ously. Kozlova (1962) claimed simultaneous moult usually for the first three or four primaries, but sometimes the first five or six. Such a rapid start of primary moult has never been recorded in migrating Dunlins caught in the first stages of moult at the Vistula mouth in Poland (J. Gromadzka pers. comm.).

The moult progressed very quickly in the Dunlins in the Taymyr which were studied in 1989. It is not known if moult was suspended after the end of incubation. If moult continues at a similar rate in the second part of the moult period, the primary moult would take *c.*50 days. This is a markedly shorter period than the 59–94 days reported for primary moult in post-breeding Dunlins (Ginn & Melville 1983).

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Relative masses of primary feathers in waders

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Summers *et al.* (1983) showed that moult scores of retrapped Redshanks *Tringa totanus* tended to increase more slowly towards the end of primary mount than near the beginning. This was partly because the outer primaries are longer and heavier than the inner primaries. Therefore, by converting moult scores to percentage feather mass grown (PFMG) one can make the pattern of increase with time more linear (Summers 1980). A "moult index" that increases linearly with time is one of the underpinning assumptions of the moult model of Underhill & Zucchini (1988), and PFMG is undoubtedly more closely linear with time than the traditional moult score. In order to compute PFMG, the relative masses of the primary feathers for the species under consideration need to be known.

One of the purposes of this note is to point out that, for those wader species for which the relative masses of the primaries are known, there is sufficiently little variation to suggest that a set of average values might suffice for all (or at least most) wader species. The other purpose of this note is to suggest a standard procedure for determining the relative masses and for computing PFMG. Improved standardisation of methods will facilitate comparisons between species and between areas in the timing and duration of moult.

To date, the relative masses of the primaries have been determined for 13 wader species (Table 1). For these species and each primary, the maximum difference between the average relative masses and the relative masses for the individual species was 1.3%. The consistent differences were for Grey Plover *Pluvialls squatarola,* which appears to have relatively lighter inner and heavier outer primaries than average, and Redshank for which the opposite pattern occurs (Table 1).

The recommended procedure for finding relative masses was described by Summers *et al.* (1980), and is repeated

Table 1. Relative masses of primary wing feathers of waders.

Species	Primary number										Source
	1	2	3	4	5	6	7	8	9	10	
Grey Plover *Charadrius squatarola*	3.1	4.0	5.1	6.8	8.4	10.5	12.7	14.6	16.3	18.5	
Bar-tailed Godwit *Limosa lapponica*	4.1	4.9	6.0	7.7	9.4	11.0	12.1	13.5	14.8	16.6	
Whimbrel *Numenius phaeopus*	3.8	5.0	6.3	7.5	8.8	10.7	12.2	13.9	15.3	16.5	
Bristle-thighed Curlew *N. tahitiensis*	4.0	5.0	6.1	7.6	9.2	10.9	12.2	13.5	15.1	16.4	(a)
Redshank *Tringa totanus*	5.0	5.7	6.7	7.7	9.1	10.6	11.8	13.1	14.2	16.1	(b)
Greenshank *T. nebularia*	4.4	5.1	6.0	7.3	8.8	10.4	12.1	13.7	15.3	16.9	
Turnstone *Arenaria interpres*	4.2	4.7	5.9	7.2	8.7	10.4	12.0	13.7	15.4	17.9	(c)
Knot *Calidris canutus*	3.9	4.5	5.5	7.1	8.6	10.6	12.3	14.0	15.7	17.8	(d)
Sanderling *C. alba*	3.9	4.6	5.4	6.8	8.3	10.2	12.0	14.2	16.0	18.7	(e)
Little Stint *C. minuta*	4.4	5.2	6.1	7.3	8.6	10.3	12.0	13.7	15.4	17.1	
Purple SandpiperC. *Maritima*	4.4	5.0	6.0	7.0	8.6	10.2	11.6	13.2	15.5	18.5	
Dunlin *C. alpina*	4.0	4.9	5.7	6.9	8.5	10.2	11.8	13.7	15.8	18.4	(f)
Curlew Sandpiper *C. ferruginea*	4.0	4.7	6.0	7.3	8.8	10.3	12.2	13.9	15.3	17.6	
Average m_i	4.1	4.9	5.9	7.3	8.8	10.5	12.0	13.7	15.4	17.4	

Sources: (a) Marks in prep.; (b) Summers *et al.* 1983; (c)Summers *et al.* 1989; (d) WCWSG unpubl. data; (e) Underhill & Zucchini 1988; (f) Kania 1990, *in litt.*

here, with some refinements. Primary feathers in good condition (i.e. showing little feather wear and with no broken-off tips) are needed. The bases of the feathers must be clean and undamaged. If they meet the criteria, the feathers from both wings should be used. The feathers are labelled, dried to constant mass in a convection oven (24–48 hours at 60°C), and then weighed as rapidly as possible. For waders, 1 mg accuracy is adequate. The feathers start reabsorbing moisture as soon as they cool off; this can be checked for by re-weighing the first few feathers after the last feather has been weighed.

To determine the relative masses of each primary for a single bird, add together the masses of corresponding pairs of primaries (assuming both wings were used), and divide by the total mass of all 20 primaries for that bird. If data from several birds are available, the means (and standard deviations) of the relative masses of each primary for each bird are computed. Other orderings of the steps in doing the calculations are possible, and most will lead to identical or nearly identical results. The key point is that the sample size should be the number of birds, not the number of wings. From previous experience, the standard deviations should be small, and the coefficients of variation can be expected to be less than about 2%.

To transform the primary moult score for a wader with moult recorded according to the system of Ginn & Melville (1983) as $s_1s_2s_3s_4s_5s_6s_7s_8s_9s_{10}$ (e.g. 5554310000) into PFMG, the formula of Underhill & Zucchini (1988) is recommended:

$$\text{PFMG} = \sum_{i=1}^{10} m_i\, p(s_i)$$

where m_i is the relative mass of the ith primary, and $p(s_i)$ is the mass of a feather with a moult score s_i relative to its mass when it is fully grown. The values for m_i may be taken from Table 1, and those for $p(s_i)$ (assumed to be the same for each primary) from Table 2. The example in Table 3 shows that a primary moult score of 5554310000 transforms to a PFMG of 28.1%, indicating that the bird has grown 28% of the primary feather mass (whereas the traditional moult score formed by summing the scores for the individual feathers suggests that the bird has completed 23/50 = 46% of its primary moult). If the wader had been a Grey Plover *Pluvialis squatarola,* and the 'correct' relative masses for this species had been used instead of the average values, the PFMG would have been calculated at 24.7%, and, if a Redshank, as 31.1%. These discrepancies represent virtually the worst case deviations amongst the 13 species considered, but will not introduce serious biases in the estimates of the moult parameters by the method of Underhill & Zucchini (1988).

Table 2. Recommended factors for converting moult scores for individual feathers to proportion of feather mass grown. The motivation for these values is given in Underhill & Zucchini (1988).

Score *s*	Proportion grown *p(s)*
0	0
1	0.125
2	0.375
3	0.625
4	0.875
5	1

Of the 13 species listed in Table 1, 12 represent five of the genera within the Scolopacidae, but all are migrants. Only one plover Charadriidae is included in Table 1. Therefore, the current and provisional guideline is that for migrant scolopacids and possibly charadriids, the average relative primary masses from Table 1 may be used to compute PFMG. Further information is required for other wader families, but also for "resident" scolopacids, such as the African Snipe *Gaiinago nigripennis,* for scolopacids from genera not represented in Table 1, and for charadriids, both migrant and resident. We would be grateful to receive air-dried fresh wings from any wader (including those in Table 1), with a sample of no more than five pairs of wings. Thus, in future, we would be able to update our knowledge of relative masses of primaries.

Relative primary masses for five non-waders are given in Underhill *et al.* (1991, Table 17), and all are different from each other and from the values given for waders in Table 1, which should therefore not be used for other families.

Table 3. Worked example of the procedure for transforming a moult score recorded as 5554310000 to PFMG.

Primary *i*	Relative mass *m(i)*	Score s_i	Proportion grown $p(s_i)$	$m_i \times p(s_i)$
1	4.1	5	1	4.1
2	4.9	5	1	4.9
3	5.9	5	1	5.9
4	7.3	4	0.875	6.4
5	8.8	3	0.625	5.5
6	10.5	1	0.125	1.3
7	12.0	0	0	0.0
8	13.7	0	0	0.0
9	15.4	0	0	0.0
10	17.4	0	0	0.0

$$\text{PFMG} = \sum_{i=1}^{10} m_i\, p(s_i) = 28.1\%$$

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