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INTERRELATIONS BETWEEN CLUTCH-SIZE, BROOD-SIZE, PREFLEDGING SURVIVAL, AND WEIGHT IN KENT ISLAND TREE SWALLOWS[1]

BY RAYMOND A. PAYNTER, JR.

INTRODUCTION

Within the last few years there has been considerable interest in the interrelations of clutch-size, brood-size, and prefledging survival, and much speculation on their evolutionary significance. The ease with which data on these subjects may be obtained and the completeness of the data vary considerably with the species studied. Precocial species are notoriously difficult to work with, whereas altricial species breeding in man-made nesting boxes offer fewer difficulties and often yield data in quantities large enough to be treated in thorough statistical detail. It is surprising that in spite of the facility with which these studies may be made, they have seldom been undertaken in North America. Thirty years ago Burns (1921:91) commented, "There is probably no other incident in the life history of our American birds in which our ornithologists are more profoundly ignorant than that of the approximate duration of nestling cycles." Yet, after more than a quarter of a century of rapid ornithological progress, the situation has improved very little. There is still an appalling lack of information on the duration of incubation and of the nestling periods of even the most abundant species. In searching the literature one usually finds only the most general statements and often merely a repetition of the opinion of an earlier author. Knowledge of clutch-sizes is hardly better, although it is material which is easily collected and presented.

The tree swallow *(Iridoprocne bicolor)* is an ideal species for studies of the early stages of development and their complex relationships, because it nests in erected boxes and often in large numbers within a fairly small area. Although nesting boxes may increase the density of the population greatly beyond what it would be if the birds depended solely on the availability of hollow trees, it is doubtful that any great strain is placed on the food supply where there are vast expanses of fields and swamps. At the Bowdoin Scientific Station on Kent Island, New Brunswick, Canada, the swallows have nested in breeding boxes set amid the extensive meadows, for nearly twenty years. The population has varied from year to year, probably depending on the number of boxes available, for the most part, although the weather and the success of the previous breeding season undoubtedly play important

[1] Contribution from the Osborn Zoological Laboratory, Yale University, and No. 24 from the Bowdoin Scientific Station, Kent Island, New Brunswick, Canada.

roles, but the population has not been studied long enough to provide sufficient data on the population changes. In the summer of 1947 about 50 new boxes were erected, and the old ones removed, in preparation for the investigation in 1948 which will be considered in detail.

I wish to express my appreciation to Prof. G. E. Hutchinson and to Dr. E. S. Deevey, Jr. with whom I have frequently discussed problems that have arisen in the preparation of this paper, and who have greatly aided in their clarification. I am also indebted to Prof. L. B. Chapman for supplying me with unpublished data on tree swallows nesting at Princeton, Massachusetts.

SPRING ARRIVAL AND NESTING

Ernest A. Joy, the late resident warden on the island, noted the date of the spring arrival of the swallows for more than 10 years and found that they were always present by the third week in April. On a few occasions they were first seen in early April and in 1946 they were back on March 29, but left after a snowstorm and again returned on April 12. Unfortunately, Mr. Joy was absent from the island during April of 1948 and the date of arrival for that year is unknown.

On May 13, 1948, when I began the study, nest building had just begun and only a few boxes contatined nesting material. Construction of the nests did not proceed without interruption, for during the night of May 13 the temperature dropped to 34°F. and no swallows were seen until May 16, when the weather cleared and became warmer. On the following day there was rain and fog, which lasted for several days, and no birds were seen again until May 19. They came and went sporadically until May 23 when they were back in large numbers and nest construction proceeded rapidly. Where the birds go during the dense Bay of Fundy fogs is unknown, although these departures are common events. The nearest large land mass is Grand Manan Island, 6 miles to the west, and presumably the birds find retreat there, but they may go to the coast of Maine, which at its nearest point is about 12 miles from Kent Island.

The first egg appeared on May 30 and 10 more clutches were started within the next two days. The last egg was laid on July 4 by a pair nesting for the second time after abandoning a nest with one egg in mid-June. In the course of the nesting season 31 nests were built that contained at least one egg. Several nests were started and then abandoned. Some of these birds built again but all were not captured early enough to be marked and traced in their subsequent movements. No birds produced two broods during the season.

On June 8 and 9 there was a severe storm with heavy rain and fog, and strong winds. During the two day period the temperature dropped to a minimum of 40°F. and rose only to a maximum of 48°F. The wind reached velocities of 25 miles per hour and 1.28 inches of rain fell. Prior to June 8 there were 22 nests either with completed or partially completed clutches and one more clutch was started on June 9. During the storm six of the nests with eggs were permanently deserted and another nest on June 10. Several nests under construction were also abandoned. It is interesting to note that only one of the deserted nests had a complete clutch and was being incubated before the storm. The remaining clutches were completed during the storm and then abandoned, with the exception of the clutch completed on June 10 and another nest that never contained more than one egg. Apparently when incubation is begun the nesting drive is even more strong than during egg laying. However, there were other nests with incomplete clutches that were not abandoned and there must be considerable variation in the nesting drive within the species.

TECHNIQUES

Every box was inspected once each day for the entire nesting season. The examination was made early in the morning except in very inclement weather, when it was deferred until later in the day. On only two days during the season, which extended until late July, was it impossible to make at least a brief inspection.

As each egg was laid it was lightly numbered with an indelible pencil in order to observe the sequence in which the eggs hatched. In no case was the marking heavy or extensive and there was probably no interference with normal embryonic respiration.

When the eggs began to hatch the young were weighed daily on a double-pan balance sensitive to 0.10 grams. In the beginning of the study the young in a few nests were not weighed until they were several days old but in most cases daily weighing began as soon as the young were hatched. Of course, not all of the young hatched in a clutch at the same time and often at the hour of inspection the full complement of young could not be weighed, although they hatched later in the day.

When the young were about six days old standard numbered bands were placed on them and account could be taken of the weight from day to day of each individual. Prior to banding, even though the birds were weighed separately, their identity was uncertain except for a few that were conspicuously smaller than their siblings or had some peculiarity, such as a scratch, that rendered them distinguishable.

In studies of this type difficulties frequently arise in determining the ages of the eggs and of the young because an egg may be laid, or a bird hatched, shortly after the nest has been inspected. For several days, in the early part of the study, the nests were inspected both in the morning and in the afternoon but in no instance were new eggs found late in the day. Austin and Low (1932) state that tree swallows do not lay during the night, although they imply that eggs may be laid at any time during the day, but Nice (1937) has found that song sparrows *(Melospiza melodia)* lay only early in the morning and this was true of the swallows at Kent Island in 1948.

In each nest a single egg was laid on successive days until the clutch was completed, but Austin and Low (1932:41) state, "We noted several exceptions, for one female laid two eggs in twenty-four hours, and in two other instances there was a lapse of two days, and in one case four days between layings." Shelley (1935) reports a situation where a single bird supposedly laid three eggs within slightly less than 24 hours and laid a single egg on each of the next two days to complete a clutch of five eggs. He found that two of the eggs were infertile but does not state which they were. While a lapse of a day or more between eggs is not unexpected, and has also been recorded by Kuerzi (1941), it hardly seems possible that a bird could lay three eggs in one day and then lay again the following day. Shelley's record must have been the product of two or more birds. The consistency with which the Kent Island swallows laid their eggs may have been unusual, in the light of the findings of previous investigations, but nevertheless a single egg was laid regularly each day in the entire series of nests.

For the sake of uniformity, a definite procedure for determining age must be adopted. In this study incubation will be considered to have begun on the day that the last egg was laid and the entire clutch will be considered to have hatched at the time of the first egg. In no case did hatching extend over more than one day, or at least no unhatched eggs or wet young were found at the time of inspection on the day following the discovery of the first hatchings in the nest. However, Austin and Low (1932) and Kuerzi (1941) found that while all of the eggs usually hatched on the same day there were exceptions. These variations are not unexpected and are probably caused by irregularities in the start of incubation. However, unless each nest is carefully observed there is no manner by which the start of incubation may be determined. Since all of the eggs do not hatch simultaneously, there is the possibility that no account is being taken of nearly a 24-hour difference in the ages of birds in the same nests. There appears to be no way to surmount the difficulty without making frequent inspections, which might be detrimental to the young. Undoubtedly, any initial differences smooth out as the birds become older and the difficulties are probably of little or no consequence in the final aspects of the study.

It will be noted that the incubation period as defined in this study, *i.e.*, from the day that the last egg is laid until the first egg hatches, is at variance with that recommended by Nice (1953), who presented sound reasons for calculating the period from the time that the last egg is laid until the last egg hatches. With the Kent Island material it makes no difference which definition is employed, since all of the eggs hatched on the same day. However, Austin and Low (1932), who at times found hatching in a given nest to be extended over two days, made their calculations from the last egg laid to the first egg hatched. Kuerzi (1941), in order to make comparisons, had to follow suit and I am forced to do the same in this study.

The nestling period is computed from the date of hatching through the date each bird was last seen in the nest. It has been found that nearly all of the young leave the nest at the same time although there is a tendency for the birds to depart prematurely when disturbed during weighing. When the young were nearly full-grown the hole of the nest box was plugged before weighing was begun and the plug was left in place for a short time after the birds were returned to the nest, allowing them opportunity to rearrange themselves in the darkened box. The plug was then quietly removed and in most cases the birds remained inside, but in a number of instances they flew out. If they flew poorly and landed in the grass they were returned to the box.

which was again plugged, and left for a longer time before the obstruction was removed. Usually they then remained inside. It is believed that disturbance during weighing may have caused many birds to fledge too early, but because all of the nests were subjected to the same disturbances a comparison between the nestling periods of various brood-sizes at Kent Island is not impossible. When these data are compared with those from other areas discrepancies may occur. The possibility that the birds fledged shortly before the nest was inspected and were therefore present for a day longer than the records indicate cannot be completely excluded. However, additional inspections during several days indicated that the young usually fledged in the mid-morning. As in every study of this nature, there are many ways in which the presence of an observer may introduce errors. It is impossible to eliminate the difficulties and still collect the data, but by using care in the interpretation of the results a reasonably accurate account may be obtained.

CLUTCH-SIZE

Of the 31 nests that contained eggs during the season, only one nest had a single egg, whereas the remainder had at least three. It is difficult to know how to treat the one-egg nest. It may have represented the complete clutch for the bird, although later in the season it built in a different box and laid four eggs. The bird was captured on the day it laid the egg, which was on June 9, the last day of the storm, and it was found to have been banded in 1947 as an adult and therefore its small clutch cannot be attributed to a young bird nesting for the first time. The egg was not incubated and the bird was never seen around the box again. Because this seems to be such an anomalous situation, it is believed best to omit the first nesting attempt in further considerations, although it affects the data very little and there are almost equally good arguments for not excluding it.

As may be seen in Table I, the remaining 30 nests, which include both first and second nesting attempts, produced a mean of 5.63 ± .98 eggs per clutch. It would be of interest to note the differences in clutch-size between the first and the second layings of individual birds, but not all of the adults were marked early enough in the study to be followed in their subsequent nestings. However, the eight birds that renested, several of which are definitely known to have built earlier without laying eggs, laid a mean of 5.00 ± 1.12 eggs per clutch, whereas the 22 birds laying for the first time produced a mean of 5.86 ± .80 eggs per clutch (Table I). Applying the test for the significance of the difference between the two means (*see* Fisher 1941, and Simpson and Roe 1939 for all statistical methods used in this paper), it is found that the difference it significant. It may be concluded, therefore, that the first clutches of the season are larger than clutches laid by birds nesting for the second time after abandoning their first nests. It is unfortunate that we are unable to differentiate between those birds that laid eggs and those that merely constructed nests earlier. Also, it should be noted that because all of the birds were not marked there is a possibility that some birds which were considered to be renesting

TABLE I—Clutch-size at Kent Island in 1947 and 1948.

Source	Winn 1949		This Study										Winn 1949 and this study	
Year	1947		1948										1947-48	
Treatment	Entire Season		Entire Season		First Nestings		Second Nestings		Unabandoned First Nests		Abandoned First Nests			
Clutch-size	No. of Nests	No. of Eggs	No. of Nests	No. of Eggs	No. of Nests	No. of Eggs	No. of Nests	No. of Eggs	No. of Nests	No. of Eggs	No. of Nests	No. of Eggs	No. of Nests	No. of Eggs
2	1	2	..	..	..	..	..	..	..	..	..	..	1	2
3	1	3	1	3	..	..	1	3	..	..	..	..	2	6
4	2	8	4	16	2	8	2	8	2	8	..	..	6	24
5	7	35	4	20	3	15	1	5	2	10	1	5	11	55
6	11	66	17	102	13	78	4	24	9	54	4	24	28	168
7	..	..	4	28	4	28	..	..	3	21	1	7	4	28
Total	22	114	30	169	22	129	8	40	16	93	6	36	52	283
Mean	5.18±1.07		5.63±.98		5.86±.80		5.00±1.12		5.81±.88		6.00±.57		5.44±1.04	

Difference between means of 1947 and 1948 significant. $0.05>P>0.02$
Difference between means of first and second nestings significant. $0.01>P>0.001$
Difference between means of unabandoned and abandoned nests insignificant.

may actually have been nesting for the first time, but late in the season. Nevertheless, seven of the eight nests were begun shortly after the storm and the first eggs were laid about June 17. The eighth nest was built by the bird that laid only one egg in its first nest. Its final clutch was begun on July 1. The close uniformity in the time of nest construction and egg laying in the seven nests led toward a common abandonment of their first nests rather than a late first laying. However, because only seven nests with eggs were abandoned (including the one-egg nest) and eight nests were built late in the season, at least one nest must have been built by a bird that laid no eggs earlier. Also, there still remains the possibility that some of the birds abandoning their eggs did not renest.

Although it appears that the clutches of birds renesting are significantly smaller than the first clutches, some doubt is cast on these observations by the work of Kuerzi (1941:24) who found that ". . . the number of eggs in the repeat set equaled the number in the destroyed set." He also found that second-year birds laid their eggs an average of nine days earlier than in their first year which agrees with the observations of Nice (1937) who found that first-year song sparrows lay slightly later than older birds. While Nice found that first-year sparrows laid smaller clutches than older ones, Kuerzi observed no difference for the swallows and it is therefore difficult to interpret the Kent Island data, but the fact remains that the late nests at Kent Island had fewer eggs than the earlier nests. Whether this was due to some young birds that laid later and had smaller clutches, or older birds renesting, or a combination of the two it is impossible to state.

The six nests that were abandoned, it is presumed after they had completed clutches, during or immediately after the storm had a mean clutch-size of 6.00 ± .57 eggs (Table I). The 16 nests that were not abandoned produced 5.81 ± .88 eggs per clutch. A statistical test is hardly needed to show that there is no significant difference between the means and therefore there is no reason to think that desertion of the nests is influenced by clutch-size.

In 1947 Winn (1949) studied the 22 nests built on Kent Island and found that the mean clutch-size was 5.18 ± 1.07 (Table I). There is no mention of abandoned nests in his study and because no nest is recorded as having failed to hatch all of its eggs it is presumed that there were no cases of renesting. A test for the significance of the difference between the mean of 1947 and that of 1948 indicates that the difference is probably significant. Yearly variation in clutch-size is not unexpected and has been reported before (*e.g.*, Lack and Arn 1947, and Lack 1950). This phenomenon will be considered in detail after the nesting data have been more fully analyzed.

GEOGRAPHIC VARIATION IN CLUTCH-SIZE

Lack's outstanding work on the significance of clutch-size (1947a, 1947b, 1948a) has received wide attention among ornithologists, although in North America there have been few attempts to duplicate his work and to test his hypotheses. The tree swallow is a wide-ranging species which might be expected to exhibit regional variations in clutch-size.

TABLE II

Clutch-size at Cape Cod in 1931 and 1932 (Austin and Low 1932, and Low 1933).

Year	1931		1932		1931 and 1932	
Clutch-size	No. of Nests	No. of Eggs	No. of Nests	No. of Eggs	No. of Nests	No. of Eggs
2	1	2	..	..	1	2
3	7	21	1	3	8	24
4	17	68	20	80	37	148
5	29	145	72	360	101	505
6	4	24	29	174	33	198
7	2	14	6	42	8	56
Total	60	274	128	659	188	933
Mean	4.56±.95		5.14±.88		4.96±.86	

Difference between means of 1931 and 1932 significant. 0.05>P>0.02

The work at the Austin Ornithological Research Station at North Eastham, Cape Cod, Massachusetts, provides a most useful fund of comparative material. In a study of the tree swallows there in 1931. Austin and Low (1932) recorded the clutches in 62 nests. It is assumed from the context of their paper that several repeat layings are included in the total number of nests under study. Two of three nests with clutches of only two eggs each were called "incomplete" but no explanation is given. Presumably they had evidence of the desertion of the nests or of the deaths of the adults prior to the completion of the clutches since the other two-egg clutch was considered to have been completed. The 60 completed clutches had a mean of 4.56 ± .95 eggs per clutch (Table II). In 1932 (Low 1933), in the same general locality, 133 nests were studied and the single one-egg clutch, the single two-egg clutch, and three of the four three-egg clutches were considered to have been abandoned, leaving 128 nests with which to work. The mean clutch for that year was 5.14 ± .88 eggs (Table II). Subjecting the data for the years of 1931 and 1932 to the test for the significance of the difference between their means, it is found that the clutch-sizes are probably significantly different.

The study was further enlarged in 1933 (Low 1934) but the data could not be collected in such great detail. Although 175 nests were under observation, the contents of 25 nests at three substations were imperfectly known, reducing the study to 150 nests. In these nests 707 eggs were laid, or an average of 4.71 eggs per nest (Table III). Unfortunately, there is no record of the distribution of the clutch-sizes within the sample and a statistical comparison with the previous years is impossible. Also, no note is made of deserted or incomplete nests. which are presumably included, since in a table (Low 1934:29) comparing the clutches at the main banding station over the three-year period the "incomplete" clutches for the years of 1931 and 1932 are included in the total number of eggs laid.

TABLE III—Regional Variations in Clutch-size.

Locality	Approx. Lat. and Long.	No. of Nests in Sample	Mean Clutch-Size	Year	Source
Fortine, Montana	48°45′N. 115°W.	52	6.23[1, 2]	8 Seasons (Years?)	Weydemeyer 1935
Kent I., N. Bruns.	44°35′N. 66°45′W.	22	5.18±1.07	1947	Winn 1949
"	"	30	5.63±.98	1948	This study
E. Westmoreland, N. Hamp.	42°55′N. 72°30′W.	20	4.55[1]	1934	Shelley 1935
"	"	18	4.33[1]	1935	Shelley 1937
"	"	19	5.53[1]	1936	" "
Princeton, Mass.	42°30′N. 71°50′W.	approx. 15-25	5.30[1]	1938	Chapman, *in litt.*
"	"	"	5.15[1]	1939	" "
"	"	"	4.65[1]	1940	" "
"	"	"	5.06[1]	1941	" "
"	"	"	5.00[1]	1942	" "
"	"	"	5.26[1]	1943	" "
North Eastham, Cape Cod, Mass.	41°52′N. 70°W.	60	4.56±.95	1931	Austin and Low 1932
"	"	128	5.14±.88	1932	Low 1933
"	"	150	4.71[1]	1933	Low 1934
Kent, Conn.	41°45′N. 73°30′W.	68	5.26±.83	1937-39	Kuerzi 1941

[1]Standard deviation from the mean not available.
[2]First brood nests only.

A comparison of the mean at Cape Cod in 1932 (5.14 ± .88) with the mean at Kent Island in 1947 (5.18 ± 1.07) indicates, of course, that there is no significant difference between them. However, 1932 may have been a year of large clutches at Cape Cod while 1947 was a year of small clutches at Kent Island and any geographic variation was thereby obscured. When the mean at Cape Cod in 1931 (4.56 ± .95) is tested against the mean for either 1947 or 1948 at Kent Island, significant differences are found ($P < 0.001$) but if the Cape Cod mean for 1932 is tested against the Kent Island mean for 1948, again no significant difference is evident. When the mean for the two years at Cape Cod (4.96 ± .86) and the mean for the two years at Kent Island (5.44 ± 1.04) are compared statistically the difference is found to be significant ($P < 0.001$). Therefore, the most that can be safely said is that while it is possible (from the significant differences between the two-year means) that there is a real latitudinal variation in clutch-size, this phenomenon may be masked by the year-to-year differences at either place. This difference is so great that two years of observation is inadequate to describe it, but it is interesting to notice that regardless of the internal variation in frequency of egg number, the most frequent number at Kent Island was always six, whereas on Cape Cod it was always five.

Valuable comparative data are to be found in the work of Kuerzi (1941) at Kent, Connecticut, where a study was made of a large colony for the years of 1937, 1938, and 1939. The mean clutch-size for 68 nests during the three-year period was 5.26 ± .83 (Table IV). It is unfortunate that the data are not presented so that yearly variations might be studied. Testing this mean against the mean for 1931 and 1932 at Cape Cod (4.96 ± .86) it is found that significant difference exists between the two ($P < 0.001$). When the mean for the Connecticut data is tested against the mean at Kent Island in 1947 and 1948 (5.44 ± 1.04) no significant difference is apparent, but when it is applied against the mean at Kent Island in 1948 (5.63 ± .98) alone, the difference is significant ($P < 0.001$).

TABLE IV

Clutch-size at Kent, Connecticut, in 1937, 1938, and 1939 (Kuerzi 1941).

Clutch-size	No. of Nests	No. of Eggs
3	2	6
4	10	40
5	30	150
6	24	144
7	2	14
Total	68	354
Mean	5.26±.83	

L. B. Chapman has made a study of nesting tree swallows at Princeton, Massachusetts, since 1931 (Chapman 1935, 1939) and has kindly supplied me with unpublished data for the years of 1938 through 1946. Unfortunately, neither the published nor the unpublished material is detailed enough to permit statistical treatment of the mean clutch-size from year to year. In all cases the number of boxes occupied each year is merely listed and no note is made of whether eggs were laid in all of the nests, or of whether any of the nests were deserted before completion. Also, the distribution of the clutch-sizes is not given. The unpublished data contain records of the mean clutch-sizes for 1938 through 1943 (Table III) but these are without standard deviations. The number of nest boxes in these years ranges from 15 to 25 and presumably the number of clutches laid, or completed, is slightly less since dividing the number of eggs by the number of boxes occupied does not always yield results in agreement with those of Chapman. At best, the above figures may be considered to be close approximations.

Shelley (1935, 1937) has published data for tree swallows nesting at East Westmoreland, New Hampshire, for the years of 1934 through 1936. The distribution of the clutch-sizes again is not given and also it is presumed that several second nesting attempts are included in his totals. The average for each year is given in Table III.

Wedemeyer (1935) observed a total of 60 nests in eight years at Fortine, Montana, but he does not present yearly averages, the number of nests studied each season, or even the years of his observations. He makes a point, however, of breaking his data down to "first brood nests" and "second brood nests." Although the tree swallow is usually thought to be single-brooded there are a few casual references to second broods in the literature. It would be extremely useful to know how common are second broods and whether there is a geographical trend in their prevalence. Wedemeyer found an average clutch-size of 6.05 eggs per nest. The 52 first brood nests averaged 6.23 eggs per nest and the second brood nests had average clutches of 4.99 eggs.

If there is a geographical cline in the clutch-size of tree swallows, as has been so well demonstrated by Lack (*e.g.*, 1947a, 1947b, 1948a) for many other species, it is impossible to prove statistically with these scant data. Before this matter is considered more fully it is well to proceed with the analysis of the nesting data at Kent Island.

DURATION OF INCUBATION

As has been explained, the duration of incubation is calculated from the day that the last egg was laid to the day that the first young in the clutch were hatched. The periods for the various clutch-sizes are presented in Table V. The mean duration of incubation for all the nests was 15.83 ± 1.46 days.

TABLE V—Duration of incubation at Kent Island in 1948.

No. of Days Incubated		13	14	15	16	17	18	Total Clutches In Class	Mean Duration of Incubation
Clutch-size	3	..	..	..	..	..	1	1	18.00
	4	..	..	3	1	..	..	4	15.25±.43
	5	1	..	..	2	..	..	3	15.00±1.14
	6	2	1	..	7	2	1	13	15.69±1.43
	7	..	..	..	..	2	1	3	17.33±.47
Total		3	1	3	10	4	3	24	15.83±1.46

Difference between mean of the combined 4-, 5-, and 6-egg clutches and mean of the 7-egg clutches significant. $P<0.01$

Austin and Low (1932) have recorded the duration of incubation for 49 nests at Cape Cod (Table VI) and have obtained a mean of 14.44 ± .87 days. A test for the significance of the difference between the means at Kent Island and at Cape Cod indicates that the difference is significant ($P < 0.001$). The period of incubation in Connecticut (Kuerzi 1941) was 14.38 ± .94 days (Table VI) and, of course, does not differ significantly from the Cape Cod mean although it does differ from the Kent Island mean. It will be noted that the mode at Kent Island was about 16 days whereas in Connecticut and at Cape Cod it was nearer 14 or 15 days.

TABLE VI—Duration of incubation at Cape Cod in 1931 (Austin and Low 1932) and at Kent, Connecticut, in 1937-1939 (Kuerzi 1941).

Locality	Cape Cod	Kent, Conn.
No. of Days Incubated	No. of Nests	No. of Nests
13	7	17
14	19	21
15	17	22
16	6	6
Total	49	66
Mean	14.44±.87	14.38±.94

The reason that the incubation period is longer at Kent Island than in either Connecticut or at Cape Cod is probably easily explained. The most obvious suggestion is that the hard storm in early June at Kent Island, which caused the desertion of some nests, may have led to the temporary abandonment of the other nests and consequently lengthened the apparent incubation periods. Lack and Lack (1951) in a study of the common swift *(Apus apus)*, found that stormy weather early in the incubation period caused the apparent incubation period to be longer than if the weather was more uniform throughout the nesting period. Landauer (1948) has reviewed the literature for the domestic fowl which indicated that even after incubation has begun the eggs may be cooled well below the temperature at which development takes place, for as long as a day, without serious deleterious effects. Presumably the eggs of other birds do not differ from those of chickens in this respect.

In order to determine whether or not the storm may have lengthened the apparent incubation period at Kent Island, the mean duration of incubation for the nests begun before the storm and the mean for the nests begun after the storm have been computed and are presented in Table VII. The earlier nests had a mean of 16.37 ± .85 days and the later nests had a mean of 14.75 ± 1.34 days. The difference between them is statistically significant ($0.01 > P > 0.001$). When the mean for the later nests is tested against the means at Cape Cod and in Connecticut, no significant difference is found and therefore, it appears that the longer over-all incubation period at Kent Island is an artifact introduced by the severe weather early in the season. Of course, it is possible that some difference in the incubation period may exist between the early and late nests, even under uniform weather conditions, but it is difficult to imagine any mechanism responsible for such discrepancies unless it is related to clutch-size. The fact that the mean clutch-sizes of the early and the late nests differ makes it necessary to examine this possibility.

There are a number of reasons for expecting clutch-size to determine the length of incubation. It may be reasoned that a bird that lays a large clutch incubates the first eggs while she is on the nest laying the other eggs and therefore hatching might begin earlier than for a bird with a smaller clutch. Although this specious suggestion may

TABLE VII—Duration of incubation for eggs in nests begun before storm and for those begun after storm at Kent Island in 1948.

Period	Before Storm						After Storm								
No. of Days Incubated	15	16	17	18	Total Nests in Class	Mean Duration of Incubation	No. of Days Incubated	13	14	15	16	17	18	Total Nests in Class	Mean Duration of Incubation
Clutch Size							Clutch Size								
3	. .	. .	. .	. .	0	. . . .	3	. .	. .	. .	. .	. .	1	1	18.00
4	2	. .	. .	. .	2	15.00	4	. .	. .	1	1	. .	. .	2	15.50 ± .50
5	.	2	. .	. .	2	16.00	5	1	. .	. .	. .	. .	. .	1	13.00
6	. .	6	2	1	9	16.44 ± .68	6	2	1	. .	1	. .	. .	4	14.00 ± 1.23
7	. .	. .	2	1	3	17.33 ± .47	7	. .	. .	. .	. .	. .	. .	0	. . . .
Total	2	8	4	2	16	16.37 ± .85	Total	3	1	1	2	0	1	8	14.75 ± 1.34

Difference between mean duration of incubation for each period significant. $0.01 > P > 0.001$
Difference between mean of combined 4-, 5-, and 6-egg clutches in the period before the storm and the mean of the 7-egg clutches significant. $0.02 > P > 0.01$

VII. Duration of incubation for eggs in nests begun before storm and for those begun after storm at Kent Island in 1948.

apply to other species, apparently it does not hold for the tree swallow since at Kent Island all of the eggs in a nest hatched on the same day. On the other hand, it might be thought that a bird would have difficulty in covering a large clutch and that a lower incubation temperature would retard the development of the embryo. Landauer (1948) has summarized the evidence for the domestic fowl which clearly indicates that temperatures below the optimum appreciably lengthen the incubation period. It should be stressed, however, that Landauer refers to experimental work in incubators and that he presents no data either for or against the supposition that larger clutches are incubated at lower temperatures than smaller clutches.

The fact that a difference has been found between the mean period of incubation for the early and the late nests makes an analysis of the relationship between clutch-size and the duration of incubation difficult. Applying the chi-square test (Fisher 1941) to the frequencies presented in Table V (the massed data for the entire season), it is found that there is some relationship between clutch-size and the duration of incubation. If the analysis is broken down further, it will be noted that the single three-egg clutch had an incubation period of 18 days and that the three seven-egg clutches had a mean incubation period of 17.33 $\pm$ .47 days. Both of these clutch-sizes were incubated considerably longer than the four-, five-, and six-egg clutches. The long incubation period for the three-egg nest may be an artifact or it may indicate that the bird did not incubate its clutch so well as birds with larger clutches. Because this nest was built after the storm, it is almost certain that the long period of incubation was not brought about by the same influences which acted on the early nests. It has been found in the herring gull *(Larus argentatus smithsonianus)* that birds with small clutches suffer from heavier predation than birds with large clutches, apparently because they do not guard their eggs with the tenacity of birds that have nearer the mean clutch-size for the species as a whole (Paynter 1949). It has been suggested that possibly a larger clutch stimulates the gull to incubate more closely, although observational proof of this is lacking. If faulty incubation appreciably lowers the incubation temperature, then in view of the work with the domestic hen, a longer period of development would be expected in very small clutches. This may well be the case with the tree swallow, although one small clutch is an inadequate sample and the idea is merely put forth as a suggestion for future research.

The long incubation period for the seven-egg clutches is of greater interest. Here is a situation that apparently supports the idea that a large clutch is more difficult to cover and that the development of the embryos is thereby retarded. Since the significance of this observation may be concealed when all of the data are massed and treated by the chi-square method, the mean incubation period for the four-, five-, and six-egg clutches, as presented in Table V, has been computed and has been found to be 15.50 $\pm$ 1.33 days whereas it is 17.33 $\pm$ .47 days for the seven-egg clutches. A test for the significance of the difference between the two means indicates very clearly that the difference is real and that seven-egg clutches require a longer incubation period. An objection may be raised to this method of treatment because seven-egg clutches were only laid before the storm and therefore their incubation periods would be expected to be longer. On the other hand, when the data for the smaller clutches are massed, only seven clutches from the period after the storm are included with the 13 clutches built earlier and their shorter incubation periods do not lower the over-all incubation period to a great degree. Therefore, the difference between the mean for the seven-egg clutches and that of the smaller clutches is not greatly accentuated. If only the nests built before the storm are considered and the mean is computed for the 13 nests with clutches smaller than seven-eggs, it is found to be 16.15 ± .76 days. When this is tested against the mean for the seven-egg clutches it is again found to be significantly different ($0.02 > P > 0.01$) and the longer incubation period for the largest clutches seems even more certain.

The question arises: Was the longer incubation period for the early nests caused by the weather or was it due to the larger mean clutch-size? This is easily answered by computing the mean clutch-size for the 13 nests with less than seven eggs in the group of nests begun before the storm and the mean for the seven nests with more than three eggs in the group of nests begun after the storm. The means are 5.54 ± .74 and 5.28 ± .87 respectively and the difference between them proves to be statistically insignificant. The mean duration of incubation for the same groups was 16.15 ± .76 days for the earlier nests and 14.29 ± 1.27 days for the later nests. The difference between the two means is statistically significant ($P < 0.001$) and it may be concluded that the longer apparent period of incubation for the early nests was probably brought about by the temporary abandonment of the nests owing to the storm.

TABLE VIII—Hatching success at Kent Island in 1947 and 1948.

Source	Winn 1949		This paper					
Year	1947		1948					
			All Nests		First Nesting		Second Nesting	
No. of Yg. Hatching	No. of Nests	No. of Young	No. of Nests	No. of Young	No. of Nests	No. of Young	No. of Nests	No. of Young
2	1	2	1	2	..	..	1	2
3	2	6	6	18	4	12	2	6
4	4	16	2	8	2	8		
5	6	30	6	30	5	25	1	5
6	9	54	8	48	4	24	4	24
7			1	7	1	7		
Total	22	108	24	113	16	76	8	37
Mean Brood-Size	4.90 ± 1.13		4.41 ± 1.37		4.75 ± 1.26		4.62 ± 1.57	

Difference between means of 1947 and 1948 insignificant.
Difference between means of first and second nestings insignificant.

HATCHING SUCCESS

Of the 30 nests which contained eggs during the 1948 season (excluding the one-egg nest), young were produced in 24. The six nests that were complete failures were those that were abandoned or, conversely, in no instance was a nest completely unproductive if the eggs were incubated. Under the discussion of clutch-size it has been demonstrated that there seems to be no relation between the number of eggs in a clutch and whether or not it was abandoned, which also means that there is no relation between clutch-size and complete hatching failure. Nevertheless, in 12 of the 24 nests some of the eggs did not hatch. There were 20 failures among the 133 eggs laid in the nests producing young, or, in other words, 15.04 per cent failed to hatch. This gives a mean of 4.71 ± 1.37 young per nest at the time of hatching (Table VIII).

In 1947 (Winn 1949) there were apparently no complete nesting failures, or at least they have not been considered in the published data. In 22 nests with a total of 114 eggs only six, or 5.26 per cent, failed to hatch, giving a mean brood-size at hatching of 4.90 ± 1.13 (Table VIII). The mean brood-sizes in 1947 and in 1948 do not differ significantly.

Before considering the egg mortality in other regions it is well to proceed with the analysis of this at Kent Island in 1948. To determine whether there might be some difference between the productivity of the nests that were built early in the season and not abandoned and those nests that represent repeat layings, or at least new nestings, the mean number of young produced per clutch has been computed (Table VIII). The nests that were not abandoned had a mean of 4.75 ± 1.26 young per nest, and the nests that were built late in the season had a mean of 4.62 ± 1.57 young. Obviously, there is no significant difference between the means but a very interesting point is brought to light. While the mean clutch-size for the second nestings was only 5.00 ± 1.12 and that of the first nesting was 5.86 ± .80, both groups produced approximately the same number of young per nest and therefore egg mortality was greater in the earlier nests. This may be better visualized in Table IX, where it may be seen that the first nestings had 18.28 per cent egg mortality while the second nestings had only 7.50 per cent failures.

The reason for the variation in egg mortality may be explained in the light of observations indicating that the early nests were incubated longer than the later nests, and that this was probably caused by the poor weather in early June which led to the temporary desertion of the nests. In his review, Landauer (1948) has shown that the eggs of the fowl are most resistant to cooling and can withstand longer periods of cooling during the first third of the total incubation period. This resistance decreases with advancing embryonic development. Although most of the tree swallow eggs were in the earliest stages of development, the storm lasted for two days and a doubling in the egg mortality for the early nests is not unexpected.

Although the temporary desertion of the early nests appears to account for the variation in egg mortality it is well to examine other

TABLE IX—Distribution of hatching failures among nests hatching young.

Source	Winn 1949				This Paper											
Year	1947				1948											
					All Nests				First Nestings				Second Nestings			
Clutch-Size	No. of Nests	No. of Eggs	No. of Eggs not Hatching	Per cent Failures	No. of Nests	No. of Eggs	No. of Eggs not Hatching	Per cent Failures	No. of Nests	No. of Eggs	No. of Eggs not Hatching	Per cent Failures	No. of Nests	No. of Eggs	No. of Eggs not Hatching	Per cent Failures
2	1	2	0	0	..	..	..	..	..	..	..	..	..	..	..	..
3	1	3	0	0	1	3	0	0	..	..	..	..	1	3	0	0
4	2	8	1	12.50	4	16	5	31.25	2	8	2	25.00	2	8	3	37.50
5	7	35	2	5.71	3	15	0	0	2	10	0	0	1	5	0	0
6	11	66	3	4.54	13	78	12	15.39	9	54	12	22.22	4	24	0	0
7	..	..	..	..	3	21	3	14.28	3	21	3	14.28	..	..	..	..
Total	22	114	6	5.26	24	133	20	15.04	16	93	17	18.28	8	40	3	7.50

IX. Distribution of hatching failures among nests hatching young.

possible causes. If it were found that large clutches suffered from greater egg mortality the phenomenon could easily be explained since the first nestings had significantly larger clutches than the second nestings. However, when a chi-square test is applied to the frequencies of hatching failures for all of the nests that produced young in 1948, it is found, without doubt, that egg mortality is independent of clutch-size. The data for 1947 show the same results.

Another possible factor, accounting for the discrepancies in the egg mortality rates, may be that the patterns of sexual behavior are not perfectly attuned early in the season and that the eggs are not so frequently fertilized. If this is the situation, one would expect to find egg mortality greater for the first eggs in the early clutches and less in the latter eggs. However, there is no indication that egg mortality is related to the order in which the eggs are laid since the hatching failures were very evenly distributed throughout the various positions within the clutch. It appears, therefore, that the observed difference between the mortality rates of the early and the late nests may be attributed to the temporary desertion of the early nests which resulted in the chilling of the eggs and the death of some of the embryos.

Although we have accounted for one cause of egg mortality at Kent Island there must be others, since those nests built after the storm did not have complete hatching success. For the most part, the reasons for the failures are unknown. Three eggs that disappeared from the nests are presumed to have been removed by the swallows since there are no mamalian predators on the island and no avian predators could have entered the bird boxes. One of these eggs disappeared from the nest during the fifth day of incubation and the other two eggs, both of which were in the same nest, disappeared on the day that the other eggs in the clutch hatched. Possibly these were carried out by the adults when they removed the shells of the newly hatched eggs. Neither egg was yellowed or visibly different in any manner indicative of infertility. None of the remaining eggs was broken or otherwise damaged and no development of the embryos was noted. It must be assumed that infertility and perhaps very early embryonic deaths were responsible for the failures.

Variations in the annual egg mortality have been reported for many species but unless the mortality can be directly attributed to storms and predation it is usually impossible to account for the fluctuations. There were no very severe storms in 1947 and this may partially account for the greater hatching success in that year (Table IX).

If the three eggs that disappeared from the nests in 1948 are eliminated from the total egg mortality of the nests producing young, it is found that 12.76 per cent of the eggs were either infertile or suffered embryonic mortality. This is not an unusual mortality rate since in 1931 at Cape Cod (Austin and Low 1932) 15.76 per cent mortality for the nests hatching young was reported, when the eggs destroyed by predators and handling are excluded, and in 1932 (Low 1933) 9.03 per cent mortality, with the same exclusions, was found.

Most of the published records show egg mortality, when all causes are included, substantially higher than that at Kent Island. In fact, the 1947 record of 5.26 per cent is among the lowest mortality rates found. Usually the authors include in their computations of egg mortality the nests which are deserted, but it would appear that this procedure may introduce a large error, in many instances, in depicting over-all reproductive efficiency. Birds which desert nests often will nest again and thus replace the lost eggs. But, on the other hand, when a portion of a clutch fails to hatch because of infertility, injury, etc., no new eggs are laid to compensate for those eggs which fail to produce young. It is obvious, for a simple example, that if in two colonies of equal size, one loses half its eggs through nest desertion and the other loses half its eggs through scattered infertility, at the end of the season, provided the deserted nests are replaced, the number of young produced per colony, and per pair of adults, or per nest within each colony, is going to be vastly different, and not at all comparable. It is unfortunate that the published records do not differentiate more often between eggs failing to hatch because of desertion and the mortality of eggs owing to other causes. Without this information it is impossible to evaluate the relative importance of prehatching mortality in the several regions where studies have been made. However, again the material from Cape Cod is adequate and it is found that in 1931 nearly 22 per cent of the eggs failed to hatch because of predation, infertility, and possibly embryonic deaths. About six and one-half per cent of the mortality was due to predation by house sparrows *(Passer domesticus)* and red squirrels *(Tamiasciurus hudsonicus)*. In 1932 the mortality dropped to about 12 per cent, of which only 3 per cent was attributed to predation.

DURATION OF THE NESTLING PERIOD

Three of the 24 nests with young had complete fledging failures but 98 of the 103 young in the remaining nests successfully left their nests. The mean age at which these birds departed was 19.21 ± .81 days (Table X).

TABLE X—Duration of nestling period for all young fledged at Kent Island in 1948.

Nestling Period in Days	No. of Young
17	2
18	13
19	38
20	42
21	3
Total	98
Mean	19.21 ± .81

To determine if there is a difference between the mean nestling periods of young in nests which fledged all of the young that were hatched, and of birds in nests which did not fledge all of the young that were hatched, the mean for the 86 birds in the 18 completely successful nests (19.28 ± .71 days) has been tested against the mean for the 12 birds in the three partially successful nests (19.51 ± .50) and the difference has been found to be statistically insignificant. Before this is examined further, it is well to push back the analysis to determine if there is any difference between the mean fledging period for the 50 young in the nine nests hatching and fledging all of their eggs (100 per cent successful), and the mean period for the 48 young in the 12 nests that suffered either egg or nestling mortality, or both. The mean for the wholly successful nests is 19.44 ± .60 days and for the partially successful nests it is 18.98 ± .99 days. The difference between the means is significant ($P<0.001$), and it appears that young in less successful nests fledge earlier. It might be thought that if clutch-size or brood-size played a role in the duration of the nestling period some difference between their means would be found. However, the mean clutch-size for the nests that were 100 per cent successful in raising their eggs and their young to fledging was 5.55 ± 1.62 and that of the nests with either hatching failures or nestling mortality was 5.83 ± .89. The difference between the means is not significantly different. The mean brood-size for the nests fledging all of the young that were hatched, but not necessarily all of the eggs that were laid, was 4.78 ± 1.29 and that of the three nests fledging less than the number hatched was 5.66 ± .45. Again there is no significant difference between the means. The reason for the earlier fledging of birds in the less successful nests is unknown but it is entirely possible that the sample with which we have to work is too small to permit subdivision and still obtain reliable results when subjected to statistical treatment. This is an ever-present difficulty in handling zoological data and one which should never be underestimated or disregarded when seeking explanations for apparent phenomena exposed by statistical methods.

To this point we have found no evidence either for or against the suggestion that brood-size may determine the length of the nestling period. We have found that birds in less successful nests appear to fledge earlier than those in completely successful nests, but no differences in the mean brood-sizes are disclosed. If the duration of the nestling period is related to brood-size it would not be expected to be exposed under these conditions and it would appear that variations in the nestling periods have been brought about by other causes. To determine whether or not there is a relationship between the brood-size and the age at which the young fledge, the mean nestling period for each brood-size has been computed and is presented in Table XI. Only nests fledging all of the young that were hatched are considered in order to avoid possible discrepancies owing to deaths during the nestling period. It will be noted that the mean nestling period for the three-young broods is the shortest while the mean increases progressively in the five-, six-, four-, and seven-young broods. If the significance of the difference between the means is tested, when the means are arranged according to brood-size, as in Table XI, it will be found that each mean is significantly different from the mean immediately above or below it. If it is postulated that small broods fledge earlier than large broods, the observations fit the hypothesis fairly well

TABLE XI—Duration of nestling period at Kent Island for young in nests fledging same number as hatched.

Brood-Size	Days in Nest					Total No. of Young	Total No. of Nests	Mean
	17	18	19	20	21			
3	. .	6	8	1	. .	15	5	18.66 ± .59
4	. .	1	1	6	. .	8	2	19.62 ± .69
5	2	3	5	7	3	20	4	18.80 ± 1.28
6	. .	3	16	17	. .	36	6	19.39 ± .20
7	. .	. .	2	5	. .	7	1	19.71 ± .44
Total	2	13	32	36	3	86	18	19.18 ± .90

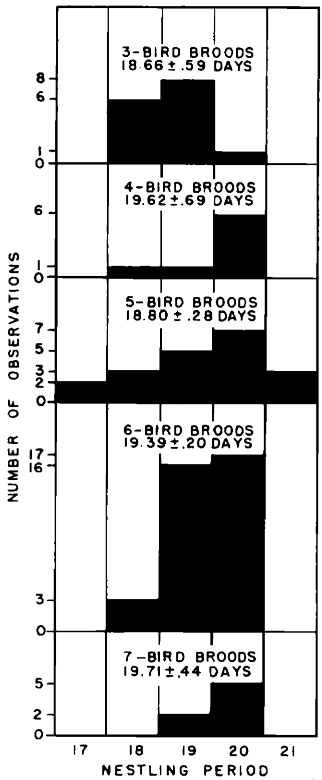

Fig. 1. Duration of nestling period at Kent Island in 1948.

except that the four-young broods are out of order and fledge too late. Also, if the difference between the means of the three-young and the five-young broods is tested it is found that it is not significantly different and the hypothesis breaks down even more. However, by arranging the data in the form of a histogram, as in Figure I, it may be seen that the mode of the three-young nests is distinctly lower than in the other brood-sizes. The only conclusion that may be reached at this time is that there appears to be a trend toward longer nestling periods in broods larger than four birds, and that the three-bird nests have a decidedly different mode than larger broods and without doubt have shorter nestling periods.

At Cape Cod in 1931 the duration of the nestling periods has been computed for 46 nests (Austin and Low 1932:43), "Estimated from the day the first egg hatched to the last day young remained in the nests, . . ." In other words, if all the eggs did not hatch on the same day, which was found to be the case at Cape Cod but not at Kent Island, the entire clutch is considered to have hatched at the time of the earliest egg, and if all the young did not fledge on the same day, which was found to be the case at Kent Island, only the maximum nestling period is recorded. Naturally, the nestling period derived from these data is going to be the mean of the maximum periods and not directly comparable with the Kent Island data.

In order to determine whether or not the two methods of treatment yield results that are statistically different, the mean nestling period at Kent Island has been computed for all of the nests producing young, assuming that all of the young were fledged at the time of the last bird in each brood (Austin-Low treatment). It is not necessary to make adjustments in these data for the time of hatching, as was done at Cape Cod, since all of the young hatched on the same day. The mean nestling period is $19.66 \pm .74$ days. When the mean is computed on the basis of individual birds, as was done in Table X, it is found to be $19.21 \pm .81$. It is not unexpected that a test for the significance of the difference between the means shows the difference to be significant ($P<0.001$) and indicates that the Austin-Low treatment yields results that are slightly higher than the true mean nestling period. Therefore, in order to compare the Kent Island results with the Cape Cod results, it is necessary to treat the Kent Island data in the Austin-Low manner.

The final problem to be considered before the Cape Cod data may be compared with that from Kent Island is whether the sample of 46 nests is composed only of nests that hatched all of their eggs and fledged all of their young, or is a sample consisting of both completely successful and partially successful nests, as in the Kent Island material. Austin and Low make no statement in their paper about the composition of the sample, but in a discussion of the reproductive efficiency (1932) they mention that 60 nests were under observation (excluding the two that were abandoned), 14 nests were complete failures and 15 nests were completely successful. By subtracting the nests that were failures, a total of 46 nests are found to have produced young. Therefore, it is presumed that all of the nests having any young were used in the sample, only 15 of which were completely successful nests. Although 33 per cent of the nests were completely successful at Cape Cod, against 87 per cent at Kent Island, the data are roughly comparable.

The mean duration of the nestling period for 179 young in 46 nests at Cape Cod in 1931 was 21.75 ± 1.93 days. When this mean is compared with that of all the young from Kent Island (19.66 ± .74) it is found that the difference is statistically significant ($P<0.001$).

In view of the suggestion that brood-size may play some role in determining the duration of the nestling period, one would expect to find the mean brood-size at Cape Cod to be larger than at Kent Island since the nestling period is longer. However, the mean brood, based on the number of young alive at the time of fledging was 4.66 ± 1.28 at Kent Island and 3.98 ± 1.05 at Cape Cod. Of course, this method of computing the brood-size involves nests that lost young between the time of hatching and the time of fledging, but we do not have definite figures on the mortality rates for the 46 nests at Cape Cod that produced fledged young and there is no other way to handle the data. The difference between the means proves to be statistically significant ($P<0.001$) and seems to contradict the thesis that larger broods have longer nestling periods. However, it should be remembered that the Kent Island broods averaged significantly larger than those from Cape Cod, and that while a brood of a given size might be raised with ease at Kent Island it might be raised with difficulty at Cape Cod.

It is unfortunate that the Cape Cod data are so amalgamated and generalized that it is impossible to apply the appropriate statistical methods to them to obtain a reliable indication as to whether there is a relationship between brood-size and the duration of the nestling period. However, Austin and Low (1932) present a table which seems to show a trend toward longer nestling periods with larger broods, but because the Kent Island data indicate that the young in less successful nests probably fledge earlier, and over 70 per cent of the Cape Cod nests were not entirely successful, the significance of these observations may be obscured by the fact that the average number of young per nest is probably taken at the time of fledging, with no regard for birds that may have lived until a short time before the others left the nest. Nevertheless, because these criticisms point toward the recording of a shorter nestling period in the larger broods than may have actually been the case, and yet the data still indicate a lengthening of the nestling period positively correlated with brood-size, it does not seem unreasonable to suggest that the Cape Cod material lends support to the observations at Kent Island which appear to indicate a positive correlation between brood-size and the duration of the nestling period.

Kuerzi's observations in Connecticut (1941) further complicate the picture since the mean duration of the nestling period for 66 nests, computed in the manner of Austin and Low, is 19.33 ± 1.44 days. This mean is slightly lower than at Kent Island (19.66 ± .74) and is probably significantly different ($0.02>P>0.01$), while it is definitely lower than at Cape Cod (21.75 ± 1.93; $P<0.001$). Kuerzi was unable to find any correlation between brood-size and the duration of the nestling period, but the significance of this observation may be very great and will be discussed below. The mean brood-size at fledging in Connecticut was 4.52 ± 1.18 days and does not differ significantly from the mean at Kent Island, although it does differ from that at Cape Cod.

It is difficult to arrive at a satisfactory conclusion from these data, but before an attempt is made to draw a tentative hypothesis it is well to bear in mind that the nestling period at Kent Island may have been shortened somewhat by disturbances owing to the daily weighings of the young since there was a tendency for the young to leave the nest before they were capable of sustained flight. To what extent human disturbance may have introduced an artifact is unknown, but there must be a minimum age at which the young are capable of leaving the nest and if all broods are subjected to the same amount of disturbance the time of departure must be shortened equally throughout the sample. Any differences in the nestling periods would be retained, presumably, although sharp demarcations might be erased. Therefore, it seems probable that the results indicating a relationship between the duration of the nestling period and brood-size are in the right order of magnitude although somewhat shortened. The birds in Connecticut and on Cape Cod were not subjected to so much disturbance and probably the nestling period data from these areas more nearly represent the normal condition, when account is taken of the different methods used for computing the duration of the nestling periods.

In retrospect, the material indicates that the duration of the nestling period is shortest in Connecticut, slightly longer on Kent Island, and longest at Cape Cod. Even though the Kent Island figure may have been artificially shortened, the fact remains that a difference exists between the periods at Cape Cod and in Connecticut. The clutch-size is largest at Kent Island, slightly smaller in Connecticut, and smallest at Cape Cod. The brood-sizes, at the time of fledging, differ in the same manner, but may be of little significance in discussing the duration of the nestling period because any relationship between brood-size and the nestling period would be expected to have been brought about earlier in the life of the birds. The significance of these observations will be considered presently.

Museum of Comparative Zoology, Cambridge 38, Mass.

[*To be continued*]

GENERAL NOTES

More Leg Sizes.—The accompanying table shows some leg size measurements made at our station in West Hartford, using a gauge which Mr. Parker Reed kindly supplied, of the sort described by Dr. Blake in *Bird-Banding*, **25**: 11-16, January, 1954. They include a measurement of one Downy Woodpecker, a species not represented in his table. Among the species which occur in both tables, our sample of Starlings showed a larger average greater diameter by .2mm, not by virtue of a higher maximum but rather by having fewer birds toward the small end of the range of measurements. Our Goldfinches averaged .2mm larger on the greater diameter (with an individual maximum of 1.8mm) and .1mm larger on the lesser diameter. It may be significant that our only Goldfinches with a greater diameter as small as 1.5mm were taken on October 31, and from November 1 on, all those taken were larger. The single Towhee which we measured was .2mm below the