BREEDING BEHAVIOR OF THE GOLDFINCH

BY ALLEN W. STOKES

THIS paper presents aspects of the breeding behavior of the American Goldfinch (*Spinus tristis*) with emphasis on pair formation, establishment of territories, and breeding success. The study was made on 24 acres of park and marshland in Madison, Wisconsin, during the summers of 1944, 1946, and 1947. The area offered the advantages of high breeding densities and nests placed so low that observation was easy.

The Goldfinch has been the subject of several good nesting studies within the past 20 years. Walkinshaw (1938, 1939) made an intensive study on a 35 acre marsh near Battle Creek, Michigan, supplemented by data collected over a period of 20 years. Drum (1939) studied aspects of territorialism during 2 summers at Douglas Lake, Michigan. Mousley (1930a, 1930b, 1932, 1935) spent entire days at a single nest in southern Quebec making excellent observations on the activities of that single pair, repeating his observations during 2 subsequent summers. The observations of Mousley and Walkinshaw on nest construction, egg-laying, incubation, and care of the young were very thorough, and I have little to add to them. The reader is referred to their studies for these aspects of the nesting cycle. I wish to express my thanks for the guidance of Dr. R. A. McCabe under whose guidance the study was carried out during the first year. This study was financed in part by a University of Wisconsin research fund established in memory of the late Charles W. Bunn and is journal paper number 18, University of Wisconsin Arboretum.

STUDY AREA

About 16 acres of the area were part of a large peat marsh bordering Lake Wingra in Madison. During the summer, the ground was usually dry and firm. The other 8 acres consisted of lawn, shrubs, and shade trees, chiefly elm (*Ulmus* sp.), red maple (*Acer rubrum* L.), poplar (*Populus* sp.), and willow (*Salix* sp.), and was on higher ground (Figs. 1, 2). With the exception of occasional small box elders (*Acer Negundo* L.) and willows there were no trees on the peat marsh proper. Elderberry (*Sambucus canadensis* L.) was the most abundant shrub, occurring in large clumps, or else as individual plants. Next in order of abundance came red-osier dogwood (*Cornus stolonifera* Michx.), buttonbush (*Cephalanthus occidentalis* L.), and Tartarian honeysuckle (*Lonicera tatarica* L.). Common forbs included Joe-Pye weed (*Eupatorium maculatum* L.), giant sunflower (*Helianthus giganteus* L.), goldenrods (*Solidago* spp.), asters (*Aster* spp.), thistles (*Cirsium* spp.), nettle (*Urtica procera* Muhl.), jewelweed (*Impatiens biflora* Walt.), wild cucumber (*Echinocystis lobata* Michx.), smartweeds (*Polygonum* spp.), swamp milkweed (*Asclepias incarnata* L.), and dodder

FEMALE GOLDFINCH AT NEST. PHOTOGRAPHED IN BUTLER COUNTY, PENNSYLVANIA, IN AUGUST, 1945, BY HAL H. HARRISON. THE MANY DROPPINGS ON THE RIM ARE CHARACTERISTIC OF GOLDFINCH NESTS TOWARD THE END OF THE FLEDGING PERIOD.

(*Cuscuta Gronovii* Willd.). Grasses and sedges covered much of the marsh. All classification of plants is according to Deam (1940).

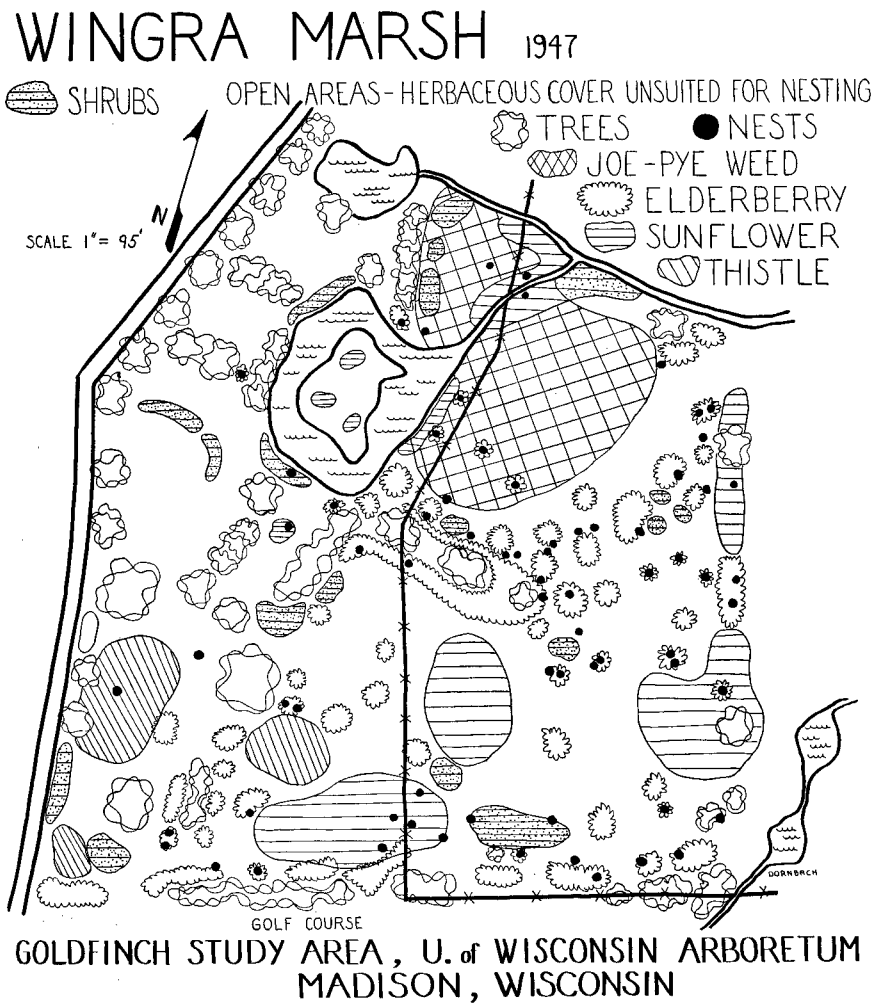

FIG. 1. Goldfinch Study Area—1947

METHODS

Observations began July 1 in 1944 and 1946. I spent the spring of 1947 in Madison and was able to observe the Goldfinches from the time of their arrival. As soon as the birds came into the study area in late June, I spent many hours watching them from a high tower or several tree lookouts. The area was carefully checked for nests 4 or 5 times throughout the nesting season by searching

all trees, shrubs, and suitable forbs, but with experience most nests were located by observing the behavior of the birds. Of the 240 nests found on the area during the 3 years, 161 were found before egg-laying started; 65 contained eggs; 11 contained young; and in 3 the young had already fledged. In the late fall of 1946, after all leaves had fallen, I found 6 nests I had overlooked (7% of the total). Nests were checked every 2 or 3 days to establish the progress and outcome. In a few cases the interval between observations ran as high as 10 days.

In 1944, 4 females and 1 male were marked with colored celluloid leg bands; in 1946, 16 males and 19 females; and in 1947, 9 males and 30 females, of which 6 males and 10 females were also marked with colored pigeon feathers attached to the rump with cement. Most of these birds were banded during the stages of nest construction or early incubation, and were watched closely to determine breeding behavior and the size of the breeding population. Observations continued each year until all birds had fledged. Approximately 600 hours were spent in the field during the 3 years.

Pair Formation

Goldfinches were uncommon birds during the winter in the Madison area. Spring migrants did not become conspicuous until May 10 in 1947, the only spring I was in Madison. By May 18 they were among the most common birds around Madison. Only a few days earlier dandelions (*Taraxacum officinale* Weber) had come into bloom like Cadmus' teeth, making golf courses and lawns an almost solid mass of yellow. Goldfinches were feeding in extraordinary numbers on these dandelions, suggesting that possibly their migration kept pace with the blossoming of these flowers, thus ensuring abundant food. Many of these birds were already paired.

It soon became obvious from daily observations on many birds that courtship and pair formation take place while the birds are still in flocks during May and early June, and probably earlier. Establishment of territory on the other hand occurs less than 2 weeks before nest building starts in early July. This is in contrast to most song birds where pair formation follows establishment of territory. Walkinshaw (1938) observed pair formation in Goldfinches to have taken place in late April. I have found no other mention of pair formation in the literature. Although my observations are incomplete, I will present the elements of behavior I associated with pair formation, although they may not necessarily be in their actual chronological order: (1) courtship song, (2) courtship flights, (3) song flights, (4) canary-like or true song.

(1) *Courtship Song.* When Goldfinches first arrived in 1947, I heard several males sing a "courtship song" at intervals of about 5 seconds and lasting for 2 seconds. Its first part was suggestive of the beginning of the song of the Song Sparrow (*Melospiza melodia*) and then it broke into a faster, higher-pitched portion resembling the true Goldfinch song. This courtship song was un-

doubtedly the same as that described by Nice (1939). The only time I ever heard it during the nesting season was on August 14 when a male had lost his mate. At that time it sang every 5 seconds for at least 10 minutes. Hence I think this song is used to attract a mate. It is not a territorial song, as Mrs. Nice correctly deduced, in that it is heard a month or more before territories are established. The fact that I heard it so seldom at Madison suggests that most Goldfinches were paired before arrival.

(2) *Courtship Flight.* Often while birds were feeding in flocks, paying no apparent attention to each other, a male darted out after a female and pursued her in a zig-zag flight, weaving in and out among the trees at break-neck speed and only a few inches behind her. Occasionally the female seemed to be chasing the male, but the action was so fast and the birds so close together that I could not be sure. Almost invariably other males joined the flight until there were as many as 6 males pursuing the same female. This usually ended in a song flight by the males while the female disappeared among the trees or bushes. On several occasions the male rejoined the female that he had chased, so pairing had apparently taken place. I spent about 10 hours watching various flocks at this stage and observed such chases every few minutes, yet never observed any stimulus in the form of posturing or call that might have set off this flight.

(3) *Song Flight.* The song flight is similar to that of the Brown Thrasher (*Toxostoma rufum*) and Yellow-breasted Chat (*Icteria virens*), a hovering, hesitant flight in a perfectly horizontal path, the bird seeming barely able to keep itself aloft. Although this flight is usually in a circular course during the nesting season, it more often is straight or irregular and of shorter duration in the courtship period. During this flight the male invariably sings his typical canary-like song. Just as soon as he stops his song flight, his song stops, and he resumes the typical undulating flight with its accompanying *per-chic-o-ree* note.

(4) *Canary-like Song.* This typical Goldfinch song has defied description, but closely resembles the varied warbling of a canary. It was most often heard from the treetops and only seldom from the tops of small bushes. Singing was most frequent during courtship and before nest building had started. Males sang in flocks even more than while alone. Although I do not know its true rôle, it is certainly associated more with courtship than with territorial establishment.

Records for the occurrence of first song at Madison for the past 4 years have been kept by James Zimmerman. They are: April 19, 1945; April 17, 1946; May 7, 1947; and April 17, 1948. He believes that song may be correlated with sudden availability of abundant food. His dates of first song reflect the fact that 1945, 1946, and 1948 were early years and 1947 late, as to development of vegetation. Onset of song and of nesting in these 4 years do not seem to be related, since 1947 was the earliest nesting season, yet latest for beginning of song.

Birds separated from the flock after pairing but apparently moved freely

without regard to territory. During this post-pairing stage the male was intolerant to other males that approached close to the female. Defense at this time took a variety of forms. Usually the defender merely flew to the intruder's perch, forcing the latter to move off. At other times the defending male flew after the intruder in the same hesitant manner of the song flight, but without singing. More rarely the 2 males became involved in a "tumble fight". Here the males flew at each other, first one above, then the other, like cabbage butterflies but with no actual violence. It often ended with the 2 males making a song flight. These flights were often seen, but were short and related only to the position of the female at that time and not to any territory. Less often the female drove other females from her mate in the same manner as the males.

Maintenance of the Bond

Once formed, the bond is maintained chiefly by courtship feeding. This occurs from egg-laying through nestling stages. After the first egg has been laid, the female spends much of her time on the nest, getting on and off at frequent intervals. When the male flies overhead she may fly to him, but more often she will extend her head, flutter her wide-spread wings rapidly, and utter a high *chee-chee-chee-chee*. If the male approaches the nest, the female moves up on the rim with bill extended for feeding. In about half the cases the male will come in to feed her, the food consisting of anywhere up to 30 regurgitated seeds. At other times the male may perch in a nearby branch or neighboring bush, making no advances towards the female. But the female is not easily put off; she flies with quivering wings to the male and will even peck at his bill in her efforts to obtain food, at which the male may finally capitulate.

The male does his share in feeding the young. If the female happens to be brooding the young as he comes to the nest, she will again beg for food as described above and be fed. She will then usually feed the young with these same seeds. On 2 occasions I have seen a male feed his mate following nest failure.

I have observed copulation on only 3 occasions. Once the male approached the female as she was begging for food. Within a few seconds he mounted, copulation lasting for only 2 or 3 seconds, during which the female quivered her extended wings. The male then flew off without further ado. In the other 2 cases there seemed to be no prelude to copulation.

Establishment and Maintenance of Territory

During May and early June, Goldfinches remained on the lawns where food was abundant, and did not come down into the marsh until ready to establish a territory. From the middle of June until the middle of August there was a steady infiltration of birds and establishment of new territories. During July, I never noticed unmated birds in the marsh. In August I observed 3 cases of aggressive males, presumably unmated. Unmated birds may have fed in the

large neutral areas of the marsh, but they certainly did not attempt to intrude on established territories. A flock of 4 unmated Goldfinches, the only ones seen outside the study area, were in an area of poor nesting habitat.

Authors disagree about territorialism of Goldfinches. Walkinshaw (1938) and Nice (1939) found no evidence of conflict between pairs and believed Goldfinches showed a definite sociability in nesting. Drum (1939), on the other hand, found definite territories that were actively defended against all males trying to settle within the territory.

FIG. 2. View of the study area looking south. The highest breeding density occurred in these loose clumps of elderberry. Photo by R. A. McCabe.

At Madison much of the territorial behavior was established by placing a mounted Goldfinch at 3 to 30 feet from the nest sites during all stages of the nesting cycle. This showed that some birds took up their territory 2 weeks before actual nest building, but usually only a day or two. Males attacked the male dummy when it was placed within 10 yards of the nest site, the reaction becoming stronger the closer the dummy was to the nest. Once a male attacked the dummy near the nest of a neighboring pair 10 yards distant. Females attacked both male and female dummies that were placed within 5 yards of the nest, and at this distance attacked more intensively than did the males.

On several occasions both male and female attacked simultaneously while I was still placing the dummy. A vigorous attack consisted of alighting on and pecking at the head of the dummy. At the other extreme the birds merely

called plaintively and flew from perch to perch near the nest. Occasionally, the males made a song flight. When the dummy was left in place for more than a few minutes, the birds soon stopped attacking and perched 5 to 10 yards away. There they usually pecked at their toes, presumably a substitute mechanism. Often the males perched facing the dummy, body erect and motionless. When neither male nor female was present when I placed the dummy, I have on several occasions seen the male flying past overhead. The instant he saw the dummy he swooped down and attacked immediately without alighting. Once a male, unaware of the dummy, was feeding low in some nearby bushes. The instant he noticed it he attacked. In 1946 the dummy was attacked by 10 males and 5 females; in 1947 by 10 males and 17 females. Both males and females attacked the dummy as late as the 10th day of incubation.

Much of the above evidence might be construed as merely defense of nest site and not *prima facie* evidence of territorial defense. But many hours spent in an observation tower and other lookouts gave additional evidence. Males on the territory commonly perched quietly and motionless on top of tall shrubs, often a dead branch. Intruding males might take up a similar position within 20 feet. The 2 males would watch each other quietly, but eventually the defender would take off after the intruder, either driving him from his perch or actively taking part in a tumble fight. The male on his territory made frequent song flights. Here, the flights reached their perfection with the male making 3 or 4 complete circles, singing his jubilant song all the time.

These song flights were most frequent at the time of territorial establishment and nest building. They also depended on the proximity of other pairs and their stage of nesting. When 2 pairs were beginning to nest at the same time, there was almost constant jockeying between males. I have seen a single male make 6 song flights within 20 minutes, interspersed with much chasing of the adjoining male. Later in the nesting cycle, territorial defense consisted more of chasing than of singing or song flights, although following nest failure or the beginning of a second nesting, territorialism became stronger again.

Although adjoining males sat on their prominent perches staring at each other for minutes on end, I never saw anything resembling a defensive posture such as described in the Song Sparrow by Nice (1937) or the Snow Bunting by Tinbergen (1939). I have just 3 records of any posturing by Goldfinches. In 2 cases I had placed a female dummy within 6 feet of a partially constructed nest. In each case the female came to the nest to place material. On sighting the dummy she crouched, holding her head forward, wings quivering, and uttering a high, fast *chee-chee-chee-chee* for a few seconds before attacking. In a third case I saw 2 males 6 feet apart on a wire doing very much the same thing for a period of a minute or more before going into song flights. I believe the song flight acts as a very strong notice of territorial bounds and takes the place of other forms of display. Certainly, the area bounded by a song flight corresponds fairly closely with the actual boundaries of the area defended.

Conder (1948) observed frequent posturing in the European Goldfinch. It consisted of pivoting through 90 degrees, body extended slightly forward. It was used as a deterrent to intruding males as well as enemies. I often noticed Goldfinches pivoting on their perches, either while in the territory or while feeding, but never associated it with display. Certainly, there was no obvious relation between pivoting and the appearance of intruding males.

Males or females flying overhead across a territory were never attacked. Likewise birds feeding within a territory could often go unmolested. But the instant a male took up a prominent position he would certainly be driven off, if the defender were in sight. Female intruders were likewise driven off, usually by the females.

During 1947, I observed territorial defense at 17 nests. There were 33 cases of male chasing male; 6 of female chasing female; 1 of female chasing a male; and 1 of male chasing female. A single conflict lasted from a few seconds to a half hour. The greatest distance from the nest that a male was seen to defend his territory was 30 yards. The latest territorial defense was September 1, 1947, when both male and female were active in driving off neighboring males and females. At this time the female was incubating her second brood.

The female may take an active or leading part in the selection of territory for, of the 2 adult banded females from 1946 that returned to the study area in 1947, one nested 50 yards from its 1946 nest, the other 15 yards. In 1948 1 adult banded male returned to within 15 yards of its 1947 nest. Two other banded but unidentified females also returned to nest in 1947. Since no aluminum bands were used in 1946, other returns may have been present in 1947, but undetected because of lost celluloid bands. If the males alone selected the territory these females could scarcely have had the chance to build so close to their former nests. Davis (1941) observed that the female kingbird selects the nest site after pairing; the male subsequently defends the territory. Additional evidence for the female selecting the nest site is given later under the section Second Broods.

Requirements and Size of Territory

Type: The Goldfinch territory consists of the nest site and immediate area, but does not necessarily include food, water, or nesting material sufficient for the pair. On the study area the chief nesting material, thistle, grew mostly in several large discrete patches (Fig. 1). Nests were never found in these or in sunflower until toward the end of the season, and then usually only in the smaller patches. I doubt if a Goldfinch could defend such an economic asset against the many Goldfinches seeking its use.

There seems to be a relationship between food supply, nest sites, and population density. In 1944, when there were 36 pairs, 18 nests (35% of total) were built in composite plants, all of which are favored sources of food for Goldfinches. Eleven of these were in giant sunflower, the only year nests were built

in this plant. In 1946 with 54 pairs 13% of all nests were in composites; and in 1947 with 60 pairs, only 5 nests or 5% of the total were in these plants. Hence, in years of high density Goldfinches seem to have difficulty in defending nest sites in plants the seeds of which are in so much demand.

Food, for the most part, consisted of seeds of thistle, Joe-Pye weed, and giant sunflower, all abundant on the marsh, but the birds usually had to forage outside of their territory for them. At 2 springs in the northwest corner of the area I could always count on seeing Goldfinches on a sunny afternoon, either bathing or drinking. Water may well be an essential component of high breeding densities for this species.

Although there were abundant shade trees in the western part of the area affording satisfactory nest sites, these were rarely used (a late fall census after all leaves had fallen still failed to disclose nests in them). The ideal sites were where elderberry grew abundantly and yet close to at least 1 large tree. The highest breeding density in 1947 was on 6.4 acres of marsh where there were 38 pairs. This makes an average territory of 7100 square feet, or a circle of diameter 95 feet. The territories reported by Drum (1939) extended to 1000 feet in length, hence the occurrence of territorialism does not depend on breeding density.

The Nesting Cycle

Although, in general, the Goldfinch delays nesting later than all other birds in eastern North America, there is a wide spread in nesting records. Roberts (1936) reports a record of a nest with 2 eggs found May 20, 1930 in Minnesota; at the other extreme he reports a nest containing 3 eggs about to hatch on Sept. 30, 1894. For Wisconsin, J. B. Hale of Madison told me of seeing copulation on May 27, 1947. I. O. Buss, formerly of Madison, found a freshly hatched nest on June 26, 1946. Such early nesting records are to be treated as anomalies and bear little relation to the normal sequence of nesting.

Since I was able to locate almost all nests on the study area, the curve in Figure 3 purports to show the dynamics of a nesting population. Since almost all nests were found either in process of construction or with eggs, I was able to date the beginning of the nests to within a few days. Extrapolation, where necessary, was based on nest chronology established at nests with precise records. The curves for 1944 and 1946 were very similar to that of 1947 and hence are not shown.

Nest construction generally started the first week in July, and in 2 weeks had come to a peak, with a minor peak almost an even month later. Nest building had ceased by the first week of September. The closest synchronization of nesting came in 1946 when 57% of all females were building simultaneously, compared with 40% in 1944 and 1947. Analyzing Walkinshaw's data (1939) for 14 nests started in July, 1936, I find a peak of nest building July 23, in close agreement with Madison.

Although nest building reaches a peak of activity about the middle of July, the total number of active nests (being built or containing eggs or young) continues to rise until the middle of August. This is probably due to the steady influx of new pairs to the study area up until that date. These late arrivals might be females that had started nesting elsewhere and then had come into the marsh for subsequent renesting attempts. But of the 53 banded females, the greatest observed move between nesting attempts was 150 yards, and almost all females remained within the same territory. Thus, there must be some physiologically retarded females arriving for an initial nesting attempt a full 6 weeks later than the most sexually advanced females.

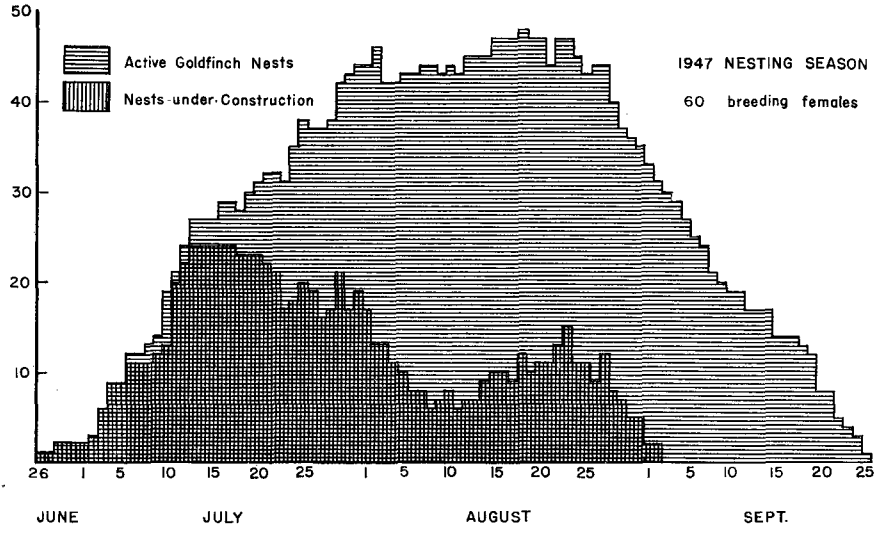

FIG. 3. Curves showing (a) rise, broad peak, and decline of entire nesting season; and (b) two distinct peaks of nest construction within this period.

The curve of total nest activity begins to drop about August 18, indicating the point at which some females stop breeding activity. Thus, the earliest nesters cease breeding at the time that the latest nesters are beginning.

Whereas the Goldfinches of the study area indicate a fairly well defined pattern of nesting, there seem to be geographical differences in the nesting cycle. On July 9, 1947, when many Goldfinches were nesting in Madison, I observed only 50 miles to the north, a flock of over 100 Goldfinches that were just beginning to break into pairs. Males were in process of chasing females in zig-zag flights a full month behind the Madison birds. Outside of this flock that was feeding on catkins of red birch (*Betula nigra* L.) along the Wisconsin River, I saw no other Goldfinches in the area.

The cause for late nesting among Goldfinches has been a subject of speculation among ornithologists, some of whom erroneously believe that these birds are dependent upon the pappus of thistle for lining the nest. There is little reason for believing this is the case, for I have found down from cattail (*Typhus* spp.), willow, and poplar in early nest linings, and in St. Paul early nests are lined with pappus from dandelions and sow thistle (*Sonchus* spp.) (Lewis, Unpub. MS.). The Goldfinch seems to have filled an ecological niche by utilizing seeds of composites as its chief food source, at least at time of nesting. Delaying nesting until July and August ensures an abundant source of food for the young.

There are few common, native composites in eastern United States that bloom early. In Wisconsin, field thistle (*Cirsium discolor*) is the first common, native composite to bloom (mid-July) hence, several centuries ago before the advent of Canada thistle (*Cirsium arvense* L.) and other European weeds, nesting could never have preceded that date by much. Goldfinches were probably much less abundant at that time, unless they were more diverse in their diet than now. At Madison the Canada thistle, the earliest common composite except dandelion, does not bloom until the last week in June and its seeds are not ripe until the first week in July (Zimmerman, Unpub. MS.), so the timetable of hatching nests is about as far advanced as would be safe.

The Nest

Site: Goldfinches will nest in a wide variety of trees, shrubs, and forbs, as long as they are growing in open sunlight. The location of 230 nests found on the area during the 3 years is given in Table 1. The preponderance of nests in

TABLE 1
THE LOCATION OF 230 NESTS ON STUDY AREA

SPECIES	RELATIVE ABUNDANCE OF PLANT	PER CENT OF NESTS
elderberry	10	68
dogwood	2	8
box elder	1	5
thistle	2	5
sunflower	2	5
aster	1	2
buttonbush	0.5	2
red maple	0.5	1
Joe-Pye weed	4	1
willow	4	1
poplar	1	0.5
cherry	0.1	0.5
wild lettuce	0.1	0.5
goldenrod	0.5	0.5

elderberry is mainly a reflection of the abundance of that shrub, but the total absence of nests from mature elm, willow, and poplar indicates that the Goldfinch has a decided preference for shrubs and forbs. Nests found outside the study area were commonly placed in red-osier dogwood and saplings of willow and poplar. Other plants included red oak (*Quercus borealis* Michx.), red pine

TABLE 2
THE HEIGHT OF 278 NESTS FOUND ON STUDY AREA

HEIGHT OF NEST ABOVE GROUND IN FEET	NO. NESTS
1	0
2	2
3	48
4	82
5	71
6	39
7	15
8	12
9	4
10–14	4
15–19	1

(*Pinus resinosa* Ait.), white cedar (*Thuja occidentalis* L.), tamarack (*Larix laricina* Koch), elm, plum (*Prunus*), hawthorn (*Crataegus* sp.), bog birch (*Betula pumila* L.), lilac (*Syringa vulgaris* L.), and nine-bark (*Physocarpus opulifolius* L.), in small numbers.

As the season advanced there was a marked increase in the use of forbs as nest sites. The Goldfinches presumably wait until these forbs have matured, but also many of the formerly favored elderberry bushes have had their crowns opened up by the weight of ripening berry clusters, thus making the nests too exposed and also affording few vertical crotches. Nests started in elderberry may drop as much as 18 inches by the time the berries become ripe, thus imperilling eggs and young in windy weather.

Where insects have attacked the main stalk of a forb, the lateral buds sprout to form an ideal rosette in which to place a nest. Almost all nests found in forbs were placed in such rosettes, and were singularly free from wind damage.

Almost all nests found in shrubs and forbs were from 3 to 6 feet off the ground; those in trees were usually from 8 to 15 feet high (Table 2). The nest is seldom well concealed for the female seeks for nest site a plant that has 2 or more nearly vertical branches forming a crotch in which to place the nest. Thus the nest is either below the leafy part of the plant as in elderberry, or else in some sparsely foliated plant as willow, poplar, or forb. This relationship of the nest to the crown of the plant is brought out by analysis of the 135 nests placed

in shrubs or forbs in 1946 and 1947. Of these, 93% were located within 2 feet of the top, and 99% within 3 feet.

I believe that food supply is a more important determiner of occurrence of Goldfinches than nest site, and that when shrubs are not available these birds will select any available plant with proper branches that grows in the open. I have found no records, however, of Goldfinches nesting in any densities in trees.

Construction: In spite of the heavy drain upon the silky fibers of swamp milkweed made by the earlier nesting Alder Flycatchers (*Empidonax traillii*) and Yellow Warblers (*Dendroica petechia*), there remained enough for Goldfinches to use, at least for the first nestings. As late as August 18 females were gleaning the last bits from stalks. Following nest failure females commonly used material from the old nest or even material from a neighboring active nest. Later nesters used nettle blossoms of which the 2 inch long stalks made an excellent binder for thistle down or milkweed fiber. Other nests consisted chiefly of grasses, nettles, or outer coatings of dead forbs. Rarely, the down of cat-tail, Joe-Pye weed, willow, or poplar was also used for lining.

TABLE 3
THE TIME REQUIRED TO BUILD NEST IN RELATION TO NESTING SEASON

	PERIOD IN WHICH NEST WAS STARTED			
	July 1–15	July 16–31	August 1–15	August 16–31
Required time to build nest in days	13.0	10.8	5.8	5.6
Number of nests	17	12	4	12
Standard Deviation in days	4.6	4.4	.96	1.3

As the season advanced, the interval between beginning of nest construction and laying of the first egg decreased steadily from an average of 13.0 days in early July to 5.6 days (statistically significant) in late August (Table 3). For such a late nesting species such an economy of time must materially increase the number of renesting attempts possible.

Egg Laying: The number of eggs in a completed clutch varied from 2 to 7 (Table 4). Mean clutch size in July was 5.3 eggs, but by late August clutches averaged only 3.7 eggs (highly significant difference). The drop in clutch size with season probably depends more on the number of renestings than the lateness of the season. The decrease between each of the bimonthly intervals from July 15 to August 31 is highly significant. For 10 females where the sizes of the first and second clutches are known, the first clutch averaged 4.8 eggs (S.D. = .40), and the second 3.8 (S.D. = .87).

TABLE 4

VARIATION IN CLUTCH SIZE WITH SEASON

DATE FIRST EGG LAID	NUMBER OF NESTS BY CLUTCH SIZE						MEAN	STANDARD DEVIATION
	2	3	4	5	6	7		
July 1–15	0	0	0	2	0	0	5.0	—
July 16–31	0	0	8	34	11	1	5.3	.65
August 1–15	0	1	8	38	5	0	4.8	.57
August 16–31	3	11	17	6	0	0	3.7	.90
September 1–15	0	3	2	0	0	0	3.4	.49
Totals	3	15	35	80	16	1	4.6	

TABLE 5

THE TIME REQUIRED FOR RESUMPTION OF EGG-LAYING AFTER NEST FAILURE

DATE OF NEST FAILURE	NUMBER OF DAYS BETWEEN NEST FAILURE AND EGG-LAYING	STAGE OF NEST AT TIME OF FAILURE
July 8	12	Nest ¾ built
July 13	21	Nest complete
August 3	6	8 days incubation
August 14–17	11–14	Young 7 days old
August 16–20	4–8	8 days incubation
August 21–22	7–8	1 egg

I have only 6 records of the time required for a female to start laying following nest failure (Table 5). This time ranges from 21 days down to a possible 4 days. These records suggest that the interval before laying may depend as much on the season of the year as the stage of nesting at the time of break-up. If so, this would agree with the acceleration in nest construction mentioned above.

Although about 30 hours were spent the first year in observing the activities of the male and female during egg laying and incubation, my observations agree closely with those of Mousley (1930a, 1930b, 1932, 1935) and Walkinshaw (1938, 1939) and will not be recounted here.

Care of the Young

The young must be fed very little the day of hatching, for I saw no food in the crops until the second day. As many as 60 sticky seeds are fed by regurgitation to the young during 1 feeding. One trip by the female to the feeding grounds is sufficient for 2 or 3 feedings when the young are less than a week old. The average time between feedings at this time was about 25 minutes; it decreased as the birds became older, and finally rose again just before the birds fledged.

The young were given the same food as was eaten by the adults. Of a dozen crops examined by artificial regurgitation, only 1 contained any animal matter, a 0.75 inch long caterpillar. Both parents ate small droppings and carried off the larger ones. The nest remained clean until about the eighth day, but extensive fouling occurred within the last 2 days before fledging, the rim becoming a solid mass of excrement (frontispiece). This fouling is not a safe criterion for nesting success, since some nests remained clean right up to the end. Nests with only 1 or 2 young are not immune to fouling, suggesting that it is not the amount of work involved that results in droppings being left.

The first week of life for the young is all victualling and voiding. After that they show more interest in their surroundings. They eye ants and beetles crawling close to the nest, crouch low when danger approaches, spend much time on warm days preening their feathers or occasionally standing up and fluttering their wings. They do not react to calls of nearby Goldfinches but wait for the almost inaudible *per-chee* of the female as she prepares to feed them before raising their heads. The young fledge when 10 to 16 days old (Table 6). The

TABLE 6

AGE OF FLEDGLINGS ON LEAVING THE NEST

AGE (DAYS)	NUMBER OF NESTS
10	9
11	4
12	9
13	7
14	6
15	3
16	2
Totals	40

Mean age at fledging—12.3 days.
Standard Deviation—±1.76 days.

mean fledging age of 12.3 days agrees fairly well with the 12.88 days recorded by Walkinshaw (1939) for 25 young. My banding operations undoubtedly caused some broods to leave the nest earlier than they might normally. This probably accounts for the relatively large number fledging at 10 days.

Within 24 hours before fledging the young develop a call, *chick-kee*, very faint when still in the nest, but audible at 50 yards when once fledged. Fledglings may remain quiet for long periods of time, but seem to recognize the male parent's voice and immediately start this *chick-kee* call. As the male comes into sight they flutter their wings in effort to get to him and utter this call incessantly

until fed. This same note may also be used as a collecting call in answer to the male, who takes over most of the duties following fledging. Whenever disturbed and scattered, the young become silent immediately, but after a few minutes they resume the *chick-kee* call, apparently to signal their presence. A week after leaving the nest, this call evolves into *chick-kee-dee*, very similar to the call of the Chickadee (*Parus atricapillus*) both in quality and pitch. It is given by the young as they follow the male about the marsh and has been heard well into October.

Reds, a male bird taken from the nest at 3 days and held in captivity, shed considerable light on the development of certain traits. Although he gained weight much more slowly than wild birds, his rate of feathering was about normal. At 13 days he was hopping about the floor, and 2 days later was able to fly up 10 inches. By 16 days he was hopping strongly and flying across the room. The next day he was seen pecking at food. By 19 days he was eating by himself, although he would still accept food from a stick. By 20 days he was a strong flier circling the room with ease and landing without a falter. By this time he had learned to drink from a dish. By 30 days he was shelling his own seeds.

Some of the stimuli for gaping were shown by Reds and his fellow orphans. Although the female may at times give a soft call to the young when she is ready to feed them, this is apparently not a necessary stimulus. Captive young at 3 or 4 days gaped when the edge of the nest was tapped or when their bills were touched with food. At about 7 days they gaped at the mere sight of food if hungry enough. When week-old young were put in closely placed nests they would attempt to be fed by the birds in the other nest, even moving over bodily into the other nest in their efforts. But once together in a nest again they would no longer try to be fed. Hence, sight of a bird, regardless of size outside of the nest, also acted as a stimulus to gaping.

Second Broods

It has been assumed that the Goldfinch is single-brooded because of its late nesting. Mousley (1935) gave some evidence on the basis of behavior that it might raise a second brood. Much to my surprise, in 1944 I found one definite record of a banded female starting a second nest following fledging of her first brood in August. In 1946 and 1947 with many more birds banded early in the season, I found 9 more females starting a second brood. I believe that most females that raise their first brood before August 20 start on a second brood. The lateness of the season is no deterrent to them, for birds were found in the nest as late as September 23 in most years. Brother Hubert Lewis found 2 broods fledging on October 15, 1946 in St. Paul, Minnesota, so in extreme cases a second brood might be started as late as September 15.

As the young reach fledging age, the male takes over most of the feeding, thus giving the female time to start her new nest. One female started her new

nest 3 days before her first brood fledged. Therefore the stimulus for renesting must precede fledging by at least 3 days. The first egg of the second clutch was laid anywhere from 3 to 10 days, but usually 5 or 6 days, following fledging in the first nest. The time between the start of the first and second clutches is remarkably uniform. Four females required 33 days, 3 took 34 days, and 3 others took 32, 35, and 36 days. Second clutches were begun between August 10 and 27.

In only 3 cases have I had both male and female of double-brooded birds banded. In 2 cases the female kept her mate and built within 20 yards of the first nest. In the other case I strongly suspect that the female changed mates although retaining her old territory. While watching her from a blind I saw her being fed at her new nest by an unbanded male. To the many males that were flying overhead she paid no attention. But when shortly afterwards a male with 5 young settled into a clump of sunflowers close to the nest, the female got off her eggs and uttered the high *chee-chee-chee* so typical of a female expecting her mate to come to the nest. I could not see whether the male was her old mate, but the behavior of the female and the size of the fledged brood suggested this. It looked here as though the female had taken a new mate, but had not completely severed her bond with her former one. Unfortunately, the nest was destroyed that night before I could watch her further.

In 4 cases the female built her nest in an entirely new territory, as far as 150 yards from the first nest. These new territories were vigorously fought for with neighboring males. In one case the male was scarcely allowed to reach the female on the nest without being driven off by a neighboring male whose territory had been reduced by the newcomer. This looks like further evidence that the female selects the nest site, in this case having placed her nest in an almost untenable position that would scarcely have been the case if the male had free selection of territory. There remains the possibility that a second-nesting female may have to seek a new mate if her old one is no longer sexually active. But the chance of an unmated male still being sexually active at this late date would probably not be any greater than for a mated male, which after all has been stimulated by courtship feeding and territorial defense during most of the preceding nest cycle. Cessation of sexual activity is usually associated with onset of molt. In Madison the first males began to show post-nuptial molt the first week in September, so this event would signal cessation of further nesting.

How extensive is second nesting among Goldfinches? In 1947 6 out of 30 banded females raised a second brood; in addition, 3 unmarked females almost certainly raised a second brood. Hence, a probable minimum of 15% of the 60 breeding females were double-brooded. At first glance the prominent second peak in the nest construction curve (Fig. 3) with its close coincidence with second nesting suggests an extensive amount of second nesting. In 1947 there were 37 nests started after August 5, the earliest record for beginning of second nesting. These nests were built mainly by 2 categories of females: those renesting after nest failure, and those beginning a second brood. For lack of more

TABLE 7

RELATION OF NEST FAILURE AND SUCCESS WITH SEASON

PERIOD IN WHICH NEST FAILURE OR FLEDGING OCCURRED	NUMBER OF NEST FAILURES	NUMBER OF SUCCESSFUL NESTS	PER CENT OF NESTS SUCCESSFUL
July 1–10	0	0	—
July 11–20	14	0	0
July 21–30	19	0	0
July 31–August 9	14	1	7
August 10–19	22	12	35
August 20–29	34	29	46
August 30–September 8	28	19	40
September 9–18	4	17	81
September 19–28	0	16	100
September 29–October 8	0	0	—
Total	135	94	41

precise information one must assume that females in either category are equally likely to begin a new nest. A comparison of nest records during July and August shows that for each 10 day period more nests failed than were successful (Table 7). Hence, considerably more than half of the 37 nests started after August 5 must have belonged to renesting females. Therefore, the second peak in nest construction can be attributed only partially to second nesting. A total of 7 females reared second broods.

Mortality

During the 3 years, 65% of the total number of eggs laid hatched and 49% of all eggs produced fledglings (Table 8). The only certain cause for mortality I ever found was from storms. Nests built in elderberry heavy with fruit or in

TABLE 8

NESTING SUCCESS AND PRODUCTIVITY

	1944	1946	1947	TOTAL
Number pairs	36	54	60	150
Total nests	56	81	102	239
Total eggs	170	206	320	696
Eggs hatched	108	119	228	455
Young fledged	63	92	183	338
Per cent of eggs hatched	64	58	71	65
Per cent eggs producing fledglings	37	45	57	49
Av. number young per pair	1.7	1.7	3.0	2.3
Per cent of females raising fledglings	.39	.48	.75	.57

forbs were sub ject to destruction by high winds and were found tilted so far over that eggs or young had fallen out. Three or 4 deserted nests were soon covered over and inhabited by Deer Mice (*Peromyscus leucopus*). I suspect that they may eat eggs from nests that were not being incubated, for I found mouse feces in the bottom of a freshly deserted nest. Garter Snakes (*Thamnophis sirtalis*) curled up beside nests on several occasions made me suspect them. One in particular was right in the bowl of a nest subsequently deserted.

Trautman (1940) found 4 out of 16 nests at Buckeye Lake parasitized by Cowbirds (*Molothrus ater*). Since these 4 nests were all found within a period of 9 days and in the same field, he suggests that a single late Cowbird might have laid eggs in all 4 of these nests. His field notes indicate that ordinarily there is little overlap between egg-laying of Cowbirds and Goldfinches (letter). I had only 1 case of parasitism and this was in a nest in which egg-laying started July 25.

Undoubtedly some nest failure was through death of the female, although with such a high density of breeding birds, most of them unmarked, it was not possible to determine this. Indirect evidence, however, points to considerable adult mortality. During the 3 years the 150 pairs laid 696 eggs, an average of 4.6 per female. But the mean size of complete clutches laid during July and the first 2 weeks of August was 5.0 eggs. If there had been no adult mortality one would expect that each female would average somewhat more than 5 eggs laid during a season, for some were double-brooded and many others had their first nest destroyed with eggs or young in the nest. It is difficult to conceive that a female would never succeed in laying at least 1 full complement of eggs. Hence there must have been considerable female mortality to keep the ratio of eggs laid to total breeding females down to 4.6.

Productivity

In 1947, 57% of all eggs eventually produced fledglings, compared with 37% in 1944, and 45% in 1946 (Table 8). This productivity must be considered minimal, for during 1946 and 1947 some adult birds were trapped at the nest site, which probably caused desertion in some cases. However the desertion rate at unmolested nests was just as high as at nests where trapping was carried on. And the year of lowest fledging success was when no banding was done until the young were ready to fledge.

Walkinshaw (1939) found 58% fledging success from 248 eggs, and Lewis (unpub.) reports 80.3% on the basis of 608 nests located in thistle found during the years 1943 through 1946 at St. Paul, Minnesota. The difference in nesting success between St. Paul and Madison is highly significant and one must infer that there are environmental differences between the 2 areas. The St. Paul study area was in the city suburbs with presumably fewer mammalian predators.

The location of the nests in thistle may also have acted as additional protection against predation or storms.

During 1944 and 1946 each breeding female produced an average of 1.7 young; in 1947 an average of 3.0. Until much more banding has been done and mortality tables of both juveniles and adults worked out, one cannot say how many young must be raised to maintain the population. If there is any truth in the old saw "safety in numbers," Goldfinch flocks may suffer less mortality than non-flocking species, in which case relatively low brood success would suffice to maintain the population.

Summary

A 3-year nesting study with emphasis on behavior, territory, and breeding success was made on 24 acres of park and marshland in Madison, Wisconsin. The area was frequently searched for nests and their outcome determined by visits every 2 or 3 days. Seventy-nine birds were banded in the early stages of the nest cycle to facilitate behavior study and estimates of the population.

Pair formation took place in May or earlier while birds were still in flocks. Elements of pair formation included courtship song, courtship flights, song flights, and true song. After pair formation, birds left the flocks, but did not take up territory until just before nesting began. The bond was maintained by the male feeding the female, as well as by song. Territory was defended vigorously by males, either by chasing, taking up prominent perches, or by song flights. Defense was strongest at the beginning of the cycle, but occasionally lasted until young were in the nest. It appeared again with renesting and second nesting. The territory did not necessarily include food, water, or nest material. In the area of densest population territories averaged 95 feet in diameter.

Nest construction began in July and reached a peak the middle of July. New pairs continued to enter the study area until the middle of August, by which time some females had already completed nesting. Breeding densities on the area increased from 36 pairs in 1944 to 54 in 1946, and 60 in 1947. Nests in shrubs and forbs were usually from 3 to 6 feet high; those in trees 8 to 15 feet. Of 230 nests found 68% were in elderberry, the commonest shrub on the area, but 22 other species of plants were utilized to lesser degree. Nest construction took an average of 13.0 days in early July and decreased steadily to an average of 5.6 days in late August.

Clutch size of 150 nests ranged from 2 to 7 eggs. Mean clutch size in July was 5.3 eggs, but for late August was only 3.7. Six records of renesting females indicated from 4 to 21 days were required between time of nest failure and subsequent egg-laying.

A captive Goldfinch was raised to study behavior. It was eating independently at 19 days, was a strong flier at 20 days, and was shelling seeds at 30 days.

Stimuli for gaping in young birds included tapping the nest, touching the bill, and the presence of other nestlings in an adjacent nest.

Approximately 15% of Goldfinches start a second brood between August 5 and September 1. The female may change mates, but more often retains the same mate and territory. In 1 case the female started a new nest 3 days before the young in the first nest had fledged. A total of 7 females reared second broods.

During the 3 years, 65% of all eggs hatched and 49% produced fledglings. This compares with 58% and 80.3% in 2 other regions. Storms were the only definite cause for nest failure, but Deer Mice, Garter Snakes, and death of the female were probable factors. The number of young produced per pair ranged from 1.7 to 3.0.

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Department of Wildlife Management, University of Wisconsin, Madison