INTRA- AND INTERSPECIFIC AGGRESSION IN HOUSE FINCHES AND HOUSE SPARROWS

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Although House Finches (*Carpodacus mexicanus*) and House Sparrows (*Passer domesticus*) are distinct taxonomically, they share several ecological and behavioral similarities. Both are gregarious and are semi-colonial nesters, defending only a small, variable territory surrounding the nest (Thompson 1960a, Summers-Smith 1963). Both species are conspicuously well adapted to man-modified habitats and regularly build nests on man-made structures. Further, numerous observers have reported interspecific conflict between the two species involving nest sites (Gilman 1908, Bergtold 1913, Evenden 1957, and Thompson 1960a). Both species feed extensively in a group and overlap considerably in food selection. The diet of the House Finch includes a wide variety of weed seeds and cultivated fruits (Beal 1907, Roessler 1936), most of which are also consumed by House Sparrows. The House Sparrow, however, has a more catholic diet, including a number of items not eaten by the finches, especially insects, grain, and feed waste (Kalmbach 1940, Southern 1945, Summers-Smith 1963). Mixed foraging flocks are common (Brown 1911) and both are regular visitors to artificial feeders.

Thompson (1960a and b) discussed similarities between the two species in courtship postures and communal displays. Both possess the head-forward threat display (Thompson 1960a and Summers-Smith 1963), and dominance of females over males in winter has been observed for both species (Thompson 1960a and Johnston 1969).

The history of the introduction and spread of the House Sparrow in North America has been reviewed elsewhere (Barrows 1889, Skinner 1904, Brewster 1906, Kalmbach 1940, Southern 1945). This species first invaded New Mexico around 1900 (Hubbard 1970) and therefore has been in contact with House Finches in this area for about 75 years. Based on the above information, one might expect that the two species are actual or potential competitors; however, they coexist successfully in urban, suburban, and rural agricultural areas in New Mexico. Although I did not attempt a direct measurement of the degree of competition (e.g. Davis 1973), there is little evidence of competitive exclusion occurring on a broad scale.

Nevertheless several authors have recorded aggressive encounters between these two species. All of these have indicated that House Sparrows are dominant to House Finches. Bergtold (1913) reported that House Sparrows were directly responsible for the destruction of 16% of the House Finch eggs in Denver, Colorado, as well as undetermined numbers of nests and nestlings. He further reported that defense efforts by adult House Finches were ineffective. Evenden (1957) described how House Sparrows destroyed the nests of House Finches. From one to several pairs of sparrows would continually harass a pair of finches, resulting in nest abandonment. Subsequently, the finch nest would be rebuilt by one pair of sparrows for their own use. Similar observations have been published by Abbott (1929) and Gilman (1908).

I undertook the present study to determine the extent of interspecific agonistic behavior between House Finches and House Sparrows under non-breeding conditions, to describe the patterns of variation in aggression throughout the winter, and to interpret the results in terms of the adaptive significance of interspecific aggression in these species. The study was conducted in two parts: (1) an observational study of free-ranging birds which utilized an outdoor feeder throughout the winter; and (2) an experimental study with caged groups of both species.

AGONISTIC BEHAVIOR AT AN OUTDOOR FEEDER IN WINTER

MATERIALS AND METHODS

I made observations of agonistic behavior in House Finches and House Sparrows at an outdoor feeding station from October, 1970 through March, 1971 in Albuquerque, New Mexico. The station was located in a suburban backyard, in an open area surrounded by sparse cover. Observations were made at a distance

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The Condor 77:375–384, 1975

TABLE 1. Presence of House Finches, House Sparrows, or both, during variable observation periods at a winter feeding station.

Species Present	Months						% of total obs. periods
	Oct	Nov	Dec	Jan	Feb[1]	Mar[1]	
House Sparrows Alone							
% of monthly totals	2.4	0	6.2	4.1	0	0	2.8
no. of observation periods	(2)	(0)	(2)	(2)	(0)	(0)	(6)
House Finches Alone							
% of monthly totals	45.8	48.3	46.9	24.5	18.2	12.5	38.7
no. of observation periods	(38)	(14)	(15)	(12)	(2)	(1)	(82)
Both Species Present							
% of monthly totals	51.8	51.7	46.9	71.4	81.8	87.5	58.5
no. of observation periods	(43)	(15)	(15)	(35)	(9)	(7)	(124)
Monthly totals	(83)	(29)	(32)	(49)	(11)	(8)	(212)

[1] As fewer observations were made during these months, the data should not be interpreted to mean that the birds used the feeder less regularly.

of 5 m from inside a house and were aided by 7 × 35 binoculars.

A wooden feeding tray (70 × 60 × 5 cm), covered with 2.5 cm mesh poultry netting to minimize food scattering, was partitioned into 6 equal-sized feeding cells, each 30 × 23.3 × 5 cm, and was supplied with a variety of seeds, including sunflower, millet, milo, corn, thistle, and hemp. Millet, the only food extensively consumed by both species, was continually present in the feeder.

Observations of agonistic behavior, totaling 37 hours, were made at different times of day. Because of the highly irregular feeding patterns of the birds, no standardized observation period was used in this study. Rather, I considered an observation period to begin when I noted birds at the feeder, and to end when all birds had left the feeding area. Observation periods varied in duration from 1 to 87 minutes (mean = 15.4 minutes, $N = 145$). This situation is similar to that described by Johnston (1969).

I recorded an agonistic encounter between two individuals in any of several circumstances, following Thompson (1960a). Simple avoidance behavior occurred when a subordinate individual retreated upon the approach of a dominant. In a supplanting attack, a dominant flew or hopped directly at a subordinate, causing it to retreat. Chasing consisted of a series of rapid supplanting attacks by a dominant directed toward a single subordinate. In the head-forward threat display, a dominant bird lowered and oriented its head and body toward an encroaching subordinate, which had violated the dominant's individual distance. Typically, the subordinate withdrew without hesitation. Occasionally, however, a reverse threat occurred, where a threatened individual successfully retaliated against an aggressor, corresponding to the "stay-threat" described by Watson (1970) for House Sparrows. In combat two birds flew up from the feeding tray, fighting with their bills and claws, and calling loudly. The winner usually returned to the feeder. I recorded the species and sex of the opponents in each agonistic encounter.

Although 162 birds were trapped and color-banded (111 House Finches and 51 House Sparrows) unbanded individuals of both species were numerous. Several flocks of each species apparently used the feeder, making it impractical to establish dominance hierarchies on an individual basis.

RESULTS

House Finches visited the feeding station more frequently than House Sparrows. Moreover, when House Sparrows were feeding, House Finches were almost always present also. Data relating to the attendance of both species alone or together at the feeder during observation periods of variable length are presented in table 1. More than half (58.5%) of the observations were made with both species at the feeder. House Finches fed alone during 93% of the remaining observations, while House Sparrows were present alone only during 7% of these. Numbers of

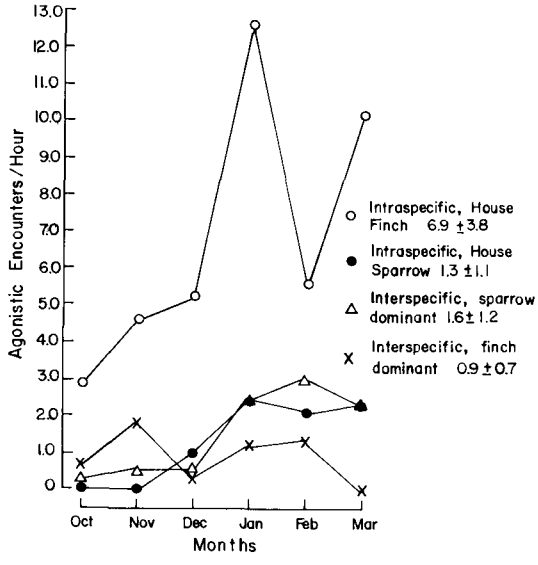

FIGURE 1. Seasonal occurrence of intra- and interspecific agonistic encounters among House Finches and House Sparrows at a winter feeding station. Group means and standard deviations are given with symbol identifications.

TABLE 2. Diurnal occurrence of intra- and interspecific agonistic encounters among House Finches and House Sparrows. The data are given in terms of the mean number of observed agonistic encounters per hour for each group. Sample sizes are given in parentheses.

	Time of day				
Type of encounter	<10 AM Enc./hr	10–12 Enc./hr	12–2 Enc./hr	2–4 Enc./hr	>4 PM Enc./hr
Intraspecific, House Finch	7.57 (66)	5.67 (51)	4.32 (27)	8.25 (55)	6.70 (44)
Intraspecific, House Sparrow	1.49 (13)	1.44 (13)	0.48 (3)	1.95 (13)	0.30 (2)
Interspecific, Sparrows dominant	1.83 (16)	0.33 (3)	0.16 (1)	2.10 (14)	0.61 (4)
Interspecific, Finches dominant	1.26 (11)	0.78 (7)	0.16 (1)	1.35 (9)	0.91 (6)
Totals	12.16 (106)	8.22 (74)	5.12 (32)	13.64 (91)	8.52 (56)

individuals of each species fluctuated too rapidly to be tallied.

Figure 1 summarizes total agonistic encounters/hour in House Finches and House Sparrows throughout the winter for each type of species interaction. As the number of individuals feeding increased, the available feeding space per individual decreased, resulting in a higher frequency of agonistic encounters. In January, the coldest part of the winter, large numbers of birds of both species used the feeder. The resultant increase in agonistic behavior is apparent in figure 1. The figure also shows that House Finches were more aggressive toward conspecifics than toward House Sparrows, while House Sparrows showed about the same amount of aggression to their own and the other species. Although I did not record specific displays, it appeared that most of the interspecific encounters won by House Finches involved the head-forward threat display performed by a finch toward an approaching House Sparrow. On the other hand, nearly all the encounters won by House Sparrows consisted of supplanting attacks.

Diurnal variation in agonistic behavior is shown in table 2. Time periods were selected arbitrarily so that the total observation time within each period was similar. Two peaks in aggressive behavior are evident, one in early morning and the other in mid-afternoon. Those peaks corresponded to periods of intense feeding activity, when many birds utilized the feeder. House Finches again directed more aggression intra- than interspecifically, while House Sparrows were as aggressive to the finches as to each other. The small sample sizes warrant caution in generalizing, however. Agonistic behavior in House Sparrows dropped off sharply in late afternoon, whereas in House Finches, aggression seemed to diminish more gradually.

An interspecific dominance hierarchy between the two species is presented in table 3. Generally females of both species were dominant to males of their species, and House Sparrows were dominant to House Finches. However, these relationships must be considered tentative because of small sample sizes. Each set of paired group encounter data was analyzed using the single classification chi-square test, and all relationships were found to be non-significant ($\chi^2 < 2.06$, df = 1, $P > .10$). Considerably more data would be needed to fully substantiate these relationships, but a trend is suggested.

ANALYSIS OF AGONISTIC BEHAVIOR IN CAPTIVE MIXED GROUPS OF HOUSE FINCHES AND HOUSE SPARROWS

MATERIALS AND METHODS

The subjects were four male House Finches, four male House Sparrows, eight female House Finches, and eight female House Sparrows, mist-netted in Albuquerque, New Mexico in April and May, 1971. All were adult. The birds were weighed upon capture, several times during the experiment, and at the termination of observations. Each subject was individually marked with color bands, as well as with paint applied to the rectrices. The birds were kept in intraspecific groups prior to experimentation, and were allotted 6 grams of white millet per individual per day. Water and grit were available ad libitum.

Three separate, adjacent cages (each $3.3 \times 2.7 \times 1.1$ m $= 9.8$ m^3) made of wood, aluminum screening, and plastic, were constructed inside a large environmentally controlled room (Louis A. Roser Co., Salt Lake City, Utah). Each cage contained numerous perches and was equipped with a small access door and a one-way vision observation window. A constant photoperiod of 12 hours light/12 hours dark

TABLE 3. Interspecific dominance hierarchy of female and male House Finches and House Sparrows, based on observed agonistic encounters at a winter feeding station. The rows represent the sex and species of the winners of encounters, the columns, the losers. Each cell contains the probability of winning and the total number of encounters for the corresponding species/sex groups. Only total encounters are given for intraspecific, intrasexual encounters.

	Losers				
Winners	Female House Sparrow	Male House Sparrow	Female House Finch	Male House Finch	Ave. prob. of win[1]
Female House Sparrow	—	.58	.59	.57	.58
	(10)	(12)	(29)	(7)	(48)
Male House Sparrow	.42	—	.58	.59	.55
	(12)	(14)	(24)	(17)	(53)
Female House Finch	.41	.42	—	.56	.52
	(29)	(24)	(38)	(124)	(177)
Male House Finch	.43	.41	.44	—	.43
	(7)	(17)	(124)	(62)	(148)
Ave. prob. of loss	.42	.45	.48	.58	
	(48)	(53)	(177)	(148)	

[1]Averages calculated by pooling the data for each row. Thus, they represent the total number of wins/total number of encounters for each group.

was maintained throughout the experiment. Relative humidity was kept below 25%.

Four mixed groups were established and maintained in different cages as follows: Group I—four male House Finches and four male House Sparrows; Group II—four male finches and four female sparrows; Group III—four female finches and four male sparrows; and Group IV—four female finches and three female sparrows. (One female finch died during, and a female sparrow died just prior to the experiment. Neither was replaced.)

Group I was observed in one of the cages from one to two and a half hours each day from 4/29/71 to 5/30/71. Subsequently, Groups II, III, and IV were run simultaneously from 5/31—6/18 and each group was observed for one hour daily. The sequence in which these groups were observed each day varied according to a rotating schedule. The male House Finches from Group I also were used in Group II. Likewise, the male House Sparrows from Group I were later used in Group III. Due to space limitations, control groups could not be accommodated.

The temperature in the environmental chamber was gradually lowered from 22°C, and maintained at a low of 2°—5° for several days, before being gradually returned to 22°C. Groups II, III, IV experienced temperatures ranging up to 39°C at the end of the experiment. A daily change of 2.8°C was desired, but the environmental controls were not reliable, and this could not be achieved.

The same criteria for scoring agonistic encounters as previously described were used for each group. For each observed encounter, the victor, loser and the location at which the encounter took place (i.e. food dish, water dish, or perches) were recorded on tally sheets.

RESULTS

The purpose of lowering the temperature was to test the hypothesis that higher rates of agonistic behavior would occur at lower temperatures. However, since control groups could not be used, temperature effects were statistically inseparable from the effects of time spent in the cage situation. Consequently, a rigorous statistical treatment could not be applied successfully to the data, and only the more general results will be reported.

Agonistic behavior. A total of 3739 agonistic encounters was recorded, of which 55% (2049) occurred intraspecifically among male House Finches. Intraspecific encounters for all groups combined accounted for 81% (3043) of the total. Of the interspecific encounters (19%, 696), the majority were won by House Sparrows (96%, 667). House Finches won very few interspecific encounters (4%, 29).

Table 4 presents the data for rates of agonistic encounters for all four intraspecific groups and all interspecific interactions. The data are given in terms of the mean number of observed agonistic encounters per individual per hour. Group means are broken down according to the locations in the cages at which encounters occurred.

Inspection of the table reveals several important relationships. Male House Finches showed the highest levels of intraspecific, intrasexual aggression, almost five times greater than aggression among female House Finches. Rates of aggressive encounters among House Sparrows of both sexes were less disparate and were slightly higher than the levels for female House Finches.

House Sparrows were clearly dominant to House Finches, regardless of the sex of either species. Although male House Finches were more aggressive intraspecifically than were

TABLE 4. The occurrence of intra- and interspecific agonistic encounters at different locations in caged groups of House Finches and House Sparrows. Data are given in terms of the number of observed encounters per individual per hour at each location for each species/sex group and interaction. The row totals are simply summed across the table. Each column total represents the total number of bird-hours for all entries combined.

	Location of encounter							
	Food		Water		Perch		Totals	
Type of encounter	Enc./ b-hr.	No. enc.	Enc./ b-hr.	No. enc.	Enc./ b-hr.	No. enc.	Enc./ b-hr.	No. enc.
Interspecific, Intrasexual								
Male House Finches	5.65	(1427)	0.21	(52)	2.26	(570)	8.11	(2049)
Female House Finches	0.80	(100)	0.06	(7)	0.78	(98)	1.64	(205)
Male House Sparrows	1.01	(251)	0.04	(10)	0.78	(194)	1.83	(455)
Female House Sparrows	0.74	(88)	0.07	(8)	2.00	(238)	2.81	(334)
Total Intraspecific	2.50	(1866)	0.10	(77)	1.48	(1100)	4.08	(3043)
Interspecific, Sparrows dominant								
Male Sp. over Male F.	0.48	(176)	0.05	(20)	0.26	(96)	0.79	(292)
Male Sp. over Female F.	0.43	(55)	0.07	(9)	0.68	(87)	1.18	(151)
Female Sp. over Male F.	0.38	(52)	0.07	(10)	0.42	(57)	0.88	(119)
Female Sp. over Female F.	0.29	(32)	0.01	(1)	0.64	(72)	0.94	(105)
Total Sp. over F.	0.42	(315)	0.05	(40)	0.42	(312)	0.89	(667)
Interspecific, Finches dominant								
Male F. over Male Sp.	0.05	(17)	0.01	(2)	0.003	(1)	0.05	(20)
Male F. over Female Sp.	0	(0)	0.04	(6)	0	(0)	0.04	(6)
Female F. over Male Sp.	0	(0)	0	(0)	0	(0)	0	(0)
Female F. over Female Sp.	0.03	(3)	0	(0)	0	(0)	0.03	(3)
Total Finch over Sparrow	0.03	(20)	0.01	(8)	0.001	(1)	0.04	(29)
Totals, all groups	2.95	(2201)	0.17	(125)	1.90	(1413)	5.02	(3739)

female finches, they were equally subordinate to House Sparrows of either sex.

Most encounters were observed at the food dish (59%, 2201). Encounters on perches accounted for 38% (1413) of the total, and only 3% (125) took place at the water dish. The facts that food was offered in limited quantities (6 grams per bird per day) and in restricted areas (in a dish, as opposed to scattered) probably contributed to the large number of encounters at the food source. Intraspecifically, male House Finches and male House Sparrows were proportionately more aggressive at food dishes (70% and 55% of encounters, respectively) than were the females (49% for finches, 26% for sparrows). House Sparrows won interspecific encounters at food dishes and on perches at equal rates. Of the few interspecific encounters won by House Finches, 69% occurred at food dishes.

Aggression at water dishes was infrequent. Most of the encounters that did occur were in the context of bathing, rather than drinking, and involved social facilitation. The sight of one individual bathing apparently stimulated others to do likewise, resulting in a series of aggressive encounters, since the water dish accommodated only one individual at a time.

Dominance structure. House Finches of both sexes were organized into stable peck-right hierarchies. House Sparrows, however, almost completely lacked dominance structure.

I determined the relative status of each individual in a group by use of a frequency-success index (F.S.I.) of agonistic behavior, defined as:

$$\text{F.S.I.} = \frac{2(w_i - l_i)}{n_i} \cdot \frac{n_i}{\sum^{m} n_i} = 2\frac{w_i - l_i}{\sum^{m} n_i}$$

where $\sum^{m} n_i$ = total number of encounters in the group, i = 1, n_i = total number of encounters engaged in by individual i, w_i = total number of wins for individual i, i.e. successful encounters, l_i = total number of losses for individual i, i.e., unsuccessful encounters, and m = number of individuals in the group.

A highly dominant individual is characterized by frequent wins and infrequent losses. Furthermore, such an individual maintains its status through extensive interaction with its subordinates, continually reinforcing its dominant position. As defined here, the Frequency-Success Index (F.S.I.) combines two major components of agonistic behavior. An aggressiveness component is reflected by the relative *frequency* with which an individual participates in agonistic encounters. A dominance

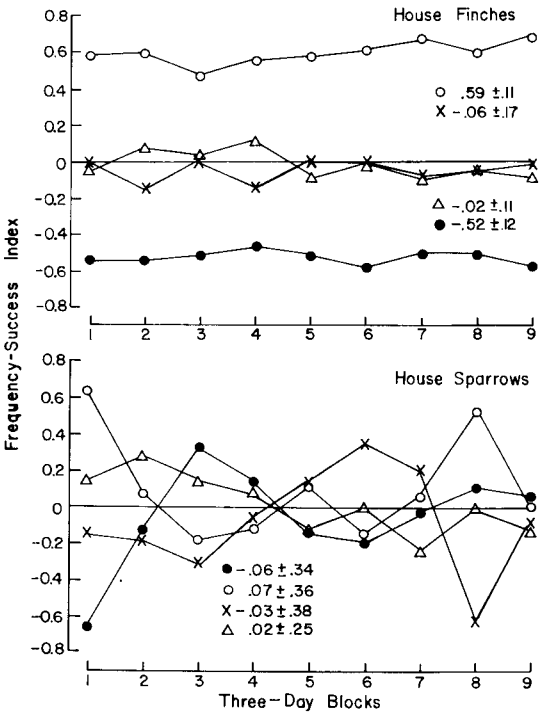

FIGURE 2. Intraspecific dominance structure of male House Finches and male House Sparrows. Symbols represent individuals in a caged group. Individual means and standard deviations are given. See text for explanation of frequency-success index.

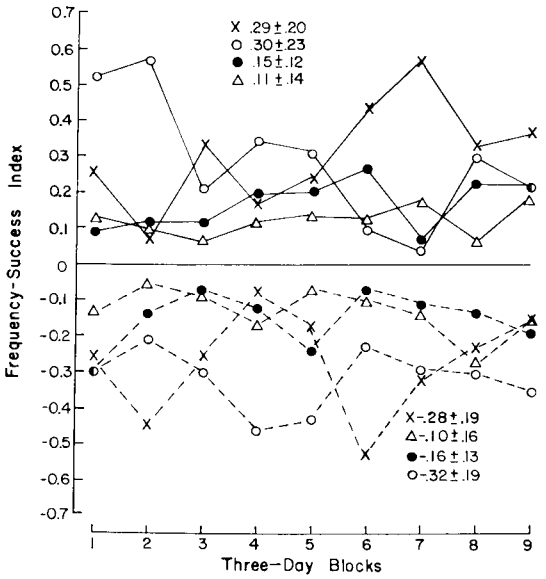

FIGURE 3. Interspecific dominance structure of male House Finches and House Sparrows. Symbols correspond to the same individuals as in figure 2. The solid lines represent sparrows, the broken lines, finches. Individual means and standard deviations are given. See text for explanation of frequency-success index.

component is represented by the *success* an individual achieves in competing with its flockmates, i.e. its proportion of wins. Kikkawa (1968) distinguished between aggressiveness and dominance in flocks of silvereyes (*Zosterops lateralis*), relating the former to physiologically mediated motivational states, and the latter to individual physical and behavioral attributes. These factors are incorporated into the F.S.I., which simply represents the difference between an individual's wins and losses multiplied by the proportion of its participation in total group agonistic activity. The factor of 2 is used to maintain unity, since each encounter is actually scored twice, as a win for one individual and as a loss for another.

Possible F.S.I. values range from -1.00 to +1.00. An individual attains the maximum F.S.I. when it participates in every group encounter without a loss. Conversely the minimum F.S.I. occurs when an individual participates in every encounter, but wins none. An F.S.I. of 0 occurs when an individual's wins and losses are equal. Typically, F.S.I. values accurately reflect the relative hierarchical status of individuals within the group. Thus high positive scores indicate dominant birds, low negative scores, subordinate birds, and near-zero scores, birds of intermediate status.

Figures 2 and 3 show the F.S.I. scores of individuals in Group I, male House Finches and male House Sparrows. Intraspecific aggression is illustrated for each species separately, then interspecific aggression is presented. The data are grouped into blocks of three-day periods of observation. The rigid dominance structure of the male finches is apparent. The House Sparrows, however, showed no consistent pattern; rather F.S.I. values appeared to fluctuate such that each individual attained both the highest and the lowest relative status at some time during the experiment.

Interspecifically, individual male House Sparrows were all about equally dominant to male House Finches. Likewise, individual male finches were about equally subordinate to the sparrows. There appeared to be no consistent relationship between an individual's intraspecific dominance rank and its interspecific rank.

Social order of female House Finches was organized similar to that of male finches, but their hierarchy was slightly less stable. Female House Sparrows showed some stability in dominance structure, primarily due to the presence of a consistently least dominant individual. Dominance relationships among other

individuals fluctuated extensively. All interspecific relationships between male and female House Finches and House Sparrows followed the pattern found for male finches and sparrows (see above).

Weights. When captured, the House Finches ranged in weight from 18.7 g to 23.6 g ($\bar{x} = 20.8 \pm 1.4$, $n = 12$) and the House Sparrows ranged from 23.8 g to 29.7 g ($\bar{x} = 27.3 \pm 1.9$, $n = 11$) with no overlap between the two samples. At the end of the experiment, the House Finches averaged 94 $\pm$ 4.9% of their capture weight (range, 83.5–101.5%), and House Sparrows, 95 $\pm$ 6.4% (range 84.1–105.5%). Thus, no appreciable weight loss resulted from the experimental conditions. No consistent relationship between dominance rank and weight loss was discernible.

DISCUSSION

A peak in aggressive behavior in free-ranging House Finches and House Sparrows occurred in mid-winter, when extreme cold, coupled with snow cover, forced large aggregations of birds to use the feeder. Similar situations in birds have been reported by Martin (1970) and Andrew (1957). Lockie (1956) noted increased aggression in corvids under severe winter conditions, but for different reasons. He found that subordinate individuals defended food items more vigorously against attacking dominants. In the case of House Finches and House Sparrows, crowding at the feeder resulted in more frequent violations of individual distance, which increased the rate of aggressive encounters. Marler (1956) found such violations to be a major cause of aggression in winter flocks of Chaffinches (*Fringilla coelebs*).

Beer (1961) studied the diurnal feeding patterns of House Sparrows in winter. He noted two peaks in feeding activity, occurring in early morning and late afternoon. My observations indicate similar peaks for aggressive behavior at the feeder. Presumably, such peaks would also occur under more natural conditions. This further substantiates the relationship between the number of individuals present and the frequency of aggressive interactions, as a result of violations of individual distance.

Differences between the two species in terms of aggressive contacts are apparent in figure 1. House Finches tend to interact more frequently with conspecifics, while House Sparrows show no marked preference for species of opponent. Studies dealing with interspecific aspects of agonistic behavior in gregarious species of birds have all indicated a much lower level of interspecific than of intraspecific aggression (Sabine 1949, Lockie 1956, Bock 1969, and Recher and Recher 1969). Therefore, the observation that House Sparrows interact with conspecifics and House Finches in nearly equal proportions appears to be exceptional.

Intrasexual caged groups of House Finches showed differential aggressiveness based on sex. Males were more aggressive intraspecifically than were females. House Sparrows did not show this relationship, the two sexes showing nearly equivalent levels of aggression. Possibly, the birds were in breeding condition when captured and this may have affected the behavior of the finches. Thompson (1960b) noted a rise in male House Finch aggressiveness with the onset of the breeding season, corresponding to a drop in female aggression. House Sparrows, however, do not appear to follow this pattern.

The cage situation intensified interspecific subordinance of House Finches. At the outdoor feeder the finches were only marginally subordinate to House Sparrows, while in cages they showed nearly absolute subordinance. Aggressive behavior in House Sparrows was about the same in both situations. The explanation of this phenomenon is not apparent, but may be related to experiential factors resulting from long, continuous contact between individuals.

Differences between the species in the locations of aggressive encounters can be related to different activity patterns. Generally, House Finches spend more time in continuous feeding than do House Sparrows, and consequently show higher rates of encounters at food dishes. House Sparrows tend to feed intensely for brief periods of time, then return to perches. Such behavior is also seen in free-ranging flocks and has been reported by Beer (1961). Porter (1904) and Summers-Smith (1963) noted the extreme wariness of House Sparrows, to which this observed feeding pattern may be attributed.

Peck-right systems of social organization have been described for many passerine species, including House Finches (Thompson 1960b). Peck-dominance or site-related dominance has been reported for pigeons (*Columba livia*) (Ritchey 1951), Budgerigars (*Melopsittacus undulatus*) (Masure and Allee 1934), House Sparrows (Watson 1970), Starlings (*Sturnus vulgaris*) (Ellis 1966), Yellowhammers (*Emberiza citrinella*) (Andrew 1957)

and Canaries (*Serinus canaria*) (Shoemaker 1939). However, Dixon (1965) and Glase 1973) have questioned the validity of this concept as a principle promoting flock integration. My observations confirm the existence of a peck-right system in House Finches and its absence in House Sparrows (fig. 2). Watson (1970) also did not find a linear hierarchy in his captive House Sparrow flocks, but interpreted his results in terms of site-related dominance. However, his flocks included juveniles, first-year birds and females in addition to adult males. In a peck-dominance system, hierarchy rank is determined by the probability of wins by a given individual, rather than by absolute dominance of one individual over another. With time, such hierarchies may become somewhat stable (Ellis 1969). This did not occur in groups of House Sparrows (see above), which were maintained for up to two months in captivity (Watson maintained his House Sparrow groups for 2–4 weeks). Dominance relationships, especially among males, fluctuated continually and were unpredictable. As noted by Marler (1955), dominance relationships must be predictable to be valid. It is likely that if a dominance structure plays a significant role in a species' social organization, it would be formed readily in captive groups, as demonstrated in the House Finch flocks.

The ecology and behavior of House Sparrows is intimately related to human activity (Summers-Smith 1963). With rare exceptions, House Sparrows are extremely sedentary and pairs retain nest sites throughout the year. These birds are remarkably opportunistic and thoroughly exploit their restricted habitats. Many aspects of House Sparrow behavior appear to have evolved under strong selection pressures to maximize utilization of available resources in complex, variable man-modified habitats. Aspects of behavior noted by Porter (1904) and Summers-Smith (1963), such as broad feeding habits, high levels of curiosity and wariness, and well developed learning abilities, are examples. This situation may also form the basis for the interspecific aggression seen in the House Sparrow.

Barrows (1889) noted some 70 species of North American birds reportedly molested by House Sparrows. Most of these interactions involved aggression at favored nest sites. House Sparrows commonly usurp nest sites of other species in two ways. Sparrows begin their breeding activities in early spring (Summers-Smith 1963, Seel 1968), and often nest in sites previously used by migrant species. The migrants return to find their nest sites already occupied and actively defended by the sparrows. Secondly, House Sparrows may forcefully evict established occupants from their nests. This behavior has been widely reported (Barrows 1889, Brewster 1906, Estabrook 1907, Stoner 1939, Sutton 1967, and Samuel 1969), and has already been mentioned with respect to House Finches. Such behavior allows House Sparrows access to the most favorable nest sites in an area, as well as assisting them in expanding into areas previously occupied by other species with similar nesting requirements.

Probably the dominance of House Sparrows over House Finches also is related to the size differences between the two species. As noted earlier, House Sparrows are somewhat larger than the finches, and this almost certainly confers them an advantage in dominance interactions. Morse (1974) has summarized much of the literature relating body size to interspecific dominance and concludes that in the majority of examples (31 out of 35), the dominant species is larger.

Interspecific aggression in House Finches and House Sparrows, then, can be related to at least three factors. The first involves violations of individual distance occurring at commonly utilized resources. In this case, the frequency of interspecific aggression appears to depend on the frequency of contacts between the two species. Marler (1957) noted that violations of individual distance by other species evoke aggressive responses as readily as intraspecific violations, which supports this view. The second factor may be a tendency for interspecific aggression in House Sparrows resulting from selection pressures operating in restricted, man-modified habitats. This factor may account in part for the observed dominance of House Sparrows over many other species, including House Finches. Thirdly, the larger size of the House Sparrow probably gives it an advantage in aggressive encounters with smaller species.

SUMMARY

Observations were made on the intra- and interspecific aggressive behavior of wild House Finches and House Sparrows which utilized an outdoor feeder from October, 1970 to March, 1971. Also, interspecific groups of these species were observed in an environmental chamber from April to June, 1971. Seasonal and daily patterns of frequency of encounters in the wild indicated a direct relationship between the number of birds

present and frequency of encounters. House Sparrows were generally dominant to House Finches, especially in cages. House Finches, particularly males, tended to interact more with their own species than with sparrows. Sparrows, however, encountered finches and each other in about equal proportions. House Finches were organized into rigid peck-right dominance hierarchies. House Sparrows showed little tendency to form hierarchy systems of any kind. Instead, individuals' ranks fluctuated continually with no apparent pattern. Three factors accounted for interspecific aggression in these species. First, violations of individual distance resulted in agonistic encounters at commonly utilized resources. Second, a tendency for interspecific aggression appears to have evolved in House Sparrows in response to limited numbers of nest sites in a restricted habitat. Third, the larger body size of House Sparrows may give them an advantage in aggressive interactions with House Finches.

ACKNOWLEDGMENTS

I would like to thank J. David Ligon for discussions and guidance throughout the course of this study. I am grateful to John P. Gluck, Jr., who advised me in statistical matters, and willingly discussed many aspects of the study. Ligon, Gluck, James R. Gosz, and Michael L. Rosenweig, all of the University of New Mexico, kindly criticized an earlier draft of this paper. Peter Marler, of The Rockefeller University, also provided helpful comments. The material presented here was submitted in partial fulfillment of the requirements for the degree of Master of Science in Biology at the University of New Mexico, Albuquerque, New Mexico.

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Accepted for publication 13 November 1973.