GROWTH OF NESTLING AMERICAN GOLDFINCHES DEPENDING ON THE NUMBER IN THE NEST AND HATCHING SEQUENCE

By Larry C. Holcomb

American Goldfinches (*Spinus tristis*) laid smaller clutches of eggs in a year when precipitation was low (Holcomb 1969). Perhaps a smaller amount of food was available for adults and nestlings. Starvation of some nestlings was reported, but this occurred in a year when precipitation was normal and food was more abundant. However, there were far more breeding pairs per unit area and they laid more eggs per clutch. An attempt to evaluate the growth of nestlings for these years is presented to discover if goldfinches adjust brood and clutch size as suggested for other birds by Lack (1947, 1954, 1966) and Ricklefs (1965, 1968).

METHODS AND PROCEDURES

Goldfinch nestlings were studied in 1963, 1964, and 1965 at Toledo, Ohio. The population was located within the city limits in an area where second-growth vegetation, hedge-rows, and weed fields prevailed. A description of nest sites, nest building, egg-laying and incubation has been reported elsewhere (Holcomb 1969).

In this paper, weight is the only growth evaluated. Nestlings were weighed each day to the nearest one-tenth gram. Mean growth and standard errors were calculated and relative growth rate was obtained by using the method reported by Banks (1959).

RESULTS AND DISCUSSION

a. *Mean growth and relative growth rate.*

It was assumed that the nestlings that hatch first were longer, had longer necks, and larger mouths than younger siblings and receive food preferentially. If there is plenty of food available and the parents bring it fast enough, the younger birds will receive a sufficient allotment after the older and larger siblings are satiated. If the food supply is limited, or the parents do not bring it fast enough, the smaller, younger birds may not get as much food as their older siblings and they may grow at a slower rate.

Table 1 shows the mean growth and relative growth rate of nestlings in relation to the sequence in which they hatched. There are obviously too little data for sixth-hatched nestlings to compare with the others. A mean of the R (rate) values over the entire nestling period was calculated as an index for comparison.

One-hundred-seventeen nestling goldfinches fledged between the ages of 8.5 and 15.5 days; mean 12.3 days. An index of growth rate was derived for the initial 10 days in the nest. After this time, fledglings were leaving nests in greater numbers. When earlier-hatched individuals left the nest, this allowed their smaller, last-hatched siblings to obtain more food.

TABLE 1. MEAN GROWTH AND RATE OF GROWTH IN WEIGHT OF GOLDFINCH NESTLINGS IN RELATION TO HATCHING SEQUENCE

Hatching Sequence	N	Day 0 x̄	(R)	N	Day 1 x̄	(R)	N	Day 2 x̄	(R)	N	Day 3 x̄	(R)	N	Day 4 x̄	(R)
1	40	1.3		35	2.0±0.1	.44	39	2.8±0.1	.35	37	3.9±0.1	.31	36	4.9±0.1	.25
2	38	1.3		34	2.0±0.1	.45	38	2.8±0.1	.36	37	3.8±0.1	.28	35	4.9±0.1	.25
3	34	1.2		34	2.0±0.1	.49	36	2.7±0.1	.33	34	3.7±0.1	.30	33	4.6±0.1	.22
4	27	1.1		30	1.8±0.1	.47	31	2.6±0.1	.37	30	3.4±0.1	.28	23	4.3±0.2	.23
5	22	1.3		22	1.7±0.1	.28	18	2.5±0.1	.40	16	3.4±0.2	.33	13	4.2±0.2	.21
6	4	1.3		3	1.8±0.4	.36	3	2.5±0.4	.33	3	3.6±0.5	.35	2	3.6	.01
	N	Day 5 x̄	(R)	N	Day 6 x̄	(R)	N	Day 7 x̄	(R)	N	Day 8 x̄	(R)	N	Day 9 x̄	(R)
1	34	6.1±0.1	.21	30	7.3±0.1	.19	33	8.4±0.1	.14	31	9.6±0.1	.12	32	10.4±0.2	.09
2	30	6.0±0.1	.21	30	7.2±0.1	.19	30	8.2±0.1	.13	29	9.5±0.2	.14	31	10.1±0.2	.07
3	28	5.8±0.2	.23	29	6.8±0.2	.17	29	8.0±0.2	.16	28	9.1±0.2	.13	29	9.7±0.2	.06
4	21	5.5±0.3	.26	23	6.8±0.3	.20	23	8.1±0.2	.18	20	9.1±0.1	.12	18	9.7±0.2	.07
5	14	5.3±0.3	.22	14	6.8±0.2	.26	11	8.3±0.2	.19	13	9.1±0.3	.09	12	9.3±0.3	.03
6	4	5.4±0.8	.40	3	6.5±0.9	.19	3	8.1±1.0	.23	3	8.8±1.5	.09	1	6.2	—.35
	N	Day 10 x̄	(R)	N	Day 11 x̄	(R)	N	Day 12 x̄	(R)	N	Day 13 x̄	(R)		Index Thru day 10	
1	32	10.9±0.2	.05	24	11.3±0.2	.03	1,	11.3±0.3	.00	11	12.0±0.3	.06		.22	
2	29	10.6±0.1	.05	23	10.8±0.1	.02	17	11.3±0.2	.04	8	11.2±0.3	.00		.21	
3	24	10.2±0.2	.05	21	10.6±0.2	.04	14	10.7±0.3	.01	8	11.2±0.4	.04		.21	
4	14	10.0±0.2	.03	14	10.2±0.3	.01	5	10.5±0.5	.03	3	11.9±0.6	.13		.22	
5	10	9.6±0.3	.03	7	9.5±0.7	—.01	4	11.5±0.1	.19					.20	
6	1	9.2	.39												

TABLE 2. MEAN GROWTH AND RATE OF GROWTH IN WEIGHT OF GOLDFINCH NESTLINGS IN RELATION TO NUMBERS IN THE NEST

No. in Nest	Day 0			Day 1			Day 2			Day 3			Day 4		
	N	x̄	(R)	N	x̄	(R)	N	x̄	(R)	N	x̄	(R)	N	x̄	(R)
1	2	1.4±.2		1	2.0		1	2.8		1	4.2		1	5.5	
2	4	1.3±.1		2	2.4±.2		2	3.0±.1		2	4.3±.1		2	5.3±.4	
3	15	1.2±.1		13	1.9±.1	.45	12	2.7±.1	.36	9	3.6±.2	.30	10	4.8±.2	.29
4	42	1.2		36	1.8±.1	.43	40	2.7±.1	.37	38	3.6±.1	.30	36	4.6±.1	.26
5	78	1.2		83	1.8	.40	87	2.7	.38	82	3.7±.1	.31	73	4.6±.1	.23
6	24	1.3±.1		23	2.1±.1	.51	23	3.0±.1	.34	22	3.7±.1	.24	20	4.7±.2	.22
	Day 5			Day 6			Day 7			Day 8			Day 9		
	N	x̄	(R)	N	x̄	(R)	N	x̄	(R)	N	x̄	(R)	N	x̄	(R)
1	1	6.0					1	8.5		1	8.9		1	9.5	
2	2	7.2		2	8.2±.5		2	8.9±.6		2	10.1±.9		2	11.6±.6	
3	11	5.9±.2	.21	9	7.1±.2	.19	9	8.0±.2	.11	9	9.1±.3	.13	12	10.0±.2	.09
4	33	5.8±.1	.22	30	7.0±.1	.20	33	8.1±.1	.14	32	9.0±.2	.10	31	9.7±.2	.08
5	66	5.7±.1	.23	71	7.0±.1	.20	63	8.3±.1	.17	62	9.4±.1	.13	62	10.0±.1	.05
6	18	5.8±.3	.22	17	6.8±.3	.14	21	8.2±.2	.20	18	9.4±.3	.14	15	10.0±.3	.06
	Day 10			Day 11			Day 12			Day 13			Index Thru day 10		
	N	x̄	(R)	N	x̄	(R)	N	x̄	(R)	N	x̄	(R)			
1	1	11.3		1	11.4										
2	2	12.7±1.0		1	12.4										
3	10	11.0±0.3	.10	11	11.2±.2	.02	6	11.1±.4	—.01	5	12.0±.6	.08		.22	
4	28	10.4±0.1	.07	18	10.7±.2	.03	14	0.8±.2	.01	10	11.2±.3	.03		.22	
5	59	10.4±0.1	.04	46	10.7±.1	.03	29	11.3±.2	.05	11	11.9±.2	.05		.21	
6	10	9.8±0.3	—.01	12	10.0±.5	.02	9	10.7±.5	.07	4	11.1±.7	.03		.21	

The assumption is made that if the remaining nestlings outnumber young that have left the nest, the nestlings receive more food per individual than previously, and those birds out of the nest are not fed as well. Only one observation of this was made. A first-hatched nestling weighed 9.2 grams on day 11. On the following day it was found a few feet from the nest and weighed only 7.0 grams but was crying loudly for food. The index values for growth over the first 10 days of nest life are very similar, with perhaps an indication that fifth-hatched nestlings grew at a slower rate than their earlier-hatched siblings.

Data presented in Table 2 show that there is a tendency for nestlings to grow faster in nests containing fewer nestlings. Unfortunately, there was only one nest with one nestling and one nest with two nestlings. An index for the first 10 days shows that mean rate of growth was nearly the same, but perhaps a little faster for nests containing fewer nestlings.

The author found (Holcomb 1969) a significantly larger clutch size of goldfinches in 1963 than 1964. This was explained as perhaps due to drought conditions in 1964 when less food was available. There appeared to be far more food available in 1963. However, there were 47 nests constructed in 1963 compared to only 29 in 1964 in the same unit of area. In 1965, only a few nestlings were followed through complete development. Therefore, because of the differences in numbers of nests in the study area and differences in precipitation between 1963 and 1964, an index for growth rate in weight was calculated for both years in relation to hatching sequence and numbers in the nest. Indexes in relation to hatching sequence in 1963 and 1964 were, respectively, nestling one, .22 vs. .21; nestling two, .21 vs. .21; nestling three, .22 vs. .20; nestling four, .23 vs. .21; nestling five .21 vs. .19. Indexes in relation to numbers in the nests were, respectively, for 1963 and 1964, three nestlings, .24 vs. .21; four nestlings, .22 vs. .21; five nestlings, .20 vs. .20; six nestlings, .20 vs. .21. These data show that nestlings grew at about the same rate in both years irrespective of their sequence in hatching. The data indicate that for 1963, there was more difference in rates of growth for nests containing different numbers of nestlings than in 1964, where three or four in a nest grew faster than five or six nestlings. Although drought conditions prevailed in 1964, the reduced clutch size and fewer number of breeding pairs provided enough food for nestling growth.

It is obvious that nestlings grew at nearly the same rates in 1964 as they did in 1963. The mean clutch size in 1963 was 5.1 and in 1964, 4.7. If all 47 nests constructed in 1963 had received the full complement of eggs, there would have been a potential of 241 nestlings to feed. On the other hand, if the 29 nests in 1964 had received the full complement of eggs, there would have been a potential of 136 nestlings to feed; 105 less than in 1963. Actually, 184 eggs were found in 1963 and 115 in 1964 of which 123 and 64 hatched, and 91 and 46 fledged, respectively. Eleven young starved in 1963, whereas only one starved in 1964.

Paynter (1954) for Tree Swallows (*Iridoprocne bicolor*) and Lack and Silva (1948) for European Robins (*Erithacus rubecula*), found slight differences in the mean weight growth of broods of different sizes. Lack and Silva (*op. cit.*) stated that food was plentiful in the year of their studies and that perhaps the differences would have been greater if food had been less abundant.

b. *Starvation and brood reduction.*

All 12 starvations occurred in nests containing four (4 nests), five (six nests) or six (2 nests) nestlings, and the last hatched individuals were always the ones that died. Eleven of the 12 starved in 1963, when food appeared plentiful, but there was a higher density of nests.

Lack (1947, 1954, 1966) showed that in bird species that have asynchronous hatching, brood size may be adjusted to food availability. The oldest and largest nestlings are fed at the expense of smaller and weaker nestlings in times of food shortage, insuring some survival of the nestlings. Ricklefs (1965) demonstrated this action in the Curve-billed Thrasher (*Toxostoma curvirostre*), and described two possibilities of adjusting brood size; 1) prior evaluation of food availability and reduction of clutch size, or 2) brood reduction after hatching when the food fluctuations are unpredictable. It is obvious that in some instances, especially in 1963, brood reduction took place in the goldfinches. In 1964, when the clutch size was reduced and there were fewer goldfinches nesting in the area, only one nestling died of starvation, even though drought conditions prevailed and food was less abundant. In 1964, perhaps the goldfinches could evaluate the nesting situation prior to laying eggs. The mechanism of prior evaluation is not at all clear. It may be that availability of food, just prior to or throughout the laying of the clutch, affects the clutch size. A suggestion has been made concerning the ultimate and proximate factors controlling the timing of reproduction in goldfinches (Holcomb 1969). The ultimate factor may be production of adequate quantities of Compositae seeds in July and August. The internal mechanism may be stimulated by a proximate factor such as long day length in June and July and then nesting is started when an adequate food source is available to support breeding adults in addition to nestlings.

Brenner (1966) reported the influence of drought on reproduction in a breeding population of Red-winged Blackbirds (*Agelaius phoeniceus*). When there was lower precipitation, the mean standing crop of insects decreased and the number of breeding females decreased in 1962 and 1963. When the precipitation was higher for 1964, the mean standing crop of insects increased and the number of breeding females increased. The mean values for weights of nestlings reported by Brenner (1964), when compared to those of Williams (1940), were lower, perhaps because of the lack of insect biomass with which to feed nestlings (Brenner suspects this may be true, pers. comm.). Willson (1966) reported many cases of brood reduction in the Yellow-headed Blackbird (*Xanthocephalus xantho-*

cephalus) when insects were fewer because of poor weather conditions.

c. *Significance of clutch size.*

Lack (1954, 1966) advances the hypothesis that birds most frequently lay a clutch size which results in the most offspring being produced. It is difficult to analyze data of this kind for a species such as the goldfinch, which has a decline in clutch size as the season progresses as well as a decline in renests (Walkinshaw, 1938; Stokes, 1950; Holcomb, 1969). The data were reviewed carefully for those clutches on which full information was available. There was a total of 62 clutches; one with three eggs, seven with four eggs, 38 with five eggs and 16 with six eggs. There were no fledglings from the three-egg clutch, 15 from four-egg clutches, 83 from five-egg clutches and 51 from six-egg clutches. Eggs did not hatch in some nests, because of predation. Thus, a mean was calculated for the different-sized clutches where the eggs hatched. There was a mean of 2.1 (seven nests), 2.7 (31 nests) and 4.3 (12 nests) fledglings produced from nests with four, five, and six egg clutches, respectively.

It is obvious that five- and six-egg clutches contribute the most fledglings. It seems quite common for a female goldfinch to lay six eggs in an early clutch and be quite successful in raising the brood. If the first nest is a failure, she probably lays not more than five eggs in the second clutch. However, even though several females lay six in a first clutch, there are more five-egg clutches than six-egg clutches early in the nesting season.

There may be some post-fledging mortality that affects nestlings from nests of six more than from nests of five. Lack (1966) has reported that young Great Tits (*Parus major*) that fledge at lighter weights do not survive as well as those fledging at heavier weights. Although this paper shows that growth rate varied little depending on the number of nestlings in the nest, Table 2 shows that mean weight at fledging is less for nestlings from nests of six than from nests of five. This lighter weight may eventually culminate in less survival and thus lead to a predominance of offspring produced by females that lay five-egg clutches.

SUMMARY

Goldfinch nestling mean growth and relative growth rate in weight were studied in relation to the hatching sequence and number of nestlings present in a nest. There was little difference in mean growth or growth rates in relation to the above situations, except that fifth-hatched nestlings grew at a mean slower rate than earlier-hatched siblings. There is a general tendency for nestlings to grow faster in nests containing fewer siblings.

There was a reduced clutch size and fewer nests in the area studied when drought conditions were present. Although food appeared less abundant, there was ample food for the reduced numbers. When the mean clutch size was larger and the nesting

population was greater, more fledglings were produced but brood reduction was common.

The most frequent clutch size was five. The significance of this clutch size is discussed with respect to number of ultimate offspring produced.

LITERATURE CITED

BANKS, R. C. 1959. Development of nestling White-crowned Sparrows in central coastal California. *Condor* **61**: 96-109.

BRENNER, F. J. 1964. Growth, fat deposition and development of endothermy in nestling Red-winged Blackbirds. *J. of the Scientific Laboratories, Denison University* **46**: 81-89.

——1966. The influence of drought on reproduction in a breeding population of Redwinged Blackbirds. *Amer. Midl. Natur.* **76**: 201-210.

HOLCOMB, L. C. 1969. Breeding biology of the American Goldfinch in Ohio. *Bird-Banding* **40**: 20-44.

LACK, D. 1947. The significance of clutch-size. *Ibis* **89**: 302-352.

——1954. The natural regulation of animal numbers. Oxford University Press. 343 pp.

——1966. Population studies of birds. Oxford University Press. 341 pp.

LACK, D., and E. T. SILVA. 1948. The weight of nestling Robins. *Ibis* **91**: 64-78.

PAYNTER, R. A., JR. 1954. Interrelations between clutch-size, brood-size, prefledgling survival, and wieght in Kent Island Tree Swallows (continued). *Bird-Banding* **25**: 102-110.

RICKLEFS, R. E. 1965. Brood reduction in the Curve-billed Thrasher. *Condor* **67**: 505-510.

——1968. Patterns of growth in birds. *Ibis* **110**: 419-451.

STOKES, A. W. 1950. Breeding behavior of the Goldfinch. *Wilson Bull.* **62**: 107-127.

WALKINSHAW, L. H. 1938. Life history studies of the eastern Goldfinch, Part I. *Jack-Pine Warbler* **16**: 3-11 and 14-15.

WILLIAMS, J. F. 1940. The sex ratio in nestling eastern red-wings. *Wilson Bull.* **52**: 267-277.

WILLSON, M. F. 1966. Breeding biology of the Yellow-headed Blackbird. *Ecol. Monogr.* **36**: 51-77.

Department of Biology,
Creighton University, Omaha, Nebraska 68131.

Received February, 1969.