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ANNUAL MOLT PATTERN IN A MALAYSIAN POPULATION OF FANTAIL WARBLERS (*CISTICOLA JUNCIDIS*)

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ABSTRACT.—During a two-year study in Malaysia, I recorded molt in 117 adult Fantail Warblers (*Cisticola juncidis*) to examine the annual molt pattern in relation to the population's breeding seasons. Adult male warblers that were molting primaries were recorded only during January, September, and October, while females in primary molt were recorded in every month except July. Molt in the secondaries, rectrices, and head and body followed similar schedules. There appears to be just one molt annually, unlike the pattern in most other parts of the species' range. Adult male warblers begin to molt synchronously at the end of the summer breeding season; most complete their primary molt before territory establishment and courtship activity in the winter breeding season. The females' postbreeding molt is less synchronous because many females in this polygynous population are caring for fledglings weeks after males stop breeding. Thus, many female birds enter the winter breeding season still in molt. Rather than risk losing a breeding opportunity, these birds apparently delay, or interrupt, their molt to begin breeding, and then complete molting after the winter breeding season. The flexible molt schedule of birds in this population is a facultative response to the seasonal availability of nesting cover and food, and enables the warblers to exploit valuable, brief opportunities for breeding.

Most birds do not molt and breed simultaneously (Snow and Snow 1964, Payne 1972). Overlap between molt and breeding has been recorded, however, in individuals of at least 121 tropical land bird species (Foster 1975). These events may overlap when birds take advantage of brief but valuable opportunities for breeding, otherwise lost. Thus, when conditions become suitable for nesting, a molting bird either (1) slows the rate of molt so that reproduction and molt can proceed simultaneously (e.g., Jones 1978), or (2) interrupts the molt altogether, breeds, and then resumes molting after breeding (e.g., Fogden and Fogden 1979).

Ideally, molt-breeding overlap should be demonstrated by successive examinations of individuals during a single molting period, but this is seldom accomplished. Usually, birds are either collected or recaptured too infrequently to distinguish between possibilities (1) and (2) above, so both types of situations are considered examples of molt-breeding overlap (Foster 1975). Fogden and Fogden's (1979) study is exceptional in this respect. By recapturing individuals within a single molt period, they showed that the Grey-backed Camaroptera (*Camaroptera brevicaudata*), a sylviine warbler in equatorial Uganda, interrupts its molt when breeding conditions arise and resumes molting after breeding.

Throughout most of its range, the Fantail Warbler (*Cisticola juncidis*) has one complete, postnuptial molt and one incomplete (everything but the remiges and rectrices) winter molt annually (Lynes 1930). However, in parts of equatorial Africa where there are two discrete rainy seasons and, hence, two periods of breeding, *C. j. perennia* has just a single, complete molt annually. Where the two rainy periods merge into one, the populations molt twice (Lynes 1930). Because the population of Fantail Warblers I studied in Malaysia also has two distinct breeding seasons annually (Avery 1982), I wanted to determine if the annual molt schedule was similar to that reported for the African subspecies, and also to examine the possibility of molt-breeding overlap in individual birds.

STUDY SITE AND METHODS

I conducted this study on the 14-ha Rice Research Center of the Malaysian Agricultural Research and Development Institute at Bumbong Lima in northwestern peninsular Malaysia. Two rice crops are grown annually, with harvests during March–April and September–October. The breeding seasons of the warblers (January–March and June–September) are determined by the availability of young rice plants in which the birds nest (Avery 1982).

I mist-netted, banded, and released birds throughout the study period (April, 1975–March, 1977). For 117 adult warblers, the presence or absence of molt on the head and body was noted, and the individual numbers of the molting remiges and rectrices were recorded. All ensheathed feathers were assumed

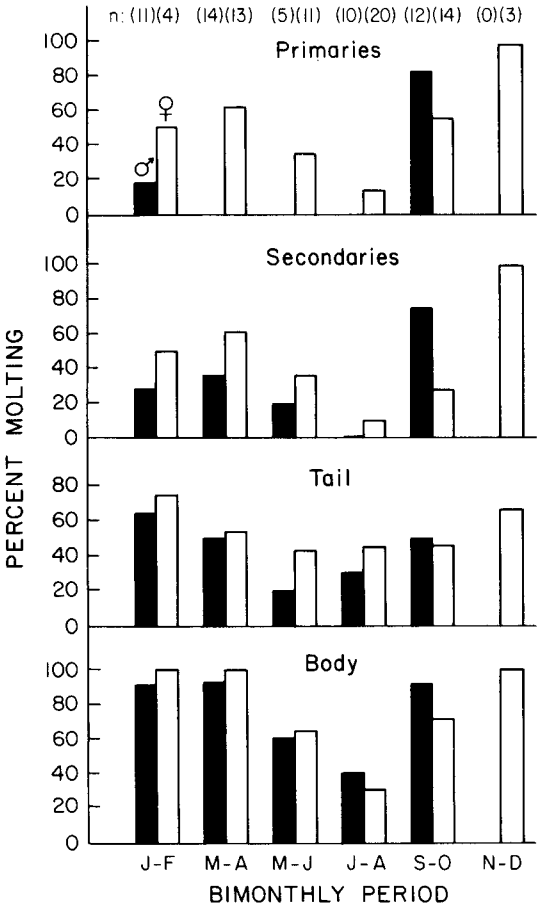

FIGURE 1. Percent of molting adult male and female Fantail Warblers in bimonthly mist net samples.

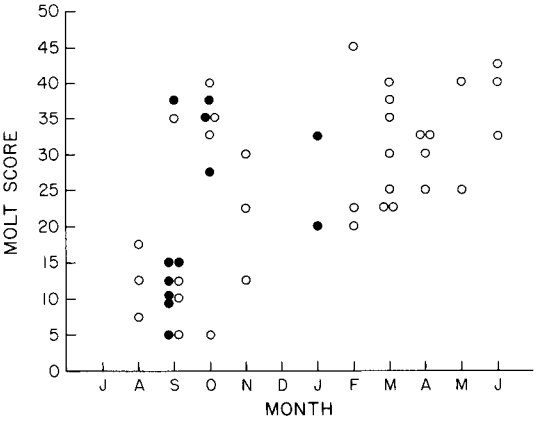

FIGURE 2. Primary molt scores of 12 adult male (●) and 33 adult female (○) Fantail Warblers from Bumbong Lima, Malaysia.

to be actively molting. Molt scores for primary remiges were calculated using a modification of the standard five-point scale (Newton 1966). I scored all molting primaries as 2.5, all primaries proximal to the molting ones as 5, and those distal as 0. The resulting scores were then plotted against month of capture to examine the timing of the primary remex molt relative to this population's breeding seasons.

All birds with a yellowish tinge on the feathers of the breast and abdomen were called "immatures" (Chasen 1939) and were excluded from the analyses. Adult males were identified by the presence of a dark brown, unstreaked crown, conspicuous pale "mirrors" on the tips of the central rectrices, and a black mouth lining. Adult females have a streaked crown, no tail mirrors, and a flesh-colored or dusky mouth lining (Chasen 1939). I checked the reliability of this aging/sexing technique by collecting 16 birds from a nearby site. Examination of the gonads and skulls verified that each of the birds (nine adult females, three adult males, and four immatures) was correctly classified using the above criteria.

Analysis of variance was used to test for differences in weights among adult birds with and without molt, during breeding and nonbreeding seasons.

RESULTS

Adult males were mist-netted in each month except November and December; females were absent from the sample in January and December. Males molting primaries were recorded only in January, September, and October. None of the 37 males caught during February through August was in primary molt. Adult females in primary molt were recorded in every month except July.

Variation in the incidence of secondary molt followed the same general seasonal pattern as the primaries (Fig. 1). The sexes differed little in molt of the rectrices or head and body feathers. The percentage of molting males consistently exceeded that of the females in the September–October period, but, with a single exception (head and body molt during July–August), the percentage of molting females was greater than that of the males at all other times.

With one exception, primaries 1–3 were not molting in any adult warbler before August (Fig. 2). During August and September, most of the birds I examined were molting the first three or four primaries. At other times, primary molt was concentrated in primaries five through ten.

DISCUSSION

The male warbler's role in the polygynous population at Bumbong Lima is largely limited to territory acquisition and courtship (Avery 1982). Males also construct the outer framework of the nests, but they do not incubate, brood, or feed the young. They perform virtually all territorial, courtship, and precopu-

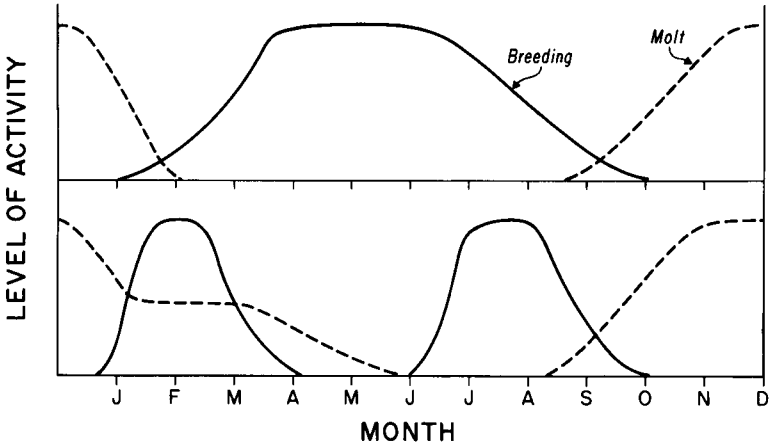

FIGURE 3. Possible patterns of molt and breeding activity by female Fantail Warblers having one extended nesting season (top) or two shorter nesting seasons (bottom) annually.

latory behaviors while airborne (Givens and Hitchcock 1953, Motai 1973, pers. observ.). In contrast, females are inconspicuous and secretive, and make short, low-level flights when going to and from the nest site for nest material or food.

In order to perform the various aerial displays efficiently and compete with other males for access to females, it seems essential that a male warbler possess a fully grown complement of primaries. Because of the polygynous mating system in this population, males that are delayed at the start of the breeding season by lingering molt might forfeit their chance of gaining a territory and so lose an entire breeding season. Thus, there is probably substantial selection pressure on adult males to complete the primary molt before the winter breeding season begins in December–January. The synchronous increase in molting adult males in September–October (Fig. 1) corresponds with the end of male participation in the breeding effort. I observed no male courtship displays or new nest initiation after mid-August.

For many nesting females, however, the summer breeding season extends into September or October, until their fledglings reach independence. The asynchronous initiation of postnuptial molt among the adult females (Fig. 1) reflects the range of observed fledging dates (21 July–1 September). Thus, many females may not begin their molt until 4–6 weeks after the males. Consequently, the winter breeding begins while most female warblers are still in the later stages of their primary molt (Figs. 1 and 2).

In parts of the Malay Peninsula where rice cultivation is absent or not intense, the Fantail Warbler breeding season probably extends continuously from about February to September (Gibson-Hill 1950, Medway and Wells 1976). In these areas, there may be little pressure on the females to begin breeding before completing their molt. Even a month's delay would leave sufficient time to raise one or two broods before the onset of the lean season in late summer (Ward 1969, Fogden 1972), and little overlap between molt and breeding would be expected (Fig. 3).

At Bumbong Lima, however, a delay to complete the molt at the start of the winter breeding season would seriously jeopardize a female's chance of successfully nesting that season, as late nests in this population are less successful than early nests (Avery 1982). Thus, a female breeds, and the rate of molt is slowed or interrupted until after the winter breeding season (Fig. 3). A reduced rate of molt lessens the daily metabolic cost of producing feathers, and molt and reproduction can proceed simultaneously (Payne 1972, Jones 1978).

Females in the later stages of primary molt were recorded through June (Fig. 2). Had these birds molted without interruption, they would have finished months earlier and no molting females would have been recorded during the April–June period. But, because I did not capture any molting females twice during the spring breeding season, I cannot say whether the protracted molting period was due to an interrupted molt or simply a reduction in its rate. I found no difference in body weights with molt condition ($P > 0.50$) or breeding season ($P > 0.10$), which suggests that sufficient food was available to breed and molt concurrently. This contrasts to the situation in Sarawak, where Fodgen (1972) found insectivorous birds lost weight owing to the demands of reproduction, remained low during the protracted molt, and recovered fully only when food once again became abundant.

My findings suggest that Fantail Warblers

are capable of responding facultatively to environmental conditions favorable for breeding. Although the nesting seasons are shortened and strictly limited by the rice-growing practices, the birds' flexible molt schedules permit them to take advantage of the two breeding opportunities annually. The molt schedule in this population appears to be similar to that of the *perrennia* subspecies in Africa, where it also has two distinct breeding seasons. This pattern may hold elsewhere in the species' range (e.g., in India, where double-cropping of rice is common), but I know of no comparative data.

It seems unlikely that a single annual molt is genetically fixed in this population because the double-cropping of rice (and, hence, double breeding seasons) in this area is relatively recent (30–40 years). Rather, flexibility in the molt schedules is probably a characteristic of the species that may be manifested whenever breeding opportunities arise. Interrupted molt has been recorded in Fantail Warblers on Malta (Gauci and Sultana 1981), and as more populations are studied, the extent of the species' ability to adjust its molt pattern to breed opportunistically will become clearer.

Relationships between molt and breeding seasons such as those described here may be regarded as special cases of a general model that views molt-breeding overlap (including interrupted molt) as an adaptation to prolong the breeding season (Foster 1974). By interrupting or slowing their molt, these birds maximize their reproductive effort during short-lived, perhaps unpredictable, breeding opportunities. In this way, energy and nutrients needed for molting are not siphoned off at the expense of reproduction.

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