DIET AND BREEDING SEASONALITY AMONG A POPULATION OF SHARP-TAILED MUNIAS, *LONCHURA STRIATA*, IN MALAYSIA

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ABSTRACT.—From April 1975 through March 1977, the food habits and breeding seasonality of a population of Sharp-tailed Munias (*Lonchura striata*) were studied in northwestern peninsular Malaysia. The abundance of munias on the study area varied in accordance with the 6-month rice-growing cycle there. The population peaked in March and September when juvenile birds were most numerous and when rice was most plentiful. Field observations and stomach analyses showed that the munias ate rice and the green filamentous alga, *Spirogyra,* almost exclusively. The primary periods of algae eating occurred in January and June–August, coinciding with the munias' two peak periods of reproductive activity, as determined by gonadal examination. Apparently munias on the study area ate *Spirogyra* as a source of protein to enable them to become physiologically ready for breeding, much as other tropical bird species eat insects. Thus, unlike other species, Sharp-tailed Munias' breeding seasonality is determined by manmade cycles of rice cultivation rather than by natural cycles of rain and insect abundance. *Received 25 June 1979, accepted 9 October 1979.*

THE Sharp-tailed Munia (*Lonchura striata*) is a small (10–12 g), rather nondescript estrildid distributed from India through Indochina to the Malay Peninsula and Sumatra. In Malaysia it is one of several bird species that regularly causes considerable damage to the rice crop. In lowland rice-growing regions, this species is very abundant and nests in close association with humans, favoring small fruit trees and garden shrubs as nest sites. The species is monogamous and both parents share in the nesting duties (Avery 1978). Sharp-tailed Munias are not restricted to the lowlands; they also frequent scrub, orchards, plantations, river banks, roadsides, forest trails, and jungle clearings, ranging from sea level to elevations of 2,000 m (Medway and Wells 1976).

The purpose of this study was to examine the food habits and time of breeding among Sharp-tailed Munias in relation to local rice-growing practices. I know of no previous field studies of this species, although a domesticated race, the Bengalese Finch, has been studied extensively in captivity (e.g. Eisner 1960, 1963; Slater 1967; Suzuki 1977). Wells (1966) examined the molt and gonadal cycles of three other Malaysian species of *Lonchura* and concluded that they have adopted a nomadic, opportunistic breeding strategy that ensures at least part of the population is ready to breed whenever environmental conditions permit. The results presented here suggest that the population of *L. striata* I studied was sedentary, had two distinct breeding seasons annually that coincided with local rice seasons, and exploited periodic blooms of protein-rich algae to supplement the breeding season diet.

STUDY AREA AND METHODS

The main study area consisted of 14 1-ha experimental plots at the Rice Research Center of the Malaysian Agricultural Research and Development Institute at Bumbong Lima, Northern Province

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 The Auk 97: 160–166. January 1980

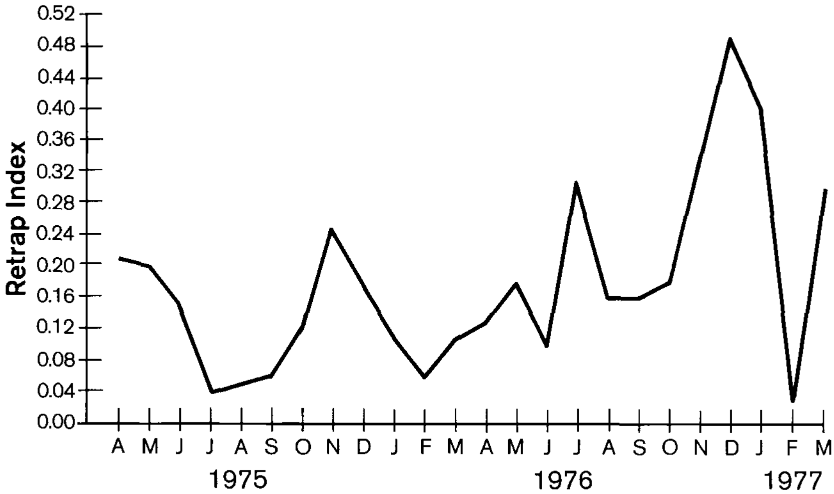

Fig. 1. Monthly retrap index values for Sharp-tailed Munias at Bumbong Lima, April 1975–March 1977.

Wellesley (5°33′N, 100°28′E). Bumbong Lima is in one of the most productive rice-growing regions of Malaysia, and much of the land is irrigated so that two rice crops are harvested annually; nonirrigated areas are single-cropped. Planting is not synchronous within the region, and harvesting occurs during extended periods (primarily February–April and August–October). There are only short periods when rice is not present in fields within about 20 km of the study site.

I mistnetted birds on 295 days between 12 April 1975 and 12 March 1977. Each bird was fitted with a numbered aluminum band, and various measurements were taken prior to release. More than 250 birds were retained and dissected to determine sex, gonadal condition, and stomach contents. The diameter of the largest ovarian follicle or ovum of each female and the length and breadth of each male's left testis were recorded. Females with an ovum or follicle at least 6 mm in diameter were considered to be in breeding condition. This standard was selected because it occurred at a break in the range of measurements recorded and was about 50% the size of the largest mature follicle measured. Testis volume was calculated according to the formula $V = \pi ab^2$, where a is the length and b is the breadth of the testis. Based on Wells' (1966) findings, I considered testes of at least 19 mm^3 to be spermatogenic.

The frequency of occurrence of food items was determined with a 10–37.5× binocular microscope. This method was used primarily out of necessity. Although weight or volumetric data would have been preferable, there were neither facilities nor personnel available to perform such analyses. The birds were not dissected immediately after collection, so a potential bias in the data may exist due to differential postmortem digestion rates for various food items.

Three times weekly, from July 1975 to March 1977, counts of birds were made along a transect through the study area. All birds were counted, and the location, size, and activity of each group of munias were recorded. The counts were made between 0730 and 0930 using 7 × 35 binoculars. Each month from September 1975 through February 1977 the availability of standing rice on the study area was assessed by estimating within each 1-ha plot the percentage of the area covered by green (unripe) and brown (ripe) rice. Throughout the paper, I use the term "munias" to refer to *L. striata* only.

Results and Discussion

Banding data and munia abundance.—During the study, 1,787 munias were trapped, banded, and released; subsequent retraps on the study area numbered 250 (217 individuals). The day-to-day netting intensity was not constant, so comparisons of netting results between months cannot be made. It is useful, however, to examine the ratio of retrapped birds to newly banded ones in each month's total (the retrap index) for an indication of the degree of turnover in the population. Despite sub-

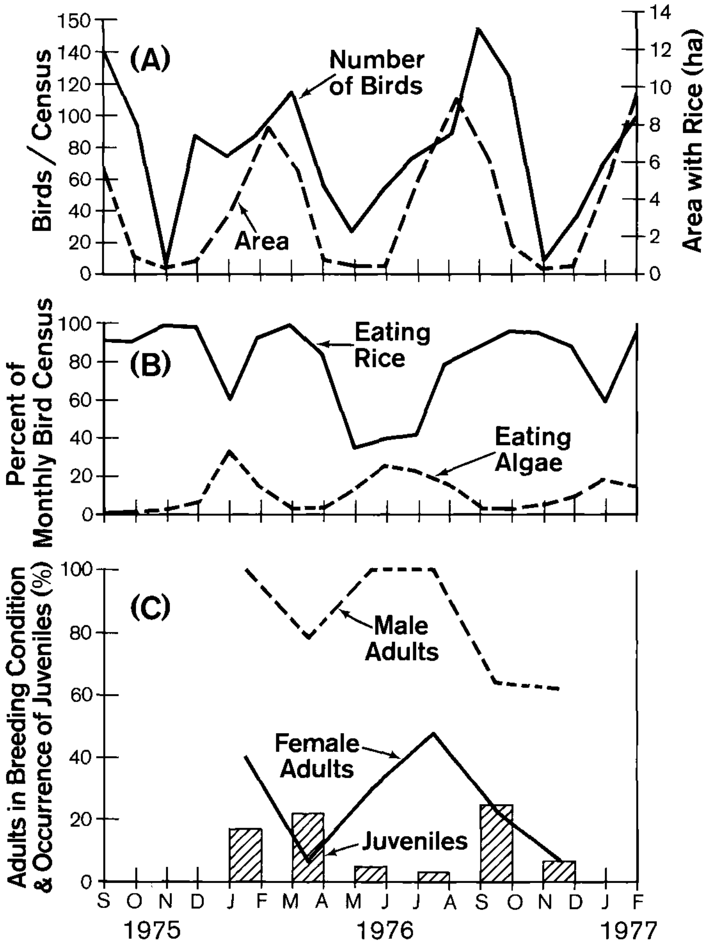

Fig. 2. Patterns of (A) Sharp-tailed Munia presence and rice availability, (B) Sharp-tailed Munia feeding activity in the field, and (C) male and female breeding condition and occurrence of juveniles in the mistnet catches at Bumbong Lima, 1975–1977.

stantial month-to-month variation, there was an overall upward trend in the retrap index during the course of the study (Fig. 1), indicating that an increasing proportion of the Bumbong Lima population was banded and was returning to the study area. The overall retrap index value was 0.13. The relatively low retrap index values (February, June–September) corresponded to times when numerous unbanded juveniles entered the population, while the peaks (April–May, November–December) occurred generally when little rice was available on the study area and most of the population had dispersed.

The interval between the banding and retrap dates for individual birds ranged from 1 day to 21 months. Nearly half (119) of the retraps were recorded at intervals greater than 3 months from the banding date. The birds retrapped in any one month always displayed a wide range of banding-to-retrap intervals. For example, 6 of the 22 retraps in December 1976 were banded earlier that month, but 2 others were from April 1975 and 4 were from March 1976. There were 11 confirmed recoveries

TABLE 1. Proportions of adult Sharp-tailed Munias containing various food items—Bumbong Lima, 1975–1976.

	Bimonthly period						
Food item	Jan–Feb	Mar–Apr	May–Jun	Jul–Aug	Sep–Oct	Nov–Dec	Total
Rice							
Males	0.92	1.00	0.82	0.76	1.00	1.00	0.89
Females	0.86	1.00	0.69	0.91	1.00	0.91	0.87
Algae							
Males	0.42	0.29	0.27	0.38	0.17	0	0.30
Females	0.29	0.14	0.56	0.68	0.42	0	0.40
Grass seeds							
Males	0	0.14	0.09	0.05	0.17	0	0.07
Females	0	0	0.06	0	0.17	0.09	0.06
Number examined							
Males	12	14	11	21	6	9	73
Females	7	14	16	22	12	11	82

of banded birds outside the study area, all within about 10 km. In addition, one bird was reportedly caught 65 km from the study area, but this could not be confirmed. There were several instances of birds that were banded in the same week being retrapped within a week of each other up to 7 months later, indicating some constancy in the composition of the population. These data, and previously published results (Avery 1978), support the belief that this species is generally quite sedentary.

Field counts of munias revealed a regular 6-month cycle closely following the pattern of rice availability (Fig. 2A). Peak numbers of munias were recorded in March and September (largely due to the addition of juveniles), with minimum numbers occurring in May and November. Rice was most plentiful in February and August and was scarce during April–June and October–December, when most of the population dispersed to other areas.

Food habits.—On a monthly basis, from 40% to 98% of the munias counted in the field were eating rice. Filamentous green algae, *Spirogyra* sp., was the only other food item of consequence recorded (Fig. 2B). The occurrence of *Spirogyra* was not quantified, but its presence in the drainage ditches and rice plots was related to the rice-planting regime. It became abundant during the early stages of the rice cycle following fertilizer applications and was available in varying amounts on the study area throughout the season until the fields were drained in preparation for harvest. Munias often fed on *Spirogyra* when rice was readily available.

Results of stomach analyses largely confirmed the field observations. Rice was found in 88% of the stomachs; *Spirogyra* in 35%. Grass or sedge seeds were recorded in only 6% of the birds. Algae was eaten mainly in January and during June–August, preceding times of peak rice abundance (Table 1, Fig. 2). Although the sexes exhibited some differences in their month-to-month and overall consumption patterns (Table 1), these were not statistically significant ($P > 0.5$).

It is conceivable that the munias ingested animal matter that was undetected in my stomach analysis because of rapid postmortem digestion. This may apply especially to microinvertebrates during the birds' periods of algae eating. I examined with the dissecting microscope several samples of algae taken from the birds' feeding areas, however, and found that only a few microinvertebrates were present, perhaps because of the liberal pesticide applications in the fields. Furthermore, numerous close-range observations of the birds' feeding behavior revealed no incidence of insectivory.

Reports of algae eating among passerines are few. Woodall (1975) found that various grass seeds and termites were the main food items of the *Lonchura cucullata* he studied, but he did observe some birds eating filamentous algae (possibly *Spirogyra*) from a small pond. Pillai (1968) observed *L. striata* eating *Spirogyra* in India, and Digioia (1974) watched a group of American Goldfinches (*Carduelis tristis*) eating *Spirogyra porticallis* "with great relish," but no details or discussion are given in either report.

Breeding seasonality.—Seasonal breeding activity was examined via three methods: gonadal condition, the presence of juvenile birds, and field observations of nesting activity.

Among 138 adult-plumaged female munias, those in breeding condition occurred primarily during January–February, May–June, and July–August (Fig. 2C). This distribution was not random ($P < 0.05$, $\chi^2 = 12.94$, 5 df). Male reproductive activity followed a similar pattern, although the distribution was not statistically different from that expected by chance ($P > 0.1$, $\chi^2 = 5.51$, 5 df). All males collected during January–February, May–June, and July–August were in breeding condition, while at other times 62–78% of the males possessed testes that were presumably spermatogenic (Fig. 2C). There were apparently always some males in breeding condition in the population. Wells (1966) reached similar conclusions regarding the species of *Lonchura* he studied, and Voous (1950) noted that the same held true for *Padda oryzivora* in Indonesia.

Sharp-tailed Munias have a distinctive juvenal plumage that persists until about 3 months of age (Eisner 1960). The proportion of juveniles in the mistnet catches was highest during January–April and September–October (Fig. 2C). In other months, juveniles were very uncommon.

Surveys of munia nesting activity and local (within 1 ha) rice conditions at 5 sites outside Bumbong Lima showed that active nesting was recorded 14 times when rice was locally available and 8 times when it was not. Absence of nesting was noted on the other 10 occasions, each when rice was unavailable nearby. The association of active nesting with locally available rice was statistically significant ($P < 0.05$, $\chi^2 = 11.2$, 1 df).

The importance of algae.—The only nongrain food item eaten by munias was *Spirogyra,* which comprised a substantial part of their diet at certain times of the year (Fig. 2B). Munias ate the algae most often during the periods of peak gonadal development (Table 1, Fig. 2). This association was corroborated through internal examination. Among the adult females dissected, 13 of 33 (39%) that contained algae in their stomachs also possessed enlarged ova or follicles, whereas only 8 of the 49 (16%) without algae did so. Adult males displayed a similar trend. Twenty-one of the 22 (95%) birds with algae possessed testes that were presumably spermatogenic, compared to 43 of the 50 (86%) without algae. The association between reproductive activity and algae was statistically significant ($P < 0.05$) among females ($\chi^2 = 5.62$, 1 df) but not among males ($\chi^2 = 1.77$, 1 df). Similar sex-differential responses in reproductive condition to the abundance of certain food items, usually insects, have been noted in other species (e.g. Payne 1969, Jones and Ward 1976).

The local *Spirogyra* was not analyzed, so its nutritional value is unknown. I have since been unable to locate any published data on the nutritional content of *Spirogyra,* but unicellular green algae, such as *Chlorella* and *Scenedesmus,* have been shown to contain about 50% protein (dry weight basis, Gordon 1970). On the other hand, various grass seeds have about 11% protein (Jones and Ward 1976), and rice has even less (Juliano 1966). In addition, the biological value of *Scenedesmus* protein was found to be "superior to that of all other vegetable proteins tested" in various animal-feeding experiments (Fowden 1962). Thus, the munias had available an abundant, easily obtainable, probably protein-rich food that may be important in their breeding biology.

Food as a factor affecting Sharp-tailed Munia breeding seasonality.—Malaysian species of *Lonchura* are generally opportunistic in their breeding, with nesting activity being dependent upon their locating a sufficiently abundant source of seeds. Because there is no overall seasonality to seed abundance, it is inappropriate to talk in terms of annual reproductive cycles; males in breeding condition may occur in a population at all times of the year. Breeding readiness is probably attained by the individual as often as the rates of physiological development allow (Medway and Wells 1976).

My results suggest that some modifications to the above scenario may be warranted, at least for *L. striata.* The banding data indicate that the population I studied was sedentary within about 15 km of the study site. Due to double cropping and the asynchrony of the rice schedules, the birds had, within this relatively small area, rice available to them year-round. At Bumbong Lima, the 6-month rice seasons are regular, well defined, and provide abundant rice as well as a protein source in the form of algae. My observations indicate that the munias at Bumbong Lima have become attuned to this situation so that their breeding activities are in concert with the availability of requisite environmental factors—rice and algae.

Food availability, for nesting adults and for young birds, is generally thought to be the ultimate factor in determining the breeding season for most tropical bird species (Lack 1954, Ward 1969). Most granivorous species, which rely on insect material to accumulate protein reserves for egg production and, often, to feed nestlings, breed during periodic rainy seasons when insects increase in abundance (Ward and Poh 1968, Jones and Ward 1976). Sharp-tailed Munias differed from this by eating algae rather than insects to obtain the necessary protein supplement.

Proximately, tissue protein levels, rather than environmental factors *per se,* may be the crucial factor in whether or not a species is able to breed (Ward 1969, Fogden 1972, Jones and Ward 1976). Although sufficient protein reserves are achieved by many individuals only during periods of high protein availability, reproductive readiness may occur whenever conditions are favorable, thus accounting for the occurrence of breeding outside the main season (Immelmann 1971, Fogden 1972).

Among the munia population at Bumbong Lima, there were two main breeding seasons, but birds in reproductive condition were recorded throughout the year, and from my results it is not possible to determine how often individuals were capable of breeding. Males, in particular, were reproductively active outside the main breeding seasons (Fig. 2C), indicating that it was easier for males to achieve or maintain breeding readiness than it was for females. This is consistent with Miller's (1962) observation that breeding seasonality should be viewed primarily as an expression of the female reproductive cycle, because egg production is more environmentally influenced than is the male cycle. The circumstantial evidence indicates that female munias are able to accumulate sufficient protein reserves most readily when algae is abundant. This occurs twice yearly and is the determining factor in the breeding seasonality of the Bumbong Lima population. Thus, unlike other species, Sharp-tailed Munias' breeding seasonality is determined by manmade cycles of rice cultivation rather than by natural cycles of rain and insect abundance.

ACKNOWLEDGMENTS

This investigation was conducted while I was a research officer assigned to the Malaysian Agricultural Research and Development Institute through the U.S. Peace Corps/Smithsonian Institution Environmental Program. I am grateful to each of these organizations for their support. I am particularly indebted to David R. Wells of the University of Malaya for his encouragement and logistical support throughout my study. Luis F. Baptista, Yui H. Hui, Peter J. Jones, Robert B. Payne, Paul F. Springer, David R. Wells, and an anonymous reviewer provided valuable comments on various drafts of this paper.

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