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BREEDING BIOLOGY OF HOUSE SPARROWS IN NORTHERN LOWER MICHIGAN

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ABSTRACT.—The breeding biology of the House Sparrow (*Passer domesticus*) in northern lower Michigan was monitored during the summers of 1986–1991 and the results compared to those obtained in other North American studies. Individuals are multi-brooded with most females laying two or three clutches per year. Overall mean clutch size for the periods of observation was 4.96, and declined as the season progressed. Hatching was asynchronous and indicated that incubation began between the laying of the antepenultimate and penultimate eggs. A strong, positive correlation of mean clutch size with latitude was noted. Incubation period, nestling period, hatching success, fledging success and overall nesting success in Michigan were similar to those found in other North American studies. No latitudinal trends were detected in any of these reproductive characteristics. In a comparison of the timing of the initiation of first and second clutches in North America, however, a strong latitudinal trend was observed, suggesting a retardation of approximately two days in the timing of breeding for each 1° of latitude poleward. *Received 20 Sept. 1993, accepted 1 Dec. 1993.*

The House Sparrow (*Passer domesticus*), indigenous throughout most of Europe, Asia, and northern Africa, has been successfully introduced into North America, South America, Australia, and southern Africa (as well as numerous islands throughout the world) and is now perhaps the most widely distributed avian species. It was introduced into the eastern United States and Canada repeatedly from 1853 to approximately 1881 (Barrows 1889) and extended its range steadily and rapidly across the United States and Canada (Wing 1943). It is now an abundant resident throughout the continental United States, the southern tier of Canadian provinces, and throughout Central America locally as far south as Panama (Lowther and Cink 1992). The House Sparrow is a common resident throughout Michigan, but breeds at much lower densities in the upper peninsula and the northern half of the lower peninsula than in the southern half of the lower peninsula (Brewer et al. 1991). Several studies on the breeding biology of the House Sparrow in various parts of its North American range have been published (i.e., Weaver 1942; Will 1973; Pitts 1979; McGillivray 1981, 1983). No comprehensive study of the species appears to have been undertaken in Michigan, however. The present study reports on aspects of the breeding biology of the House Sparrow in northern lower Michigan.

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METHODS

The study area consisted of three occupied farmsteads (four in 1986) near the Univ. of Michigan Biological Station (UMBS), Cheboygan County, Michigan. The three sites were active dairy farms with numerous barns and sheds, while the one additional site used in 1986 was an occupied but inactive farmstead with no stock maintained on the premises. No nest-boxes were present at any of the study sites in 1986 so that all House Sparrow nests under observation in that year were located in crevices in buildings (both outside and inside the buildings), in holes in trees, or in the branches of trees. Fifteen next-boxes were placed on buildings and trees at each of the three sites in March 1987 and many of the nests observed in 1987–1991 were located in nest-boxes.

The periods of observation in the six years were 7 June to 10 August 1986 (except for a 6-day hiatus from 12–17 July), 4 June to 17 August 1987, 13 June to 13 August 1988, 12 June to 12 August 1989, 18 June to 12 August 1990, and 16 June to 15 August 1991. The periods of observation mean that only partial or no data were collected on first broods at the sites, a fact which may affect some of the comparisons below. Active nest sites were visited daily (normally between 07:00 and 11:00 h EDT) during the egg-laying period (until the clutch was complete) and from late in the incubation period throughout the nestling period until fledging. Visits were made at three- or four-day intervals during incubation. Eggs were numbered with a felt-tip pen and were weighed and measured on the day of laying. Nestlings were individually marked on the day of hatching by toenail clipping and were banded with U.S. Fish and Wildlife Service bands at 10 days. After the nestlings were 11 or 12 days old, they were not handled or counted to avoid premature fledging. Fledging date was determined by noting the day on which no nestlings remained in the nest, and all young banded were assumed to have fledged unless found dead in the nest-box. Females were captured at nest-box nests when the oldest nestlings were five days old, and tarsus length was measured with dial calipers, flattened wing chord was obtained with a metric rule, and mass was measured with a 50-g Pesola balance. All females were also banded with a USFWS band. Interbrood intervals, the number of days from the fledging of one brood to the initiation of the next clutch, were determined for 50 marked females in 1987–1991 (some of which reared experimentally manipulated broods).

Utilizing the modal values observed in this study for clutch size (5), incubation period (12 days), and nestling period (14 days), the date of initiation was estimated for all clutches in which it was not directly observed. Due to the fact that observations were not begun until early- to mid-June, most first clutches were missed. The first fledgling flocks (flocks formed as fledglings become independent of parental feeding about 7–10 days post-fledging [pers. obs.]) were not observed before about 10–15 June, however, which indicates that the peak of first clutch initiations did not occur until about 1 May. A marked peak in clutch initiation occurred in the 10–19 June interval in each year of the study, which undoubtedly corresponded to the peak period of initiation of second clutches. Based on an inspection of the daily progression of clutch initiations, I decided to consider 27 May as the first date on which "second clutches" could be initiated following the successful fledging of a first brood and arbitrarily considered clutches initiated after that date to be "second broods". Clutches initiated after 2 July were considered "third broods".

In 1989–1991, brood sizes of 41 "second broods" were manipulated at hatching to create supernormal- and subnormal-sized broods. Nestlings were removed from one nest when 0 or 1 day old and added to other nests with young of the same age to create broods of 7–9 young (each supernormal brood contained at least one and as many as three more young than the clutch size of the nest). Data from these manipulated broods and other experimentally manipulated nesting attempts (see Anderson 1989) are not included in the analyses

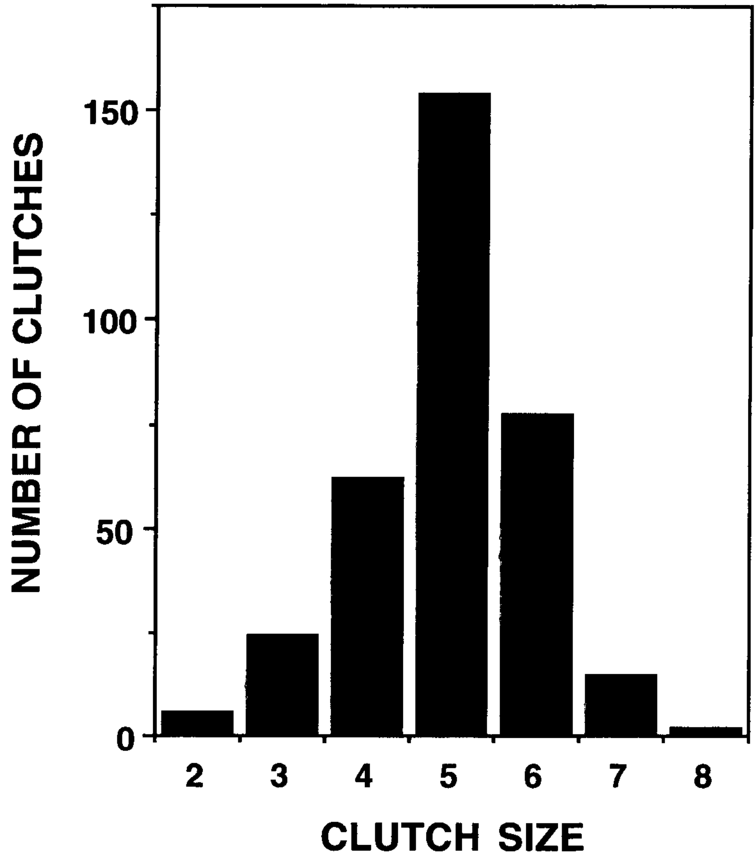

FIG. 1. Frequency distribution of clutch size of the House Sparrow in northern lower Michigan, 1986–1991 (N = 340).

below, except as noted. Frequent handling of eggs and young resulted in some egg breakage and nestling mortality. Observer-related mortality, either accidental or experimental, is not included in the analyses that follow.

RESULTS AND DISCUSSION

Clutch size varied from 2 to 8 with a strong mode of 5 and a mean of 4.96 (SE = 0.06, N = 340) (Fig. 1). Mean clutch size varied considerably among years, from a mean of 4.58 in 1986 to a mean of 5.18 in 1988 and 1990, with the differences among years being significant (one-way ANOVA, $F_{5,334} = 4.56$, $P < 0.001$). Clutch size also varied seasonally with a marked decrease in mean clutch size for clutches initiated in late July and August (Fig. 2). Analysis of covariance (with period of initiation

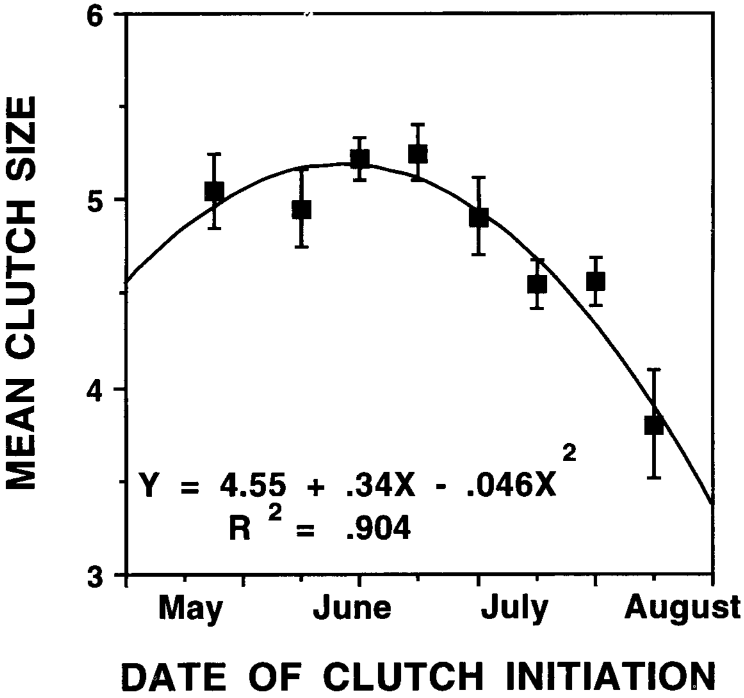

FIG. 2. Seasonal change in mean clutch size of the House Sparrow in northern lower Michigan. (Data plotted as mean ± SE for ten-day intervals beginning with interval 1 = May 11–20.)

as a covariate and ignoring clutches initiated in May because of lack of data for some years) still resulted in significant annual variation in clutch size ($F_{5,311}$ = 4.73, $P < 0.001$). No significant interaction between year and initiation period was observed, however ($F_{5,306}$ = 0.45, $P > 0.80$), suggesting that the slope of the seasonal change in clutch size did not change with year. A similar decrease in clutch size has been noted in Great Britain (Seel 1968), and at other locations in North America (Will 1973, Anderson 1978). Due to the fact that observations were not begun until early- or mid-June, very little data are available for clutches initiated before mid-May. This, plus the marked decrease in clutch size near the end of the breeding season, suggests that the observed overall mean clutch size may be lower than the true mean for the entire breeding season, a fact which complicates comparison with other North American studies. Data from other North American studies of the House Sparrow are summarized in Table 1. Mean clutch size shows a strong positive correlation

TABLE 1
SUMMARY OF DATA ON BREEDING BIOLOGY OF THE HOUSE SPARROW IN NORTH AMERICA

Location (Latitude)	Mean clutch size	Mean incubation period (days)	Mean nestling period (days)	Hatching success	Fledging success	Nesting success	Source
Mississippi State, Mississippi (33°28′N)	3.93*	12.2	17.1	0.832[a]	0.770	0.641[a]	Sappington 1975, 1977
Plainview, Texas (34°10′N)	4.23*	11.3	n.a.	0.596*	0.534*	0.318*	Mitchell and Hayes 1973, Mitchell et al. 1973
Stillwater, Oklahoma (36°07′N)	4.47	n.a.	13.9	0.502*	0.649*	0.326*	North 1968
Martin, Tennessee (36°20′N)	4.67	11.8	14.6	0.515	0.654	0.337	Pitts 1979
McLeansboro, Illinois (38°05′N)	4.46	n.a.	n.a.	0.658[a]	0.533	0.351[a]	Will 1973
Portage des Sioux, Missouri (38°55′N)	4.64	n.a.	14.8	0.646	0.628	0.406	Anderson 1978
Lawrence, Kansas (39°02′N)	5.14	11.76	13.91	0.625[a]	0.646	0.404*[a]	Lowther 1979a, 1983
Ithaca, New York (42°26′N)	4.73	n.a.	14.4	n.a.	n.a.	0.705[a]	Weaver 1942, 1943
Coldspring, Wisconsin (43°00′N)	4.96	11.7	15.4	0.508*	0.612*	0.311*	North 1972
Pellston, Michigan (45°32′N)	4.96[b]	11.55	14.3	0.717	0.779	0.559	This study
Calgary, Alberta (51°05′N)	5.03*	n.a.	n.a.	0.698*[a]	0.665*	0.464*[a]	Murphy 1978

* Calculated from data presented in the source(s).
n.a. = data not available.
[a] Based on completed clutches only.
[b] Based on only part of the breeding season.

with latitude ($r = 0.757$, $P < 0.01$). Murphy (1978) and Anderson (1973, 1978) also noted significant positive correlations between latitude and clutch size in North American populations of the House Sparrow.

The curvilinear regression equation relating mean clutch size (Y) to latitude (X) explained a higher proportion of the variation of clutch size (multiple $R = 0.863$) with both the X and X^2 terms contributing significantly to the regression ($t = 2.56$, $P < 0.05$ and $t = 2.29$, $P = 0.05$, respectively): $Y = -6.20 + 0.48X - 0.005X^2$. This suggests that there is a damping of the rate of increase in clutch size with increasing latitude at more northern latitudes in North America. Incubation period, defined as the period from the laying of the last egg in a clutch until the hatching of that egg (Thomson 1964), varied from 10 to 13 days with a mode of 12 (mean = 11.55, SE = 0.05, N = 119). This is very close to the mean incubation period in other North American studies of the species (Table 1). No correlation was found between latitude and mean incubation period ($r = -0.280$, $P > 0.55$).

At least one egg hatched in 81.3% of the 316 nests for which hatching data were available. No significant differences were observed among years in the proportion of nesting attempts in which eggs hatched ($\chi^2 = 6.54$, $P > 0.10$). Hatching success, defined as the percentage of eggs laid (including eggs from nests in which the clutch was deserted or lost prior to completion) which hatched successfully was 71.7% (N = 1457 eggs). Hatching success in other North American studies has ranged from 50.8% in Coldspring, Wisconsin (North 1972) to 83.2% in Mississippi State, Mississippi (Sappington 1977) (Table 1). Note that some studies, including Sappington's (1977), calculated hatching success based on completed or incubated clutches only, ignoring losses of eggs in attempts which failed prior to clutch completion, which means that all of the hatching success values in Table 1 are not strictly comparable. This discrepancy is, however, not too great in that these losses normally involve only one or two eggs from a small percentage of the total breeding attempts. The average hatching success for all North American studies, including the present study (each taken as a single data point regardless of sample size), is 63.0%. No latitudinal trend in hatching success is detectable ($r = 0.115$, $P > 0.75$).

Hatching was asynchronous, requiring more than one day in most nests (Table 2). In 210 nests in which two or more chicks hatched the mean hatching interval was 1.31 days (SE = 0.05). Hatching interval did not differ significantly with clutch size (ANOVA, $F_{4,204} = 1.73$, $P > 0.10$), although it did differ significantly with number hatching (ANOVA, $F_{5,204} = 3.87$, $P = 0.002$). Sappington (1975) reported a mean hatching interval of 0.35 days for the House Sparrow in Mississippi, while Seel (1968)

TABLE 2

MEAN HATCHING INTERVALS OF HOUSE SPARROWS IN NORTHERN LOWER MICHIGAN

Number of young hatching	Number of nests	Mean hatching interval[a] (days)
2	14	0.71 (0.73)[a]
3	28	1.07 (0.77)
4	66	1.30 (0.66)
5	69	1.44 (0.70)
6	29	1.55 (0.74)
7	4	1.50 (0.58)

[a] Hatching interval was estimated for each nest by assuming that the young that had hatched since the last nest check 24 h earlier had hatched at the midpoint between the two nest checks. Therefore, the estimated hatching interval for a nest was one day less than the number of days over which hatching was observed. Numbers in parentheses are one standard error.

reported a mean hatching interval varying from 1.17 days for two-egg clutches to 2.00 days for six-egg clutches in Great Britain.

The nestling period lasted from 11 to 18 days with a mean duration of 14.3 days (SE = 0.10, N = 137). Manipulated broods from 1989–1991 are included as nestling period did not differ significantly among reduced, control, and supernormal broods (Anderson, unpubl. data). In a two-way ANOVA, nestling period did not differ annually ($F_{5,125} = 0.38$, $P > 0.85$), with brood (for "second" and "third" broods, $F_{1,125} = 0.41$, $P > 0.50$), or with the interaction of year and brood ($F_{5,125} = 0.37$, $P > 0.85$). The mean nestling period noted in other North American studies varied from 13.9 to 17.1 days (Table 1). No correlation of mean nestling period with latitude was observed ($r = -0.398$, $P > 0.30$).

At least one young fledged from 87.9% of the 232 nests in which eggs hatched and for which complete data were available. Fledging success, defined as the percentage of eggs hatched which resulted in fledged young, was 77.9% (N = 719 hatched eggs). Broods involved in brood-size manipulation experiments in 1989–1991 (both reduced and supernormal broods) were not included in this analysis. Fledging success in nine other North American studies varied from 53.3% in McLeansboro, Illinois (Will 1973) to 77.0% at Mississippi State (Sappington 1977) (Table 1). No correlation was noted between fledging success and latitude ($r = 0.219$, $P > 0.50$). Mean fledging success for the ten North American studies was 64.7%.

Nesting success, the proportion of eggs laid which result in successfully fledged young, can be estimated by taking the product of hatching success and fledging success. Nesting success in the present study was 55.9%. Nesting success in ten other North American studies varied from 31.1% at Coldspring, Wisconsin (North 1972) to 70.5% at Ithaca, New York

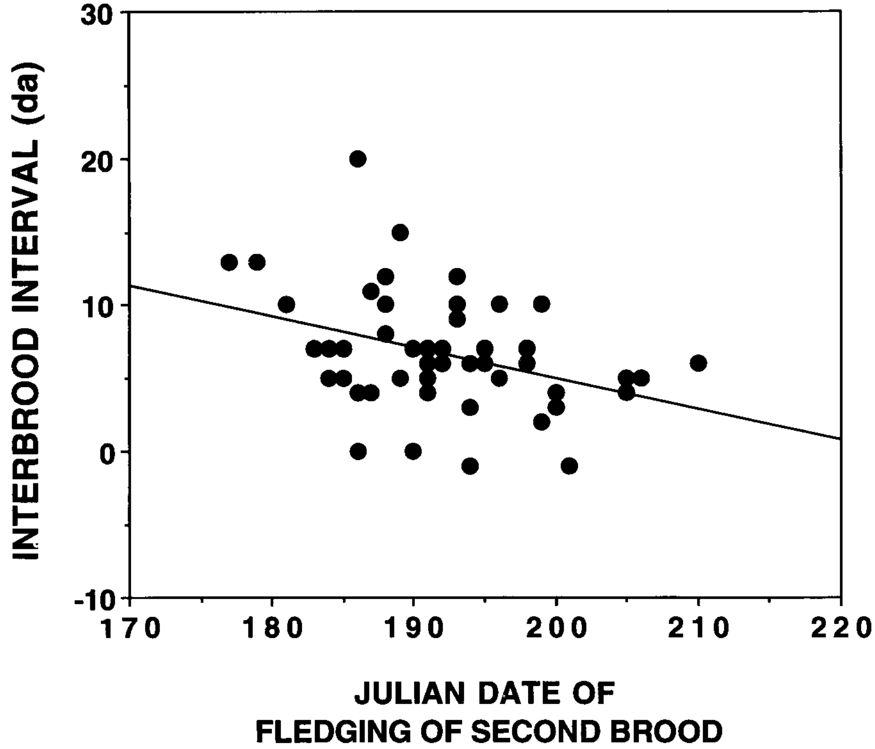

FIG. 3. The relationship between date of fledging of the second brood and the interbrood interval (days from fledging of one brood to initiation of egg-laying in subsequent clutch) for 50 marked females laying third clutches, 1987–1991 ($r = -0.367$, N = 50, $P < 0.01$).

(Weaver 1942) (Table 1), and the mean nesting success for all the studies was 43.8%. No relationship was found between nesting success and latitude ($r = 0.225$, $P > 0.50$).

The interbrood interval between "second" and "third" broods of 50 marked females varied from −1 to 20 days (mean = 6.68 days, SE = 0.57). In two instances the female began her "third clutch" one day before the "second brood" young fledged (once in the same nest and once in a nearby site). In two other instances, the female began laying on the day the young fledged. Such brood overlap has previously been reported in the House Sparrow (Lowther 1979b). There was a strong mode of clutch initiation 4–7 days after fledging of the "second brood" with 30 (60%) of the marked females having interbrood intervals in that range. Interbrood interval did not vary significantly among years of the study (ANOVA, $F_{4,45} = 0.952$, $P > 0.40$), with initial brood size ($r =$

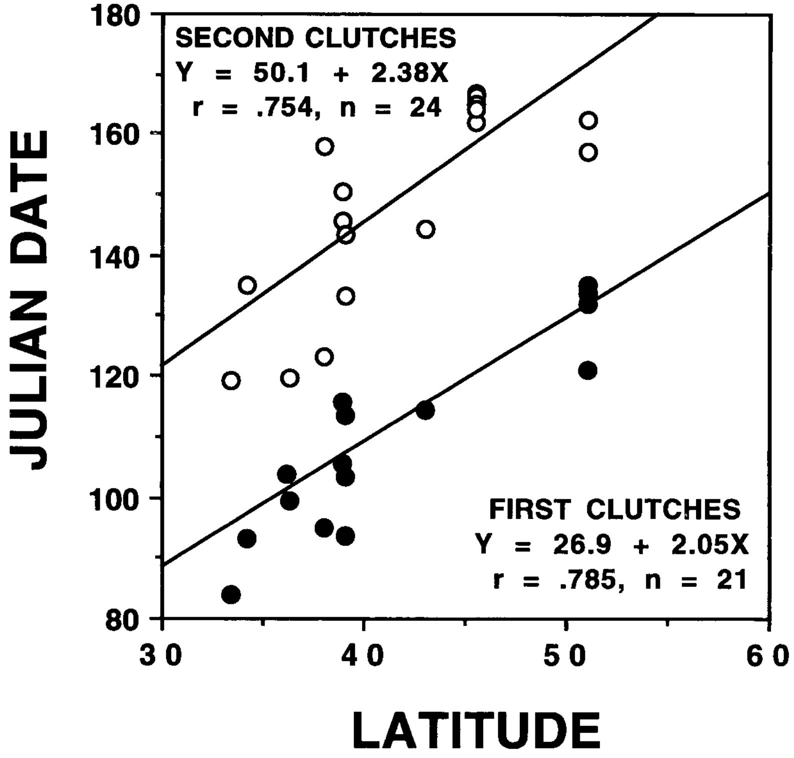

FIG. 4. The relationship between latitude and the peak initiation dates of first and second clutches of the House Sparrow in continental North America. Most dates are midpoints of modal periods of clutch initiation, although some are mean or median dates. Data were obtained from the following sources (Anderson 1973, unpubl. data; Lowther 1979a; McGillivray 1983; Mitchell et al. 1973; Murphy 1978; North 1968, 1972; Pitts 1979; Sappington 1977; Will 1973).

0.174, N = 48, $P > 0.20$), or with the number of young fledging from second broods ($r = 0.195$, N = 50, $P > 0.15$) (in all cases supernormal broods were included). In 1989–1991, interbrood interval did not differ significantly between females that reared supernormal "second broods" (mean = 7.17 days, SE = 1.30) and control females (mean = 6.96 days, SE = 0.93) ($t_{34} = 0.13$, $P > 0.85$). Interbrood interval did show a significant negative relationship with the fledging date of the "second brood" ($r = -0.367$, N = 50, $P < 0.01$) (Fig. 3).

Peak dates of initiation of first and second clutches in North American studies are plotted against latitude in Fig. 4 (in most cases the peak date is the midpoint of an interval in which the peak numbers of clutches were initiated). The correlations between peaks of both first and second clutches and latitude are highly significant ($r = 0.785$, $P < 0.01$ and $r = 0.754$, $P < 0.01$). The least squares linear regression equations for the data are also presented in Fig. 4. The slopes of both of the regression lines are close to 2 (2.05 and 2.38) suggesting that there is a delay in the chronology of breeding among North American populations of the House Sparrow of approximately two days for each degree of latitude poleward. A similar retardation with latitude was noted for the date of initiation of first clutches at 20 sites in Asia, Europe and North America (the slope of the regression equation was 1.94, Dyer et al. 1977). This is only half of the four-day retardation observed in the phenology of plants and arthropods (Hopkins 1938), and may be reflective of the effect of endothermy on breeding phenology. It may also reflect in part the adaptive physiological differences among House Sparrow populations observed by Hudson and Kimzey (1966). Threadgold (1960) observed a retardation in the onset of spermatogenesis with increasing latitude in North American populations of the House Sparrow, but the number of locations, four, was insufficient to perform meaningful quantitative comparisons. In a comparative study of coastal populations of the Song Sparrow (*Melospiza melodia*), Johnston (1954) found a three to four day retardation in the onset of breeding for each degree of latitude. A considerable amount of annual variation in the timing of the peaks of first and second clutches at some locations is also evident in Fig. 4. This variation is apparently due primarily to annual variation in local climatic conditions (i.e., early or late springs).

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