Body measurements of Mallard caught in Britain

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Most of the ducks caught for ringing at Wildfowl Trust trapping stations are Mallard *Anas platyrhynchos*, and these are usually weighed and measured before release. An analysis of body weight and condition has been completed (Owen & Cook 1977). This paper describes an analysis of linear measurements of ducks caught at various sites between 1965 and 1975.

Wing length and other measurements have previously been used to indicate differences in body size of ducks (Harris 1970; Owen & Cook 1977). Wildfowl have a simultaneous moult of primary feathers, and wing length during the flightless period gives an indication of the stage of moult. Smart (1965) showed that the wings of Redhead *Aythya americana* ducklings reared early in the season were longer after they had completed growth than were those of late broods.

Wing and body measurements of many bird species have been related to the origins of populations and Griffiths (1967, 1971), in a preliminary analysis of wing length, indicated that there may be differences related to the origins of British-wintering Mallard. He examined the frequency distribution of wing length of birds caught at different trapping stations and at different times of year at the same station. He attributed differences in wing length between samples caught in early September and later in the season to immigration of longer-winged birds, and annual differences in mean wing lengths to different migration patterns causing the arrival of birds from different populations. He did not, however, consider the possibility that the wing feathers of flying birds might still be growing early in the season or that there may be other explanations for annual differences in measurements.

This paper describes a more detailed analysis of wing length and other measurements, having examined the sources of variability and bias that have to be considered. The wing length of a large sample of Mallard later recovered is examined in an attempt to relate measurements to the origin of the ducks.

Materials and methods

The Mallard were caught at four sites, by cage traps at Abberton Reservoir, Essex, and in duck decoys at Borough Fen, Cambridgeshire, Nacton, Suffolk, and Slimbridge, Gloucestershire. In the three decoys most of the catching was in the late summer, autumn and early winter, whereas at Abberton birds were caught at all times of year, including the summer moult period.

Body weight and wing length were the only measurements taken regularly. The wing length was standard chord in Borough Fen and Slimbridge decoys and the maximum chord (British Trust for Ornithology 1972) in the other two stations. In order to test the comparability of the two measurements the four operators measured the wings of a sample of 17 Mallard on the same day. They were asked to measure the wings exactly as they normally did.

Other measurements were taken on smaller samples. Bill (culmen), skull (longest dimension of the head), sternum (the length of the sternal ridge, nearest the skin) and tarsus (the tarso-metatarsal bone) were measured with calipers. Body length (tip of tail to 'shoulders') and total length (body length plus extended but not stretched neck and head) were measured on a flat surface with a ruler. Some bone measurements were taken by various of the observers but there is less likelihood of observer bias than when measuring wings.

Results

Reliability of wing measurement

The results of the operators' test are given in Table 1. The correlation coefficient and coefficient of dependence (r^2) were, as expected, high between all observers although 10% of the variation was due to operator differences in the two operators measuring standard chord. The best correlation was between the two measurements of maximum chord (by King & Revett). Other correlations were intermediate. There was a slight difference in means between operators using the same method and a difference of 6·6 mm between the two methods. After correcting the maximum chord measurements to standard chord by subtracting 7 mm, the average difference between measurements of the same wing by different operators ($\bar{d}$) was up to 2·7 mm, and the largest difference 7 mm (3% of wing length). The mean deviation from the mean of the four measurements of each individual bird was greater in the two operators measuring standard chord.

Wildfowl 29 (1978): 123–34

The test showed that there was considerable variability between measurements taken by different observers although mean deviations of 1—2 mm were less than 1% of wing length. By all criteria tested the observer variation was less when the maximum chord was measured, as predicted by Evans (1964).

Variation in measurements by the same observer was tested by comparing measurements of the same ducks recaptured within two weeks at Borough Fen Decoy (standard chord). The mean deviation in a sample of 51 measurements was 2·3 mm and the range 0–7 mm. Some of this variation would be expected if the ducks were caught in different conditions (e.g. if the feathers were damp or dry), but normal within operator variation does appear to be of the same order as that between operators. Within operator variation would probably be reduced if the maximum chord method were adopted.

Reliability of other measurements

Bone measurements are not likely to be as variable between or within operators although variation in the shape of the proximal end of the tarso-metatarsal bone may introduce some variability. Variability in the thickness of subcutaneous fat and flexibility of the bone itself makes the sternum measurements rather inaccurate. They can be used only in comparisons between relatively large samples (Owens & Cook 1977).

Because of the elasticity of the neck and the difficulty of measuring body length ac-

Table 1. Variation between wing measurements of 4 observers on the same sample of 17 Mallard, before and after correction for method used.

		OPERATOR		
		Cook Borough Fen	King Abberton	Revett Nacton
Lane	r(r^2 in %)	0·95 (90)	0·97 (94)	0·98 (96)
	$\bar{x} - \bar{x}_2$*	−1·3	−8·0	−6·5
	d. range†	0–7	2–11	0–10
	corr $\bar{d}$‡	2·64	1·71	1·76
	range	0–7	0–4	0–5
Revett	r	0·96 (92)	0·99 (98)	
	$\bar{x}_1 - \bar{x}_2$	+5·2	−1·5	
	d. range	0–10	2–10	
	corr $\bar{d}$	2·65	1·71	
	range	0–7	0–4	
King	r	0·97 (94)		
	$\bar{x}_1 - x_2$	+6·7		
	d. range	2–11		
	corr $\bar{d}$	2·24		
	range	1–5		

	Standard chord		*Maximum chord*	
	Cook	Lane	King	Revett
Overall sample mean	259·40	258·10	266·10	264·60
Mean deviation§	1·74	1·21	0·91	1·09

* $\bar{x}_1$ = mean of the operator on the vertical axis.
† d range = smallest and largest difference between 2 operators.
‡ corr. $\bar{d}$ = mean difference (irrespective of sign) between operators after compensating for the method of measurement.
(Standard chord = Maximum chord − 7 mm).
§ Mean deviation = the mean deviation of individual operator measurements from the mean of 4 observers for the same individual wing.

curately, such measurements are only useful for comparative analyses.

Mean measurements

Means, ranges, standard errors and coefficient of variation for all the measurements taken are given in Table 2. Also shown are t values to test the significance of differences in means between ducks of different ages. The wing length of adult males were found to be significantly longer than those of juveniles but this was not the case with females. Adult males had significantly longer skulls than juveniles although the difference was slight (1·1%). The difference in sternum length was significant in both sexes, probably because junvenile sterna were not fully ossified at the rear end and were easily compressed.

The wings of young geese are 3–6% shorter than those of adults (Beer & Boyd 1962, 1963). Matthews & Campbell (1969) also found small but significant increases in the culmen lengths of juvenile Greylag Geese *Anser anser* between autumn and winter. Young Mallard measured in this study are in most respects full-grown in their first

Table 2. Means, ranges and standard errors of measurements of Mallard by age and sex. All measurements in mm. All taken at Borough Fen Decoy except skull (Slimbridge). AM (Adult male) JM (Juvenile male) AF (Adult female) JF (Juvenile female).

Measure	Class	n	Range	Mean	s.e.	C(%)†	t age‡
Wing*	AM	665	250–298	274·8	0·26	2·5	6·67***
	JM	907	238–292	272·4	0·24	2·6	
	AF	880	235–280	258·6	0·24	2·8	1·29 NS
	JF	754	234–277	258·1	0·24	2·6	
Skull	AM	293	106–124	115·5	0·20	3·0	5·52***
	JM	598	104–124	114·2	0·13	2·8	
	AF	265	97–116	106·7	0·20	3·0	0·91 NS
	JF	455	97–119	106·5	0·15	3·1	
Culmen	AM	500	45·6–63·1	54·6	0·11	4·5	1·78 NS
	JM	500	46·2–60·0	54·8	0·10	4·0	
	AF	500	45·5–58·9	51·3	0·10	4·1	1·14 NS
	JF	500	44·0–59·8	51·5	0·09	3·9	
Tarsus	AM	500	40·8–51·0	45·7	0·10	4·8	0·74 NS
	JM	500	39·8–49·5	45·6	0·07	3·5	
	AF	500	39·9–48·0	43·4	0·09	4·5	1·41 NS
	JF	500	37 8–49·7	43·3	0·06	3·2	
Sternum	AM	100	105–122	112·8	0·37	3·3	4·58***
	JM	100	98–119	110·4	0·38	3·5	
	AF	100	97–112	104·1	0·32	3·4	3·56***
	JF	100	93–113	102·4	0·35	3·0	
Body length	AM	12	287–312	298·3	2·24	2·6	0·25 NS
	JM	36	278–310	297·3	1·51	3·0	
	AF	18	262–295	282·9	2·40	3·1	0·57 NS
	JF	25	272–295	284·3	1·14	2·0	
Total length	AM	12	575–602	590·2	2·37	1·4	1·41 NS
	JM	36	564–607	585·0	1·95	2·0	
	AF	18	524–571	548·4	2·58	2·0	0·76 N
	JF	25	520–574	545·3	2·93	2·7	

* Because of the possible effect of moult and feather abrasion (see below) only birds caught in October–December are included.
† C = standard deviation/mean (expressed as percentage).
‡ ***P < 0·001 NS = Not significant.
Nearly all tests between sexes are highly significant in both adults and juveniles P < 0·001.

autumn, and they also achieve adult weight by December (Owen & Cook 1977).

Variations in wing length

Abrasion

A total of 266 birds of all ages and sexes were measured twice in the same season at Borough Fen Decoy. The rate of abrasion is calculated by dividing the total of differences in wing length by the total of the intervals. Operator variability precludes more detailed examination. The total loss of wing length was 157 mm in 7,778 days, an abrasion rate of 0·6 mm per month. The sample included birds recaptured throughout winter and spring, so the abrasion over the whole 11 months between moults can be calculated as 6·7 mm, 2·5% of mean wing length. Pienkowski & Minton (1973) recorded an abrasion rate equivalent to a total loss of 7–8 mm in Knot *Calidris canutus*. Although the loss was similar to that in Mallard, it represented 4% of wing-length of Knot.

Moult

Only at Abberton were flightless ducks caught, measurements being available for 5 years, 1968–1972. Means and coefficients of variation of wing lengths, together with the number of birds caught in each half-month from June to December are shown in Figure 1. The data should be treated with caution since the number and sex ratio of Mallard on the reservoir are not known. Thus if birds were more vulnerable to catching during particular moult stages their moult pattern would not reflect that of the population from which they were drawn. Comparison of the moult of the two sexes is, however, justified.

The number of males caught at Abberton was highest in May and June, when most females are incubating or leading broods (only five females were caught in May). Both sexes apparently begin the moult in early July but it is probable that this is unrepresentative in the case of females since the numbers caught are small. In late July and August there is a considerable increase in the number of females caught and it is probable that this represents the start of the moult for most females. There was also an increase in the number of fledged young in the catches in late July and August. While males have completed the moult in early October the wings of some females are not fully grown until early November. This confirms the findings of Lebret (1949) and Boyd (1961) that not only do females moult on average later than males, but that there is a greater spread of female moult. As Boyd points out the spread is due to variation in individual breeding success since females do not become flightless until their young have fledged. This has also been confirmed by Balat (1970), who found that 98% of male Mallard could fly by 15th August. There were indications of slight annual variations in moult timing in both sexes in England but samples were too small to make detailed comparisons.

There were no consistent correlations between body weight of flightless birds and their wing length (an indication of moult stage). Only one of eight tests proved significant—adult males in 1970 $r = -0{\cdot}532$ $P < 0{\cdot}01$. Other tests give both positive and negative correlations. The absence of consistent correlations probably indicates that the data are inadequate rather than that there are no weight changes during moult. This should be investigated in more detail.

Annual variations

Consistently large samples were obtained at Borough Fen Decoy and the annual means (October–December) for all classes are shown in Figure 2. Adult males had significantly longer wings than juveniles in 4 out of 8 seasons, but only in one year were adult female wings longer than those of young females. There are several significant differences between years. The length of adult male and female wings are significantly correlated ($r = 0{\cdot}908$, $P < 0{\cdot}01$) but there were no significant correlations either between the wing length of juveniles of different sexes or between juvenile wings and those of adults in the same season. Neither was there a relationship between the wing length of juveniles and that of adults in the following season. Thus the length of adult wings in any particular season may be controlled by conditions just prior to or during the moult, and this operates in a similar way on birds of both sexes. There was insufficient retrap data to test whether measurements of individuals changed in different seasons.

Since juvenile ducks caught late in the year may originate from elsewhere in Britain or from overseas (Ogilvie & Cook 1971) to ensure that locally bred birds are being measured samples should be of those caught early (but after the completion of growth). Figure 3 shows the mean wing lengths of juveniles caught at Borough Fen in September and also the proportion of the catch which were juveniles in

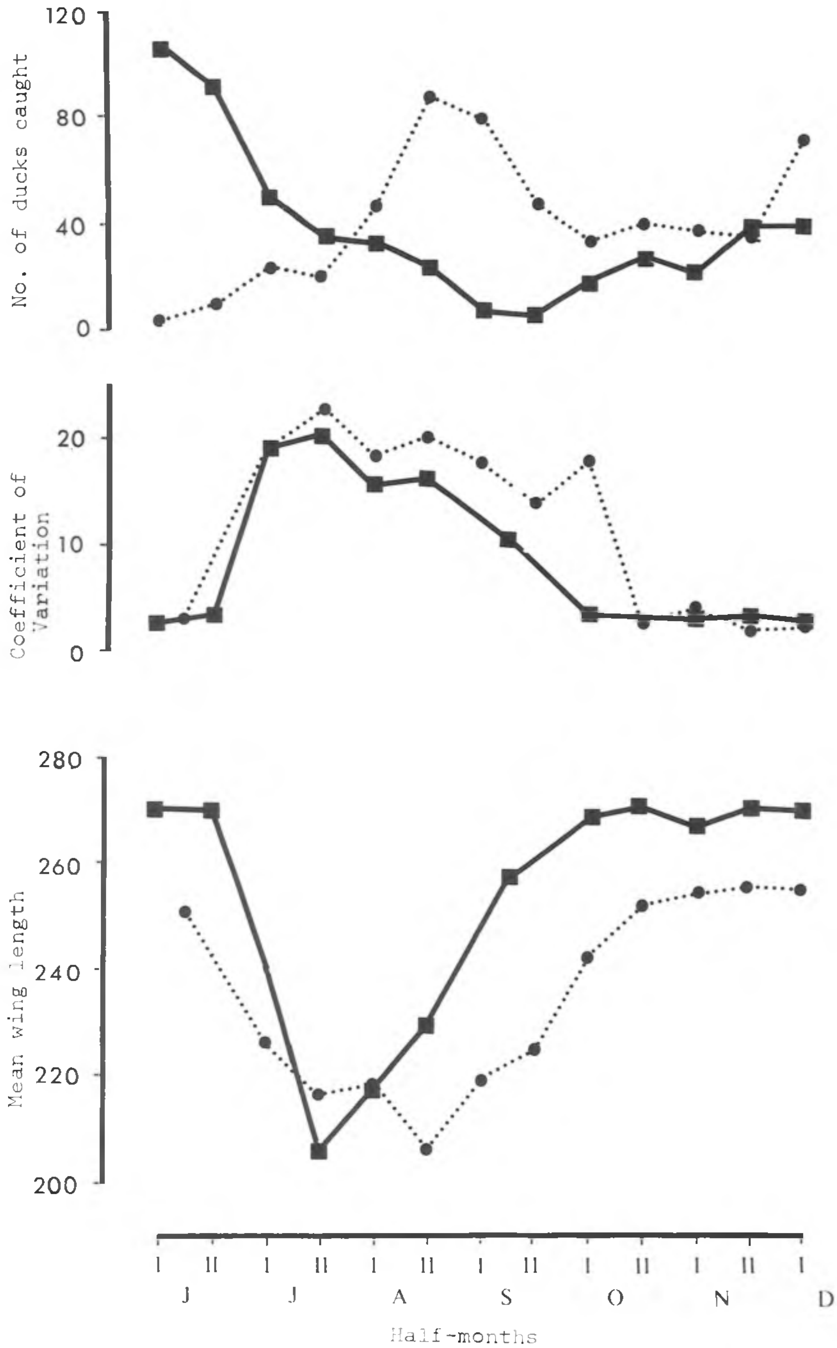

Figure 1. Mean and coefficient of variation (standard deviation/mean) of wing lengths of adult Mallard caught at Abberton Reservoir in each half month June–December 1968–1972. Also shown is the mean number of ducks caught in traps during the same period. Solid lines—males, broken lines—females.

July–September. Although the juveniles are more easily caught and therefore predominate in catches, the proportion does give an approximate indication of the quality of the foregoing breeding season (Ogilvie & Cook 1972). There are significant annual variations and the wing lengths of males and females are correlated ($r = 0{\cdot}759$, $P < 0{\cdot}05$). The correlation between wing length and breeding success is significant for females ($r = 0{\cdot}922$, $P < 0{\cdot}01$) but not so for males ($r = 0{\cdot}476$).

Owen & Cook (1977) had already demonstrated a relationship between the body weight of juveniles and their proportion in the catch. Both weight and wing length could be related to the earliness of the breeding season since Smart (1965) found that late-hatched Redhead ducklings had shorter final wing lengths than those from early broods. The distribution of juvenile wing lengths approximated to a normal distribution in most seasons. There was a suggestion of a bimodal distribution in some years, however, especially those which also showed a wide spread of wing length. Thus young ducks may show wing length variations related to hatching date within a breeding season as well as between years.

Origin of trapped Mallard

Because of variability in the numbers caught there are few occasions where comparisons between samples from different catching stations were possible. The wing lengths of adult male Mallard (after adjustment for the method of measurement) caught at Borough Fen and Abberton in October—December over 5 seasons is shown in Table 3. There are highly significant differences in each year, which might indicate differences in the origins of birds visiting the different stations. Boyd & Ogilvie (1961) found that the proportion of overseas migrants at Abberton was substantially higher than at Borough

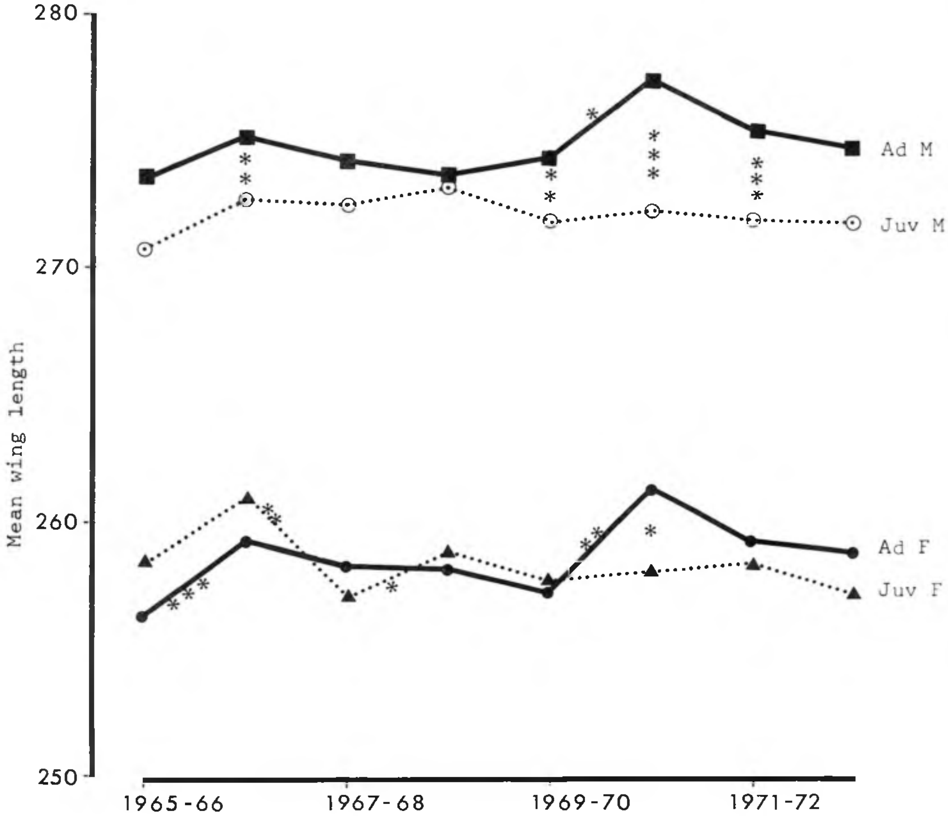

Figure 2. Mean wing length of Mallard caught at Borough Fen in October, November and December in each of 8 seasons. Asterisks between lines indicate significant differences between sexes, those along the lines significance of difference between consecutive years. *$P < 0{\cdot}05$, **$P < 0{\cdot}01$, ***$P < 0{\cdot}001$.

Table 3. Wing lengths of adult male Mallard caught at Borough Fen Decoy and Abberton Reservoir in October, November and December in 5 seasons.

Season	Mean wing length Borough Fen	n	C	Abberton	n	C	t	P
1968–1969	273·7	93	2·4	267·5	42	3·5	4·33	0·001
1969–1970	274·5	96	2·3	266·4	10	2·0	3·91	0·001
1970–1971	277·6	36	2·6	269·5	19	2·0	4·08	0·001
1971–1972	275·5	95	2·8	270·5	62	3·0	3·84	0·001
1972–1973	274·8	35	3·1	268·8	38	2·3	3·49	0·001

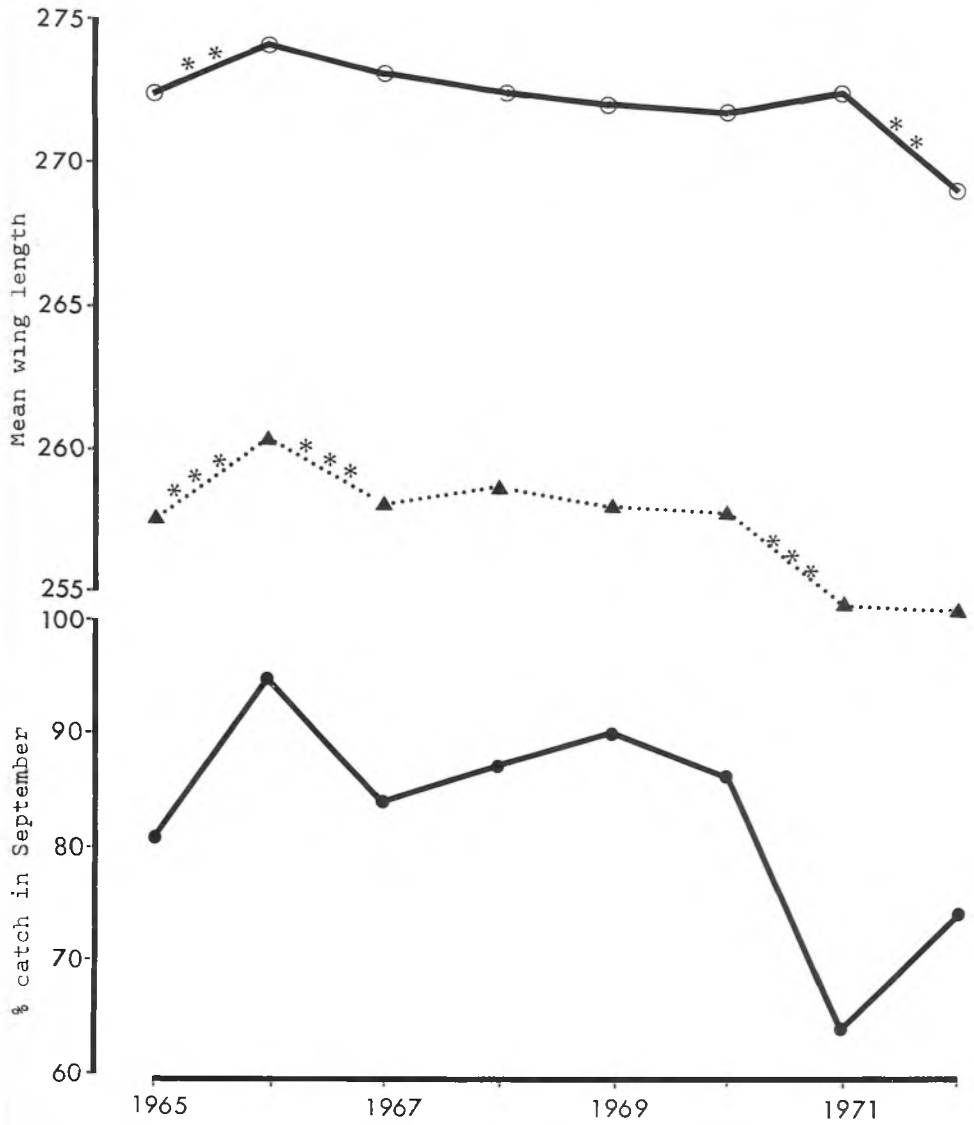

Figure 3. Mean wing lengths of Mallard caught at Borough Fen in September in relation to their proportion in the catch. Asterisks indicate differences between consecutive years, as in Figure 2.

Fen and this was examined for the period 1968–1972. Sixty-seven out of 233 recoveries (28·8%) of ducks ringed at Abberton were overseas compared with 76 out of 318 (23·9%) of those from Borough Fen. The difference was not significant ($x^2 = 1·6$), thus the difference is not attributable to the proportion of 'foreign' birds. It may indicate a difference in the moulting area of the populations using the two catching stations (see above).

There are sufficient recoveries of ducks ringed at Borough Fen Decoy in recent seasons to allow analysis of the wing lengths of birds recovered in different regions of Europe (Table 4). For British recoveries only adults ringed in October (earlier ones may not have fully grown feathers) and juveniles ringed in September were included, since Mallards ringed early in the season are from the local breeding population (Matthews 1963; Ogilvie & Cook 1971).

The wing length of juveniles recovered in Britain and abroad are identical for both sexes, whereas British adults have slightly shorter wings than foreign ones. The difference was only significant for adult females, but the 'British' sample had significantly shorter wings than those recovered in each of the other regions. Abmigration causes a preponderance of males in the overseas recoveries of British-ringed Mallard especially in area 3 (Ogilvie & Cook 1971), and this inbalance was noted for foreign-ringed ducks recovered in Britain. Adult females are therefore likely to be the more homogeneous group in that they are more likely to return to breed in their region of origin. It is not surprising therefore that it is only in this group that differences can be detected.

Evans (1964) suggested that the wing length of Dunlin *Calidris alpina* could, in combination with other characteristics, indicate the birds' region of origin, and Griffiths (1971) suggested that such a separation might be possible in Mallard caught in Britain. Our analysis gives little support to this suggestion and it seems likely that spurious conclusions on immigration patterns could be drawn because of seasonal and annual variations in the measurements (see Figures 2 and 3). Even our adult female sample could be biased if there were annual

Table 4. Wing length of Mallard caught at Borough Fen Decoy and recovered in different seasons.

Region		Adults				
	n	male mean	C	n	female mean	C
Britain*	37	271·0	3·2	80	255·5	2·8
Area 1†	29	272·8	3·0	61	259·2	3·3
Area 2	7	272·3	3·9	21	260·5	3·3
Area 3	56	274·7	3·1	30	259·9	3·3
Area 4	47	270·6	2·8	33	259·8	3·4
All foreign	139	272·8	3·1	145	259·7	3·3
			Juvenile			
Britain*	263	270·9	2·7	164	257·5	2·5
Area 1†	46	270·3	2·9	9	263·2	4·6
Area 2	28	269·7	2·6	3	268·7	0·6
Area 3	89	271·4	2·7	13	258·0	4·0
	87	270·7	2·6	27	258·4	3·6
All foreign	250	270·7	2·9	52	259·7	3·6

* Only adults ringed in October in Britain and recovered in a subsequent season are included. Juveniles are ringed in September and recovered in a different season.
† Foreign recoveries include all birds recovered overseas irrespective of season of recovery.
Area 1 Norway, Sweden, Finland.
Area 2 USSR, Bulgaria.
Area 3 Poland, DDR, FDR, Denmark.
Area 4 Netherlands, Belgium, France.

differences in movement patterns. Population differences, if they exist, are more likely to be found by comparing the measurements of locally caught birds in different regions of Europe.

Variations in other measurements

Since mean bill and tarsus lengths of juveniles were constant between September and December it is likely that young ducks are full grown with respect to body size by September, although they are at that time lighter than adults (Owen & Cook 1977). Similarly Matthews & Campbell (1969) found only minor differences between measurements of Greylag Geese of different ages.

Samples of 100 measurements (where available) taken between September and December for each age and sex class in each of 5 years were compared and these are shown in Table 5. There are many significant differences between yearly means although absolute differences are small, usually below 2%. Whereas differences between adult measurements are not consistent between the sexes or between years, those of juveniles are consistent in both respects. The number of years available did not allow detailed comparisons but the trends in bone measurements broadly followed those in wing length (Figure 2).

It appears therefore that juveniles reared in unfavourable seasons (or perhaps as second broods (Smart 1965)) not only have shorter wings but also have smaller bones (smaller samples of skull length from Slimbridge also showed significant annual variations). Such differences may occur in other species since H. Boyd (in litt.) records that yearling Brent Geese *Branta bernicla* caught in arctic Canada had smaller culmens than adults. Since geese are fully grown in their second summer this may reflect differences in the size of individuals reared in different seasons. In arctic geese, and probably also in ducks, it is important that juveniles fly as soon as possible in order to escape the onset of winter and reduce predation risk and it may be that in late seasons the young mature more quickly. Accelerated maturity may be achieved at the expense of body size, as well as weight (Owen & Cook 1977).

Table 5. Mean bill and tarsus measurements of Mallard measured between September and December in each of five seasons.

		Season								
		1965		1966		1967		1968		1969
AM	Bill	54·3		54·5	*	55·3	*	54·6		54·6
	n	100		31		100		65		42
	tarsus	45·3	*	46·0		45·7		46·0		45·5
	n	100		31		100		65		42
AF	Bill	50·9		51·2		51·4		51·7		51·2
	n	100		45		100		72		65
	tarsus	42·8	**	43·6		43·3	***	44·1		43·7
	n	100		45		100		72		65
JM	Bill	54·4	**	55·2		55·0		55·2	**	54·4
	n	100		100		100		100		100
	tarsus	45·0	**	45·8		45·9		45·9	*	45·5
	n	100		100		100		100		100
JF	Bill	50·8	*	51·5		51·7		52·0	*	51·4
	n	100		100		100		100		100
	tarsus	42·4	***	43·4		43·5		43·7	*	43·3
	n	100		100		100		100		100

Significance levels between consecutive years only shown. Many other between year differences are significant.

* $P < 0{\cdot}05$ ** $P < 0{\cdot}01$ *** $P < 0{\cdot}001$

Correlations between measurements

Correlation coefficients between pairs of measurements are shown in Table 6. Coefficients are in general very small, in only one case (juvenile male skull/bill) was more than 50% of the variability accounted for. It is unlikely therefore that any measurement on its own will give a reliable measure of body size in Mallard. Wing length was most consistently correlated with the other independent measurements and is probably the best single measure, although it is not available as an indicator of body size during moult. Because they are easily and reliably measured, skull and tarsus lengths are convenient as routine bone measurements. Skull length is preferred to culmen because the exact position of the tip of the feathering is often indistinct. There is always higher variability in bill measurements than in those of the skull (see Table 2).

Discussion and conclusions

The data presented in this paper were collected opportunistically, necessarily so because of the variation of catching success and in the size of the samples caught. One of the main aims of this analysis was to assess the value of such data and to recommend improvements in procedure or measuring techniques.

Wing length is the most useful single measurement, since it can be used to examine feather abrasion and moult as well as giving an indication of body size. Since bird wings are curved in two directions, variability can be introduced both within and between operators. Our analysis confirmed the observations of Evans (1964), that differences between operators and the variability of measurements by a single operator are minimized if the maximum chord measurement (of the flattened wing) was taken. To allow comparisons between samples caught at different stations in future, all operators should adopt this method.

Bill (culmen) length is a standard measurement for taxonomic purposes but because of variability in the extent of the feathering at the base of the bill of Mallard, it is suggested that skull length would give a more consistent measurement as an indication of body size. The advantage of using the skull would be greater in species where bill length made a smaller contribution to the length of the head. Sternum length cannot be reliably determined on live wildfowl.

Having obtained a sufficiently large sample to provide reliable means of the various measurements, it would be desirable to direct effort towards answering specific questions. For example operators should routinely

Table 6. Correlations between various measurements of Mallard. Only juvenile measurements (with the largest sample sizes) were tested. Sample sizes in brackets, significance as in table 5.

Juvenile female	Juvenile male Wing	Skull	Bill	Tarsus	Sternum	Body	Total
Wing	—	0·512 (56) ***	0·345 (52) *	0·408 (52) **	0·570 (42) ***	0·003 (30) NS	0·485 (30) **
Skull	0·375 (52) *	—	0·773 (56) ***	—	—	—	—
Bill	0·236 (52) NS	0·679 (52) ***	—	0·292 (52) *	—	—	—
Tarsus	0·252 (52) NS	—	0·426 (52) **	—	—	—	—
Sternum	0·173 (51) NS	—	—	—	—	0·451 (36) **	0·371 (30) *
Body	0·378 (21) NS	—	—	—	0·353 (25) NS	—	0·199 (36) NS
Total	0·410 (21) NS	—	—	—	0·378 (25) *	0·430 (25) *	—

measure retrapped ducks, to examine within operator variability and to assess the rate of feather abrasion. The value of wing measurements and weights taken during the moult would be greater if all ducks were measured and information collected on whether the caught sample was representative either in moult status or sex ratio of the local population.

The mobility of Mallard within and between seasons makes it difficult to examine geographical variability in measurements. Yet detailed analysis of individuals trapped at the various stations, backed up by an analysis of the distribution of recoveries, may yield some useful results. Although the number of birds available is variable and catching unpredictable, it should be possible to predict the most profitable season to examine, for example, the differences in the measurements of ducks caught at different stations. It would also be useful to supplement catches from the stations with samples trapped with nets or by other means.

Despite its limitations, the present analysis did provide some interesting information. There were small but significant annual variations in all those measurements with sufficient samples and there are indications that these are due to differences in the timing (and probably food supply) of the preceeding breeding or moulting season. Whether these small differences affect the fitness of the ducks is unknown. Indeed it is possible that they may be advantageous to a population. In a long-lived species, subject to major seasonal and annual variations in feeding and breeding conditions, genotypic heterogeneity would be advantageous since it would allow the population to exploit a variety of situations.

Acknowledgements

The Mallard measurements on which this paper are based were taken by W. A. Cook, R. King, K. Lane & D. Revett. They also cooperated by participating in the test of operator variability and bias. We are also grateful to S. Ellis for help with the analyses and for preparing the figures, and to M. A. Ogilvie for providing the data on recovered ducks. G. V. T. Matthews and H. Boyd made constructive criticisms on a draft.

Summary

This paper describes an analysis of wing length, head and body measurements of Mallard *Anas platyrhynchos* caught at four Wildfowl Trust ringing stations in England in the years 1965–1975.

A test on operator bias in wing length measurement showed that wing length as measured by the maximum chord method was, on average, 6·6 mm greater than when using standard chord. Maximum chord was a more easily repeatable method and produced more consistent results between operators. Within operator variability was of the same order as that between operators.

Adult males had longer skulls and wings than juvenile males but there was no significant age difference in females. Measurements of retrapped birds indicated that the abrasion rate was about 0·6 mm per month, equivalent to a loss of 6–7 mm between moults, 2·5% of mean wing length. There were significant differences between the wing length of Mallard caught at different stations but this was not related to the proportion of overseas migrants in the catch.

Measurements of wing lengths of flightless Mallard confirmed previous findings that females have a later and a greater spread of moult than males.

There were significant annual differences in most of the measurements taken and there were indications that the size of juveniles was related to the quality (earliness) of the breeding season. It is suggested that differences in the final wing length of adults are related to feeding conditions during their moult.

Analysis of wing lengths of birds subsequently recovered provided no consistent evidence that these were related to the birds' origin. The only significant difference was in adult females, those recovered in Britain having shorter wings than those recovered overseas. Because of the mobility of juveniles and adult males any differences that might exist would not be detected by the method used.

On the basis of this analysis the following recommendations were made:

a) all operators should measure wing length using maximum chord;
b) the skull length as well as bill and tarsus length should be measured routinely to provide an indication of body size, especially in moult;
c) geographical variability should be examined by taking all possible measurements on ducks caught at the various stations, when large samples are likely to be caught;
d) wing length and weight changes during moult should be examined in more detail to determine the duration of the flightless period and the stresses of moult in Mallard.

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A male Mallard *Anas platyrhynchos* coming out of eclipse. (*Joe B. Blossom*)