Short-term oscillations in avian molt intensity: evidence from the golden eagle Aquila chrysaetos

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From a year-long study of molt in the golden eagle Aquila chrysaetos, we recorded 2069 contour feathers replaced in 137 d (6 May–19 September). Very few contour feathers were lost outside this period. From precise daily counts of feathers lost, and using time series analysis, we identified short-term fluctuations (i.e., 19-d subcycles) around a midsummer peak (i.e., a left-skewed normal distribution). Because these subcycles have never before been reported and because the physiological basis for many aspects of avian molt is poorly known, we offer only hypothetical explanations for the controls responsible for the subcycles.

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It is remarkable that there has been only one article ever published documenting the number of feathers a bird loses during a molt (Jollie 1947). Even though Jollie’s collection periods varied from 1 to 5 days, his data provide a reasonable approximation of seasonal trends in feather loss. This paper provides daily counts for the same species, the golden eagle Aquila chrysaetos. Our more precise counts reveal a previously undescribed phenomenon in avian molt.

Some general statements about the procession of body molt in birds (e.g., molt begins with the head) have been published (see review of raptor molt in Ferguson-Lees and Christie 2001), but molt studies, by and large, do not give quantitative data on body molt and deal quantitatively only with flight feathers (e.g., Edelstam 1984, Bloom and Clark 2001). Other studies treat the effects of artificial hormone regimes on molt (Payne 1972), but as stated succinctly by Payne (1972:146), and still true today, “If there is a common scheme among birds for the physiological control of molt, no one has come close to finding it.”

Many studies are available of the general progress of remige molt based on “molt card” data taken from one time handling of many individuals of some species of passerines (Ginn and Melville 1983). Murphy and King (1992) took a different tack: they quantified the mass of feathers and other surface materials lost daily through the molt. Dolnik and Gavrilov (1979) quantified protein drain during chaffinch Fringilla coelebs molt. Of course studies, wherein data from many birds are pooled, have little chance of detecting short-term trends in the individual.

Methods

For this study, we collected contour feathers daily throughout the 2000 molt and for half of the 2001 molt of an adult female eagle. We classified feathers by topographic region. Jollie’s methods (1947) are not given in detail, but he stated (pers. comm. 28 March 2001) that he did not count downy feathers. We counted down but found that accurate counts were possible only on calm, dry days. Also, down is lost in moderate numbers even in winter. Because of these differences, we will present down results elsewhere.

In a study like this, investigators face a dilemma. If the study bird is placed indoors without sun, rain, and wind, even tiny feathers can be found readily, but molt may be aberrant due to environmental influences. If placed outdoors, tiny feathers may be lost. Our decision was to house the bird outdoors and twice (or more often) daily (but at least at sun up and dusk) search the lawn-covered 80 m² pen. Because we did not find all tiny
contours of the face, we deleted from our counts all dark contours <27 mm in length and all pale contours <20 mm in length. As such, a complete count must be adjusted upward to include these feathers which, from close inspection of the head, were completely molted each year. Also not counted were feathers lost (aborted) while growing (n=3, or <0.1% of the molt).

The bird was taken as a nestling about 1960 in Montana and held in the Red Lodge Zoo (45°N, 109°W), Montana. The study was conducted in 2000 and 2001 near Oracle, Arizona (33°N, 111°W), at 1390 m elevation where the bird resided since July 1995. Because reproduction is known to impair molt (Ginn and Melville 1983, Edelstam 1984, Hahn et al. 1992, Espie et al. 1996), we postponed the study until after 1995 when the bird ceased egg laying. The bird was extremely tame, well adjusted to captivity, fed ad libitum, healthy (Ellis and Kéry 2004), and appeared to molt normally.

To study trends in the 2000 data, but not in the incomplete 2001 data, we employed time series analyses (SAS version 8.02). A third order polynomial was first fitted to the data to remove long-term trends. Residual deviances from this model output were then tested for autocorrelation.

Results

In Fig. 1, we find the same mid-July peak found by Jollie (1947). However, our more precise (i.e., daily) counts strongly suggest peaks around Julian days 165, 184, 203, and 222 and hint at lesser peaks earlier and later. To test if these were periodic cycles, we detrended the data by fitting a third order polynomial (Fig. 1A). The autocorrelation function of the residual deviances (Fig. 1B) clearly showed evidence of a cyclic pattern with a period of 19 days. There were significant positive correlations at days 1–3 and 17–22, and significant negative correlations at days 7–13 and 27–32.

Discussion

Golden eagle feather counts present a left-skewed, bell-shaped curve centered at midsummer and with great, but non-random, variation around the mean. Four subcycles are clearly evident. Time-series analyses showed that these oscillation are regular and 19 days in length. In Jollie’s data (1947), the subcycles were somewhat masked because of less frequent (i.e., non-daily) counts, yet two or more oscillations are evident.

Inasmuch as the existence of subcycles in molt was unknown until this study, we can only speculate as to their physiological basis. One possible explanation of the subcycles is that they are artifacts derived from having our data based on feather numbers rather than feather mass. However, molt dates for the 31 heaviest feathers (i.e., primaries, secondaries, tertaries, rectrices, and stiff scapulars) by and large coincided with peaks in molt, not valleys, so a treatment of feather loss based on daily mass (vs. our daily counts) should show the same cyclicity seen in Fig. 1A.

Another hypothetical explanation for our subcycles is that a controlling hormone is also produced with a midsummer peak and subcycles paralleling feather loss. Alternately the ultimate mechanism may be the instantaneous protein requirement (the mass of protein [or of sulfur amino acids] that must be laid down daily to replace feathers lost on previous days). This logic suggests that, when the protein requirement approaches protein delivery...
capability. Also, the complex workings of the vascular net surrounding the feathers may somehow explain the periodicity in feather loss. It is known that, at least in some situations, feathers adjacent to a recently molted feather are retained until the new feather is partly grown (Payne 1972:106).

It was not the purpose of this study to quantify daily values for hormone levels, protein loss, or protein requirements, but the need for such work is suggested by the subcycles we identified. Attempts to demonstrate trends in protein requirements (e.g., Dolnick and Gavrilov 1979, Murphy and King 1992) and primary feather mass (Underhill and Summers 1993) have been published, but only studies which, like ours, involve frequent sampling and independent treatment of data from individual birds are likely to identify short-term cycles like we found in contour molt. The only study, of which we are aware, that demonstrates periodicity anything like what we found is Bairlein’s (1986) report that body weight in two individuals of one species of warbler followed semi-monthly cycles. Future work should focus on documenting, in individuals of other species, the presence or absence of subcycles like we found in the golden eagle and in providing physiological explanations of the same.

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References


