Body weights and carcass composition of the Common Eider

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Introduction

An annual cycle of body weight in waterfowl, associated mainly with breeding, has been demonstrated in the Mallard *Anas platyrhynchos* (Folk, Hudec and Toufar 1966), Canada Goose *Branta canadensis* (Hanson 1962), Redhead *Aythya americana* (Weller 1957), Common Eider *Somateria mollissima* (Gorman and Milne 1971; Cantin, Bedard and Milne 1974), Long-tailed Duck *Clangula hyemalis* (S. Petersen, pers. com.) and Blue-winged Teal *Anas discors* (Harris 1970). This paper presents details of the fluctuation in body weight and changes in the major body constituents of the Common Eider in the course of the year.

The annual cycle

The annual cycle of the Eiders can be divided into five parts.

(a) Overwintering. Eiders spend most of the period October–April in large flocks and only disperse in small groups or individual pairs immediately prior to nesting during April. In the east of Scotland their food consists largely of mussels *Mytilus edulis*.

(b) Pre-breeding. In preparation for breeding the female during April increases her food intake by up to three times the normal amount in order to lay down fat for incubation (Gorman and Milne 1971). Males actively defend an area around their mates during this pre-breeding period against other males in the flock and spend relatively little time feeding as a result.

(c) Incubation. During incubation females rarely leave the nest, unless to drink, and they will have lost about 40% of their gross body weight by the time the chicks are hatching.

(d) Post breeding. The females alone care for the young, which are frequently herded together into creches in the care of guard-females (Gorman and Milne 1972). Where the nursery areas for the chicks and the food resources of the adult females are spatially separate, the creche system allows breeding females the opportunity to leave their chicks in order to feed and recover body tissue lost during incubation (Gorman and Milne 1972). Female mortality reaches a peak during June and July, underlining the stressful nature of this particular breeding sequence (Garden, Rayski & Thom 1964).

(e) Moulting. In July, females moult their body feathers and move out to sea to join the flock of moulting males. Whilst in eclipse plumage, the birds moult all of their wing and tail feathers and are flightless for a period of some three weeks during August. In September they undergo another complete change of body feathers from the eclipse plumage into a new nuptial plumage.

Materials and methods

All of the birds used for carcass analyses were collected, under licence, during the period 1966–1969 from the population which breeds at the Sands of Forvie National Nature Reserve, Scotland. Most birds were shot on the Ythan estuary, a few pre-breeding females were killed on the road by passing traffic, incubating females were removed from nests, and moulting individuals were collected at sea a few miles south of the Ythan.

Total body weight was measured soon after collection, and then the birds were plucked and re-weighed. The lower intestine and the feet were removed before the carcass was minced. In some cases the individual weight of breast muscle, liver and gut were also taken before mincing.

The total weight of minced material was measured and a 25% sub-sample was removed and freeze-dried. Fat was extracted in a Soxhlet apparatus for about 6 hours using diethyl ether. Protein values on the fat free tissues were obtained by nitrogen determination in a Technicon Auto-analyser, using 6·25 as the conversion ratio for %N to grams protein. Ash values were determined by burning samples at 400°C. The differences between total dry weight and the sum of fat, protein and ash have been listed under 'Others' and include such relatively minor components as glycogen, carbohydrates, free amino acids, structural lipids and errors in drying. These usually comprised about 10% of the total dry weight. The weights or constituents of the feathers have not been incorporated in any of the values given but total weights of feathers varied between about 150–200 g during the year.

Results

Variations in body weight

Mean body weights throughout the year are given for females in Figure 1(a) and for males in Figure 2(a). The only significant changes in

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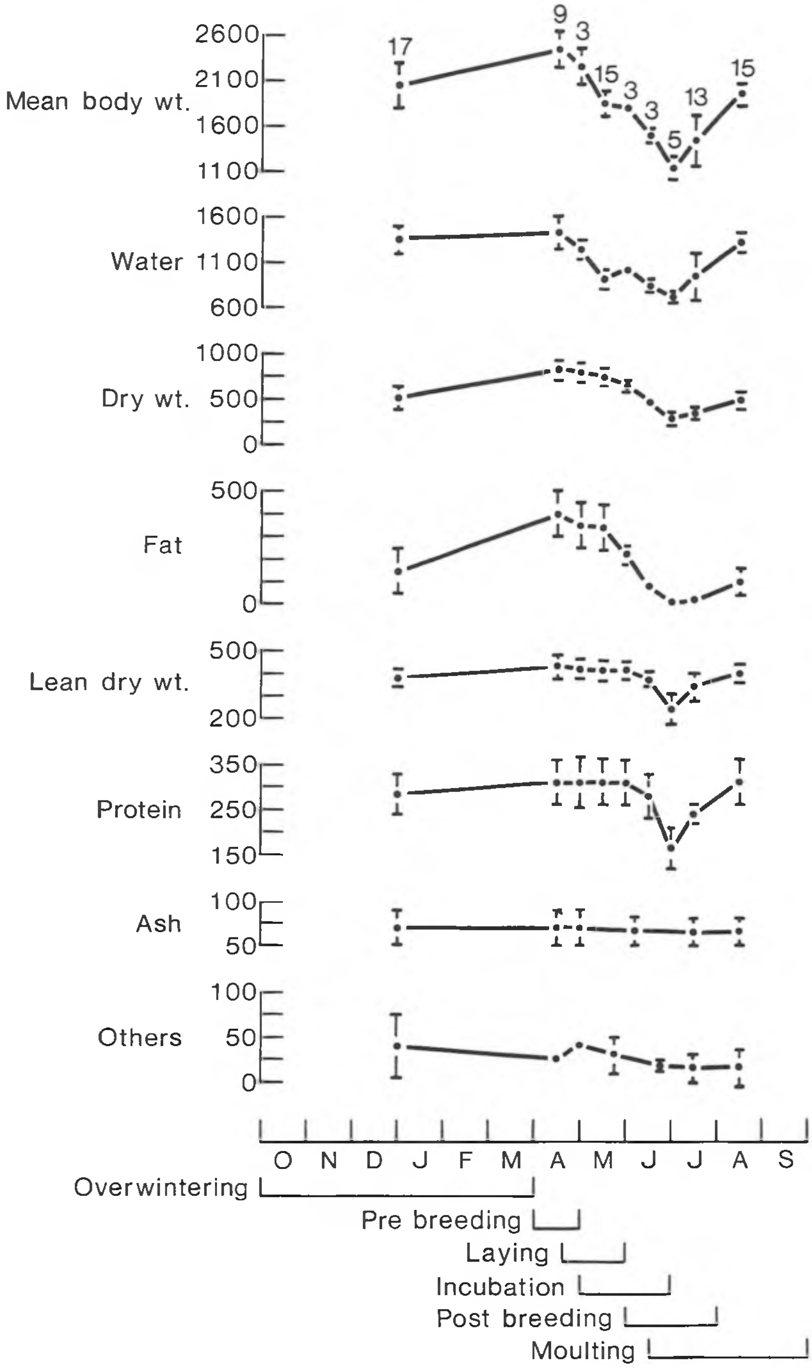

Figure 1. Carcass composition of adult female Eiders. Mean values with two S.E.'s either side of the means; sample sizes given on the top diagram.

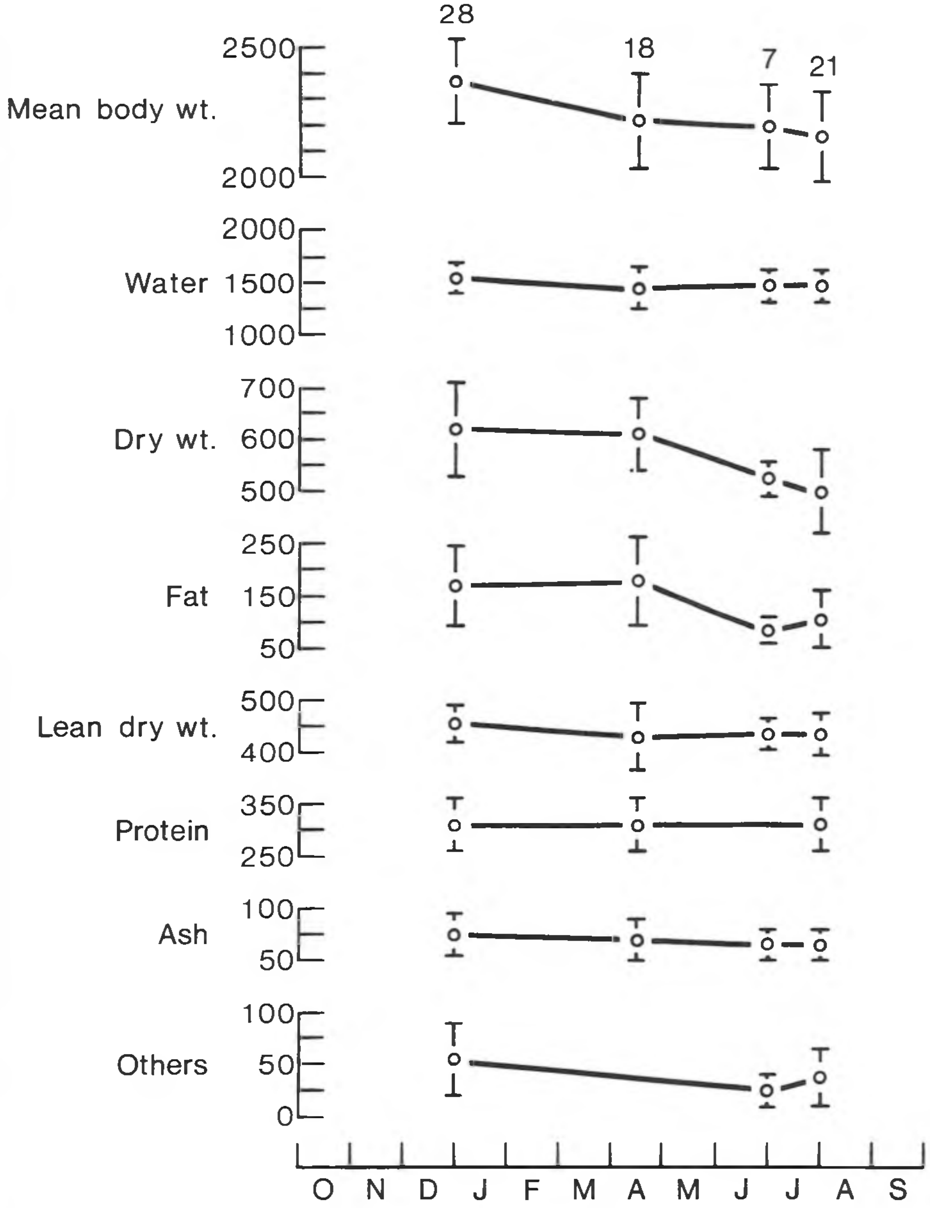

Figure 2. Carcass composition of adult male Eiders. Mean values with two S.E.'s each side of the means; sample sizes given on the top diagram.

body weight are those which are clearly associated with breeding in adult females. The overwintering weight of females is lower than in males but, prior to egg-laying, females increase to a maximum of about 2500 g. 63% of the pre-breeding increase in body weight of females results from fat deposition. Females lose weight through egg laying and incubation to a minimum of about 1150 g at hatching time, and then regain weight during June/July before entering body moult in August.

Adult males lose only a small amount of body weight in spring, (when females are rapidly gaining weight) and again during moult in late summer, having remained fairly stable in between.

Water content

The mean water content of the carcasses varied between 1432–1558 g in males (Figure 2(b)) and between 732–1419 g in females (Figure 1(b)).

Significant dehydration occurred in laying and in early incubating females ($d = 4{\cdot}99$; $p < 0{\cdot}001$), whereas none of the changes in water content of adult males were significant.

Dry weights

Similarly, total dry weights of adult males did not vary significantly during the year (Figure 2(c)), but there was a significant increase in dry weight of females through pre-breeding, egg laying and into incubation ($d = 6{\cdot}8$; $p < 0{\cdot}001$), which was then reversed during incubation until females were significantly down in carcass dry weight from the end of incubation and through the post breeding phases (Figure 1(c)).

Fat content

The pre-breeding increase in body weight of adult females was largely due to deposits of subcutaneous and visceral fat, accumulated during April. These fat deposits were completely metabolized by the end of incubation (Figure 1(d)).

The lean dry weight of adult males again did not vary throughout the year, whereas there was a statistically significant drop in the lean dry weight of adult females towards the end of incubation and at the time of hatching ($d = 5{\cdot}04$; $p < 0{\cdot}001$). This was almost entirely due to the utilization of protein from the pectoral muscles and gizzard during incubation.

Protein, ash and 'others'

Protein analyses confirmed the view that changes in lean dry weight of females resulted from changes in protein content of the carcass (Figure 1(f)) whereas there was no change in the protein content of male carcasses throughout the year (Figure 2(f)).

The ash weight of carcasses did not vary significantly in either males or females during the year.

Values of 'Others' (including carbohydrates, structural lipids, free amino acids, and glycogen) have been derived by difference. There were no obvious changes in these values from overwintering to the post breeding situation in either sex.

Variation in body weight between years

Throughout the period 1960–1974 large samples of birds were trapped in winter for ringing, and their body weights recorded. Since no significant differences could be detected between mean body weights in the months October through to March in most years, these data have been pooled therefore to give means for each winter period (Figure 3, see opposite page).

Mean winter weights were lower in years 1965–1966 through to 1970–1971 than in the earlier years 1960–1961—1964–1965. This was followed by an increase to a higher level over the years 1971–1972—1973–1974. A similar pattern was followed by both sexes, but was more evident among females than males. Mean weights during winters 1965–1966, 1966–1967 and 1968–1969 were significantly lower than in other winters ($p < 0{\cdot}05$).

There appears to be no relationship, however, between overwintering weights and the subsequent mean body weights recorded at other times of the year (i.e. pre-breeding, laying, post breeding and moulting) but samples at those times were small. Mean numbers on the Ythan in winter have fluctuated between a minimum of 650 and a maximum of 1200 (Milne 1974). A highly significant inverse relationship between wintering numbers and mean adult body weights in winter can be demonstrated (Figure 4).

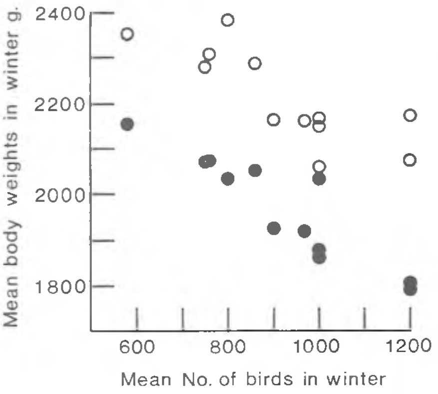

Figure 4. Relation between mean body weights of adult Eiders in winter and mean numbers on the Ythan estuary in winter. ○–○ Adult males: ●–● Adult females.

Regressions:

Males: $y = 2644{\cdot}8 - 0{\cdot}4704X$; $r = 0{\cdot}8126$.

Females: $y = 2515{\cdot}9 - 0{\cdot}5989X$; $r = 0{\cdot}9167$.

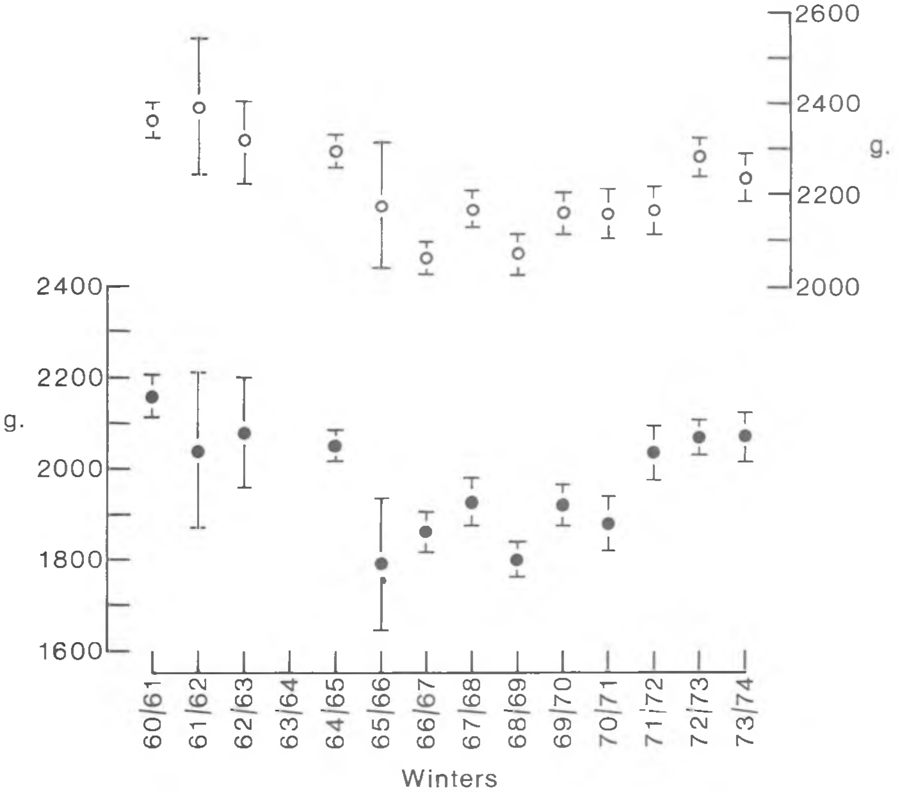

Figure 3. Mean body weights of adult Eiders overwintering at Forvie, with two S.E.'s each side of the means.
○—○ Adult males.
●—● Adult females.

Breeding success is extremely variable between years at Forvie (Milne 1974) where fledging success is usually of the order of 10% but with occasional 'good' years when fledging may be as high as 50%. Mean weights of 1st winter birds were lower following 'good' breeding than after 'poor' breeding (Table 1) ($d = 8{\cdot}3$; $p < 0{\cdot}001$). The inverse relationship between mean body weights in winter of 1st year birds and the numbers of young fledged each year (Figure 5) is statistically significant (for Males $r = 0{\cdot}7237$; $p < 0{\cdot}01$ and for Females $r = 0{\cdot}7609$; $p < 0{\cdot}01$).

Body weights of females are demonstrably linked with their subsequent breeding performance since a statistically significant correlation exists between mean weight of females in winter and mean clutch size in the following spring ($r = 0{\cdot}6326$; $p < 0{\cdot}05$) (Figure 6). No relationship, however, could be found between winter weights and number of females breeding nor hatching success of eggs.

Discussion

The changes in body weight of Eider females, directly resulting from their breeding cycle, has previously been described by Gorman & Milne (1971, 1972) and Cantin, Bedard & Milne (1974). The pattern of incubation, in which the female abstains from feeding throughout the 26 days, has almost certainly evolved in relation to severe egg predation which can occur when females leave the nests (Bourget 1973; Campbell 1975; Choate 1967; Clark 1968; Milne 1974; Milne & Reed 1974). The resulting metabolism of body fat and protein under these circumstances, is responsible for the changes in carcass composition of females described above. The dehydration which occurs during egg laying

Table 1. Mean body weights of 1st winter Eiders at Forvie, (a) following 'poor' breeding success in the preceding summer and (b) following 'good' breeding success in preceding summer.

		Males			Females		
(a) Winter	Total nos. fledged in summer	N	Mean body weight (g)	2 × S.E.	N	Mean body weight (g)	2 × S.E.
1961	200	3	2133·3	176·4			
1962	75	12	2020·8	111·8	5	1920·0	92·8
1965	300	26	2070·9	63·7	38	1823·1	61·6
1966	100	26	1944·2	87·5	32	1819·5	62·1
1967	200	16	1938·8	105·3	17	1797·4	89·5
1969	25	2	2015·0	340·0	9	1811·1	167·1
1972	10	2	1962·5	115·0	3	2061·7	173·8
1973	210	8	2129·4	109·4	6	1930·0	106·3
Totals		95	2006·3	43·4	110	1833·8	33·0
(b)							
1963	1600	30	1777·5	71·7	41	1672·6	71·3
1968	900	298	1714·6	23·5	333	1645·4	20·0
1970	800	60	1811·0	65·2	86	1663·6	48·7
1971	850	55	1936·2	73·9	71	1731·6	55·1
Totals		443	1809·8	22·0	531	1678·3	18·9

diff. between (a) & (b), $d = 8{\cdot}11$; $p < 0{\cdot}001$. diff. between (a) & (b), $d = 8{\cdot}8$; $p < 0{\cdot}001$.

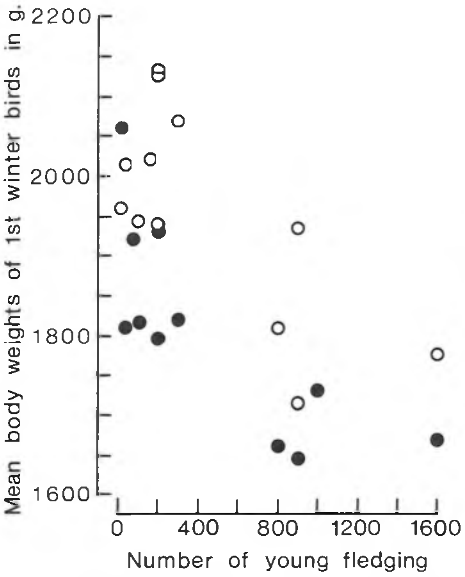

Figure 5. Relationship between mean body weights of 1st winter birds and the numbers of fledged young the previous summer. Open circles—males, closed circles—females.
Regression equations are:
Males: $F = 2041{\cdot}3 - 0{\cdot}1950BW$ ($n = 12$; $p < 0{\cdot}01$).
Females: $F = 1895{\cdot}9 - 0{\cdot}1908BW$ ($n = 11$; $p < 0{\cdot}01$).
Where F = no. fledged young and BW = mean body weight.

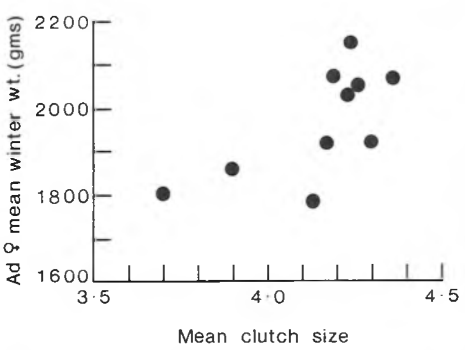

Figure 6. Relationship between mean body weights of females in winter and the mean clutch size in the following spring.

and early in incubation presumably results from egg production, and water from the catabolism of fat may help to restore the water balance during incubation. The presence of fresh water pools in the nesting area may be important in determining nest location since females frequently visit freshwater to drink during the incubation period.

The pre-breeding increase in total fresh weights of females was associated with a corresponding increase in dry weight, resulting from increases in both fat and protein. Massive fat deposits are held sub-cutaneously and throughout the posterior end of the body cavity and on the mesenteries; at the start of incubation fat may form up to 50% of total dry weight, and 16% of fresh body weight. The decline in body weight of females through incubation was a result of dehydration, a depletion of fat reserves, and a loss of body protein.

Males are, on average, heavier than females throughout the year with the exception of the short period prior to egg-laying. Fluctuations in body weights of males are minor, and are associated with the prebreeding period when guarding their mates and with moulting.

There were no significant changes in total body water, lean dry weight, protein or ash values in adult males throughout the year, but total dry weight and fat weights were lower in the period June–September when males were leaving the breeding area to moult.

The variation of overwintering weights between years seems to be consistent for both sexes and may reflect the environmental conditions under which the birds were living. The inverse relationship between numbers of young birds fledged in the population in summer and their body weights through the first winter might suggest some direct relationship between available food supplies and body weights. If this is so then one might further postulate that the longer term fluctuations in overwintering weights of adults also reflect their available food supplies.

Presumably, if food in winter is limiting, then a hierarchical social organization within the flock would tend to produce the relationship between numbers and body weights which has been described in Figures 4 and 5. These data support the hypothesis that some density-dependent homeostatic mechanism is operating within the winter population. Further studies are in progress to try to test this hypothesis.

The relationship between mean body weight in winter and mean clutch size the following spring (Figure 6) is similar to the findings of Reynolds (1972) for Mute Swans *Cygnus olor*. Reynolds also described increases in body weight prior to egg laying, a decrease in clutch size with laying date and postulated that both laying date and clutch size were largely determined by the food reserves gained by the female prior to laying. Those findings parallel those for Eiders and for a few species of geese which have been sufficiently documented such as Blue Goose *Anser caerulescens*, Ross's Goose *Anser rossii* or Canada Goose. The significance of winter food supplies and social organization within wintering flocks of waterfowl to their subsequent breeding performance is still little understood, and is a factor in the management of such populations which requires some attention.

Acknowledgments

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A male Common Eider *Somateria m. mollissima.* (*B. A. Crosby*).