomach flushing of the largest nestling in each nest had no apparent immediate effects, and all flushed nestlings were returned to their nests. Of the 21 birds flushed in June 1993, 10 (47%) fledged. This percentage was lower than the fledging rate for all 264 nestlings banded in 1993 (72%) and lower than the fledging rate of other largest nestlings banded in June (58%). However the latter difference was not significantly different (χ^2 = 0.47, P = 0.40, N = 21 flushed, 17 nonflushed).

Twenty-one additional nestlings that were the largest in their nest were flushed in 1994 and were compared to the 110 largest non-flushed nestlings banded in that year. Again the fledging rate of non-flushed birds (81%) was higher than that of flushed birds (62%). However, when other factors were examined, it became apparent that flushing was not the major cause of this result. Rates of fledging success declined as the season progressed. Eighty-four percent of the 96 non-flushed nestlings that hatched prior to 15 May in 1994 fledged, but only 57% of the 14 non-flushed nestlings hatched after 15 May fledged. Because in 1994 13% of the non-flushed, but 47% of the flushed nestlings were hatched after 15 May, this seasonal effect must be controlled in an evaluation of the effect of flushing. If only those nestlings that hatched early in the season are compared, the differences of 84% fledged for the non-flushed and 73% for the flushed, are not significant (χ^2 = 0.96, P = 0.32, N = 96, 11). The same nonsignificant relationship holds true for late nestlings, of which 57% of the unflushed birds fledged, and 50% of the flushed birds fledged (χ^2 = 0.12, P = 0.73, N = 14, 10).

When multiple 2 × 2 tables give similar results that are not significant, it is possible to combine their evidence and strengthen the analysis with a Mantel-Hansen test of common odds ratios (Snedecor and Cochran 1980). This test on the three chi square tests reported above gave a similarly nonsignificant result (single-tailed test, P = 0.126).

To test possible effects on nestmates of siblings that were flushed, data from late nests (in which eggs hatched after 15 May) in both years were combined into one analysis. Fledging rates of the second largest nestlings in nests in which the largest was either flushed or not flushed were compared. In late nests of 19 second nestlings with older sibs that had been flushed, only 26% fledged. Of the 22 second nestlings with older sibs that had not been flushed, 59% fledged. This difference is significant (χ^2 = 4.45 P = .035 N = 41).

TABLE 1

RETENTION RATES BETWEEN ANNUAL CENSUSES TAKEN AT THE END OF THE BREEDING SEASON OF FLUSHED AND NON-FLUSHED ADULT RED-COCKADED WOODPECKERS

Category	Males		Females		Total			
	N	%	N	%	N	%	χ^2	P
Retained in 1994								
Flushed 1993	18	83%	12	83%	30	83%		
Non-flushed 1993	107	72%	54	65%	161	71%	2.0	0.157
Retained in 1995								
Flushed 1994	17	76%	4	100%	21	81%		
Non-flushed 1994	138	78%	73	63%	211	73%	0.62	0.43
Retained in 1995								
Flushed 1993[a]	15	100%	10	60%	25	84%		
Non-flushed 1993[a]	79	75%	35	71%	114	74%	1.18	0.28

[a] 1995 Retention of birds that were present in 1993 and 1994.

However, this effect was not seen in the sibs of flushed and non-flushed nestlings in early nests. In early nests 83% of 81 nestlings with older non-flushed sibs fledged, and 82% of 11 nestlings with flushed sibs fledged.

Discussion.—Direct studies of the diets of wild birds, although often relevant to research questions, are uncommon in the literature (see review by Rosenberg and Cooper 1990). This lack of diet work may be attributable in part to a desire not to damage the studied population. In the present study, stomach flushing had no statistically significant effects on subsequent survival of adult Red-cockaded Woodpeckers. In fact, there was higher (nonsignificant) survival of flushed adult birds which could not be due to the flushing procedure and is probably a random effect. This lack of an effect of flushing on adult survival supports the conclusions of Brensing (1977), who had flushed 2100 passerines and reported no loss in weight of recaptured birds. Ford et al. (1982), who used the technique on Australian passerines, reported virtually no mortality during the procedure, Jenni et al. (1990) flushed warblers and reported mortality of less than 1% during handling. These researchers were using short-term recapture rates of adult birds in mist nets to make assessments about survival rates. Their recapture rates were approximately 30% for both flushed and non-flushed birds. In my study, longer term differences could be assessed. Even so, the results still suggest that the procedure does not adversely affect the survival rates of adult birds.

Because the flushed nestlings and their brood mates did show a lower survival rate than the control groups, I recommend caution when considering the flushing technique for nestlings. The largest effect of the procedure was not on the flushed nestlings themselves but on their nestmates, where flushing of late season nestlings was associated with a significantly reduced survival rate of their sibs. Apparently some factor in the environment reduces the success rate of late nests and flushing causes additional stress. This environmental factor may be related to food abundance.

My observations indicate that woodpeckers often hatch more chicks than survive to banding age and that the mortality of these nestlings is related to competition among them for food. Siblings pulled from a nest at 5–8 days of age can have up to a 12 g difference in their weights between the largest and smallest nestling, even though hatching occurs almost simultaneously for the first two nestlings. The smaller nestlings usually appear emaciated and do not have the enlarged stomachs characteristic of healthy nestlings. This difference in fledging rate is most pronounced for the smallest nestlings in a nest. In both 1994 and 1995, the fledging rate of the third largest nestling at banding time was 12% less than that of the largest nestling. At the time of banding in 1994, even though sibs hatched at approximately the same time, there was a 2.1 g difference in the mean weights of the largest and the second largest nestling. This difference was associated with a 4% decrease in their survival. In 1995 there was a 2.5 g difference and a 5.5% difference in survival. Thus it appears that survival to fledging is highly sensitive to food resources. Perhaps the one time removal of stomach contents from the largest chick increased its subsequent demand for food and led to the reduced chances for survival of its nestmates, even though there was no apparent direct effect of the procedure on the survival of the flushed nestling.

I conclude that stomach flushing can be an effective non-destructive method of sampling the diet of small adult and nestling birds, including endangered species. Even so, only well-trained researchers should use it, and it is not recommended for use on nestlings in small populations. The full effect of the procedure on nestlings and their sibs is still unclear. Additional studies are needed on other species using larger sample sizes. Analyses of the samples collected in this study will be reported elsewhere (Hess and James, in press; James et al. 1997).

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Morphological differences among populations of House Sparrows from different altitudes in Saudi Arabia.—The House Sparrow (*Passer domesticus*) is widely distributed throughout the world, both as a result of introduction and natural spread from Africa (Summers-Smith 1988, 1990). Johnston and Selander (1973) examined geographical variation in House Sparrow populations from both North America and Europe and found that the degree of geographical variation within North America is less than in Europe. This is presumably because sparrows have relatively recently become established in North America. In this paper we study differences between two populations of House Sparrows (*P. d. indicus*) separated by only 150 km, and which are close to the center of their ancient range (Summers-Smith 1988).

Study area and methods.—We examined morphology of sparrows at two different locations in Saudi Arabia. The first is at Taif (21°04′N, 40°16′E, elevation 1900 m) and the second at King Abdul-Aziz University campus in Jeddah (21°30′N, 39°12′E) on the Red