Development of Courtship Feeding in the American Goldfinch (*Carduelis tristis*)

Doris J. Watt and Laura A. Sadowski
Department of Biology
Saint Mary's College
Notre Dame, Indiana 46556

Introduction

Many cardueline finches display courtship feeding, a behavior that typically involves the transfer of food from a male to a female during the courtship or reproductive period. In the American Goldfinch (*Carduelis tristis*) the behavior is variable in expression, from a brief touching of bill tips to prolonged bouts of food transfer involving the insertion of one bird's bill into the other's. In addition, some form of the behavior may be seen throughout the year in captive flocks and may involve homosexual as well as heterosexual pairs of birds (4, 5), suggesting that courtship feeding in American Goldfinches may have social functions beyond those of reproduction.

The American Goldfinch is unusual compared to other North American passerines in that its breeding season occurs late in the summer, beginning in July or early August. This late season probably reflects the bird's dependency on the production of Composite seeds to feed the nestlings (4, 8). The result is a prolonged summer period in which courtship feeding may develop, presumably functioning in the establishment and stabilization of male-female relations leading to pair-bonding and mating.

The purpose of our study was to document the development of heterosexual courtship feeding through the late spring and summer season. As the breeding season approached we studied the process of pair-formation, and related the outcome of these pairings to both the male's and female's dominance rank.

Methods

Ten American Goldfinches, presumably members of a single flock, were caught in mist nets 21 March 1984 near Saint Mary's College, Notre Dame, St. Joseph County, Indiana. The birds were kept in an aviary (2 meters on a side) in the Science Building, Saint Mary's College, under U.S. Fish & Wildlife Service permit #PRT2-7801-TW. Artificial lighting was provided to maintain a 10-hour light: 14-hour dark (winter) schedule initially, and then increased to a 12-hour light: 12-hour dark (summer) schedule on 18 June 1985. Three plastic thistle feeders were suspended in the aviary providing seeds *ad libitum*, and a continuous supply of fresh water was available from a plastic dispenser. Each bird was individually marked with colored leg bands on 2 April, and weight, wing length, sex and a description of each bird's plumage were recorded at that time.

The captive flock was observed by the first author and members of the animal behavior class at Saint Mary's College from 2-23 April. Dominance interactions between pairs of birds were recorded and later tabulated in the form of a dominance matrix (Figure 1). [Bird "labels" were assigned based on sex ("F" or "M") and rank ("A", "B", etc.) in the spring hierarchy for all 10 birds. These labels were easier to use for figure captions than identities based on color-band combinations.] From 23 May to 8 August the second author observed the flock and recorded (1) frequency of courtship feedings, (2) identities of participating feeders, and (3) dominance interactions between pairs of birds during the week of 11-18 July. These latter data were tabulated in a dominance matrix (Figure 2). All observations were made through a one-way window in the aviary from which feeders and perch sites (wires) could be seen.

SPRING

♂ – ♂

LOSER

WINNER	AM	BM	CM	DM
AM		3	3	5
BM	0		0	1
CM	0	0		1
DM	0	0	0	

♀ – ♀

LOSER

WINNER	AF	BF	CF	DF	EF	GF
AF		10	1	8	0	5
BF	3		2	8	1	4
CF	2	1		4	0	0
DF	4	0	0		0	3
EF	0	0	0	0		1
GF	0	0	0	0	0	

FIGURE 1. Matrix of dominance encounters between pairs of birds within a flock of 10 American Goldfinches during April.

SUMMER

♂ - ♂

LOSER

WINNER	AM	CM	BM	DM
AM		6	5	11
CM	1		3	1
BM	2	2		7
DM	0	2	0	

♀ ♀

LOSER

WINNER	AF	CF	BF	EF	DF	GF
AF		5	7	4	0	2
CF	1		5	4	5	1
BF	3	1		2	2	5
EF	0	1	1		1	1
DF	0	0	0	0		2
GF	0	0	4	1	0	

FIGURE 2. Matrix of dominance encounters between pairs of birds within a flock of 10 American Goldfinches during July.

Results

Data recorded for the birds used in the study are given in Table 1. The six females of the flock were generally dominant to the four males during the spring season (Figure

TABLE 1. Identities of birds by label and wing length, weight, sex, and description of plumage on 2 April 1985 for 10 American Goldfinches.

Bird Label*	Wing length (mm)	Weight (g)	Sex**	Plumage Description
AM	70	13.1	M	Yellow 85% of body, black tail, wings
BM	73	12.8	M	Few black feathers on crown, yellow flanks, little on back
CM	71	11.8	M	Brightest male, yellow back, flanks, throat, black crown
DM	71	13.4	M	Wings, crown black, yellow on flanks, throat, neck, back
AF	68	14.0	F	Yellow flanks, throat, a few black feathers on head
BF	69	12.6	F	Yellow only on rump
CF	70	11.9	F	Little yellow on throat, sides
DF	67	11.2	F	Bright yellow throat, flanks, black bill tip
EF	69	12.7	F	Yellow throat, chest, molt on head, rump
GF	68	11.9	F	Little yellow on flanks

*See text for explanation of labels.
**M = male, F = female

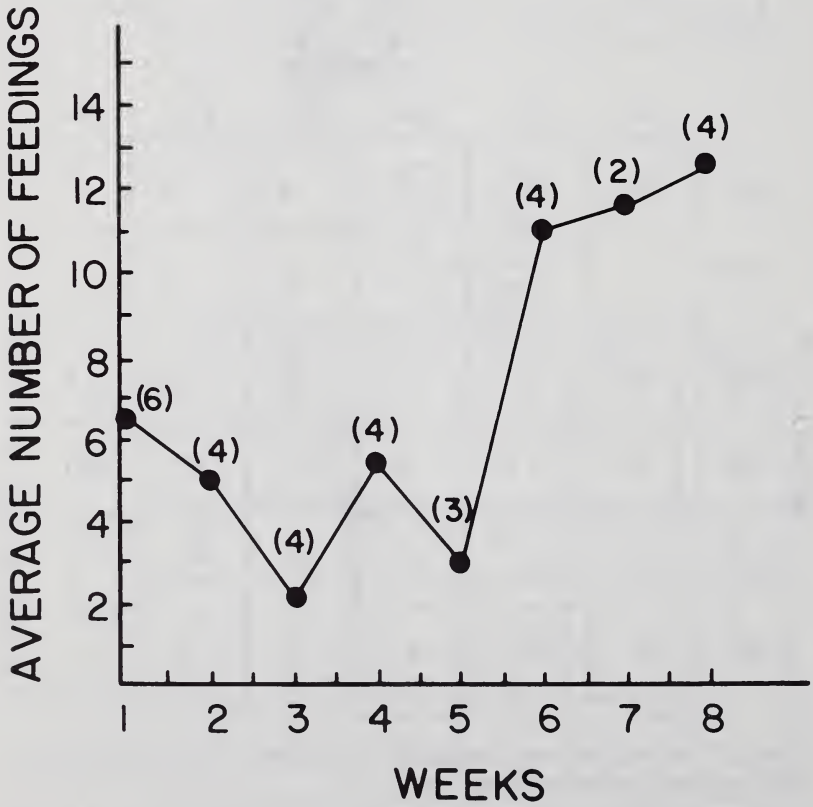

FIGURE 3. Intra-sexual dominance interactions for American Goldfinch males (top) and females (bottom) during April. The winner of the encounter is given to the left of the row, the loser is listed at the top of the column.

1), and relatively subordinate during the summer season (Figure 2). We extracted the intra-sexual interactions from the dominance matrices (Figures 3 and 4). The relationships between individual birds of the same sex remained relatively stable with only CM and BM switching ranks among the males from spring to summer (Figures 3(top) and 4(top)), and CF and BF, and EF and DF switching ranks among the females (Figures 3(bottom) and 4(bottom)).

WINNER \ LOSER	AF	BF	CF	DF	EF	AM	BM	GF	CM	DM
AF		10	1	8		8	4	5	5	8
BF	3		2	8	1	1	5	4	7	3
CF	2	1		4		5	1		4	3
DF	4					2	6	3	1	
EF								1		
AM		3						3	3	5
BM	1									1
GF									1	3
CM		1								1
DM	5			3	2			1		

FIGURE 4. Intra-sexual dominance interactions for American Goldfinch males (top) and females (bottom) during July. The winner of the encounter is given to the left of the row, the loser is listed at the top of the column.

Courtship feeding rates increased rapidly following the mid-June increase in light period (Figure 5), and a pattern of relationships between birds feeding one another developed as the season progressed (Table 2). Early in the study many individual birds participated in feeding one another (see Week 1 of Table 2). By Week 3 the birds seemed to begin "pairing up"; for example, GF and CM frequently engaged in feeding behavior. By weeks 4 and 5 GF and CM, and DF and AM seemed to favor each other over other feeding partners. DM fed females less and less frequently. By week 5 the relationships that were the most prominent in later weeks appeared (GF with CM and DF with AM). Although none of the males remained completely "faithful" to a female, a definite pair relationship existed by weeks 7 and 8 with CM feeding

LOSER

WINNER	AM	DM	CM	AF	CF	BF	EF	BM	DF	GF
AM		11	6	3	2	8	2	5	1	1
DM			2	2	3	4	1			1
CM	1	1		3	1	3		3	1	5
AF	3				5	7	4	1		2
CF	3	1	4	1		5	4	2	5	1
BF	1		1	3	1		2	3	2	5
EF	1	1			1	1		3	1	1
BM	2	7	2		1	2	1			3
DF	3		1							2
GF		2				4	1			

FIGURE 5. Weekly average number of courtship feeding bouts per hour for a group of 10 American Goldfinches starting 23 May. Daylength was increased 18 June to stimulate breeding activities. Numbers in parentheses are numbers of hours observed for that week.

GF almost exclusively and AM feeding DF. The remaining females (AF, BF, CF, and EF) never formed a bond with any particular male even though they were occasionally seen being fed by males.

AM was by far the most diverse "feeder" at the start, feeding almost all of the females at one time or another (Table 2). The strongest bond was between GF and CM. Whenever GF would give a soliciting call, CM would fly to her from wherever he was perched and begin feeding her. None of the other birds in the group showed this type of relationship.

Dominance ranks appeared to influence male courtship feeding in the following way: The more dominant a male was, the more likely he was to feed females, and the more likely he was to develop a feeding relationship with one particular female (presumably a pair bond). Male AM dominated other males both early and late in the season, CM became second in rank, rising over BM in dominance, and DM was least dominant throughout the study (Figures 3 and 4 (top)). AM and CM were the most frequent feeders, averaging 87% of the feedings per week over the study period (Table 2).

Females were affected in the opposite manner by dominance rank: The more subordinate a female was, the more likely she was to be fed by males. Females DF and GF became the least dominant females within the female dominance hierarchy (Figure 4 (bottom)). These two females were the ones that became paired with the dominant males and involved in courtship feeding relationships with them by the end of the study. Other, more dominant females became less and less frequently involved in feeding bouts with time (see Table 2).

Discussion

Our observations of general behaviors were comparable to works of other authors

TABLE 2. Identities of birds involved in and numbers of courtship feeding bouts during an eight-week period for 10 American Goldfinches.

Week #	Pair Identities (Male left, female right)	Number of Feeding Bouts	Total Per Male (%)
1	AM-DF	8	
	-GF	8	16 (.46)
	CM-AF	1	
	-CF	2	
	-GF	3	6 (.17)
	DM-AF	3	
	-DF	3	
	-GF	7	13 (.37)
2	AM-DF	3	
	-GF	3	6 (.86)
	CM-DF	1	1 (.14)
3	AM-DF	6	6 (.67)
	CM-GF	3	3 (.33)
4	AM-AF	1	
	-CF	1	
	-DF	2	
	-GF	2	6 (.38)
	BM-GF	1	1 (.06)
	CM-GF	5	5 (.31)
	DM-DF	4	4 (.25)
5	AM-DF	8	
	-GF	1	9 (.69)
	CM-GF	4	4 (.31)
6	AM-DF	9	
	-GF	9	18 (.58)
	BM-EF	1	1 (.03)
	CM-GF	8	8 (.26)
	DM-DF	3	
	-EF	1	4 (.13)
7	AM-BF	1	
	-DF	6	7 (.33)
	BM-BF	1	1 (.05)
	CM-GF	13	13 (.62)
8	AM-AF	6	
	-DF	9	
	-GF	1	16 (.36)
	BM-BF	2	2 (.04)
	CM-GF	23	23 (.51)
	DM-DF	1	
	-EF	3	4 (.09)

on American Goldfinches (4, 5, 8) and other finch species (1, 2, 7), in particular, with regards to female dominance during the non-breeding season (1, 7) and male dominance during the breeding season (2) for House Finches (*Carpodacus mexicanus*). Dominance encounters did not fit into a linear hierarchy as easily in the summer as in late spring (Figures 1 and 2). The number of non-linear relationships in the July matrix are an indication of the "breakdown" of the social group as individuals would normally begin mate-pairing during this period.

In our study dominance rank of the male determined his success in pairing with a female for courtship feeding (and presumably mating). Dominance has been shown to be an important component of survival in Silvereyes (*Zosterops lateralis chlorocephalia*) in Australia (3) and Wood-pigeons (*Columba palumbus*) (6). Dominance

rank may also be related to reproductive fitness in finches through the associated ability to obtain mates, as indicated by our study.

Dominance may also be associated with survival in female American Goldfinches during the non-breeding season. Our only indication of such an advantage was the relatively high body weight of the most dominant female (see Table 1) in our study. It is less clear how females that are relatively dominant are at an advantage during the breeding season. Watt et al. (9) suggested that for White-throated Sparrows (*Zonotrichia albicollis*), one type of female may decrease in aggressiveness and dominance from the winter to spring season, gaining advantages from both strategies. In our study the subordinate female American Goldfinches were preferentially fed by males. Perhaps dominant females are too aggressive and do not allow a male to approach near enough to feed them. It remains to be determined whether or not field conditions, where birds can interact more freely, might result in a different scheme of courtship feeding and mate choice.

Finally, the relative importance of non-courtship feeding behavior during the winter months has not been studied. If food is actually transferred during times of stress in free-living groups, then "who feeds whom" might be of importance. Perhaps these behaviors only represent an extended period of feeding fledglings, and perhaps, the flocks are family groups.

Literature Cited

1. Johnson, R. F. 1969. Aggressive foraging behavior in House Sparrows. Auk 86:558-559.
2. Kalinoski, R. 1975. Intra- and inter-specific aggression in House Finches and House Sparrows. Condor 77:375-384.
3. Kikkawa, J. 1980. Winter survival in relation to dominance classes among silvereyes *Zosterops lateralis chlorocephalia* of Heron Island, Great Barrier Reef. The Ibis 122:437-446.
4. Middleton, A. L.A. 1978. The annual cycle of the American Goldfinch. Condor 80:401-406.
5. Mundinger, P. C. 1970. Vocal imitation and individual recognition of finch calls. Science 168:480-482.
6. Murton, R. K. 1967. The significance of endocrine stress in population control. The Ibis 109:622-623.
7. Thompson, W. L. 1960. Agonistic behavior in the House Finch. Part II. Factors in aggressiveness and sociality. Condor 62:378-402.
8. Tyler, W. M. 1968. *Spinus tristis tristis* (Linnaeus) Eastern American Goldfinch. Pp. 447-466. *In* O. L. Austin Jr. [ed.], Life histories of North American cardinals, grosbeaks, buntings, towhees, finches, sparrows and allies. U. S. Natl. Mus. Bull. 237, Part 1.
9. Watt, D. J., Ralph, C. J., and Atkinson, C. T. 1984. The role of plumage polymorphism in dominance relationships of the White-throated Sparrow. Auk 101:110-120.