A method of sexing Moorhens

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The sexes of monomorphic birds are usually not readily distinguishable in the field, though measurements of different parts of the body may differ between the sexes, and permit the statistical identification of males and females. Bill measurements have proved reliable in several seabirds, e.g. in the Fulmar *Fulmarus glacialis* (Dunnet & Anderson, 1961), Herring and Lesser Black-backed Gulls *Larus argentatus* and *L. fuscus* (Harris & Hope Jones, 1969), Red-billed Gulls *L. novaehollandiae* (Mills, 1971) and Puffin *Fratercula arctica* (Corkhill, 1972), where bill length and bill depth of birds of known sex are used to calculate a 'discriminant function' (see below). Williams & Miers (1958) sexed the New Zealand Swamphen *Porphyrio p. melanotus* by bill length and body weight. In the American Coot *Fulica americana* the sexes can be separated by tarsus plus mid-toe measurement, as well as by voice and behavioural display (Gullion, 1952). Behavioural differences can also be detected in Moorhens *Gallinula chloropus* (Wood, 1974).

In a study of individually marked Moorhens at Newburgh, Aberdeenshire (Anderson, 1965), where mated pairs had previously been sexed by behaviour, some of the above methods were examined. Dead specimens from Slimbridge, Gloucestershire, sexed by dissection, were measured and from combinations of these measurements, discriminant functions were calculated.

Methods

Four body measurements were taken:

(a) Tarsus plus toe (henceforth abbreviated to T + t). This differed from Guillion's (1952) method insofar as the *underside* of the foot and tarsus of the Moorhen was measured, Figure 1. This allowed ease and consistency of measurement as the 'knee' or tibio-tarsal joint of an active bird can be held securely at right angles against the stopped end of a wing-rule whilst the middle toe is straightened. The claw is not included.

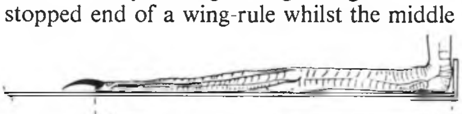

Figure 1. Measurement of tarsus + longest toe using wing-rule with stopped end.

(b) Bill plus frontal shield length (culmen length). This was taken by vernier calipers, from the tip of the upper mandible to the top of the shield to give a maximum measurement.

(c) Wing length, from the carpal joint to the end of the longest primary feather, followed the flattened chord method recommended in The Handbook of British Birds (Witherby *et al.* 1940).

(d) Weights were taken on a dial scale balance accurate to 1 g.

It was also possible to sex some birds at Newburgh by observing copulation, but reversed copulation does take place (once in 13 copulations by one pair). Cloacal examination outside the breeding season (Mosby, 1960) with a clinical auriscope was not successful.

Seasonal variation in adult body measurements

By maintaining a marked population of Moorhens at Newburgh over several seasons it was possible to detect seasonal variations in culmen length, weight and wing length of retrapped birds. No change was found in T + t length, e.g. in bird No. 129, five measurements taken over seven years varied only 1 mm on either side of the 125 mm mean.

Seasonal changes in culmen length in both male and female are due to enlargement of the frontal shield in early spring from January onward (Figures 2 and 3). A reduction in its length generally begins in September but there may be individual variation in this decrease associated with the post-breeding moult as early as July and through to November. Data for the summer months are insufficient to show this clearly.

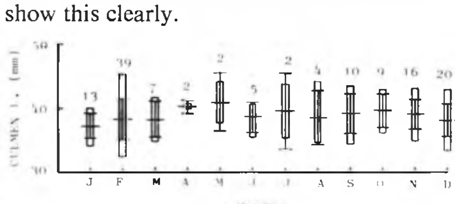

Figure 2. Culmen lengths of adult Moorhens at Newburgh. Mean, standard deviation, range and sample size.

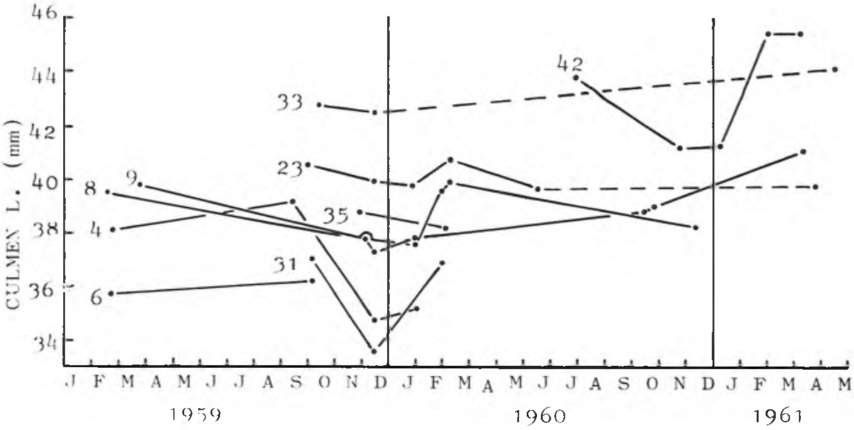

Figure 3. Seasonal variation in culmen length of adult Moorhens at Newburgh. Serial number of individual bird at first recorded measurement.

Moorhens put on weight in late summer and autumn, and lose weight through winter from December to February (Figures 4 and 5). Females however, can be at their heaviest when gravid, to such a degree that they may have difficulty in flying. At such times some females are heavier than their mates, e.g. in a pair sexed by behaviour and subsequently checked by discriminant function, the female No. 8 averaged 392 g over several seasons and its mate, No. 42, averaged 400 g; on 6th April 1961 she weighed 415 g and her mate 400 g. On 13th May 1963, having almost completed laying a clutch of 10 eggs, she weighed 465 g.

Moult of the primaries occurs in July and August; the feathers are dropped simultaneously and the growth of new flight feathers to full length is assumed to be fairly rapid. (Body moult, which is most evident at the beginning of September, was still found in some birds at the end of October). Wing length is regarded as acceptable from the beginning of October and throughout the winter. Unfortunately, the tips of the primaries get damaged when territorial boundary disputes begin in Spring. This is caused by abrasion against the tail at the termination of a boundary confrontation (Anderson, 1965);

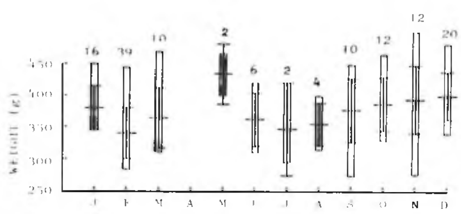

Figure 4. Weights of adult Moorhens at Newburgh. Mean, standard deviation, range and sample size.

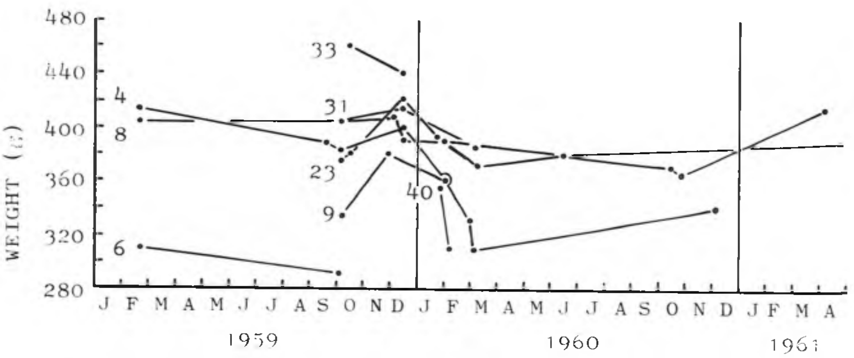

Figure 5. Seasonal variation in weights of adult Moorhens at Newburgh. Serial number of individual bird at first recorded measurement.

the tail is suddenly flicked up and held vertically, and the wing-tips raised together, to rest on top of it. After such territorial encounters some Moorhens have the outer primaries badly broken and the tail feathers much reduced in length.

Measurements of sub-adult birds

First year birds became indistinguishable from adults from mid-September onwards to early April at the latest; for the purpose of this study, all were regarded as adults from 1st May. At Newburgh, T + t measurements of sub-adults had reached a maximum by the end of December. Culmen growth, rapid until October, slowed down and in some instances became negative in the winter months, to resume growth in early spring. Body weights followed a similar seasonal pattern to culmen growth, but the winter check and decrease was more marked (Figure 6).

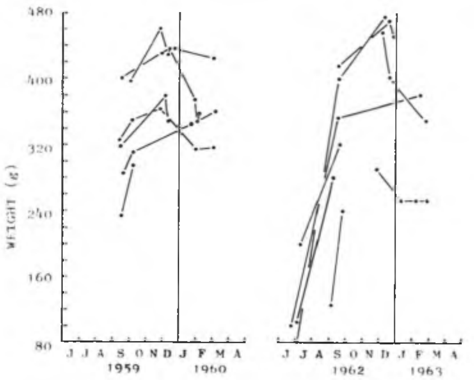

Figure 6. Seasonal variation in weights of sub-adult Moorhens at Newburgh.

Measurements of sexed specimens from Slimbridge

64 adult and 1st winter specimens from the Wildfowl Trust at Slimbridge were examined. To check whether there was any size difference between them and the Newburgh birds (the two populations being separated by more than 640 km) the wing lengths of eight adult male Newburgh birds, were compared with that of nine Slimbridge ones, all of which were full-winged. The mean lengths were 186·13 mm and 182·22 respectively and the difference was not significant ($P > 0{\cdot}05$). A further comparison between eight Newburgh and 18 Slimbridge birds was made with T + t length which does not vary seasonally. The mean lengths were 129·38 mm and 125·67 respectively and the difference was not significant ($P > 0{\cdot}2$).

In the Slimbridge birds, males are larger, on average, than females in all four standard measurements (Figure 7, Table 1). There is an overlap in range of measurement, but in adults the differences between the sex-means are highly significant. In sub-adult birds, mean culmen and weight differences are not significant ($P > 0{\cdot}1$ and $P = 0{\cdot}1$).

Discriminant function analysis

Statistical methods to derive discriminant functions are described by Rao (1952) and Moroney (1958). Those of Cormack (Dunnet & Anderson, 1961) and A. Carothers (unpubl.) were followed in the present analysis. The T + t measurement is regarded as the most dependable one of the 4 standard measurements as it does not vary seasonally. It has been combined with each of the other three measurements to give the following discriminant functions:

D_1 ..... 0·59 (T + t) + 1·08 (culmen L.) = 112·52

D_2 ..... 2·82 (T + t) + 2·79 (wing l.) = 824·67

D_3 ..... 2·33 (T + t) + 0·17 (wt.) = 338·65.

The scatter of points indicating male and female measurements related to the three different discriminant functions (males above the line, females below it) are shown in Figure 8. Some points lie upon the discriminant line and a few, both male and female, lie on the wrong side of it. Normal curves for the data showed that, for a combination of T + t and culmen length, 12% of males would be wrongly sexed and the same percentage of females also. The percentages wrongly sexed by the combinations T + t and wing length, also T + t and weight, are less good at 16% in each case. The probabilities of misclassification are obtained by evaluating the discriminant D for any chosen pair of measurements (Table 2), and the appropriate symbol is designated to the bird (cf. Dunnet & Anderson, 1961).

Discriminant functions were also calculated for combinations of weight and wing length D_4 ..... 0·26 Wt. + 30·57 Wing L. = 5,424·28 weight and culmen length D_5 ..... 0·15 Wt. + 12·82 culmen L. = 540·42 culmen length and wing length D_6 ..... 1·04 culmen L. + 0·75 wing L. = 170·33 as an additional check on a small number of known pairs, sexed by behaviour but whose tarsus + toe measurements were not available. These are included in Table 3 which shows the measurements of eight mated pairs sexed by

Table 1. Comparison of male and female adult and sub-adult standard measurements; tarsus + longest toe length, culmen length, wing length and weight.

		Male					Female			
		N	X̄	Range	δ	P	N	X̄	Range	δ
Ad.	T + t(mm)	18	125·67	118–136	4·80	<0·001	23	115·74	107–123	4·52
	Culmen(mm)	18	39·94	36·5–44·3	2·46	<0·001	23	36·31	31·9–43·2	2·79
	Wing(mm)	16	178·81	167–190	5·90	<0·001	18	170·22	161–183	5·96
	Wt.(g)	18	358·56	270–459	58·05	<0·01	23	313·78	240–416	46·43
Sub-ad.	T + t(mm)	14	126·57	115–136	5·60	<0·001	9	115·44	108–122	5·18
	Culmen(mm)	14	39·59	33·1–46·9	4·17	>0.1	9	37·06	34·0–39·6	2·40
	Wing(mm)	12	175·92	159–183	6·47	<0.01	8	167·63	162–175	4·07
	Wt.(g)	14	316·5	245–390	39·80	=0·1	9	285·67	225–370	45·5

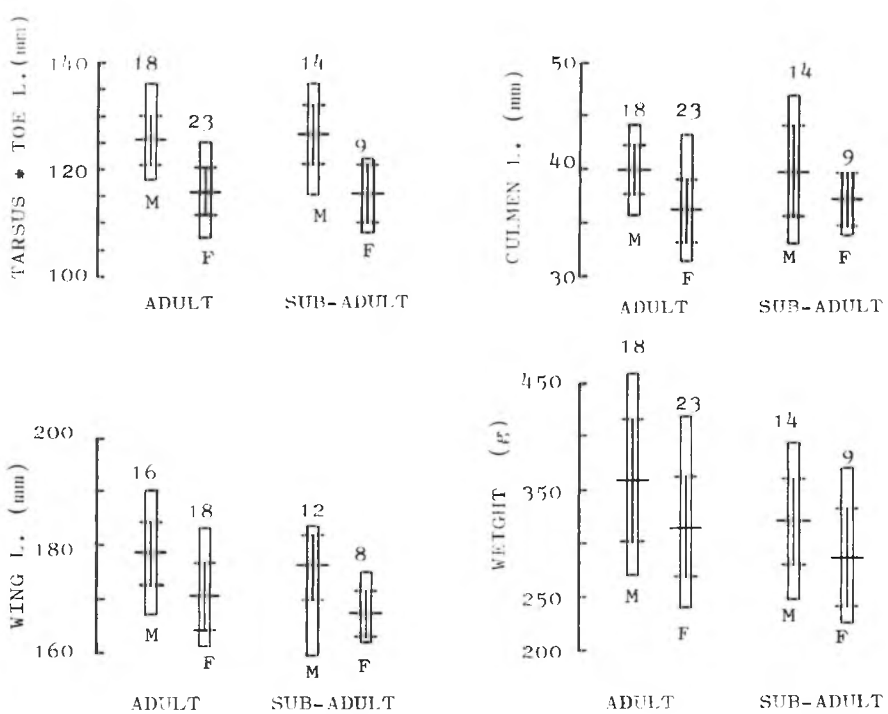

Figure 7. Standard measurements of adult and sub-adult Moorhens from Slimbridge. Mean, standard deviation, range and sample size.

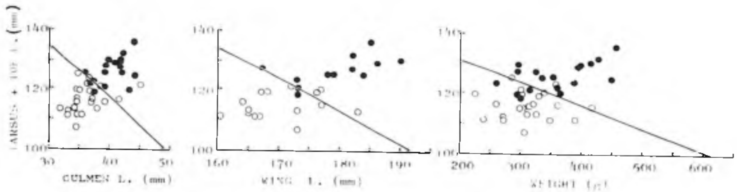

Figure 8. Separation of males (filled circles) and females (open circles) by discriminant functions.

Table 2. Probability of misclassification of sex for three pairs of measurements:

$D_1 = 0{\cdot}59\,(T + t) + 1{\cdot}08\,(\text{culmen L.}) - 112{\cdot}52$
$D_2 = 2{\cdot}82\,(T + t) + 2{\cdot}79\,(\text{wing L.}) - 824{\cdot}67$
$D_2 = 2{\cdot}33\,(T + t) + 0{\cdot}17\,(\text{wt.}) - 338{\cdot}65$

Probability of misclassification %	Designation	D_1	D_2	D_3
50–25	(♂) or (♀)	0–1·9	0–14·2	0–8·6
25–10	♂ or ♀	1·9–3·9	14·2–28·5	8·6–17·75
10–5	♂+ or ♀+	3·9–5·1	28·5–39·25	17·75–23·8
5–1	♂++ or ♀++	5·1–7·8	>39·25	>23·8

Table 3. Average measurements of breeding adults in pairs. See text for values of D.

♂ Sexed by behaviour					Sex by discriminant						Paired to Bird No.
Bird No.	T + t mm	Cul mm	Wing mm	WT. g	D_1	D_2	D_3	D_4	D_5	D_6	
33	—	43·2	181	433	—	—	—	♂++	♂++	♂++	8
42	—	43·4	—	400	—	—	—	—	♂++	—	8
23	—	40·1	180	386	—	—	—	♂+	♂	♂+	9
33	—	43·2	181	433	—	—	—	♂++	♂++	♂++	53
35	—	38·5	181	377	—	—	—	♂++	(♂)	♂+	47
100	134	43·4	—	381	♂++	—	♂++	—	♂++	—	47
92	122	39·0	179	400	(♂)	♂	♂	♂+	♂	♂	71
114	119	41·2	—	357	♂	—	(♀)	—	♂+	—	63

♀ Sexed by behaviour					Sex by discriminant						Paired to Bird No.
Bird No.	T + t mm	Cul mm	Wing mm	WT. g	D_1	D_2	D_3	D_4	D_5	D_6	
8	—	38·8	172	392	—	—	—	(♀)	(♂)	♀	33
8	—	38·8	172	392	—	—	—	(♀)	(♂)	♀	42
9	—	38·9	177	342	—	—	—	♂	(♂)	♂	23
53	—	36·7	174	370	—	—	—	(♀)	(♀)	♀	33
47	—	37·5	—	355	—	—	—	—	(♀)	—	35
47	—	37·5	—	355	—	—	—	—	(♀)	—	100
71	120	35·0	—	335	♀+	—	(♀)	—	♀+	—	92
63	124	35·5	—	328	(♀)	—	(♂)	—	♀	—	114

behaviour and further checked by discriminant function. Female number 9 has been wrongly classified as male by D_4, D_5 and D_6 but its three available measurements are well above the mean for females. Its mate, however, has measurements above average for males. The pair 114 and 63 have been misclassified by discriminant D_3 due to the male's below average T + t length; the same measurement in the female is above average, as is her weight. Further, 114's T + t length is the only male measurement in Table 3 which is smaller than that of the mate. Changes of mate, by male 33, and by females 8 and 47 among the eight pairs have also helped to establish the correct sex in those pairs.

It is concluded that discriminant function analysis can be most reliably used to distinguish the sexes in birds measured concurrently so that the effects of seasonal changes in certain measurements are minimised. With large enough sexed samples, it should be possible to calculate functions appropriate to specific times of the year, thus eliminating seasonal bias.

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Summary

A method of sexing Moorhens *Gallinula chloropus* in the hand was tried using discriminant analysis with three combinations of four body measurements taken from specimens sexed by dissection. The most reliable is length of tarsus + middle toe combined with culmen length, giving 88% of birds correctly sexed. Seasonal variation in the four standard measurements were examined in a marked population of Moorhens at Newburgh. Culmen length varies according to breeding cycle. Wing length can be affected by damage to wing-tips during territorial display posturing. Moorhens lose weight from December to February and maximum weight of the female is at egg-laying. Tarsus + longest toe length does not vary once its full length is reached in sub-adulthood. Moorhens may be sexed by behaviour but reversed copulation sometimes occurs.

References

Anderson, A. (in Dunnet, G. M.) 1965. Research at Culterty Field Station. *Scot. Birds* 3: 219–35.

Corkhill, P. 1972. Measurements of Puffins as criteria of sex and age. *Bird Study* 19: 193–201.

Dunnet, G. M. & Anderson, A. 1961. A method for sexing living Fulmars in the hand. *Bird Study* 8: 119–26.

Gullion, Gordon, W., 1952. Sex and age determination in the American Coot. *J. Wildl. Mgmt.* 16: 191–7.

Harris, M. P. & Hope Jones, P. 1969. Sexual differences in measurements of Herring and Lesser Black-backed Gulls. *Brit. Birds* 62: 129–33.

Mills, J. A. 1971. Sexing Red-billed Gulls from standard measurements. *N.Z. J. mar. Freshwat. Res.* 5: 326–8.

Moroney, M. J. 1951–58. *Facts from figures.* London and Beccles.

Mosby, H. S. 1960. *Manual of game investigational techniques.* Washington, D.C.: The Wildlife Society.

Rao, C. R. 1952. *Advanced statistical methods in biometric research.* New York.

Williams, G. R. & Miers, K. H. 1958. A field method of sexing the Swamp-hen or Pukeko. *Emu* 58: 125–7.

Witherby, H. F., Jourdain, F. C. R., Ticehurst, N. F. & Tucker, B. W. 1940. *The Handbook of British Birds,* Vol. 1. London: Witherby.

Wood, N. A. 1974. The breeding behaviour and biology of the Moorhen. *Brit. Birds* 67: 104–15.

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