BREEDING BIOLOGY OF HOUSE SPARROWS IN NORTH MISSISSIPPI

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Detailed studies on various aspects of breeding biology of the House Sparrow (*Passer domesticus*) have been made in Europe (e.g., Summers-Smith 1963; Seel 1968, 1970; Mackowicz et al. 1970) and in the United States (e.g., Weaver 1943, Mitchell et al. 1973, North 1973, Will 1973). This study was conducted in Oktibbeha County, Mississippi, during the breeding seasons of 1972–1974 (Sappington 1975) and is the first to be made below 34° latitude. It includes data on the activity of breeding birds and helpers at the nest with corresponding analyses of nest-building, egg-laying, incubation, hatching success, nestling feeding rate, nesting efforts, fledging age, and fledging success.

MATERIALS AND METHODS

This study was conducted on the main campus and adjoining areas of Mississippi State University, Oktibbeha Co., Mississippi. 33° 28′ north latitude and 88° 48′ west longitude. It continued for 3 years, 1972 through 1974, with emphasis on the breeding season which normally lasted from February to August. Four nesting areas were studied: (1) 4 trees (*Magnolia grandiflora*) espaliered on the walls of Lee Hall in the central part of the campus, designated as "Tree"; (2) a large barn where sheep and horses were fed and kept overnight, designated as "Horse Barn"; (3) an equipment shed and orchard, designated as "Shed"; and (4) a cluster of buildings associated with a pig feed lot, designated as "Pig Farm." Only Tree colony was studied in 1972. All colonies were studied during 1973, but only Pig Farm and Shed colonies were studied in 1974.

Individual House Sparrows from each area were captured by (1) baited traps, (2) mist nets at roost sites (Sappington and Jackson 1973), (3) hand nets at nests, and (4) hand-lifting young from nest before fledging. Each captured bird was banded with a U.S. Fish and Wildlife Service metal leg band and/or color-marked with a coded combination of colored plastic leg bands and released or put back into the nest.

Only records of marked birds that were readily identifiable were used for analysis. The mated pair at each of 280 nests was identified by the arrangement of the metal and colored leg bands. Nest-building activities and feeding of nestlings were observed through 7×35 binoculars. The birds at Tree, Pig Farm, and Horse Barn colonies were accustomed to people passing near their nests at all hours of the day. No observation blinds were necessary in observing breeding activities at these locations. At Shed colony which occupied a single, remotely-located building, the birds were wary of observers. However, with an automobile as a blind, I was able to make observations within 6 m of the nest without disturbing the birds.

Construction of 221 nests at 100 sites was observed. I plotted the location of each nest on a sketch map and recorded the identifying markings of the mated pair and presence of any helper. Individual nests or blocks of nests located in the same area were observed for ½ or full-day periods beginning at 07:00 and lasting through 18:00 CST.

A total of 285 nest-days was spent in observing nest-building. A nest-day is defined as a day spent by one person observing a single nest.

At 229 nests I was able to establish the date of the appearance of the first egg. These nests were checked daily between 07:00 and 08:00 until the last egg was laid. The date of the laying of the first egg and appearance of the last egg in each clutch were recorded. For those nests in which incubation occurred, clutch size was determined to be the number of eggs at the beginning of incubation. The incubation period was taken as the time between the laying of the last egg and date of hatching of the last young when all eggs hatched.

One week after each clutch was completed, each nest was checked for hatching 3 times daily—between 07:00 and 08:00, 12:00 and 13:00, and 18:00 and 19:00. The dates of the hatching of the first young and the hatching of the last young were recorded. Hatching success (%) was calculated from the total number of eggs laid.

Feeding of nestlings, ranging in age from 1 to 20 days, was observed at 254 nests between 05:00 and 19:00 for 177 days. My observations include 145 days on which I made continuous observations from 05:00 to 19:00 and 32 days on which I observed nests for shorter intervals. Because of the placement of nests I was generally able to observe from 1 to 7 nests at one time, giving a total of 673 nest-days of observation.

The number of visits to the nest with food was used as a measure of feeding activity. Royama (1966) stated that feeding frequencies for another hole-nesting species (*Parus major*) are far too variable to be used as a true index of food consumption per nestling, but according to Pettingill (1970), no matter how food is supplied, the individual nestlings receive an equal amount during the course of the day due to automatic apportionment.

Records were kept of the number of visits to the nest by each parent and helper (a bird other than the parents). Observations were made during all weather conditions except heavy rain. According to Kendeigh (1952), cloudiness, fog, or wind do not affect feeding rates; only heavy rain affects them and then only temporarily. For calculations of total daily visits to the nest and visits per nestling, only those observation periods which lasted the entire day were used.

A nesting effort was arbitrarily considered to be an incubated clutch. Fledging was considered to be the time when a young bird took flight from the nest the first time. Age at fledging, or nestling period, was calculated from the day of hatching until the day of fledging. Fledging success (%) was calculated from the total number of eggs laid and number of eggs hatched.

Statistical analyses were performed using the UNIVAC 1106 computer at Mississippi State University. The analysis of variance, as well as basic statistics, including means, standard deviation, and standard error were obtained from these data by the first option of UNIVAR (1973 version), a basic statistics program written by D. M. Power. Basic statistics for samples of more than 2000 cases were obtained by using the program, BMD 01V, ANOVA for One-Way Design of the Biomedical Computer Programs (Dixon 1974).

When only 2 numbers were compared for significant difference, the Chi-square test was used. Yates' correction (Chase 1967) was applied when the expected frequency was fewer than 5 cases. When 2 percentages were tested for significant differences, as in percent success, a computer program written by Jerome A. Jackson of Mississippi State University was used. The program calculates a t-value which may be compared with a tabular t. The method of this test is based on the arcsine transformation as suggested by Sokal and Rohlf (1969).

I used a probability level of 0.05 as the criterion for significance in all statistical analyses.

RESULTS AND DISCUSSION

During the 3 breeding seasons of 1972–1974, 987 House Sparrows were color-banded at the 4 locations; 311 were adults, and 676 were juveniles. The male-female ratio of total marked adult birds was 1:1.03 (153 males and 158 females). Other studies have shown that the sex ratios for House Sparrows have not differed greatly from 1:1 (Summers-Smith 1963, Will 1973, North 1973). I also used observational data from roosting and feeding studies to get an indication of the male-female ratio for the study areas. Among roosting birds, males constituted 52.1% of the total, and among feeding birds, they constituted 50.1% of the total. These figures do not differ significantly from my findings of 49.2% males in the breeding situation. Of the marked adults, 82.6% were breeders (78.4% males; 86.7% females).

Summers-Smith (1958) stated that the mated male and female House Sparrow remain faithful to each other and to their nest site for life. He does, however, cite exceptions involving bigamy, desertions, and the holding of more than one nest site by a single male. In my study of 100 nest sites, the mated pair remained faithful to each other for only 60.5% of the cases during a particular breeding season. However, the number of males having only 1 mate (69) was significantly higher than those having more than 1 mate (45) during a breeding season. There was no evidence that pairs remained together for 2 consecutive breeding seasons. Although 39.5% of the males had more than one mate during a single season, no cases of simultaneous polygamy were observed.

Of 156 breeders of known origin, 125 (80.1%) nested at the location where they were banded. The difference between numbers of sedentary breeders and transient breeders was highly significant. Generally, breeding House Sparrows returned to the area where they were banded but not necessarily to the same nest site of previous years. Attachment to the nest site appeared to be strongest in the male. Of the total nest sites, 86.0% were retained by the male for the entire breeding season as opposed to 45.0% by the female. There was a highly significant difference between number of sites occupied by a single male (86) and number occupied by more than one male (14) during the breeding season but no significant difference between number of sites occupied by a single female (45) and number occupied by more than one female (55). Individual males showed very little attachment to their nest site after the breeding duties were over. In subsequent breeding seasons only 10% (6 of 60 cases) of the sedentary breeding males returned to their previous nest site. After the breeding season all birds used communal roosts instead of their nest sites for the fall and winter months. The old nests were torn out by people, or weathering deteriorated them. These factors may have been reasons why so few sparrows returned to their old nest sites in subsequent years.

During the 3 seasons of 1972–1974, 584 nests were built at 296 sites at the 4 locations. This activity embraced a time span of approximately 5 months each year. Typically, it began in early February and lasted until near the end of July. During the 3-year period the earliest nest was started 10 February, and the latest was started 21 July. Bent (1958) stated that nestbuilding occurs in various places of the United States during every month of the year.

Nest-building was observed at 221 nests of which 5 (2.26%) had helpers. Although cooperative nest-building is common among some weaver finches (Crook 1960, MacLean 1973), I have seen no previous reference to this practice by House Sparrows. A rhythmic pattern was manifested in both nest-building and egg-laying. Peak periods of nest-building were generally followed within a week by intensive egg-laying. Others have reported similar patterns (Mitchell et al. 1973, Summers-Smith 1963, Weaver 1939).

Of 584 nests built, 532 contained eggs. Egg-laying during each of the 3 years embraced a span of approximately 5 months beginning in late February and continuing through July. The first egg was laid 24 February, and the last egg was laid July 28 for the 3-year period.

I did not quantify the amount of time spent incubating by each sex of the mated pair. Weaver (1943) stated that only the female incubates since the male was never observed to sit on the eggs. On the other hand, Daanje (1941) stated that both sexes incubate the eggs. Summers-Smith (1963) found that both sexes spent spells of time on the eggs during incubation, but since the male does not develop a brood patch, it cannot be truly said that he incubates. I observed that the male relieved the female at the nest 5 or 6 times per day for periods up to 20 min in length. Presumably the female was feeding at this time. At night only the female sat on the eggs. Although communal behavior in egg-laying and incubation has been exhibited by other social species, Mexican Jay (*Aphelocoma ultramarina*) (Brown 1970) and Smooth-billed Ani (*Crotophaga ani*) (Davis 1940), there was no evidence of such behavior in the House Sparrow.

For 229 nests the mean incubation period was 12.2 days (S.E. = 0.12) (Range = 10 to 17 days). The 17-day period occurred in the Horse Barn colony in 1973 and may be attributed to the sudden occupancy of the area by a Barn Owl (*Tyto alba*) which caused such stress that both incubation and feeding were often halted for several hours at a time. My data do not differ significantly from that found by others (12 days, Weaver 1943; 11.2 days, Seel 1968; 11.3 days, Mitchell and Hayes 1973). Weaver (1943) and Summers-Smith (1963) stated that the hatching period may be spread over 2 or 3 days. I found a much shorter time span for hatching completion. Hatching began in the early morning and did not last beyond 18:00 of the same day. There was only 1 exception in which 1 nest in 1973 required 2 days for

TABLE 1
COMPARISON OF MEAN DAILY VISITS TO NESTS WITH HELPERS (W) AND NESTS WITHOUT HELPERS (WO)

Parameter[1]	Mean	Standard Error
Visits by parents		
W	222.7**	± 2.0
WO	206.6	± 2.9
Visits by helpers	31.4	± 0.5
Total visits		
W	254.1**	± 2.8
WO	206.6	± 2.9
Visits per nestling		
W	71.5**	± 0.4
WO	58.1	± 0.7
Number of nestlings		
W	3.6	± 0.04
WO	3.6	± 0.04

[1] Based on 321 nest-days of observation at nests with helpers and 352 nest-days of observation at nests without helpers.
** ($p \leq .01$).

hatching completion. For the entire study period the earliest hatching date was 11 March and the latest was 16 August.

Feeding of nestlings was observed at 254 nests, of which 161 (63.4%) had multiple-feeders (helpers). A chi-square test indicated there were significantly more nests with helpers than without helpers. In nests with helpers mean daily total visits amounted to 254.1 of which 31.4 (12.4%) were from helpers (Table 1). Nests without helpers received a mean of 206.6 daily visits, significantly fewer ($p < 0.01$) than at nests with helpers. For all nests observed the mean daily feeding frequency was 229.3 with 64.5 per nestling. The mean hourly feeding rate was 16.5 (S.E. = 0.09) with a mean of 3.6 nestlings per nest. Kendeigh (1952) reported a feeding rate of 20 times per hour for nestling House Sparrows with 4 young per nest. Comparison of our data sets using chi-square indicates that they do not differ significantly. Temporal patterns were present in the hourly feeding rate (Sappington 1975). Three peak periods occurred daily, late morning, mid afternoon, and late afternoon. Feeding was minimal between 05:00 and 06:00 and between 18:00 and 19:00.

A great deal of variation occurred in both total visits to the nest and visits per nestling depending on ages and number of young per nest. However,

these parameters varied very little (no significant difference) after the 8th day of age in nests with both 3 and 4 nestlings (Sappington 1975). It appeared that the feeding rate changed very little after the first half of nestling life. Summers-Smith (1963) found that the frequency of feeding nestling House Sparrows increased until the 14th day, after which there was a decrease. My results were similar to those of Seel (1969) who discovered a common pattern of feeding in broods of nestling House Sparrows of all sizes which was a rising phase up to nestling day 8½ to 11½, followed by a levelling off phase. Increased feeding in my study was halted at the approximate time that homeothermy is supposedly accomplished in the nestling House Sparrow (Pettingill 1970).

One might surmise that the larger the brood the more visits to the nest. I found a direct relationship between brood size and daily visits to the nest, but there was an inverse relationship between brood size and visits per nestling (Sappington 1975). Seel (1969) found the same relationship for broods of 1 to 3 nestling House Sparrows, and Moreau and Moreau (1940) found that the smaller the brood the greater the number of feedings that each received. These findings agree with the results of von Haartman (1953). He found that it is not the number of nestlings but their reactions that stimulated parents to bring food.

Kendeigh (1952) found that nests with fewer birds fledged earlier. My study generally showed this trend but the differences are very slight and are non-significant for nests which fledged 2, 3, 4, or 5 birds with or without helpers. Moreau and Moreau (1940) also found that the smaller brood does not fledge earlier.

I observed that a marked change in the behavior of both the nestlings and helpers occurred 2 or 3 days prior to fledging. Nestlings become exceedingly quiet, lying crouched in the nest. Helpers no longer fed them. On the day of fledging parents rarely fed the young until they left the nest. Fledging generally occurred in the early morning and seldom did all young leave the nest at once.

Summers-Smith (1963) and Weaver (1943) found that the fledging period of a single nest may be spread over 2 or 3 days. From 180 nests in my study all young fledged by 12:00 on the same day. Never were there more than 4 h between the fledging of the first and last nestling from the same brood. This synchronized pattern of fledging should not be considered unusual, but could be expected because of the small age differential in nestlings within the same brood as experienced in this study.

My study of 180 nests showed that time spent in the nest varied from 14 to 23 days with an overall mean of 17.1 days (S.E. = 0.15). The 23-day period which occurred in Horse Barn colony may be attributed to the presence

of the Barn Owl. Summers-Smith (1963) gave a nestling period of 11 to 19 days (mode of 18) for Great Britain. Kendeigh (1952) cited the nestling period to be 14 to 16 days for Illinois. Weaver (1942) found that the time spent in the nest varied from 12 to 16 days with a mean of 14.4 days for New York. Although my study showed a higher nestling period than did the Illinois or New York study, there was no significant difference. Also, there was no significant difference in mean number fledged from nests with helpers (2.8) and nests without helpers (2.9).

Each nest site was used an average of 2.84 times (S.E. = 0.10) during a single breeding season. This figure is somewhat higher than those of 2.1 (Summers-Smith 1963), 2.0 (Will 1973), or 1.68 (Weaver 1943) but approaches 3.0 found at a site studied by Mitchell et al. (1973). Use was highest in 1974 when each nest site was occupied an average of 3.2 times. In 1974 there was a scarcity of sites as compared to the 2 previous years. Nest sites were limited to only the Pig Farm and Shed locations during 1974, and at the Pig Farm 5 of the 7 buildings normally used were torn down, thus limiting the number of available sites.

The number of incubated clutches per pair (N = 142) ranged from 1 to 4 with a mean of 1.84 (S.E. = 0.07) which compares favorably with 2.1 of Craggs (1967) and Summers-Smith (1963). Percent of pairs having 1, 2, 3, or 4 nesting efforts were 39.4, 40.9, 15.5, and 4.2 respectively. The number of eggs laid per female per season (N = 596) ranged from 3 to 16 with a mean of 7.46 (S.E. = 0.29). This figure is not significantly different from the 7.95, 8.94, or 8.61 eggs per female per season reported by Weaver (1943), Will (1973), and Summers-Smith (1963) respectively. The number of eggs hatched per pair (N = 495) ranged from 2 to 16 with a mean of 6.37 (S.E. = 0.26) as compared with 5.88 (Will 1973) and 6.11 (calculated from data from Summers-Smith 1963).

Breeding success was based on results from 224 nests. Clutch size ranged from 2 to 6 eggs with a mean of 4.2 (S.E. = 0.06). Nests containing 4 eggs each accounted for 60.3% of the clutches. McAtee (1940) found that clutch size in Maryland ranged from 2 to 6 with a mode of 5. Bent (1958) gave a range of 3 to 7 with a mode of 5 throughout the United States. My average is well within these ranges. Others report similar means from Great Britain—3.9 Seel (1968) and Craggs (1967), 4.1 Summers-Smith (1963)—and from the United States—4.3 Mitchell et al. (1973), 4.4 Will (1973), 4.7 Weaver (1943). My average is not significantly different from these previous studies. The number hatching per nest was 3.4 (S.E. = 0.08) in nests in which at least 1 hatched. The number fledging per nest was 2.8 (S.E. = 0.09) in nests in which at least 1 fledged.

Hatching success, based on all eggs laid (Table 2), was 83.2% which is

TABLE 2
OVERALL BREEDING SUCCESS OF HOUSE SPARROWS AT MISSISSIPPI STATE, MISSISSIPPI

Category	Value
Total clutches	224
Clutches lost	19
Eggs lost	72
% of eggs surviving	92.1%
Number of eggs hatched	758
% of total eggs hatched	83.2%
% of surviving eggs hatched	90.4%
Number of young fledged	584
% of total eggs	64.1%
% of incubated eggs	69.6%
% of eggs hatched	77.0%

significantly higher ($p < .01$) than 71.0% (Summers-Smith 1963), 61.0% (Mitchell et al. 1973), or 65.8% (Will 1973). It is also somewhat higher than the average of 77.0% which Nice (1957) attributed to altricial hole-nesting species, but is not significantly different from 85.4% calculated for House Sparrows from data reported by Seel (1968). Fledging success, based on total eggs laid, was 64.1% for the entire period (Table 2). This figure compares with 66.0% given by Nice (1957) for hole-nesting altricial birds, but is significantly higher ($p < .01$) than 50.0% (Summers-Smith 1963), 41.0% (Mitchell et al. 1973), or 35.1% (Will 1973) reported for House Sparrows in other studies. Although some previous studies were quite detailed, specific mention of cooperative breeding activities is almost lacking and at best fragmentary. One might assume that my high breeding success could be attributed to the activity of helpers. However, there was no significant difference in fledging success from nests with helpers (68.5%) and nests without helpers (72.2%). The higher breeding success in my study does not appear to be the result of assistance by helpers, but may be attributed to the small percentage of eggs lost to breakage and predation (7.9%), high hatching success of surviving eggs (90.4%), and rather small percentage of nestlings (23.0%) which died or fell to predators.

SUMMARY

Breeding biology of the House Sparrow (*Passer domesticus*) was studied in 4 colonies of marked birds during the breeding seasons of 1972–1974 in Oktibbeha Co., Mississippi.

The male-female ratio of breeding birds was 1:1. The male generally remained faithful to his nest site (86.0%) but not so faithful to his mate (60.5%) for the entire breeding season.

Each nest site was used an average of 2.84 times per season, but the number of incubated clutches per pair was 1.84. There was a trace of cooperative nest-building, but there was no evidence of communal egg-laying or incubation. Rhythmic patterns were manifested in both nest-building and egg-laying with peak periods of nest-building followed within a week by intensive egg-laying.

Mean clutch size was 4.2 eggs. The mean incubation period was 12.2 days. A mean of 3.4 eggs hatched, and 2.8 young fledged per nest. Young fledged at 17.1 days of age.

Nestlings were fed at a mean rate of 16.5 times per hour. Feeding of nestlings by sparrows other than the parents was observed in 161 of 254 nests in which feeding was significantly higher than in those nests without helpers. Helpers accounted for 12.4% of the feeding in those nests which they visited.

Hatching success (83.2%) and fledging success (64.1%) were significantly higher than those reported by other researchers but do not appear to be the result of assistance by helpers; they may be attributed to the small percentage of eggs lost to predation and breakage, high hatching success of surviving eggs, and low mortality of nestlings.

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