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The Reproductive Strategy of the American Goldfinch, *Spinus tristis tristis*, in Iowa

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Abstract. The American Goldfinch, *Spinus tristis tristis,* begins breeding later than any other bird in the north temperate zone. The breeding season in Iowa extends approximately from early July to late September. Data from observations on 30 nestings (124 eggs) indicate that if the breeding season is divided in half, the percent of eggs hatching is seen to decrease from 87% to 57%, and the percent of young fledging from 95% to 62% in the latter half. There is considerable evidence that breeding is cued by the blooming of thistle (*Circium* spp.), a plant upon which go'dfinches depend for nest-lining and food for the young. Apparently exploitation of this abundant resource provides an advantage sufficient to outweigh the problems of a relative decrease in nesting success due probably to increased predation pressure later in the breeding season.

Photoperiodic timing of reproduction is common in animals inhabiting the north temperate zone, with birds among the more highly photosensitive species. The gonadal photoperiod response culminates in late spring breeding and is considered the rule for temperate zone species. The American Goldfinch is a major exception to this rule since these birds normally do not breed until mid-July or August. Little is known about the photoperiod response of the American Goldfinch, but with such late breeding it seems apparent that additional stimuli are important. Since pair-formation occurs long before nesting, some photoperiodic influence is suggested. In addition, there is a strong correlation of reproductive timing with maturation of thistle (*Circium* spp.) (Nickell, 1951) which is used by Goldfinches for nest-lining as well as food for the nestlings (Stokes, 1950). Mundinger (1968) has suggested that mature thistle might provide a visual cue which stimulates the culmination phase of reproduction.

This study was undertaken to determine the timing of the breeding season of the American Goldfinch in Iowa, and to investigate the nature of reproductive cues used by this species.

METHODS

The population of American Goldfinches was surveyed daily from May 30 to September 30 during the summer of 1969 in the following three areas: Hickory Hill Wildlife Refuge in Iowa City, Sugar Bottom Public Use Area and the MacBride Field Campus of the University of Iowa, both in the Coralville Reservoir area. When a nest was discovered, it was observed daily until the young

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were fledged or the nest was destroyed or deserted. A total of 30 nests containing 124 eggs were observed.

Data for each observed nest included dates of egg-laying, hatching and fledging, as well as numbers of eggs, hatchlings and fledglings for each nesting pair. Calculation of percent of eggs that hatched and percent of youngs that fledged were employed in relating nesting success to time of breeding.

The hypothesis of visual cueing on thistle down (pappus) was tested at the MacBride Field Campus by simulating mature thistle heads (tying cotton balls to shrubs in the nesting habitat) and comparing onset of reproduction at the MacBride Field Campus relative to the other two study areas.

Observations

Breeding pairs of American Goldfinches are common in Iowa, nesting in semi-open areas containing scattered low trees and shrubs. The sturdy nests, usually built in an upright fork of a small tree, are composed largely of grasses and small plant fibers and lined with thistle pappus. Typically, the female builds the entire nest, although the male may carry nesting material and occasionally sits in the nest when the female is absent. In my study areas, the average nest elevation was 4 ft. 7 in.

There is usually a lapse of a few days between cessation of building and initiation of egg laying, after which the female lays one egg a day until her clutch is completed. I observed clutches of from two to seven eggs (both extremes were infertile); the mean of observed clutches was 4.6 eggs, and the modal clutch size was five eggs. Contrary to the behavior of most other bird species, the female Goldfinch begins incubating as soon as the first egg is laid, resulting in extended hatching over a two to four day period. Since the entire brood normally leaves the nest together, the extended hatching period produces fledglings in differing states of maturity, although this difference ceases to be obvious within one or two days after the birds have fledged.

During the summer of 1969 I observed the first nest with eggs on July 27, and the latest successful clutch was begun on September 2. The young from that clutch did not leave the nest until September 28. The peak nesting period (when most females were beginning their egg-laying) occurred in mid-August.

On the basis of the dates of first eggs of each pair, I divided the breeding season in half at August 15, and compared nesting success in each half. There was no significant difference in clutch size: the mean in the first half was 4.60 eggs, while that in the second half was 4.56 eggs. However, while 87% of the eggs laid in the first half hatched, only 57% of those laid in the second half

hatched. Of those that hatched, 95% of those from the first half fledged, while only 62% from the second half fledged. Although the relative amount of predation contributing to lack of hatching success was constant at about 25% in both halves (the other 75% being due to infertility) the decrease in fledging success in the second half was due almost entirely to increased predation. (Evidence of predation included broken eggs and a damaged nest.)

Female Goldfinches showed considerable interest in the cotton which was supplied at the MacBride Field Campus, and collected cotton several weeks before I found any evidence of breeding. This contrasted with the response of male Goldfinches, which was to examine the cotton balls as if looking for seeds, but not to remove or carry cotton. I was unable to follow the females far enough to determine whether they were using the cotton as nesting material at this early date, although I did find cotton incorporated into several nests representing later breedings.

Discussion

Photoperiodic control of reproduction is assumed to evolve when organisms are subject to seasonal stress which presumably selects for a life history oriented towards reproduction at the optimal season. In temperate regions, photoperiod is a highly dependable cue, being more regular than any other environmental parameter. It is logical to assume that a successful species will have a reproductive cycle initiated by a critical photoperiod that will result in the production of offspring when conditions are most likely to be favorable. The typical pattern exhibited by temperate zone birds is gonadal stimulation by increasing day-lengths in early spring culminating in offspring at the time of maximum food availability. Thus almost all passerines feed insects to their nestlings (regardless of whether or not the adults are insectivorous) and young are normally produced in late spring coincidental with the peak in the insect population.

The American Goldfinch belongs to a sub-family of finches known as the Carduelinae which is behaviorally divergent from other groups of finches. Although the correct taxonomic relations among the finches are still being debated, the carduelines form a natural group within the finches including, among others, the crossbills, grosbeaks, and canaries. In contrast to other passerines, many carduelines feed their young exclusively on seeds, and tend to nest semi-colonially. This type of nesting may be considered an adaptation for efficient use of a plant food source, being somewhat analogous to the herd behavior of herbivorous mammals contrasted to the territoriality of predators.

For the carduelines, there is evidence that food may act as a reproductive cue. Crossbills have been found breeding at all sea-

sons, and breeding appears to be initiated by a flock's discovery of an abundant supply of pine seeds, on which the young are fed (Dawson and Tordoff, 1964). Goldfinches also feed their young on seeds, and it is obvious that spring breeding is incompatible with a need for a large seed supply, since few plants go to seed in the spring.

Therefore, Goldfinches breed late, and my data indicate that this late breeding involves a certain risk. According to Lack (1968) most birds begin breeding somewhat *before* the optimal time in order to produce a second and third brood in the same season. In this case, nesting success tends to increase as the breeding season progresses. In contrast, Goldfinches rarely raise more than a single brood per season. Mundinger (1968) has estimated that less than 10% of a population of Goldfinches is double-brooded, and Stokes (1950) claims that only females which have raised a brood by mid-August (a small proportion of the total breeding population) usually start a second one, although the second is more likely to fail. Apparently, the peak of the predator population occurs during the latter half of the Goldfinch breeding season. The addition of the current year's young to the effective predator population puts increased pressure on prey species, and Goldfinches are by far the most abundant bird species with nestlings at this time.

The apparent overriding requirement of food availability carries the assumption that the photoperiod response of the Goldfinch is probably modified, and supplementary cues necessary to allow reproduction synchronized with seed availability.

Mundinger (1968) investigated the annual testicular cycle of the American Goldfinch, and found evidence for a modified photoperiod response. The pre-nuptial molt and loss of melanin from the bill were shown to be controlled by blood testosterone levels, and these changes are initiated in early March, correlating with the time of increased Leydig cell activity in the testes. However, approximately half the male Goldfinches sampled did not have testes in full breeding condition (did not have mature sperm in the seminiferous tubules) by July 1. Apparently photoperiod has an effect on reproduction, but longer day-lengths may be necessary for maximal development.

Mundinger also supplied cotton in Goldfinch nesting habitat, and reported an advance in nest-building of one or two weeks. However, he considered the advance relative to the beginning of nest-building in the same location in previous years and not in comparison to that of the breeding population of a nearby area in the same year. Since the start of breeding may vary somewhat from year to year, the apparent advance Mundinger demonstrated may not be real. For instance, I found no advance in nest-building at the MacBride Field Campus relative to the other areas being

observed concurrently.

There is considerable circumstantial evidence that the presence of thistle is the reason, if not the cue, for breeding late in the summer. Goldfinches almost always nest near a supply of thistle (Mundinger, 1968; Nickell, 1951; Stokes, 1950) and in some areas may nest almost exclusively in thistle plants (Nice, 1939). I found only two nests actually in thistle, but all were either in or adjacent to a field containing thistle. It is possible that the *blooming* of thistle may act as a secondary visual cue which stimulates the culmination phase of breeding, since Goldfinches do recognize thistle before it goes to seed, and are capable of finding and removing the hidden seeds and pappus from beneath the petals.

Although it seems obvious that the utilization of thistle in some way determines the timing of reproduction in the American Goldfinch, there is a paucity of concrete data concerning both the mechanism of action of photoperiod in this species, and the identification of possible secondary cues. In addition, the inconsistency displayed by the American Goldfinch of maximizing reproductive success by exploiting an abundant food resource while sacrificing a second brood and suffering loss of young to increased predation remains to be resolved and presents a unique system for study of the survival stategy associated with late breeding.

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