PRIMARY MOLT IN *CIRCUS CYANEUS* IN RELATION TO NEST BROOD EVENTS

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A number of authors have suggested a close relationship between molt and nest brood events (Welty 1962: 382; Stresemann and Stresemann 1966: 325; Voitkevich 1966: 229). To explore this relationship in hawks we analyzed molt records collected during an intensive Marsh Hawk (*Circus cyaneus hudsonius*) study conducted on a 40,000 acre (16,000 ha) tract in central Wisconsin (Hamerstrom 1969) from 1959 through 1973. The Marsh Hawk seems an ideal species for studying the relationship between molt and nest brood events because it exhibits a wide range of hatch dates, and renesting is rare or nonexistent.

METHODS

Hamerstrom (1963) trapped 163 breeding Marsh Hawks near nests and recorded molt on cards (Hamerstrom and Hamerstrom 1971). The usual procedure was to stay away from nests until after the hatch to avoid disturbance. Therefore we do not know the actual hatch date in most cases, but have estimated chick ages on the basis of the length of primary four, using a scale Frances Hamerstrom (MS) developed. In this way the respective hatch date of each nest was recorded as the hatch date with nest brood events for 112 breeding adults (66 females and 46 males). Only breeding birds were included in the analysis in order to deal with a geographically homogenous population; spring and fall migrants are thus excluded. As trapping depends on nest defense, our last dates are largely determined by the fledging of the young, which occurs before the adult wing is fully molted. One breeding adult that showed gunshot scars and was retarded in molt was excluded from the sample.

RESULTS AND DISCUSSION

All Marsh Hawks in our sample molted their primaries from the wrist outward, supporting the findings of Stresemann and Stresemann (1960: 396). This sequence of molt has been reported for one adult captive female Pallid Harrier (*Circus macrourus*) but activating mechanisms were not studied (Piechocki 1955).

Fig. 1 shows the stage of molt of breeding adult Marsh Hawks' primaries on their respective capture dates. Breeding subadult females are also included.

The stage of molt is defined as the sum of the growth of all new primaries, giving each fully grown new feather 10 points and 1 point for each 10th of partial growth. For example, a bird with the first four primaries fully grown and the fifth half grown receives a molt sum of 45. If

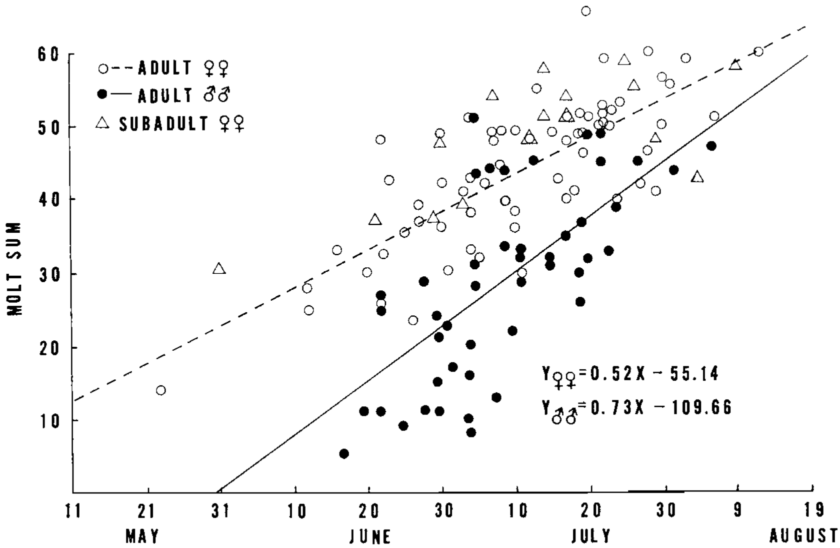

Fig. 1. Molt of breeding adult and breeding female subadult Marsh Hawks in relation to date. Each symbol denotes the molt sum of a single bird. Molt sum equals 10 points for each fully grown new feather plus 1 point for each 10th of partial growth. The Pearson product moment correlation was used in the analysis.

the molt had not progressed equally in both wings, we used an average of the two sums. If all the birds in the sample had progressed uniformly farther in molt at progressively later capture dates, a correlation coefficient of one or perfect correlation would have occurred.

The stage of molt is significantly correlated with time of year (r = 0.77 for females and r = 0.65 for males, $P < 0.01$) although variation occurred (standard error of the estimate is 6.43 for females and 10.03 for males). The high correlation between molt and calendar date indicates that some factor associated with time of year, such as day length, is a significant activator of Marsh Hawk molt.

In this study, we consistently treated males and females separately for the following reasons. First, males begin molt later than females as Fig. 1 shows. Second, males molt at a faster rate. The slopes of the regression lines in Fig. 1 indicate the average rates of molt. The slope for the females is 0.52 and for the males is 0.73. If these rates remain constant the males overtake the females.

We caught 16 breeding subadult females and three breeding subadult males. As Fig. 1 shows the subadult females vary only slightly from the adult females in stage of molt.

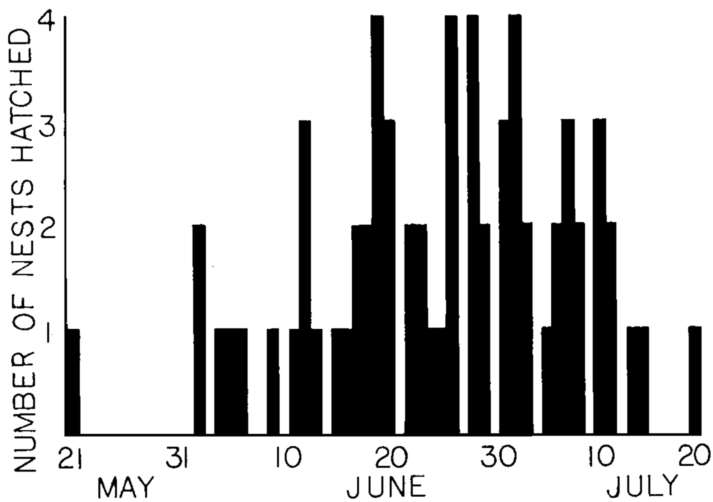

Fig. 2. Distribution of Marsh Hawk hatch dates during the breeding season.

As the correlation between molt and capture date was not perfect, we studied the possible relationship of nest brood events, such as hatch date, with molt. The wide range of hatch dates on the study tract is shown in Fig. 2. If hatch date were a principal activator of molt, a high correlation between molt and hatch date should be apparent. Fig. 3 shows the stages of molt of the adults in relation to the days after hatching of their young. The correlation between molt and days after hatch is low and indicates that events directly related to the incubation period do not play a significant role in activating the molt ($r = 0.22$ for females and $r = 0.01$ for males, $P > 0.05$, standard error of the estimate is 9.86 for females and 13.26 for males). The discrepancy between males and females in the above results may be explained by cases of polygyny (Hamerstrom 1969).

These results led us to believe that more than one factor may be involved in activating molt. By adding hatch date as a second variable some of the individual differences among birds may be explained. A multiple correlation between molt, date, and days after hatch yields a correlation coefficient of 0.78 for the females, an increase of less than 0.01 over the simple correlation between molt and date. The multiple correlation for the males is 0.67, an increase of 0.02. The correlation involving hatch date cannot be given as much significance for the males because of the occasional polygyny. It is plain that hatch date plays no significant part in activating molt.

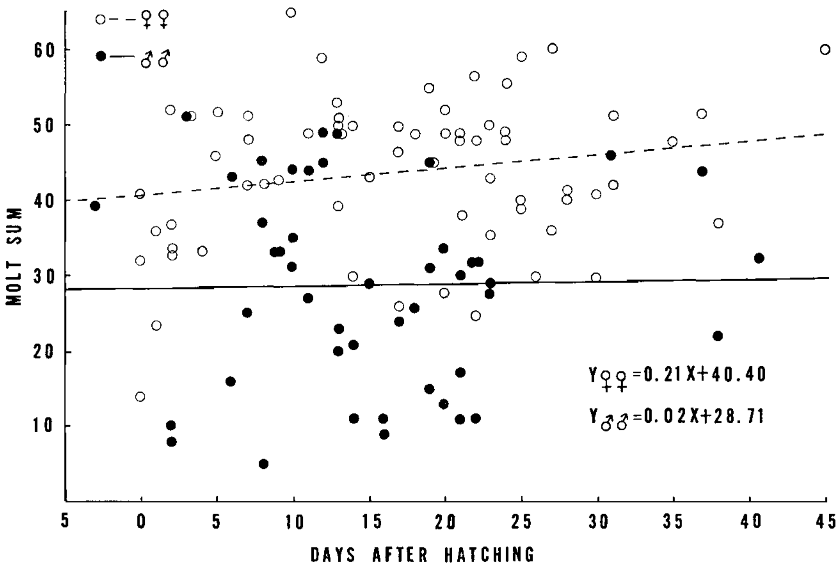

Fig. 3. Molt of breeding adult Marsh Hawks in relation to days after hatching of the first egg. Each symbol denotes the molt sum (see Fig. 1) of a single bird.

In order to explore further the significance of nest brood events in activating molt, we studied the possible effect of the number of young. Our basic assumption was that a pair of Marsh Hawks that had to supply food to a larger number of young would molt more slowly because of added stress. It is difficult to standardize the amount of stress on the parent involved in the raising of young because of variation in food supply and hunting experience. In addition, a bird that hatched four young and lost two shortly before fledging underwent more stress than a bird that had only two young throughout the fledging period. As we had no means of computing death dates of the young, only those raised to fledging were considered. We again used a multiple correlation to find the importance of the number of young fledged as a third variable. The correlation between molt, date, and the number of young fledged is 0.77 for the females, an increases of less than 0.01 over the simple correlation between molt and capture date. The correlation for the males is 0.65, no increase. Thus if number of young plays any role in activating molt, it is a minor one.

At this point we shifted our attention from factors affecting the beginning of molt to factors affecting the progression of molt. We found more feathers growing simultaneously during the early part of the primary molt than is the case later on (Fig. 4). For example, while primary

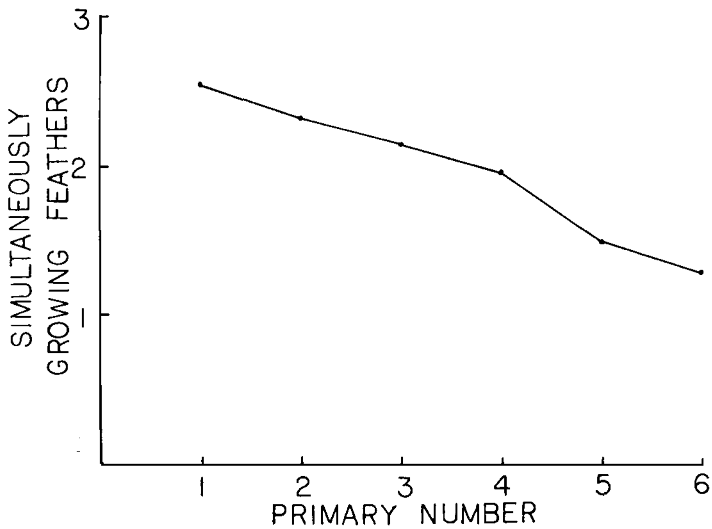

Fig. 4. Number of simultaneously growing primaries as primary molt progresses.

one is growing, primary two is commonly also incoming and sometimes even primary three; the average number of growing primaries is 2.4. Very few nests have hatched by this time. At the other extreme when primary six (the last in our series) is growing, we never found more than one other primary coming in at the same time (primary five) and that only occasionally; the average number growing is 1.4. The simultaneous molt of several primaries makes a gap in the wing that becomes smaller as molt progresses toward the wingtip. This arrangement would seem to fit the Marsh Hawk's seasonal energy budget well, for an adult could better afford to grow several feathers at once early in the season, before the young have hatched and added their demands. Similarly, a smaller gap would give the bird more efficiency in flight later in the season when the adults are hunting for their young as well as for themselves.

Acknowledgments

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SUMMARY

A study of 112 breeding adult Marsh Hawks in central Wisconsin from 1959 through 1973 revealed a high correlation between date and primary molt. We found no significant correlation between primary molt and such nest brood events as hatch date and the number of young fledged. Breeding males begin primary molt later than breeding females but proceed at a faster rate. Both sexes have more primaries incoming at once and thus a larger gap in the wing in the early part of the molt sequence than later.

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