

73,603

## BIRD-BANDING

A JOURNAL OF ORNITHOLOGICAL INVESTIGATION

VOL. IX

JANUARY, 1938

No. 1

### THE BIOLOGICAL SIGNIFICANCE OF BIRD WEIGHTS<sup>1</sup>

By MARGARET MORSE NICE

THE recording of the weights of birds has two chief values: first, we need to know the average weight of a species just as much as its length; second, there are many biological problems on which weights of birds will throw light. How does the same species vary in weight from one locality to another? How does weight fluctuate throughout the year? Throughout the day? According to sex, age, and stage of the nesting cycle? How much individual variation is there when other factors are similar? Finally, to enter the realm of experiment, how much do birds eat in relation to their weight?

Some banders are faithful in weighing their birds. In this country two lists of large numbers of individuals of different species have been published, one for New England (Wetherbee), the other for northern Ohio (Stewart). Several lists have appeared giving for the most part single weights of a number of species (Broun, Esten, Grinnell, Wetmore, Whittle), while in a few instances single species have been treated somewhat at length (Linsdale and Sumner, '34a, '34b, '37, Nice, '37, Partin, Snyder). Weights of many species are given in Roberts's "Birds of Minnesota." An important contribution is that of Heinroth's in which weights are given for 436 species from all over the world (see Huxley for a reworking of this data in English).

The purpose of the present paper is twofold. First of all, it is a plea to banders to *weigh their birds at every capture*. Secondly, it is hoped to encourage those who have data on the subject to analyze their records and get the greatest value possible from them.

The total of my own records is not large—some 1400 weights on 30 species, yet they have yielded important data, especially in those cases where representative numbers were obtained. All of the weights were taken in Columbus, Ohio, from the fall of 1931 to the spring of 1936.

Each bird was placed in a cloth bag and weighed on scales sensitive to one-tenth of a gram. The weight of the bag fluctuated with atmospheric conditions and had to be determined each day. The wing and tail of each bird was measured by means of dividers, and it was found that with a number of species, particularly the native sparrows, the majority of individuals fell into two size-classes, and

<sup>1</sup> Read at the Charleston meeting of the American Ornithologists' Union, November, 1937.

with Ridgway as a guide, the larger birds were recorded as males, the smaller as females, using the wing measurement as the basis. With Song Sparrows I was able to check my judgment on 260 breeding birds, all of which were color-banded. One hundred and twenty-one of the males had wing measurements between 65 and 69 mm., 102 of the females between 58 and 63 mm. Eight males and seventeen females had wings measuring 64 mm., while four males fell into the female range with wings of 62 and 63 mm., and four females into the male range with wings of 65 and 66 mm. Thus nine per cent of all the birds were intermediate in measurements, while three per cent overlapped.

As to the Chickadees, most of the weights are on a pair of color-banded birds; the male, besides being slightly larger, was seen to feed his mate. During the nesting season, the presence or absence of the incubation patch is an indication of sex in some species.

The data obtained on seasonal and daily fluctuation in weight are summarized in Table I. Many of the species are classified by sex, but totals are also given, so the results are comparable with those of other observers.

In the last column the percentage of increase is given of the average of the weights taken from 3:00 to 6:00 P.M. over those from 6:00 to 8:00 A.M. In the seven species in which sufficient data were obtained, the increases range from 4.6 per cent in the Song Sparrow to 10.8 per cent in the Junco. Other investigators have reported the following average daily increases: Partin with the House Finch (*Carpodacus mexicanus frontalis*) 3.5 per cent; Linsdale and Sumner, ('34a), with the Golden-crowned Sparrow (*Zonotrichia coronata*), 3.9 per cent; and Stewart with the Eastern Goldfinch (*Spinus t. tristis*), 8.4 per cent. With 45 weighings on two captive male Western Mourning Doves (*Zenaidura macroura marginella*) in Oklahoma I found ('17, '29) an average daily increase of 8.6 per cent. Stewart states that "The ratio diminishes as the size of the bird increases," but this does not seem to be borne out within the limits of weight of the above birds—12 to 100 grams.

#### SEASONAL FLUCTUATIONS

It will be noted in the table that as a rule spring weights are higher than fall weights and winter weights the highest of all.

*Fall Weight.* There is no evidence in the birds which I captured of high weight in the fall in connection with migration.

Do transients that remain for one to three weeks gain weight? It was only with White-throated Sparrows that I obtained data on this problem, and only in the fall of 1931, which happened to be unusually mild. Five males and eight females repeated from 5 to 26 days after the first capture, the average stay of the males being 16 days and the females 12 days. (Most of the weights were taken in the early morning; in cases where comparison had to be made between one of these and a weight taken later in the day, 8 per cent

was deducted from the latter.) Seven birds that stayed from 5 to 22 days showed an average loss of 0.7 of a gram, 5 birds that stayed from 6 to 26 days showed an average gain of 0.9 of a gram, while one bird that stayed 12 days gained 5.3 grams or 24 per cent of her original weight. From these figures it is clear that with one exception there was no gain in weight in White-throated Sparrows that stopped in Columbus on their fall migration.

Kendeigh reports that in northern Ohio in the fall the later migrants of White-crowned and White-throated Sparrows are heavier than the earlier, while the reverse is true in the spring. Similar results were found by me with White-throats in the fall of 1931. Twenty-five males in the first half of the migration averaged 25.9 grams, and 19 in the second half 26.5; 32 females in the first half averaged 23.8 grams, and 19 in the second half 25.2 grams.

Rather unexpectedly a difference in the weights of the White-throats was shown in two succeeding fall seasons as follows:

1931. 44 males ranged from 23.2-28.9, averaging 26.2 grams.  
(Sept. 26 to Nov. 8)

1932. 6 males ranged from 27.5-30.8, averaging 29.2 grams.  
(Oct. 7 to 14)

1931. 51 females ranged from 21.0-27.8, averaging 24.1 grams.  
(Sept. 26 to Oct. 26)

1932. 24 females ranged from 22.3-29.2, averaging 26.0 grams.  
(Oct. 5 to Nov. 8)

The average in 1931 of the 95 birds of both sexes was 25.0 grams, of the 30 in 1932, 26.6 grams—a 6 per cent increase. If the 19 birds captured in 1931 before October 6 are omitted, the 37 males weighed 26.1 grams and the 39 females 24.3 grams, the 76 averaging 25.2 grams, a gain of 5.5 per cent. In an attempt to check this matter of greater weight in 1932 than 1931, I found it was only with Song Sparrows that I had sufficient data for comparison: in October and November, 1931, 65 birds of both sexes averaged 21.4 grams in weight, while in 1932, 40 averaged 21.9 grams, an increase of 2 per cent.

In 1931, in Columbus, October averaged 3°F. above normal, while in 1932 it averaged 0.6° below normal, the first half averaging 4° below normal. Linsdale and Sumner ('34a) found an increased weight in Golden-crowned Sparrows in cool weather and a loss on hot days. I do not know that any data has been published on average weights during the fall migration in different years, but this is an interesting problem. The White-throats did not linger with us in 1932 as they had done the previous fall, the longest period of stay, according to captures, being 7 days.

*Winter Weight.* That many species respond to the cold of winter by putting on a coat of fat is shown by the preponderance of cases in which weight increases at this season.

The Song Sparrows on Interpont gained weight in December, reaching their peak in January. Individual males sometimes gained

TABLE 1  
SEASONAL AND DAILY FLUCTUATIONS IN WEIGHT OF TWENTY SPECIES  
(All Weights in Grams)

Species	Total No.	Sex	Age	Fall		Winter		Spring		Summer		Daily Increase No. Per- centage
				No.	Range	No.	Average	No.	Range	No.	Average	
<i>E. Bob-white</i> .....	12	♂	201.7	6	180.8-220.7	193.5	6	191.3-223.2	209.9			
<i>Colinus c.</i> .....	18	♀	200.4	10	160.3-228.3	193.6	8	184.0-217.5	200.0			
<i>virgatus</i> .....	30	Both	201.0	16		193.0	14		209.4			
Percentage.....					100%			103.5%				
<i>E. Mourning Dove</i> .....	2	♂							144.0			
<i>Zenaidura</i> .....	1	♂	142.8						140.0			
<i>macroura marginella</i> .....	3	Both										
<i>N. Blue Jay</i> .....	8	Both	66.9	3	89.4-98.0	92.9	2	77.6-90.2	80.4	3	79.4-90.2	85.7
<i>Cyanocitta c.</i> .....					100%				86.5%			
Percentage.....												
<i>Carolina Chickadee</i> .....	8	♂	11.0	1	10.5	11.2	3	10.8-12.0	11.2	4	10.4-11.0	11.0
<i>Parus h.</i> .....	9	♀	9.8	1	10.3	10.1	3	9.9-10.2	10.1	5	9.0-10.0	9.6
<i>carolinensis</i> .....	17	Both	10.4	2	10.4	10.7	6		10.7	9		10.2
Percentage.....					100%			103%				98%
<i>Tufted Titmouse</i> .....	36	Both	22.4	8	20.7-25.3	22.2	21	20.3-24.8	22.2	7	20.5-23.8	22.4
<i>Parus t. bicolor</i> .....					100%			103%				98%
Percentage.....												7
<i>7</i> 5.5%												
<i>Ohio House Wren</i> .....	7	Both	11.1	2	11.0-11.8	11.4				5	9.0-12.1	11.0
<i>Troglodytes aedon</i> .....					100%							96.5%
<i>ladawani</i> .....												
Percentage.....												
<i>Carolina Wren</i> .....	6	Both	19.4	1	18.0	19.8	4	18.9-20.5	19.8	1		19.6
<i>Thryothorus l. ludowi-</i> .....					100%			110%				109%
<i>cinereus</i> .....												
Percentage.....												
<i>Catbird</i> .....	13	Both	35.9							11	32.5-41.7	36.1
<i>Dumetella carolinensis</i> .....												2
												32.0-37.0
												35.3
<i>E. Robin</i> .....	16	♂	80.9	4	72.8-97.1	83.9	4	72.8-97.1	83.9	12	68.8-89.5	79.1
<i>Turdus m.</i> .....	23	♀	81.2	2	79.2-81.7	80.5	4		80.5	18	74.0-96.0	82.3
<i>migratorius</i> .....	39	Both	81.1	2		80.5	4		83.9	30		81.3
Percentage.....					100%			104.2%				101%
												23
												8.1%

TABLE 1 CONTINUED ON NEXT PAGE



as much as 25 to 44 per cent of their April weights. In Table I we see that the Song Sparrows averaged 11 per cent increase over the fall weight, and the Junco 6 per cent. In the case of the White-crown, where 25 per cent increase is shown, the winter weights were based on only two individuals, and more data would probably decrease this ratio. As to the Cardinal, I feel that the figures are not representative: the average of the six fall weights is too high owing to one exceptionally heavy male, and the winter average is too low owing to a predominance of early-morning weights and the repeating of several thin females. If only noon weights are considered, there was a gain in winter in both sexes: males—4 weights in fall and spring 43.6 grams, 6 in winter 45.3 grams (increase 3.9 per cent); females—5 in fall and spring 41.7 grams, 9 in winter 42.7 grams (increase 2.4 per cent). In the case of the Blue Jay, the data are too few for conclusions, only 8 weights and those taken on 7 individuals. The Bob-white winter weights were obtained in December. Stewart found a marked decrease in February with some of this species.

Increased weight in winter has been reported for many species: Starlings (*Sturnus v. vulgaris*) (Hicks); Fieldfares (*Turdus pilaris*) (Zedlitz); House Sparrows (Kendeigh); House Finches (Partin); Golden-crowned and Fox Sparrows (*Passerella iliaca*) (Linsdale and Sumner, '34b); Bramblings (*Fringilla montifringilla*) and Yellow Hammers (*Emberiza citrinella*) (Zedlitz). The single Ruby-crowned Kinglet (*Corthylio c. calendula*)—a male—captured by me December 7, 1932, at 10:00 A.M. weighed 8.1 grams, which is more than other records I can find: 6.5 grams in northern Ohio (Stewart), 5.8 grams October 1 on Cape Cod (Broun), 6.2, 6.4, 6.4 grams, October 11, Washington, D. C. (Wetmore).

On the other hand some birds show little change in winter—the Carolina Chickadee and Tufted Titmouse in the table, Northern Black-capped Chickadee (*Parus (Penthestes) atricapillus borealis*) and Marsh Titmouse in Sweden (*Parus p. palustris*) according to Zedlitz, and Chinese Tree Sparrow (*Passer montanus saturatus*) according to Shaw. All these birds sleep in cavities, and hence are not exposed to the cold as are birds roosting in the open. It would be interesting to know whether or not woodpeckers gain in winter. Zedlitz found no winter gain in Magpies but his data were few; figures from Hesse quoted by Linsdale, '37, appear to show an increase. Spotted Towhees (*Pipilo maculatus falcifer*) showed little change in weight from October to May in Berkeley, California, where they are permanent residents.

*Weight in Spring and Summer.* In Table I we find that in the five species of native sparrows the average spring weights range from 4 to 12.6 per cent above the average fall weights.

Higher weights in spring than in the fall were found with White-crowned and White-throated Sparrows by Kendeigh. As for winter-resident species, Heydweiller reports that the Eastern Tree Sparrow

attains its maximum weight "just preceding the spring departure during the first two weeks in March"; while Linsdale and Sumner, '34b, found, from 1422 weights of the Golden-crowned Sparrow, a peak in January and a much higher peak in May, and with the Fox Sparrow 711 weights showed similar peaks in December and May.

That the curve is different for the Song Sparrows in Columbus, Ohio, is shown by the averages of the winter and spring weights of the males (373 cases): December 23.8 grams, January 24.9 grams, February 24.1 grams, March 23.0 grams, April 22.4 grams, May and June 21.3 grams.

The Song Sparrows start the nesting season at a somewhat higher weight than they showed in fall. This probably remains about the same for the male from April on until after the young hatch, then the father loses about 9 per cent of his weight. As to the female, her weight suddenly rises—10 to 20 per cent—while she is laying eggs. This increased weight, due to the developing eggs, would seem to be the reason why some people record females weighing more than males during the breeding season. In Table I high weights of females in spring and summer are attributable to this cause in the case of the Catbird, Robin, Cowbird, and Song Sparrow. Ten weights of non-laying female Cowbirds average 38.7 grams, and 4 weights of laying females 42.7 grams.

There is some evidence that the female Song Sparrow gains a small amount of weight during incubation. Riddle and Braucher found an 8 per cent increase in pigeons and doves during incubation and attributed this gain to the inactivity of the birds.

While feeding young, the female Song Sparrow, like her mate, loses some 9 per cent of her weight. With the Tree Sparrow in Manitoba, Heydeweller reported "almost 20 per cent [loss] for the males and 10 per cent for the females" when feeding young.

It will be seen that weights during the nesting season give a complicated picture, sometimes of high and sometimes of low weight.

As to the molt we should expect weight to be at its lowest point then, and the few data I have on Song Sparrows support this supposition. Beck found a heavy loss at this time with four domestic fowls. Laskey, however, reports the "highest weight during the inactive period of molting" in the case of male Mockingbirds (*Mimus p. polyglottos*) in Tennessee.

#### WEIGHT AND SEX

In many birds there is a decided size-difference between the sexes. This was true in only one of the species which I captured—the Cowbird—the females averaging 76 per cent of the weight of the males. In the case of 204 Bronzed Grackles (*Quiscalus quiscula œneus*) killed in Ontario, March 26, 1930, the females averaged 77 per cent of the weight of the males (Snyder). In a series of 28 Yellow-billed Magpies (*Pica nuttalli*) the females averaged 83 per cent as heavy as the males, and in the same number of Black-billed

Magpies (*Pica p. hudsonia*) the females averaged "nearly 86 per cent as heavy as the males" (Linsdale, '37).

In four species of native Sparrows I found the females averaging the following percentages of the males' weights: Junco 95, White-crowned Sparrow (fall and spring) 88, White-throat, 92, and Song Sparrow 93.4. Female Fox Sparrows were found to average 98 per cent the weight of the males (Linsdale, '28) and female House Finches 99 per cent (Partin). These figures include breeding birds; mine do not, except for the Song Sparrows and Cowbirds.

#### WEIGHT AND AGE

In small passerines the immature birds often average slightly less in the fall than the adults. In seven species of Fringillidæ, Wetherbee found the immatures averaging from 2 to 8 per cent lighter than the adults. With the 10 weights of non-laying female Cowbirds in Columbus, the 3 weights of birds banded one or two years previously averaged 43 grams, while the 7 weights of new captures averaged 37.1 grams. Some of my old Song Sparrows were heavy, and others were not.

With various larger species there is much more difference with age: Starlings (Hicks), Crows (Hicks and Dambach, Zedlitz), Gallinaceous birds, Geese, etc.

#### WEIGHT AND LOCALITY

There is very little information on this interesting subject. Partin found evidence of differences in weight between House Finches in Los Angeles and Pasadena—a distance of only a few miles. There is very little data on the comparative weight of subspecies. From evidence at hand it would seem that the Eastern Mourning Dove is appreciably heavier than the western form; weights of the former from New England, Washington, D. C., and Ohio (3 males and 3 females) range from 138.4 to 152.7 grams and average 143 grams; weights of the latter from Oklahoma and California (3 males and 2 females) range from 102.5 to 121 grams, averaging 107.7 grams. Mr. John W. Aldrich of the Cleveland Museum of Natural History has kindly put at my disposal weights of 99 Horned Larks collected from December 5 to February 23. Weights of 24 male Northern Horned Larks (*Otocoris a. alpestris*) ranged from 42.0 to 51.4 grams, with a median of 44.8 grams; five females ranged from 35.0 to 43.5 grams with a median of 42.9 grams. Weights of 57 male Prairie Horned Larks (*O. a. praticola*) ranged from 28.5 to 44.7 grams, with a median of 37.5 grams; of 13 females from 31.6 to 36.9 grams with a median of 34.2.

#### WEIGHT AND INDIVIDUALITY

This is an almost untouched subject, but one that merits investigation. One of Linsdale's and Sumner's ('34a) Golden-crowned Sparrows was one-fourth heavier than the other male and 28 per cent heavier than the two females. With the breeding Song Spar-



rows the April weights for the males ranged between 19.6 and 24.2 grams.

#### PERCENTAGE OF FOOD EATEN IN RELATION TO WEIGHT

Experiments on the percentage of food eaten by birds in relation to their weight have been carried out in Europe and two main conclusions reached: the colder the weather, the greater the food consumption; the smaller the bird, the more—proportionately—does it eat.

A Masked Weaver (*Ploceus cucullatus abyssinicus*) weighing 40 grams ate 20 per cent of its weight daily at a temperature of 18°C. (65°F.), 25 per cent at 9°C. (48°F.), and 28 per cent at 7°C. (45°F.); a Red-billed Weaver (*Quelea quelea*) weighing 18 grams ate 28 per cent of its weight at 18°C., 30 per cent at 9°C., and 33 per cent at 7°C. (Schildmacher). Stevenson states that the average number of native sparrows trapped in the summer months at Gates Mills, Ohio, was 7.6 when the temperature was lower than 75°F. (23°C.), and only 3.7 when it rose above 80°F. (27°C.).

On the basis of night and early-morning weighings of 15 species ranging in size from warblers to Mourning Doves trapped in Illinois, Taber concluded that "the daily food consumption of wild birds averages approximately 15 or 16 per cent of their weight. This is true regardless of the size of the species." That he was mistaken in this last point is evident from Table II, where the inverse relation between size and relative food consumption is clearly shown. The smaller bird has a relatively larger surface than a large bird and hence loses more heat than the other.

TABLE II  
PERCENTAGE OF FOOD EATEN IN RELATION TO  
WEIGHT OF BIRD

	Species	Weight of Bird	[Food	Authority
Falconiformes				
Common Buzzard	<i>Buteo buteo</i>	855-900	4.5 per cent	Rörig
Kestrel	<i>Falco tinnunculus</i>	200	7.7 per cent	Rörig
Galliformes				
Domestic Fowl	<i>Gallus domesticus</i>	1800	3.4 per cent <sup>2</sup>	Beck
Bob-white	<i>Colinus v. virginianus</i>	170	8.8 per cent <sup>2</sup>	Nice
Charadriiformes				
Lapwing	<i>Vanellus vanellus</i>	195	7.8 per cent <sup>1</sup>	Groebbels
Dunlin	<i>Calidris (Pelidna) alpina</i>	114	8.5 per cent <sup>1</sup>	Groebbels
Columbiformes				
Pigeon	?	516	5.4 per cent	Scharnke
Pigeon	?	360	6.5 per cent	Riddle
Dove	?	160	8.6 per cent	Riddle
W. Mourning Dove	<i>Zenaidura macroura marginella</i>	100	11.2 per cent <sup>2</sup>	Nice
Strigiformes				
Tawny Owl	<i>Strix aluco</i>	442-475	5.0 per cent	Rörig
Little Owl	<i>Athene noctua</i>	164-172	5.5 per cent	Rörig

Passeriformes				
Blackbird	<i>Turdus merula</i>	118	7.3 per cent <sup>1</sup>	Groebbels
Song Thrush	<i>Turdus philomelos</i>	89	9.8 per cent <sup>1</sup>	Groebbels
Redbreast	<i>Erithacus rubecula</i>	16	14.7 per cent <sup>1</sup>	Groebbels
Chaffinch	<i>Fringilla caelebs</i>	22	13.2 per cent <sup>2</sup>	Groebbels
Goldfinch	<i>Carduelis carduelis</i>	13	17.5 per cent <sup>2</sup>	Groebbels
Great Titmouse	<i>Parus major</i>	18	26.0 per cent <sup>1</sup>	Rörig
Blue Titmouse	<i>Parus caeruleus</i>	11	30.0 per cent <sup>1</sup>	Rörig

<sup>1</sup> Dry weight, which was estimated as 40 per cent of the live weight of the mealworms fed.

<sup>2</sup> Seeds and grain.

#### SUMMARY

1. Weight was found to fluctuate from 4.6 to 10.8 per cent throughout the day.

2. As a rule spring weight exceeded fall weight, while winter weight was highest of all.

3. Weighings of White-throated Sparrows showed that in the mild fall of 1931 the birds averaged lighter than in the cold fall of 1932; that in 1931 birds that stayed from 5 to 26 days at Columbus failed to gain weight, and that later fall migrants were heavier than earlier migrants.

4. Many species gain weight in winter, but some do not.

5. Weight in the breeding season fluctuates considerably; the female increases markedly while laying eggs, and both parents lose weight while feeding young.

6. In many species the males are heavier than the females; in native sparrows captured in Columbus the female averaged from 88 to 95 per cent as heavy as the male, in Cowbirds 76 per cent.

7. Immature birds often weigh less than adults.

8. More food is eaten in cold weather than in warm.

9. Relatively more food is needed by a small bird than a large one.

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- 5708 Kenwood Avenue, Chicago, Illinois.