

### Consumption of Green Wheat Enhances Photostimulated Ovarian Growth in White-crowned Sparrows

AMELIA O. ETTINGER AND JAMES R. KING

*Department of Zoology, Washington State University, Pullman, Washington 99164 USA*

For many years we have observed that White-crowned Sparrows (*Zonotrichia leucophrys gambelii*) that overwinter in southeastern Washington shift from predominantly seed-eating to predominantly grazing on green grass as soon as it emerges in mid- to late February. Morton (1967) described this shift in detail and noted a later shift, in late March and early April, to nearly exclusive feeding on buds, mainly of hackberry (*Celtis douglasii*). Gonadal recrudescence in this population of White-crowned Sparrows begins in February (King et al. 1966). In view of the correlation between the onset of gonadal growth and the shift in food source, we hypothesized that substances in green plants may have hormone-like effects akin to those found in rodents, rabbits, and quail. Green plants contain substances that are known to enhance reproductive functions in rodents and rabbits (Friedman and Friedman 1939, Bradbury and White 1954, Pinter and Negus 1965, Hinkley 1966, Negus and Pinter 1966, Berger and Negus 1974) and to inhibit reproduction in voles (Berger et al. 1977). Reproduction in California Quail (*Lophortyx californicus*) is inhibited, perhaps by estrogen analogs, in dry years in which the quail consume large amounts of dry, stunted, green vegetation (Leopold et al. 1976). Evidently nothing further is known about the potential role of green plant substances in avian reproduction. As a by-product of other investigations, we therefore examined this role experimentally by photostimulating White-crowned Sparrows fed either a standard ration (controls) or a standard ration mixed with fresh, green wheat leaves (experimentals). Because we do not intend to continue this opportunistic experiment beyond a pilot stage, we report its results here briefly for consideration by other investigators.

We captured White-crowned Sparrows near Pullman, southeastern Washington in September and October and kept them in an outdoor aviary until 26 November, by which time the photorefractory period had ended (Farner and Mewaldt 1955). We then transferred 35 birds to a constant-condition room with a photoperiod of 18L:6D and maintained them as previously described (Farner and Wilson 1957). We supplied 18 birds with pulverized chick-starter mash *ad libitum* and 17 birds with this mash combined with freshly sprouted wheat leaves (germinated on wet filter paper without chemical additives). The mash and wheat leaves [1:1.3 w/w, a ratio equivalent to that used by Hinkley (1966)] were mixed in a blender to form a homogeneous, green, and slightly aromatic powder. After 20 days of photostimulation (i.e. during the log-linear phase of gonadal growth), we killed the birds, excised their testes, ovaries, or oviducts, and weighed the fixed organs to the nearest 0.1 mg by routine methods (Farner and Wilson 1957, Farner et al. 1966). Owing to a shortage of birds, we did not include a zero-day control group, but this omission is not crucial to the interpretation of our results. Ample experience with overwintering populations of White-crowned Sparrows in southeastern Washington has shown that testicular weight and ovarian weights are about 0.8–1.3 mg (Farner and Wilson 1957) and 3.4 mg (Farner et al. 1966), respectively, at the end of November.

The mean body weights of the control and wheat-fed birds did not differ significantly at the end of the experiment (Table 1). Mean testicular weights of the two groups also were essentially identical, as were mean oviductal weights; but the mean ovarian weight of the wheat-fed birds exceeded ( $P < 0.05$ ) that of the control birds by 58% (Table 1). Kern (1970) showed that exogenous estradiol cypionate potentiated photostimulated oviductal growth but inhibited ovarian growth in White-crowned Sparrows. The data in Table 1, therefore, indicate that a substance or substances in green wheat had a gonadotropic rather than an estrogenic effect in females. This result resembles that of experiments wherein dietary supplements of fresh lettuce increased uterine weight in intact *Microtus montanus* but not in ovariectomized ones (Berger and Negus 1974). The lettuce had a gonadotropic but not an estrogenic effect.

Contrary to the ovarian effect, consumption of green wheat did not potentiate testicular growth in White-crowned Sparrows (Table 1). The simplest explanation for this is that the testes were growing at a maximum rate, which could not be enhanced by the active substance(s) in the wheat. This hypothesis can be tested by feeding the ration to birds kept either on a nonstimulatory photoperiod or on a photoperiod that causes a slower rate of testicular growth than 18L:6D. It is not clear from our experiments, or from earlier ones with other species, whether the active substance in green plants is gonadotropin-like or a pituitary or hypothalamic secretagogue that stimulates the release of gonadotropins or their releasing hormones. Bradbury (1944) thought that the "rabbit ovulating factor" extracted from green plants was a secretagogue. This is consistent with the observations by Hinkley (1966) that feeding green wheat to *Microtus montanus* results in nearly the doubling of gonadotropic cells in the anterior pituitary gland.

TABLE 1. Body weights (g, mean  $\pm$  SE,  $n$ ) of White-crowned Sparrows and weights of their sexual organs (mg) after 20 days of photostimulation (18L:6D) with and without green wheat supplement.

Treatment	Females			Males	
	Body weight	Ovarian weight	Oviducal weight	Body weight	Testicular weight
With wheat	28.2 $\pm$ 0.71 (12)	25.0 $\pm$ 3.66 (12) <sup>a</sup>	6.4 $\pm$ 0.99 (12)	32.1 $\pm$ 1.24 (5)	74.8 $\pm$ 4.74 (5)
Without wheat	28.6 $\pm$ 0.74 (13)	15.8 $\pm$ 1.48 (13) <sup>a</sup>	6.2 $\pm$ 1.30 (11)	31.7 $\pm$ 0.74 (5)	74.5 $\pm$ 17.61 (5)

<sup>a</sup> 0.05 <  $P$  < 0.02 (all other paired means not significantly different,  $P$  > 0.05).

It is likewise not clear whether the potentiating effect of green leaves on ovarian growth is ecologically significant. Photostimulated ovarian growth in White-crowned Sparrows is approximately linear for at least 30 days (Farner et al. 1966) and can be described by the equation:  $\log W_t = \log W_o + kt$ , where  $W_t$  is ovarian weight after  $t$  days of photostimulation,  $W_o$  is initial ovarian weight, and  $k$  is the logarithmic growth-rate constant (days<sup>-1</sup>). If initial ovarian weight in both control and wheat-fed birds averaged 3.4 mg (Farner et al. 1966: Fig. 2), then we estimate from the foregoing equation that the consumption of green wheat leaves accelerated ovarian growth by about 6 days during the 20-day experiment (i.e. the control group would require about 26 days of photostimulation to attain the mean ovarian weight reached by the wheat-fed group in 20 days). An acceleration of 6 days in 20 is potentially significant, but we are unable to devise a clear-cut way to extrapolate this result into a natural setting where the photoperiod changes daily over approximately 90 days between the onset of ovarian growth and the onset of migration. It thus remains moot whether gonadotropic substances in green vegetation are significant proximate regulators of the ovarian cycle of White-crowned Sparrows.

Finally, the avid feeding by White-crowned Sparrows on green vegetation in late winter and spring may be primarily for nutritional advantages that only fortuitously involve gonadotropic effects having no deleterious effects on fitness. We offer two speculations about nutritional advantages: (1) The close correlation between the onset of prenuptial molt (Mewaldt and King 1978) and the consumption of green vegetation suggests that the birds may preferentially eat a protein-rich vegetable food to support the cost of molt early in the season before arthropods become available. The crude protein of green leaves is maximal (averaging about 20.2%) at the beginning of the growing season and progressively decreases through the spring and summer to about 5.5% (Kuppuswamy et al. 1958). In contrast, the crude protein content of the seeds of eight species of wild grasses and forbs averages 14.5% (Bump et al. 1947: Table 172). The apparent advantage of eating young grass for its higher protein content may be diluted by a lesser digestibility of leaves than seeds (as exemplified in tests on laboratory mammals: Kuppuswamy et al. 1958), but we have been unable to unearth information on relative digestibilities of various foods for nongalliform birds. Nevertheless, preferential feeding on rich foods during periods of special nutritional demand is well known (e.g. Goldberg et al. 1980) and should not be overlooked as an explanation for the pattern observed in White-crowned Sparrows. (2) White-crowned Sparrows may switch to grazing on green grass late in the winter simply because the supply of seeds has become depleted so that it is more efficient to forage for grass.

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### **Wing- and Tail-flapping in Anhingas: a Possible Method for Drying in the Absence of Sun**

ANN M. FRANCIS

*Department of Zoology, Birge Hall, University of Wisconsin, Madison, Wisconsin 53706 USA*

Anhingas (*Anhinga anhinga*) commonly spread their wings and perch in the sun, ostensibly to dry wettable feathers (Bent 1922, Life histories of North American Petrels and Pelicans and their allies, Washington, U.S. Natl. Mus. Bull. 230). The flight feathers themselves appear not to become appreciably wet, but the body feathers absorb water that helps reduce the submerged bird's buoyancy (Owre 1967, *Ornithol. Monogr.* 6: 61; see also Casler 1973, *Auk* 90: 324). While drying, the wings and tail are usually held open but immobile, presumably to allow sunlight and breeze to strike the body plumage. I observed two perched Anhingas flapping their spread wings and tails after emerging from the water, however, a behavioral pattern not reported in the literature.

The behavior occurred at Wakulla Springs, Florida just after sunset (1815 E.S.T.) on 12 March 1980, an overcast day with occasional drizzle. The birds vertically raised and lowered both wings simultaneously through a 60° arc ( $\pm 30^\circ$  from the horizontal). The tail also moved vertically, through about 90°, and was raised when the wings were lowered and vice-versa. Flapping occurred 3–5 times per second for 11 min in one bird and at least 20 min in the second.

Because the birds did not appear to direct attention toward any conspecifics, it is unlikely that such behavior is an intraspecific signal. Also, I never observed such flapping behavior during times of wing-spread posture in sunlight. Therefore, it is possible that Anhingas flap their wings and tails on overcast days or after sunset to create air currents that facilitate drying of the body feathers in the absence of direct sunlight.

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