WINTER LOSSES FROM STARVATION AND EXPOSURE OF WATERFOWL AND UPLAND GAME BIRDS IN OHIO AND OTHER NORTHERN STATES[1]

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A CONSIDERABLE literature relative to winter losses of waterfowl and game birds in the northern United States has been accumulating during recent years. Believing that additional data concerning such losses is important to ornithologist and conservationist, we here cite instances of winter mortality in Ohio, and give brief accounts of losses in other northern States. Our data chiefly concerns sporting waterfowl and the Bob-white, and treat briefly the Ring-necked Pheasant and Ruffed Grouse. Observations in Ohio were made principally by us. Data on observations in other States were obtained from scientific publications, newspapers, sporting magazines, and from answers to questionnaire letters which were sent to responsible wildlife conservationists in 11 northern states.

WATERFOWL

The most striking winter loss of waterfowl in Ohio which has come to our attention took place in March of 1932. The highest death rate was at the western end of Lake Erie where there was present a large concentration of waterfowl.[2] Losses likewise occurred in such widely separated Ohio localities as Lake St. Marys in Auglaize and Mercer counties, Indian Lake in Logan County, and Buckeye Lake in Licking, Fairfield and Perry counties.

The winter of 1931-32 was unusually mild until March, there occurred only two snowfalls of consequence, and the longest freezing period of any moment lasted only 4 days. Partly because of the mildness of fall and winter, an unusually large number of waterfowl individuals and species remained in Ohio, and in several sections the wintering population seemed more than five times greater than during any of the preceding 10 winters. Apparently the large number of wintering waterfowl was partly the result of the enormous amount of baiting and feeding that was done in the fall of 1931, especially

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[2] This waterfowl concentration also covered sections of the state of Michigan and province of Ontario adjacent to western Lake Erie. Winter losses also occurred in these sections.

in the marshes adjacent to Lake Erie.[3] Some estimate of the unusual waterfowl concentration can be obtained from Trautman's observations at Buckeye Lake. Throughout that season an average of slightly over 1,000 individuals, comprising 16 duck species and the Coot, were recorded. In other winters between 1921 and 1934 the duck population seldom exceeded 500 birds and usually fewer than 10 species. Reports by Dr. Harry C. Oberholser, Trautman, Wickliff, and others indicated that correspondingly large waterfowl numbers wintered on Lake Erie and adjacent marshes. The wintering flocks were greatly augmented by early transients during the latter part of February. This combination of a large wintering population and large transient invasion resulted in an unusually accentuated waterfowl population by March 1, 1932. Table 1 gives the waterfowl numbers recorded at a few Ohio localities in that month.

TABLE 1. SWANS, GEESE, DUCKS AND COOTS RECORDED AT BUCKEYE LAKE, LAKE ST. MARYS AND THE SANDUSKY MARSHES IN MARCH, 1932. (FIELD DATA OBTAINED BY TRAUTMAN, WICKLIFF, AND OBERHOLSER.)

COMMON AND SCIENTIFIC NAME	LOCALITY AND DATE					
	Buckeye Lake March 12	Lake St. Marys March 15	East Harbor March 18	Toledo to Port Clinton March 23	Bay Bridge March 24	East Harbor March 25
Whistling Swan, *Cygnus columbianus*	...	3	1	...	1	1
Canada Goose, *Branta canadensis*	...	600	...	...	...	...
Lesser Snow Goose, *Chen hyperborea*	...	2	...	...	...	...
Blue Goose, *Chen caerulescens*	...	1	...	...	...	...
Mallard, *Anas platyrhynchos platyrhynchos*	200	1,000	300	400	100	160
Black Duck, *Anas rubripes*	2,500	2,500	1,000	1,000	800	900
Pintail, *Anas acuta tzitzihoa*	300	1,000	2,000	500	1,500	1,500
Green-winged Teal, *Anas crecca carolinensis*	10	250	...	...	3	15
Blue-winged Teal, *Anas discors*	...	1	...	...	...	2
Shoveller, *Spatula clypeata*	...	10	...	20	25	30
Gadwall, *Chaulelasmus streperus*	3	3	800	15	150	200
Baldpate, *Mareca americana*	10	2	100	1,000	2,000	1,000
Wood Duck, *Aix sponsa*	...	1	...	...	...	...
Redhead, *Nyroca americana*	12	50	40	200	300	300
Ring-necked Duck, *Nyroca collaris*	100	250	250	200	2,500	800
Canvas-back, *Nyroca valisineria*	...	2	500	700	400	500
Lesser Scaup, *Nyroca affinis*	25	50	50	200	100	100
American Golden-eye, *Bucephala clangula americana*	3	1	20	50	1	2
Buffle-head, *Bucephala albeola*	12	2	15	18	10	12
Old-squaw, *Clangula hyemalis*	...	1	...	...	...	...
Ruddy Duck, *Oxyura jamaicensis rubida*	2	2	...	...	...	...
Hooded Merganser, *Lophodytes cucullatus*	8	2	2	2	10	15
American Merganser, *Mergus merganser americanus*	10	50	150	200	170	100
Red-breasted Merganser, *Mergus serrator*	...	...	1	...	...	...
American Coot, *Fulica americana americana*	200	1	1,000	500	450	500
Total	3,395	5,784	6,229	5,005	8,520	6,137
Grand Total						35,070

[3] It is our belief that baiting and feeding practices sometimes interfere with the expression of the migratory instincts of waterfowl, causing many to delay their migration and ultimately to attempt to winter (Trautman, in press). Baiting of waterfowl has been recently prohibited by Federal regulations.

If March weather conditions had been normal the waterfowl would have suffered no undue hardships. Normal weather did not prevail, for on March 5 a prolonged cold period began. Some conception of general weather conditions are obtained from Figure 1. This figure indicates

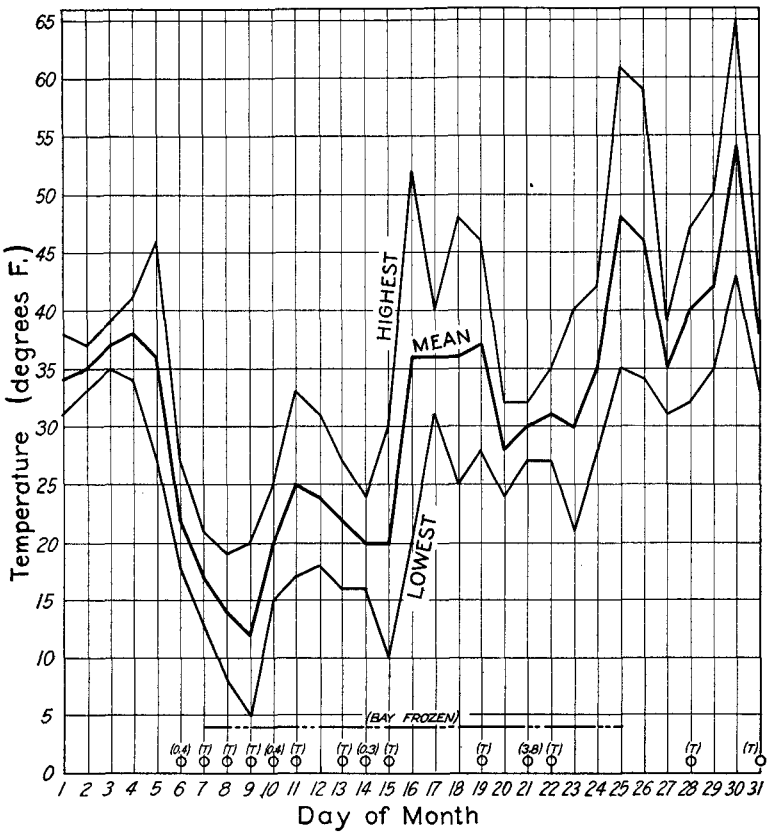

Fig. 1. Maximum, mean, and minimum temperature curves at Sandusky, Ohio, March, 1932. Snowfall is indicated in inches for 24 hour periods, and T indicates a trace. The period during which Sandusky Bay was frozen is shown by the broken line (Data from U.S. Weather Bureau).

that in the vicinity of the city of Sandusky the daily mean temperature dropped sharply from 36° F. on March 5 to 12° on March 9, and that temperatures averaging below freezing continued until March 15. On March 20 freezing temperature again prevailed and remained for the next 4 days, after which the mean temperature rose to higher levels. Sleet and snow fell generally throughout Ohio from March 6 to 10 and again, in larger quantities, on March 21-22. Sandusky Bay and adjacent waters were frozen from March 7 to 25, and the ice

reached a maximum thickness of 7 inches.[4] The inland lakes of Ohio were ice-covered from March 7 to 25, except for a few small holes.

On March 12, one week after the beginning of inclement weather, Trautman made his weekly investigation of the birds about Buckeye Lake. That day he found over 3,000 ducks, 200 Coots (see Table 1) and many other water birds huddled about a small, open hole at the ice-covered, western end of the lake. More than 200 ducks and over 150 Coots seemed too weak to fly. About 35 birds, all apparently dead, were lying on the ice. The dead birds identified were 5 Mallards, 6 Black Ducks, 4 Pintails, 3 Ring-necked Ducks and 8 Coots. The remainder could not be identified because they were lying out of reach on thin ice or frozen deeply in thicker ice. Gross examinations made by Trautman on 2 Mallards, 1 Black Duck, 2 Pintails, 1 Ring-necked Duck and 5 Coots showed no marked pathological lesions, no unusual amount of parasitism, and no mechanical injuries. The birds were greatly emaciated, and their alimentary tracts indicated no recent feeding. On the basis of this investigation and reports from elsewhere concerning waterfowl starvation William H. Reinhart, then Ohio Conservation Commissioner, issued a general order on March 14. The order directed that wherever possible, grain should be fed to all waterfowl in Ohio that were in obvious need of food.

Realizing the need for further investigations, Trautman and Wickliff began a survey of lakes in inland Ohio, and the waters and marshes adjacent to the western end of Lake Erie. March 15 was spent at Lake St. Marys, where all except a few individuals of the recorded 24 waterfowl species (see Table 1) were huddled about a small hole in the otherwise ice-covered lake. With few exceptions the birds seemed in relatively good condition, presumedly the result of having ready access to corn and other grains in nearby fields, and to additional grain which had been scattered over the ice for them by Ohio game protectors.

On March 18 Trautman and Wickliff investigated several Lake Erie marshes that are situated between the cities of Port Clinton and Sandusky. On this day Lake Erie, Sandusky Bay and adjacent waters were frozen over, except for a few, small open holes. Sleet, ice, and snow covered the fields and marshes, effectively sealing most of the "natural" food of waterfowl. The birds were seemingly in fair condition in those few marshes where large amounts of grain had been scattered for them while the storm was in progress, or where grain in a nearby field was available. Elsewhere the waterfowl were in a deplorable state, particularly in East Harbor marsh (Ottawa County). In this marsh were found about 900 living Coots, most of them too weak to fly. At least 400 of these were observed to leave the frozen waters to feed on the dried grass of lawns about cottages. More than 100 dead Coots and over 5,000 living and 88 dead ducks (see Table 1) were found. Identification of some of the dead ducks was impossible because they

[4] Letter from C. C. Cooper, October 15, 1935.

were frozen deeply in the ice or were lying on thin ice beside an open hole and hence unapproachable. From the dead birds identified we inferred that Black Ducks, Ring-necked Ducks and Canvas-backs comprised at least 65 per cent of the total, and Mallards, Gadwalls, Baldpates, Pintails, Redheads and Lesser Scaups the remainder. On March 25 we found an additional 29 dead ducks and 27 Coots, although we covered only about 20 per cent of the marsh.

From March 23 to 25 a reconnaissance party, consisting of Harry C. Oberholser and M. A. Charlton of the U.S. Biological Survey, the late Harry Crossley of the Ohio Division of Conservation, Trautman and Wickliff, investigated other marshes about Sandusky Bay and the western end of Lake Erie. During that period the snow was more than 3 inches deep and lakes and streams ice-covered, but general weather conditions had become rather favorable. It was apparent that the crisis had passed, since "natural" food was rapidly becoming available in large quantities. In addition the Ohio Division of Conservation, many hunting clubs and other organizations had begun the "artificial" feeding of waterfowl. Mortality among the birds had almost ceased and many of the survivors seemed to be rapidly recovering.

In our investigations about Lake Erie we found over 300 dead ducks and approximately the same number of dead Coots. We can give no accurate estimation of the total number of dead waterfowl but believe it was at least a thousand.

Examination of Dead Waterfowl

Of the 53 dead waterfowl which were saved for future examination, 20 Coots and 25 ducks of 8 species were sufficiently entire and preserved so that complete data were obtained. These birds were weighed in the field by Trautman and Wickliff. Upon returning to Columbus, Trautman made outlines of breast contours, and later he and Wickliff made gross laboratory examinations to ascertain the general condition of each bird. After the birds had remained in a formalin solution for almost three years, Bills completed the laboratory examinations.

The weights of the examined ducks and Coots are given in Figures 2 and 3 and in Table 2. Included in the figures are "normal weight" ranges for each species. These ranges are a composite of extreme weights which have been compiled from Forbush (1925: 196, 200, 206, 223, 232, 235, 241, 244), Phillips (1923: 68-9, 139, 189-90, 307-8; 1925: 122, 163-4, 183, 273), and Phillips and Lincoln (1930: 292-9).[5]

[5] Our experiences with waterfowl lead us to believe that these composite weights adequately cover the normal range for each species. We realize that the lower weight limit must be arbitrary since there is no sharp demarcation between thin and emaciated individuals.

In comparing these "normal weight" ranges with weighed birds now in the University of Michigan Museum of Zoology, it was found that all except a few of those ducks collected in late fall or early winter were *above* the average in weight for their species as shown by the "normal weight" range; those taken in spring were *below* the average in weight for their species. A few, normal-appearing, spring individuals were slightly beyond the lower end of the "normal weight" range.

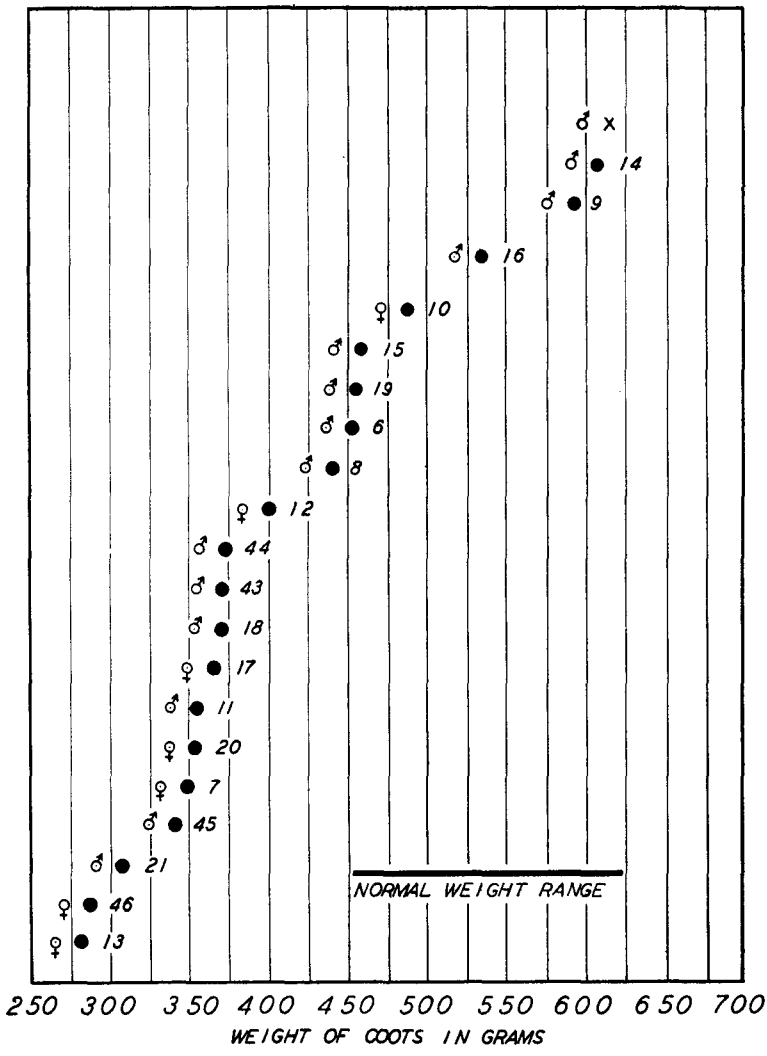

Fig. 2. Weights of Coots from Lake Erie marshes compared with the "normal weight" range for the species. Each dot represents an individual, and specimen number and sex are indicated. X designates the supposedly normal Coot collected at Buckeye Lake, April, 1932.

Also included in Figs. 2 and 3 are the weights of 2 apparently normal ducks and one Coot. These were collected by Trautman at Buckeye Lake on April 21, 1932, one month after the March stress period. The April birds weighed more than did those individuals of the same species found dead in March.

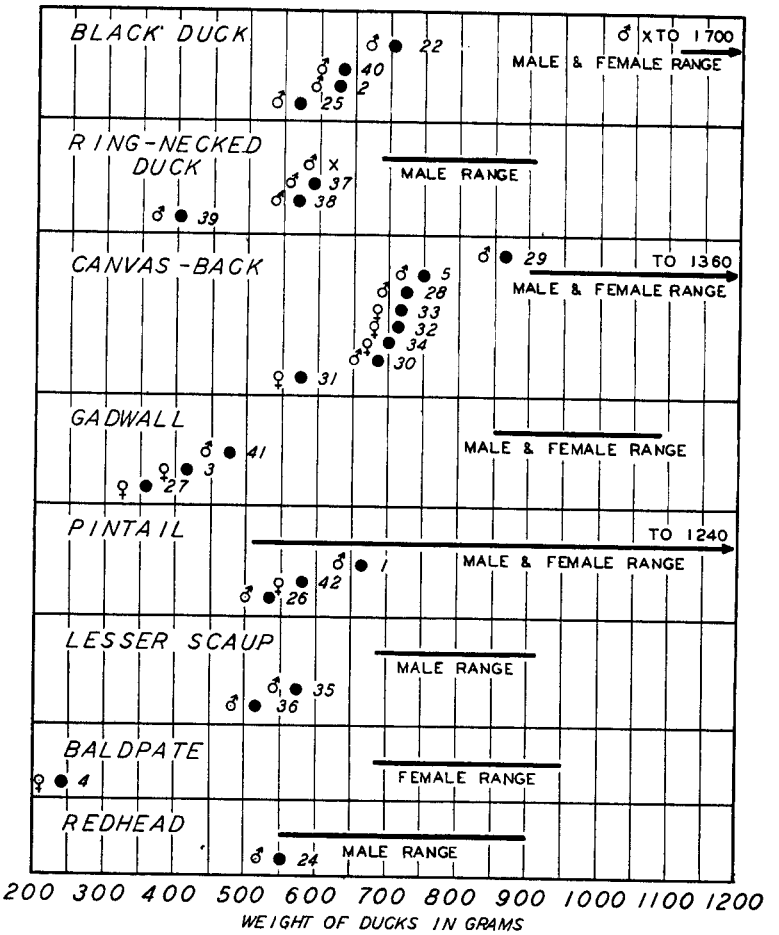

Fig. 3. Weights of March ducks from Lake Erie marshes compared with the "normal weight" range for the species. Each dot represents an individual, and specimen number and sex are indicated. X designates the supposedly normal ducks collected at Buckeye Lake, April, 1932. The extreme lower limit of the male and female ranges applies only to the females since that sex is the lightest in weight.

Figure 2 shows that the majority of the Coots are below the "normal weight" range. Examination disclosed that 3 contained moderate deposits of fat, 3 had slight amounts, and each of the remaining contained only a trace or no fat. Figure 3 shows that, except for the Pintails and Redhead, the March ducks are beyond the lower limit of the "normal weight" range. Figures 4 to 8 show breast contours of Coots and of 5

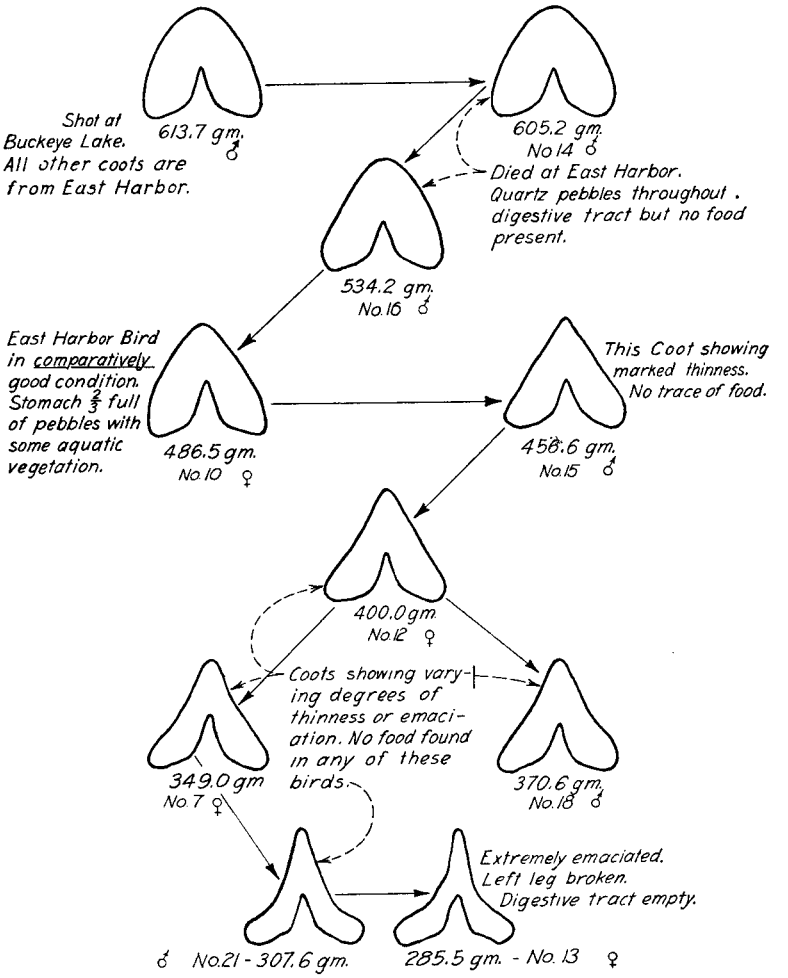

Fig. 4. Diagrams of breast contours of Coots in relation to their weights.

duck species,[6] collected at East Harbor; also contours of the seemingly normal birds from Buckeye Lake. The contours show a direct correlation between amount of fat and general physical condition and weight, since the fullest contours are from the heaviest birds, and vice versa. Obviously, the most emaciated birds had oxidized and used all of their reserve fat and almost all muscle tissue before succumbing.

Examination of the 45 birds revealed food in the crop and gizzard of one Coot and 8 ducks. The amount of food per bird was small, and

[6] Not all of the breast contours have been included, but the extreme weight range is covered. This method of showing relative condition has been previously used by Errington (Leopold, 1933: fig. 25, opp. 262).

consisted of the stolons, leaves, and stem portions of aquatic plants, material that probably was grass, a few gastropods and a few larvae of aquatic insects. Coots No. 44 and 46 had eaten feathers, some of which were attached to skin. Several Coots had varying amounts of undigested grain in their intestinal tract, suggesting the possibility that they had died after "natural" or "artificial" food became available, and that apparently they had been by that time too weak to make a recovery. Alimentary tracts of all birds contained grit, which consisted mostly of quartz pebbles. The amount was usually small, since less than 12 pebbles were found in most tracts. Sand was present, especially in the intestines, and occurred in larger amounts than did grit. The Coot intestines contained on the average more grit than did those of the ducks.

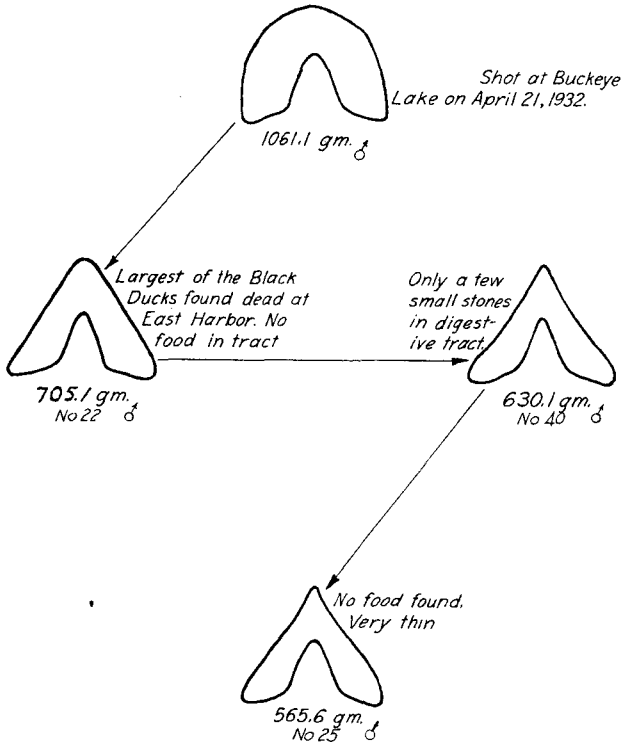

Fig. 5. Diagrams of breast contours of Black Ducks in relation to their weights.

TABLE 2. AMOUNT OF PARASITIC INFESTATION IN FORTY-FIVE DUCKS AND COOTS WHICH DIED IN THE LAKE ERIE MARSHES OF OHIO DURING MARCH, 1932.[1]

Specimen No.	Common Name	Sex	Weight in Grams	Nematoda	Acanthocephala	Cestoda	Trematoda[2]	Protozoa (Coccidia)	Remarks
14	Coot	M	605.2	N	N	N	N	N	
9	Coot	M	592.4	N	N	N	N	N	
16	Coot	M	534.2	N	N	N	N	N	
10	Coot	F	486.5	N	N	N	N	N	
15	Coot	M	456.6	N	N	N	N	N	
19	Coot	M	454.7	N	N	N	N	N	
6	Coot	M	452.9	N	N	N	N	N	Lead shot
8	Coot	M	439.9	N	N	N	N	N	
12	Coot	F	400.0	N	N	N	N	N	Severe enteritis
44	Coot	M	372.9	N	N	N	N	N	Lead shot
43	Coot	M	371.2	N	N	N	N	N	
18	Coot	M	370.6	N	N	N	N	N	
17	Coot	F	365.3	N	N	P1	N	N	
11	Coot	M	357.0	N	N	N	N	N	
20	Coot	F	353.6	N	N	P1	N	N	
7	Coot	F	349.0	N	N	N	N	N	Severe enteritis
45	Coot	M	340.9	N	N	N	N	N	
21	Coot	M	307.6	N	N	N	N	N	
13	Coot	F	285.5	N	N	N	N	N	Left leg fractured
46	Coot	F	282.9	N	N	N	N	N	Abdominal abscesses
22	Black Duck	M	705.1	N	N	N	N	N	Lead shot
40	Black Duck	M	630.1	N	N	P2	4L	N	
2	Black Duck	M	624.5	N	P3-S-L	P1	3C	N	
25	Black Duck	M	565.6	N	N	P1	N	PS	
37	Ring-Neck	M	591.2	N	N	P1	5S	N	Large liver abscess
38	Ring-neck	M	573.3	N	N	N	N	N	
39	Ring-neck	M	405.7	N	P1-S	P1	N	N	
29	Canvas-back	M	867.6	N	P1-S	P1	N	N	
5	Canvas-back	M	750.2	N	P1-S-L	P2	10 C-5S	N	
28	Canvas-back	M	722.6	N	N	P2	N	N	
33	Canvas-back	F	718.7	N	P2-S	P3	6L	N	
32	Canvas-back	F	714.3	N	N	P1	N	N	
34	Canvas-back	F	700.1	N	P3-S-L	P1	3L	N	
30	Canvas-back	M	685.1	N	N	P1	N	N	
31	Canvas-back	F	574.8	N	P1-S	P1	N	N	Lead shot
41	Gadwall	M	477.7	N	N	P1	N	N	
3	Gadwall	F	414.1	..	..	...	..	N	Intestinal tract missing
27	Gadwall	F	359.9	N	N	P2	N	N	
1	Pintail	M	663.8	N	N	N	N	N	
42	Pintail	F	580.1	N	N	N	N	N	
26	Pintail	M	533.6	N	N	P2	N	N	Lead shot
35	Lesser Scaup	M	570.3	N	N	N	N	N	
36	Lesser Scaup	M	513.1	N	N	N	N	N	
4	Baldpate	F	240.4	N	N	N	N	N	
24	Redhead	M	552.7	N	N	N	N	N	

[1] N, no infestation; P1, light, P2, medium, P3, heavy infestation; S, small intestine; L, large intestine; C, caeca; M, male; F, female.
[2] Figures indicate number of trematodes found.

Pathological examinations (see Table 2) of the bird carcasses by Bills revealed a fractured limb, embedded shot, and abscessed areas in a Coot and a duck, and indications of severe enteritis in 2 Coots. One to 17 lead shot were counted in the gizzard of 4 ducks, and additional shot were found in the intestines of 3 other ducks and 2 Coots. The intestinal tracts of all except a few birds were contracted, giving a shrunken appearance, but except for the 2 Coots with enteritis, no lesions of marked significance were found. All examined tissues showed a minimum of post mortem changes as a result of their frozen condition when collected and later preservation in formalin.

As shown in Table 2, 18 of the 20 Coots examined, or 90 per cent,

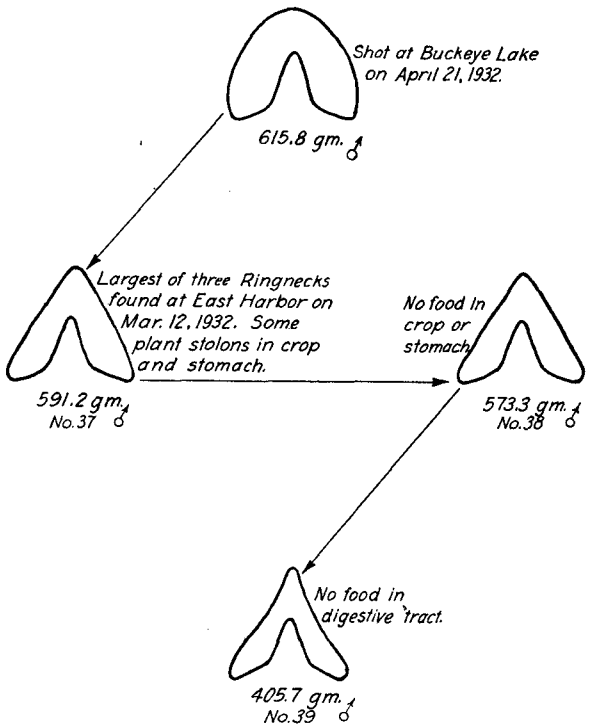

Fig. 6. Diagrams of breast contours of Ring-necked Ducks in relation to their weights.

disclosed no parasitism. Two parasitised birds contained light infestations of tapeworms (Cestoda). Sixteen of the 25 ducks, or 65 per cent, contained intestinal parasites, of which 4 ducks were very heavily infested. The parasites were indentified to class and the numbers counted or estimated. Tapeworms were found in every positive duck, thorny-headed worms (Acanthocephala) were found in 7 ducks, or 28 per cent, and flukes (Trematoda) in 6 ducks, or 24 per cent. No round worms (Nematoda) were found in Coots or ducks. Coccidia oocysts were observed in one duck, and no pathological changes resulting from heavy coccidia concentrations were noted. Negative results were obtained from examinations of the gizzard, heart, trachea, eye and other organs. Muscle tissue was not carefully examined for parasites.

Our evidence concerning amount of injury, disease, parasitism, or pathological condition caused by shot does not appear to be sufficiently great to warrant the conclusion that these factors were the sole cause of death. However, our examinations could not be conducted under optimum conditions, which may have caused the above-mentioned factors

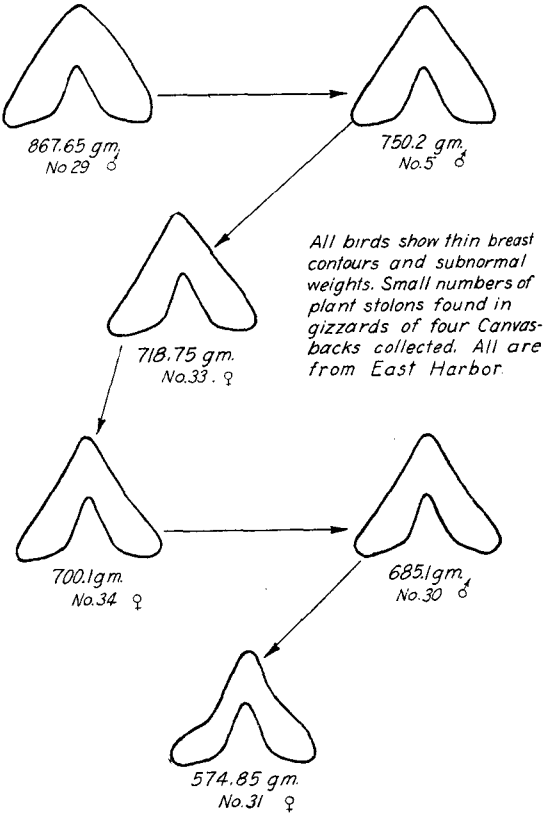

Fig. 7. Diagrams of breast contours of Canvas-back Ducks in relation to their weights.

to appear less important than they in reality were. As examples: the most satisfactory examinations for blood protozoa and microfilaria require blood smears from living birds or specimens recently dead. Our specimens were long dead. The finding of so few coccidia immediately suggests failure to discover the majority of protozoa or bacteria present. Recently dissolved shot may have been a greater detrimental factor than suspected. Lastly, the birds may have recently recovered from some parasitic or bacteriological infestation which displayed no visible trace but which left the birds in a weakened condition.

Granting that injury, disease, etc., were factors in the death of some of these waterfowl it is apparent to us that starvation and exposure played a part, and particularly with those birds whose reserve energy of fat and muscle tissue was almost entirely utilized. Such individuals

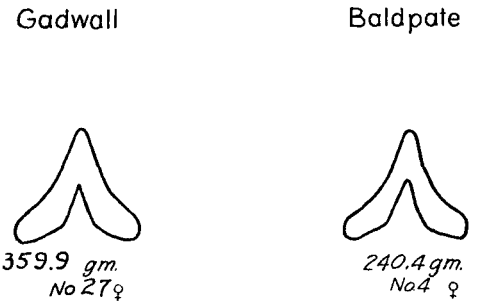

Fig. 8. Diagrams of breast contours of Gadwall and Baldpate ducks in relation to their weights. These individuals, collected at East Harbor, were extremely emaciated.

were obviously too weak to have survived under natural conditions. From his experiments upon captive quail, Errington (1939:25-6) believes that 50 per cent of the full weight of an individual Bob-white represents very nearly the minimum level from which recovery under the best of circumstances is possible. Our most emaciated waterfowl were more than 50 per cent below compiled "normal weight" range. The questions now arise: what about those waterfowl which were only slightly below or within the "normal weight" range and which contained some fat and considerable muscle tissue? Did injury, disease, ice formation over eyes and in bills and nostrils cause their death, or was starvation a contributing or major factor? Leopold (1937:410) has shown that well-conditioned, healthy Bob-whites with alimentary tracts filled with food will succumb to low temperatures and adverse conditions. In a personal communication Dr. Hicks informs us that he found Bob-whites in Ohio "frozen in a huddled lump with their crops full or nearly full of corn and other high grade foods." Kendeigh (1934:315-17) experimented with English Sparrows (*Passer domesticus*) that were kept in darkness without food, and found that the survival time was shorter, the total percentage of initial weight lost before death was less, and the weight at death was higher with those sparrows subjected to temperatures below zero F. than with those kept in average temperatures somewhere between zero and 102.3°F. All of this evidence substantiates the assumption that bird species and individuals have a threshold of tolerance to cold. Below this threshold a well-conditioned individual will succumb because it cannot oxidize body tissue fast enough to keep itself alive. Obviously the threshold of cold tolerance differs greatly among the many groups and species of birds, and probably between individuals of a species. Such variation in tolerance to cold may explain why many Coots in comparatively good flesh died at East Harbor, and why the

hardy Black Ducks, which normally winter in a colder climate, died only after almost all of their body tissue had been utilized.

Whatever the causes of death, our field experiences with waterfowl in 1932 and in other years, have convinced us that proper, "artificial" feeding during the average stress periods will save some of the waterfowl from death, and will usually reduce mortality to a culling of crippled, diseased, parasitised, or greatly emaciated birds.

To demonstrate that waterfowl mortality during winter stress periods is not unusual we cite a few recent occurrences. In the New York City region during late February of 1934, 200,000 ducks were reported to have been in danger of starvation (Pearson, 1934:143). Prompt feeding of several tons of grain was believed to have prevented a large loss of birds. Dr. Gardiner Bump (*in litt.*, October 24, 1935) of the New York Conservation Department stated that although pathological examinations of ducks found dead in New York waters during March of 1934 revealed parasitism in many, mortality was attributed mainly to exposure too severe for weakened and emaciated birds to endure. Dr. Oberholser (1934:181-2) records the feeding of ducks along the Potomac River in January of 1934, and states that such feeding did much to prevent starvation.

In February of 1936, Gromme (1936:324-5) recorded the death "of hundreds and probably thousands of winter ducks" on Lake Michigan near Milwaukee, Wisconsin. The freezing of the surface water of the lake caused a food shortage, resulting in death by starvation, or the freezing of the weaker birds in the ice. Many of the examined ducks were found to be extremely emaciated and their digestive tracts were empty of food.

Bob-white

Published records of Bob-white (*Colinus virginianus virginianus*) mortality in Ohio from starvation and exposure to low temperatures and adverse conditions are surprisingly few. Kendeigh (1933:9-13) gives the most complete published account of such mortality when he discusses reasons for fluctuation in seasonal abundance of Bob-white. In the years from 1930-4, Trautman gathered considerable evidence of annual winter mortality of Bob-white in Ohio.[7] Since little of his investigations have been published, and published records of winter mortality from Ohio are comparatively few, the following conclusions and an instance of winter mortality are here given:

The investigation indicated that: (1) inability to obtain sufficient food during the stress periods of winter was often an important factor in reducing the Bob-white breeding population in Ohio, (2) some mortality from starvation and exposure occurred every winter, (3) in freezing weather following severe sleet storms, or during heavy snows

[7] The accumulation of much of this evidence was made while Trautman was associated with the Ohio Division of Conservation.

a high mortality among Bob-whites took place, (4) the heaviest mortality occurred on modern, "clean" farms where cover was deficient, and (5) during the most severe storms the death of Bob-whites from starvation and exposure occurred on farms where normally the cover and food was abundant (Trautman, 1935:18-20).

One of the best examples of winter mortality was observed in December of 1932. In the autumn of that year 3 coveys of Bob-whites on a farm in southern Paris Township, Union County, Ohio, were under weekly observations. The fall weather had been mild until December 10, and the birds comprising the 3 coveys seemed to be in excellent condition. On December 10, sleet and 3 inches of snow fell, and was followed by 3 inches more on December 13. With the falling of the first snow the temperature declined sharply and remained low until December 16 when it reached a minimum of 4 degrees below zero, F. On December 16, while conducting his weekly examination, Trautman found that 2 of the coveys, of 18 and 28 individuals each, were in apparently good condition. These Bob-whites were wintering in fields containing corn in shocks and the birds were feeding upon the corn. The birds in the third covey, an unusually large one of 32 individuals, were faring badly because they remained in a wheat-stubble field where their previously abundant food supply, of the achenes of the rag-weed (*Ambrosia elatior*), was covered by crusted snow. When found at 2:15 P.M., the living birds of this covey were huddled in a roughly-shaped circle in a brushy fence corner. Six were too weak to fly, 15 could fly less than 50 feet at a time, 5 flew well, and 5 were missing. The remaining bird was found dead. An autopsy of this adult male disclosed that it had a normal wing measurement (108 mm.) was not unduly parasitised, contained no injury or lesions attributable to disease, and weighed only 82.25 grams.[8] Partly because of the scattering of food for the living birds of this covey, 28 were alive on January 1, 1933.

A review of the literature not chiefly pertaining to Ohio indicates that: (1) Bob-white is especially susceptible to starvation and exposure during low temperatures, (2) references to winter mortality before 1910 are comparatively few and are generally vague, and (3) since 1910 a greater amount of literature has been produced. The primary reason for a larger literature production is the recent, marked increase in more thorough scientific work. However, it is possible that some of the increase in literary output is the result of an actual increase in extent and number of winter mortalities. Anyone who has studied the changing farming practices in the North-Central States during the past 50-year period realizes that the modern tendency of brush and weed removal and general "cleaning up" of farms has resulted in less favorable wintering conditions for Bob-white (Trautman, 1935:18-20).

[8] Fourteen Bob-whites, collected in central Ohio during December, had an average weight of 192.00 grams.

The earlier references to winter mortality from starvation and exposure generally consist of simple statements about destruction of great numbers of birds by deep and crusted snows (Judd, 1903:202 and 1905:18; Forbush, 1912: 370-3). The recent references are often very detailed, and contrast sharply in this respect with earlier ones. Several publications by Errington (1933a:11; 1933b:130-1; 1933c:32; 1933d:44; 1934:112-14; 1935:46; 1939: 22-7), and one by Errington and Hamerstrom (1936:366-72) cite specific instances of Bob-white mortality from adverse weather conditions in Iowa and Wisconsin. Scott (1937:21-7) gives conclusive evidence of reasonably strong Bob-whites in Iowa having been imprisoned and killed by drifting snow and other individuals having met death by exposure to severe weather. Green and Beed (1936:90-2) give definite evidence of a high mortality of Bob-white from starvation and hunger during "Iowa's most severe winter in 117 years [the 1935-36 winter]." Leopold (1937:408-16) presents excellent data on a heavy winter killing in Wisconsin, records (Leopold ,1933:77-8) the adverse effects of sleet storms upon Bob-white in Missouri, and (Leopold, 1931:79 and 1933:349) indicates that starvation and exposure losses take place in all North-Central States. A letter from H. W. MacKenzie (April 8, 1936) states that some Bob-white mortality from adverse weather conditions occur every winter in Wisconsin. Gardiner Bump (*in litt.*, October 24, 1935) recorded the death of Bob-whites in New York from starvation and exposure, as did Harry D. Ruhl (*in litt.*, April 15, 1936) for Michigan.

Ring-necked Pheasant

There appears to be no published record of pheasants (*Phasianus colchicus torquatus*) in Ohio dying from starvation or exposure to low temperatures. During the extremely cold winter of 1935-6 Dr. Hicks[9] observed pheasant mortality from starvation and exposure that was somewhat similar to that observed by Green and Beed (1936:83-4) in Iowa, but which involved the death of only a few "hens and wounded cock birds whose vitality was probably below par" (*in litt.*, March 4, 1939). Apparently such mortality can be expected in Ohio, since losses from adverse weather conditions have been observed in other northern States. Green and Beed (1936:84) record the death in Iowa, during the severe 1935-6 winter, of 250 birds of an original 400. Of the 250 individuals, 131 froze to death or died by choking from ice accumulations in nostrils and bills, 37 were snowed under, 13 died of pneumonia, and one died of starvation. The remainder died from other causes not directly attributable to severe weather conditions. A heavy pheasant loss from starvation and exposure is recorded by Beed (1938:509). He estimated the loss in the Waubay Refuge, Day County, South Dakota at 80 per cent of the population.

[9] Dr. Hicks has been conducting intensive studies of the pheasant in Ohio for several years.

Examination of 126 pheasant stomachs showed that 104 contained no food, and the remaining ones had only small amounts. Bump (1937:58) recorded the death from starvation of 39 pheasants in New York during the severe 1935-6 winter.

The comparative scarcity of authentic records for all northern States seemingly indicate that the species can withstand all except the most severe conditions. Errington (1939) has experimentally shown that pheasants can better retard or endure starvation than can Bob-white and can more quickly recover after a temporary food crisis.

Ruffed Grouse

The comparative lack of evidence of winter killing of Ruffed Grouse (*Bonasa unbellus*) through starvation and exposure, indicates that such mortality must be rare. There appears to be no published record of winter killing of grouse in Ohio. According to Dr. Bump (*in litt.*, October 24, 1935), no case of actual starvation was found in New York by 1936, although a large number of birds had received pathological examinations. Dr. E. C. O'Roke tells us that he has seen no evidence of death from starvation in approximately 120 Michigan grouse that have been brought in to him for pathological examination. Leopold (1933:349-50) gives no specific instance of winter mortality but states that grouse-killing winters are much less frequent in occurrence than are winters which kill Bob-white, because starvation of grouse is averted by budding. He likewise states that winter losses occur from a "special form of imprisonment" in which the grouse dive into the snow and are caught by an encrustation of sleet or ice on the surface. King (1937:531) states that a "2 day ice storm once in 5 years can do away with all of the increase built up during that period." He gives no specific instance of its occurrence.

From the writings of Leopold (1931 and 1933) and King (1937) we gather that as long as grouse have sufficient suitable snow in which to remain at night or during low temperatures, winter losses of this budding species from imprisonment, exposure, or starvation will be very low. It is only when deep snows become encrusted with sleet or ice, or there is ice without deep snow, that winter losses from adverse weather conditions may occur. Even then death is generally not caused by starvation or exposure to low temperatures, but by imprisonment of grouse beneath encrusted ice, or by their having been forced to roost in trees or on the ice-covered ground where they become the prey of predators.

Conclusions

Winter mortality of waterfowl and some species of upland game birds, caused by starvation, exposure to low temperatures, or a com-

bination of both, occurs in widely scattered localities in the northern United States.

Such mortality generally takes place during or immediately following severe sleet or snow storms when low temperatures freeze the surface water shutting off the usual food supply.

During the average stress period apparently only those birds die which are weakened by disease, parasitism, lead poisoning, mechanical injury such as are made by gunshot wounds, or ice formation over eyes, in bill and nostrils.

In extreme stress periods, and especially when the accumulated, adverse effects of winter are most pronounced, mortality of normal birds may occur from starvation and exposure.

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