Chapter 24

Primary moult of the Kelp Gull *Larus dominicanus vetula* in the Western Cape, South Africa

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We transformed the primary moult protocols of 147 adult Kelp Gulls to Proportion Feather Mass Grown (PFMG), and used the Underhill–Zucchini moult model to estimate the parameters of moult: mean starting date, 29 January; duration 168 days; mean completion date 16 July, with 95% of birds estimated to start and complete moult within 43 days of these dates. The average number of feathers moulting simultaneously was 1.9. The paper introduces the concept of Proportion Feather Mass Missing (PFMM); although there was no trend for the number of moulting feathers to change through moult, the PFMM increased, because large gaps in the primaries occurred towards the completion of moult.

Keywords: Kelp Gull, *Larus dominicanus vetula*, primary moult, South Africa, Underhill–Zucchini moult model

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Introduction

The nominate race of the Kelp Gull *Larus dominicanus* has a wide distribution in the southern hemisphere, including southern South America, the Antarctic Peninsula, the subantarctic islands of the Southern Ocean, Australia and New Zealand. In contrast, the subspecies *vetula* occurs only in southern Africa. Several aspects of the biology of *L. d. vetula* have been studied, including its distribution (Crawford 1997), population size and conservation (Crawford et al. 1982, Steele & Hockey 1990), movements (Underhill et al. 1999), survival (Altwegg et al. in press), breeding biology (Williams et al. 1984), chick growth and energetics (Visser et al. in prep.) and plumage development and age at first breeding (Crawford et al. 2000). In this study we focus on an aspect that has received little attention as yet, namely the moult. We estimated the primary moult parameters for *L. d. vetula*, using records of moult and an appropriate model for avian primary moult.

Material and Methods

We collected primary moult protocols for 142 adult Kelp Gulls, from our own observations (mainly during bird ringing operations), moult cards curated by SAFRING, and moult protocols submitted to the electronic database of SAFRING. The records were distributed throughout the year and consisted of actively moulting birds as well as birds which were not in moult. The data therefore correspond with data type 2 of Underhill & Zucchini (1988), and the moult parameters were estimated using the model developed by these authors. A lack of records prevented us from analyzing the moult protocols of immature birds.

The Underhill–Zucchini moult model (Underhill & Zucchini 1988) requires an index of primary moult that increases linearly through time. For many species, this can be achieved, to a good approximation, by converting the moult protocols into Proportion Feather Mass Grown (PFMG), using transformations devised by Summers et al. (1980, 1983). The conversion requires that the ratios between the mass of each primary feather and the combined mass of the primary feathers (relative feather masses) are known. Underhill & Joubert (1995) demonstrated that small samples are adequate for estimating relative feather mass of primary feathers because there is little intra-specific variation. We therefore processed and weighed complete sets of primary feathers taken from two freshly dead adult Kelp Gulls which had moulted shortly before death. One of the specimens was collected at Robben Island (33°47'S, 18°21'E), the other at Dyer Island (34°40'S, 19°25'E). Both had died of natural causes. The extracted feathers were cleaned and dried in an oven at 60°C for 48 hours. Each feather, from the inner primary (P1) to the outer primary (P10), of each wing was then weighed individually on an Ohaus GA200D balance (precision: 0.0001 g). The average feather mass of each primary (estimated across the four wings of the two specimens) were used to calculate PFMG for moult protocols, following Underhill & Summers (1993) and Underhill & Joubert (1995). We also estimated the Proportion Feather Mass Missing (PFMM) using the obvious approach based on the calculation of PFMG; for feathers with moult scores 1 (missing or pin), 2 (small brush), 3 (about half grown) and 4 (about three-quarters grown), we computed 0.875, 0.625, 0.375 and 0.125 of the relative feather masses, respectively, and added these values. PFMM provides a measure for the size of the “gap” in the primary feathers which takes into account the relative sizes of the missing feathers.

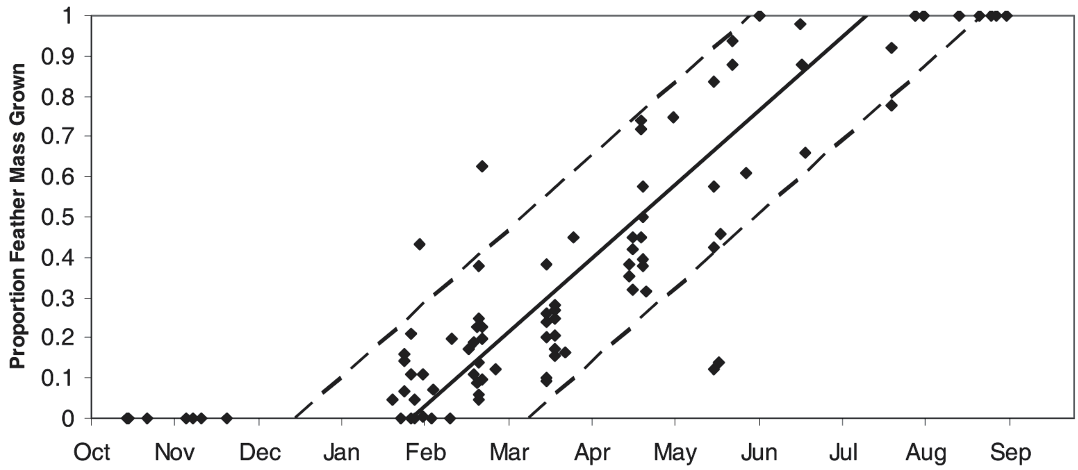

Figure 1: Proportion Feather Mass Grown (PFMG) plotted against date for 142 adult Kelp Gulls in South Africa. The timing of primary moult of the average bird is shown by the solid line, and 95% confidence limits by the dashed lines (Table 1)

Results

Relative feather mass ranged from 4.2% of total primary mass for P1 to 16.5% for P10 (Table 1). Thus P10, the outer primary was nearly four times as heavy as P1, the innermost.

Our sample of adult moult protocols included 40 birds prior to moult (all primaries old), 79 birds in moult and 23 birds which had completed moult (all primaries new) (Fig. 1). The Underhill & Zucchini (1988) moult model identified four birds as outliers: moult protocols 5555551000 on 31 January, 5555555300 on 23 February, 5521000000 on 20 May and 5531000000 on 22 May (Fig. 1, the four markers outside the 95% confidence intervals); the first two of these were unusually early and the second two unusually late. These four records were removed and the moult parameters re-estimated. The duration of moult was estimated to be 168 days or 5.6 months, with 29 January the mean starting date and 16 July the mean date of completion (Table 2). The standard deviation of the mean starting date was 22 days, so that the estimated period during which 95% of birds started to moult was 43 days (= 1.96 × 22) on either side of 29 January (Fig. 1, Table 2).

Of the birds in moult, the majority (60%) were moulting two primaries simultaneously; 25% were moulting one primary and 15% were moulting three. The average number of feathers in moult at one time was 1.9. Birds moulting three primaries were scattered across all stages of moult; there was no correlation between the number of feathers moulting and PFMG for actively moulting birds (r_{71} = –0.056, P = 0.64). On the other hand, the percentage feather mass missing (PFMM) was positively correlated with PFMG (r_{71} = 0.35, P = 0.003; linear regression PFMM = 0.0695 + 0.0223 × PFMG) (Fig. 2). There was a large scatter of values for PFMM towards the end of moult. The largest value for PFMM was 26% for a bird growing its three outer primaries with protocol 5555555421 on 23 April.

Discussion

The Kelp Gull is the third larid for which relative primary feather masses have been determined (Table 1). The results were very similar to those for the Hartlaub's Gull *Larus hartlaubii* (Crawford & Underhill 2003); but differed slightly from the Grey-headed Gull *L. cirrocephalus* which has a slightly more pointed wing shape, as measured by the P10 to P1 ratio (McInnes 2006) (Table 1). The relative primary feather mass of gulls are similar to those of waders (Charadrii), for which P1 and P10 average 4.1% and 17.4% of total primary feather mass, respectively. However, the wing shapes of gulls are not as pointed as those of the Common Tern (*Sterna hirundo*) and Arctic Tern (*S. paradisea*), for which P1 and P10 comprise 2.8% and 21.3% of primary feather mass, respectively; a ratio of 7.6, compared with c. 4 for the waders and gulls (Underhill & Summers 1993; Underhill & Joubert 1995, Table 1). Underhill & Joubert (1995) suggested that species with large P10 to P1 ratios were likely to show extensive seasonal movements. The ratios of the three common gull species in southern Africa are 3.9 for the Kelp and Hartlaub's Gulls, and 4.4 for the Grey-headed Gull, which is by far the most nomadic of the three

Table 1: Mass (mg) of each primary feathers (P) of both wings of two adult Kelp Gulls (KG) from the Western Cape, South Africa. Also given are the estimates of relative feather mass (%) of each primary, and comparative estimates for Hartlaub's Gulls (HG) and Grey-headed Gulls (GHG)

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P Total
Right 1 (g)	247	293	343	414	520	618	697	820	905	951	5808
Left 1 (g)	230	276	324	410	516	582	677	720	899	942	5576
Right 2 (g)	245	295	342	414	521	617	695	819	903	952	5803
Left 2 (g)	246	293	343	415	522	616	695	821	904	953	5808
KG (%)	4.2	5.0	5.9	7.2	9.0	10.6	12.0	13.8	15.7	16.5	
HG (%)[1]	4.1	4.9	5.8	7.2	9.1	10.6	12.3	14.2	15.5	16.2	
GHG (%)[2]	3.8	4.7	5.7	7.0	9.0	10.7	12.1	14.3	15.8	16.8	

[1] (Crawford & Underhill 2003)
[2] (McInnes 2006)

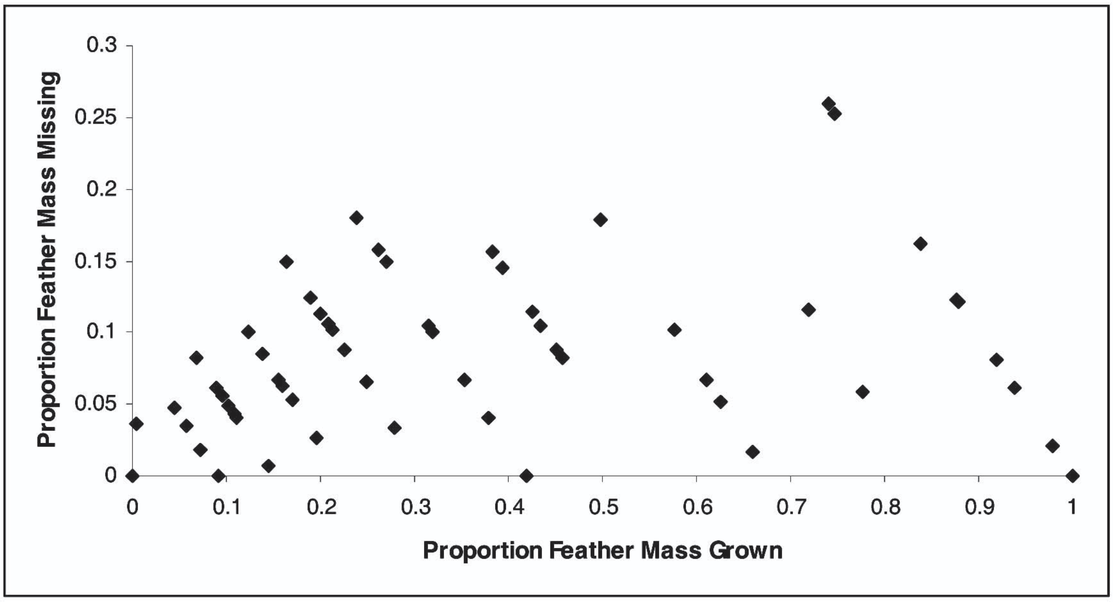

Figure 2: Proportion Feather Mass Missing (PFMM) (see text) plotted against Proportion Feather Mass Grown (PFMG) for moulting adult Kelp Gulls in South Africa. The pattern of lines is a consequence of the way in which moult protocols are recorded

species (Underhill et al. 1999).

Egg-laying in the subspecies *vetula* in Southern Africa is from October to December and most checks fledge in December and January, with stragglers fledging until early March (Williams et al. 1984). The wide 95% confidence intervals surrounding the estimated mean start date (86 days) indicates that primary moult was not synchronized (Table 2). This lack of synchronization of moult probably reflects the lack of synchronization of breeding.

Primary moult started with the smaller inner primaries, which, being small, cost less energy to replace than the outer larger primaries. Because the number of primaries moulted at any one time was consistent throughout the moult, the gap in the primaries (measured as PFMM) was smaller at the start of moult than towards the end. Because the outermost primaries are large (P8–P10 account for 46% of the total primary feather mass, Table 1), it is inevitable that PFMM is larger towards the end of moult than the beginning (Fig. 2). This would be true even if fewer feathers were moulted simultaneously towards the end of moult. This is the first species for which PFMM has been computed and plotted, and more examples are needed to evaluate the insights provided by this concept.

Kinsky (1963) described in qualitative detail the primary moult of the nominate subspecies of Kelp Gull in New Zealand; his results are outlined in Higgins & Davies (1996), suggesting that little new information accumulated over four decades. The description was based largely on small samples of museum specimens. In Kinsky's paper, it is difficult to distinguish results concerning primary moult from the moult of other feather tracts; he explicitly suggested that primary moult lasts on average four months. But his sample sizes were small (12 adult birds between February and June, the main period of primary moult in New Zealand). Qualitatively, he stated that primary moult was first noted in January, but that the majority of individuals commenced the moult February and early March. He stated that primary moult "is completed by July". Curiously, he noted that "Wellington birds" did not complete primary moult "before mid-August, and often somewhat later." His sample sizes in July, August and September were 17 (all in moult), 28 (86% in moult) and 17 (41% in moult), respectively. Presumably, the large samples for these months were mostly from Wellington. Kinsky (1963) noted, in agreement with Dwight (1901), that the "full moult" is completed at the same time as the completion of primary moult. It is possible that he was trying to work as closely as possible to the moult pattern for large southern hemisphere gulls devised by Dwight (1925), the authority on the topic, who considered that primary moult lasted 2.5 months. However, if the Wellington birds are typical, rather than exceptional, then the timing of primary moult of Kelp Gulls in New Zealand appears to be closely similar, both in timing and duration, as primary moult in South Africa.

The only other gull species for which moult parameters have been estimated using the Underhill & Zucchini (1988) moult model are Hartlaub's Gull (Crawford & Underhill 2003) and Grey-headed Gull, for which moult duration were 115 days and 136 days respectively. In order to make a com-

Table 2: Estimates of primary moult parameters for adult Kelp Gulls (KG) in the Western Cape, South Africa. Comparative estimates are given for Hartlaub's Gulls (HG) and Grey-headed Gulls (GHG). Standard deviations (days) are given in parentheses, CI denotes confidence intervals

Species	Mean starting date	Duration	Mean completion date	Std Dev	Starting date 95% CIs	Completion date 95% CIs
KG	29 Jan (4)	168 (8)	16 Jul (6)	22 (2)	17 Dec–13 Mar	3 Jun–28 Aug
HG[1]	11 Oct (6)	115 (10)	3 Feb (6)	32 (3)	9 Aug–7 Dec	2 Dec–7 Apr
GHG[2]	12 Oct (4)	136 (9)	25 Feb (8)	25 (2)	24 Aug–30 Nov	7 Feb–15 May

[1] (Crawford & Underhill 2003)
[2] (McInnes 2006)

prehensive comparison of moult parameters for gulls, a larger sample of gull species, including species from the northern hemisphere, is necessary.

For other gull species, moult parameters have been estimated by a variety of methods, both formal and informal, and only qualitative comparisons are possible. The only available data for another species of large gull in the southern hemisphere appears to be for the Pacific Gull *L. pacificus* in Australia; primary moult of adults is said to span four months within the period January to July (Higgins & Davies 1996). In the northern hemisphere, the moult duration of large gulls is described as c. 4.5 months for Common Gull *L. canus*, between four and six months for Herring Gull *L. argentatus*, 6.7 months for Glaucous Gull *L. hyperboreus*, and 6.2 months for Great Black-backed Gull *L. marinus* (Ginn & Melville 1983). Most of these moult duration estimates are comparable with the 5.6 month period for the Kelp Gull estimated here. Further investigation of gull moult, using the Underhill–Zucchini (1988) moult model, would demonstrate whether there is a latitudinal patterning to duration of moult in large gulls.

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