MORTALITY OF THE GREAT BLUE HERON AS SHOWN BY BANDING RECOVERIES

BY D. F. OWEN

This paper is a preliminary attempt to present the mortality rate of the Great Blue Heron, *Ardea herodias,* based upon banding recoveries; more recoveries would doubtless give a better picture of this mortality, and hence further large-scale banding of the nestlings of this species is desirable.

The longevity of the Great Blue Heron is here calculated by using recoveries of dead birds which were banded as nestlings in the United States and Canada from the earliest year of banding, 1916, up to and including the year 1945. Most birds banded during and before 1945 should now be dead, but birds banded since then are omitted as more than a negligible proportion of them might still be alive. The 349 recoveries used in the following analysis were obtained in the period 1916–1958.

For the purposes of this paper, the term "older birds" refers to all birds alive after the June 30 following the year of hatching. The word "adult" is avoided because of uncertainty as to the age when the Great Blue Heron achieves reproductive condition.

Mortality Rate

In Table 1, deaths are grouped by age in years, each year being reckoned from July 1 to June 30. A few nestlings which were reported before they could have left the nest successfully have been omitted, as also have a few birds reported with insufficient details of recovery. The method of analysis follows that used for the Gray or Common Heron *Ardea cinerea* in Britain (Lack, 1949). Table 1 shows that

TABLE 1

The Age at Death of Great Blue Herons Banded as Nestlings 1916–1945

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Number found dead	248	41	14	13	11	5	6	3	0	1	1	0	0	1	2	1	0	1	0	0	1

of the recovered Great Blue Herons, 71 percent died within a year of leaving the nest, and that the average annual mortality in later years was 29 percent. The expectation of life of the Great Blue Heron after leaving the nest is 1.5 years, but once a bird has reached the beginning of its second year the expectation of further life is 2.9 years.

The average annual mortality may be calculated by $\frac{D_2 + D_3 + D_4 \ldots\ldots}{D_2 + 2D_3 + 3D_4 \ldots\ldots}$ where $D_2, D_3, D_4 \ldots\ldots D_n$ = the number of birds found dead in the 2nd, 3rd, 4th ..... nth years, respectively. The expectation of further life (e) may be calculated by $e = \frac{2 - m}{2m}$ where m = the annual mortality.

Greater mortality in the first year of life than in subsequent years has been shown to occur in many species of birds (Lack, 1954), and in the Great Blue Heron, as in the Gray Heron, this mortality is very high. In Table 2 the mortality of the Great Blue Heron in North America and the Gray Heron in Britain is compared, the mortality of birds during the first year of life after leaving the nest being 71 percent and 69 percent, respectively, and the average annual mortality of older birds being 29 percent and 31 percent, respectively. The Gray Heron is similar in morphology and habits to the Great Blue Heron and these two birds are considered by some to be conspecific. These two sets of figures, calculated in the same way, perhaps suggest that the banding recoveries give a good estimate of the mortality rate in these two species, especially when one considers the comparatively small size of the British Isles and the different types of bands used.

TABLE 2

COMPARISON OF THE MORTALITY OF GREAT BLUE HERON AND GRAY HERON

	Great Blue Heron (North America)	Gray Heron* (Britain)
Number of recoveries used	349	195
Mortality in first year (percent)	71	69
Average annual mortality after first year (percent)	29	31
Expectation of life after leaving nest (years)	1.5	1.5
Expectation of further life at beginning of second year (years)	2.9	2.7

* Figures for Gray Heron from Lack (1949). Lack (1949) gives the expectation of further life at the beginning of the second year as 2.8 years, but this is corrected to 2.7 years in Lack (1954: 92).

In Scandinavia, banding recoveries of the Gray Heron, analyzed somewhat differently, indicate that 67 percent of the birds leaving the nest die in their first year, and that the average expectation of further life is 3.1 years (Olsson, 1958). In Belgium, recoveries indicate that 78 percent die in their first year (Verheyen and Le Grelle, 1952), while in France the figure is about 73 percent (Bourlière, 1947).

Table 3 shows the monthly mortality of Great Blue Herons. For this analysis all available banding recoveries have been used. During the first year after leaving the nest the greatest mortality occurred in the period August–December; thereafter there was a steady decrease in the number of birds dying in each month. This high mortality is presumably caused by inexperience. Similarly, in the Gray Heron there is a high mortality during the first year, which appears to decrease from January onwards (Lack, 1949). Recoveries of Black-

TABLE 3

SEASONAL VARIATION IN MORTALITY OF GREAT BLUE HERONS

Month	Mortality in first year after leaving the nest: Age in months	Mortality in first year after leaving the nest: Number dying	Mortality of older birds: Number dying (not separated by age)
July	1	22	12
August	2	70	8
September	3	60	10
October	4	49	14
November	5	52	13
December	6	47	17
January	7	28	12
February	8	15	7
March	9	9	7
April	10	5	15
May	11	4	13
June	12	4	8

crowned Night Herons *Nycticorax nycticorax* banded as nestlings in North America likewise show a high mortality in the period August–December and a steady decrease in subsequent months (Hickey, 1952). Table 3 also shows the number of older birds dying during each month. There are fewer figures available for older birds than for first-year birds, but there seems to be little monthly variation in the death-rate, except perhaps that in April and May the mortality of older birds exceeds that of first-year birds. Similar results were obtained by Hickey (1952) for the Black-crowned Night Heron. It must be mentioned that the month when a Great Blue Heron is reported dead is not necessarily always the month during which the bird died. Great Blue Herons are large birds and a carcass might remain in a recognizable condition for a long time before being reported. However, the figures given in Table 3 can be taken as an approximation.

CAUSES OF DEATH

Of 139 recoveries of older Great Blue Herons, 24 percent were reported as shot, and of 392 first-year birds, 28 percent were reported as shot; this difference is not statistically significant. Similarly, in the Black-crowned Night Heron the difference between the number of older and first-year birds reported shot is not significant (Hickey, 1952). Lack (1949) states that "many" of the Gray Herons recovered were shot, and he considered it possible that birds were more frequently shot in their first year of life than later, but he did not analyze his figures. In Scandinavia, rather more first-year than older birds were reported shot (Olsson, 1958), but the difference is not statistically significant.

The remaining Great Blue Herons were reported as "found dead" or dead from a variety of causes. Apart from shot birds, the reliability of a report of the cause of death of a bird is in most cases questionable, hence the figures have not been analyzed further.

DISCUSSION OF MORTALITY RATE IN GREAT BLUE HERON AND GRAY HERON

Hickey (1952) has drawn attention to the numerous possible sources of error involved in an analysis of banding recoveries. Errors are likely to be considerable in any analysis of recoveries of birds breeding and migrating over a large area, such as North America, where the chances of recovery might vary markedly from place to place. The Great Blue Heron is migratory over much of its range, and any difference in the wintering area or migration route of first-year and older birds might affect the chances of recovery of these two classes. There is some evidence that such differences exist. Thus, of the 349 recoveries used in Table 1, 45 were from Mexico, Central America and the West Indies, and the chances of a banded bird being reported from these areas, with its large population of non-English speaking people, would presumably be less than in an area such as the eastern United States. Of these 45 recoveries, 24 were birds in their first year and 21 were older. These figures may be compared with 266 recoveries from the eastern United States, comprising 200 first-year and 66 older birds. Thus, of the birds recovered in the area comprising Central America, Mexico and the West Indies, proportionately more were older (47 percent) than from the eastern United States

(25 percent). The difference between the proportion of older to first-year birds in the two areas is statistically significant ($P = > 0.01$). Many of the first-year birds have, of course, already died before or on migration to their winter quarters; this would explain the smaller proportion of first-year birds recovered in Mexico, Central America and the West Indies, as compared with North America. If then it is assumed that the chances of recovery from these two areas are not equal, the fact that proportionately more older birds die south of the United States means that a smaller proportion of the total number of banded older birds than banded first-year birds is reported. However, recoveries of Great Blue Herons in Central America, Mexico and the West Indies comprise only 13 percent of the total recoveries used in Table 1; hence this potential source of error cannot be large. All that can be said at present is that the first-year mortality shown in Table 1 should be slightly lower, and the mortality of older birds should be slightly higher. Possibly, if there were more figures available, more local variations in the proportion of older to first-year birds dying might be detected.

Another possible source of error is that older birds tend to lose their bands or that after a time the bands become illegible. This would reduce the number of reports of the older birds. Many ornithologists seem to think that loss or illegibility of the inscription occurs more frequently among sea-birds than birds that feed mainly in fresh-water. In the Shag, *Phalacrocorax aristotelis,* the calculated average annual mortality from dead recoveries was 44 percent, whereas using Jackson's "negative method" on live recaptures it was calculated at 14 percent, a significant difference (Coulson and White, 1957). In the Gray Heron, the average annual loss of weight of the bands was only about one percent of the total weight, whereas in the Herring Gull, *Larus argentatus,* there was an average annual loss of weight of about five percent due to abrasion and corrosion (Olsson, 1958).

The additional fact that the average annual mortality of older birds calculated from dead recoveries of Great Blue Herons and Gray Herons is so similar, despite the different types of bands used, suggests that loss or illegibility of the bands is not an important source of error.

It would be possible to check the validity of the figures given in Table 1 for average annual mortality of older birds, if we knew precisely the reproductive rate of the Great Blue Heron. Lack (1949) was unable to explain how with such a high mortality rate for older birds and an apparently low average number of young per nest (2.14 at one colony in England), the Gray Heron population was able to maintain itself. But since 1949 I have found that this low reproductive rate is not typical of all years. The number of young leaving the nest varies markedly from year to year and from colony to colony, depending upon the availability of food to the parent birds (Owen, *in press*). Thus, at one colony in the south of England nearly half the young died of starvation in one year, while in the next hardly any died. Similar differences were found at other colonies and in other years. In the Gray Heron the clutch-size did not vary significantly over six years and the variable average number of young leaving the nest could be attributed to mortality in the nest caused by food shortage. Such differences as these would have to be taken into account when comparing average annual mortality of older birds with the reproductive rate. No comparable figures are available for the Great Blue Heron.

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Summary

1. Based on the recoveries of birds banded as nestlings, the mortality of the Great Blue Heron in the first year of its life was calculated at 71 percent, and the average annual mortality in subsequent years at 29 percent. These figures are similar to those calculated for the Gray Heron in Britain.

2. During the first year of life there is a high death-rate in the period August–December, which then decreases steadily.

3. Possible sources of error in calculating this mortality rate are discussed. Evidently a greater proportion of older birds than first-year birds die in Mexico, Central America and the West Indies than in the eastern United States, presumably because many of the birds banded as nestlings have died before reaching winter quarters.

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Museum of Zoology, University of Michigan, Ann Arbor, Michigan.

Comparative Endocrinology. Edited by Aubrey Gorman. 1959. 746 pp. Price, $15. John Wiley Sons, Inc., New York. This book contains forty-three papers delivered at the Columbia University Symposium on Comparative Endocrinology held at Cold Spring Harbor, New York, May 25-29, 1958. The papers provide a discussion of recent developments. Four deal primarily with birds: A. Wolfson, *Ecologic and physiologic factors in the regulation of spring migration and reproductive cycles in birds;* A. V. Nalbandov, *Neuroendocrine reflex mechanisms: bird ovulation;* E. Witschi, *Endocrine basis of reproductive adaptations in birds;* A. V. Nalbandov, *Role of sex hormones in the secretory function of the avian oviduct.* Many of the other papers contain information on birds or comparative data of interest to students of avian physiology, behavior and ecology. —E. EISENMANN.

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(Above) Chaetura andrei meridionalis feeding nestlings. Niteroi, Rio de Janeiro, Brazil. November 29, 1953. (Leicaflash, 1/100 sec., obj. 13.5 cm., distance 3 m.) Photo by H. Sick.

(Below) Nest of *Chaetura andrei meridionalis*, with eight living young on wall of attic. Niteroi, Rio de Janeiro, Brazil. December 15, 1955. Photo by H. Sick.