

THE BIOLOGY OF THE BENGALESE FINCH

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THE Bengalese Finch is a domesticated form of the Sharptailed Finch, *Lonchura striata* (Estrildidae), which has been kept in captivity for at least 200 years. The original stock probably came from southeast China and appears to have been domesticated by the Japanese, there being no apparent connection with Bengal (see Eisner, 1957). It is, I believe, a potentially most useful laboratory animal for it is extremely easy to keep, requires comparatively little space, and breeds freely and reliably all the year round. The present account is based on four years' work with the Bengalese in the Department of Zoology and Comparative Anatomy, Oxford, these results being obtained incidentally to a study of parental behavior in this species. I wish to acknowledge my debt to Professor Sir Alister Hardy and Dr. Niko Tinbergen for affording me the opportunity of working in Oxford, to the Nuffield Foundation for the purchase of apparatus and birds, and to Newnham College, Cambridge, and the Ford Foundation for personal grants.

MANAGEMENT

The staple diet of my finches consisted of a mixture of yellow and white millets and canary seed (see Morris, 1955), to which was added a proprietary mineral mixture (containing mainly calcium and phosphorus but also traces of magnesium and other ingredients), cod liver oil, and wheat germ oil. Sluis Universal Food, a diet intended for insectivorous birds, was always available in the cages, but not much of this was eaten except when young birds were being fed. Maggots (blowfly larvae) and lettuce were given occasionally, the latter especially always being taken very eagerly. Fine sand, shell grit, and cuttlefish bone were constantly available, as was water for drinking and bathing.

The Bengalese is highly social, with a minimum of aggressive behavior, and thus many individuals can be kept together in the same cage. My practice was to keep males and females in separate groups from which individuals were taken as required and put into the breeding cages. Each pair was put into a cage measuring 60 cm. wide by 45 cm. high by 30 cm. deep, which was provided with a nest box about 10 cm. cube in one upper corner. In these they bred without difficulty. The nest boxes were backed by sliding glass panels, which permitted

observation of and access to the nest, the birds being remarkably tolerant of disturbance at the nest.

The floor of the cages consisted of a sliding tray that was kept lined with newspaper in order to facilitate cleaning. It was found sufficient to clean the cages about once a week as the droppings of these birds are normally very dry.

The birds were housed in a hut that was kept always at natural day-length, artificial light never being used after dusk. The facilities for temperature control were not fully adequate. During most of the year, the temperature was maintained within the range of 20–24°C; but this temperature was not maintained when the weather was unusually cold in winter, although the room never fell below 15°, while during hot spells in summer the room temperature often rose, up to 30°.

LONGEVITY

As the natural death rate among these birds is low, I have not yet been able to accumulate sufficient information to provide an estimate of longevity. The expectation of life of Bengalese Finches must be at least three or four years once they have survived to maturity. Of the first nestlings hatched in my stock, during April to June 1955, ten reached maturity. Of these, four have died at 23, 29, 51, and 56 months, and one was accidentally killed at 56 months: the remaining five were still alive in June 1960.

PLUMAGE COLOR AND NESTLING MOUTH MARKINGS

The Bengalese Finch is characteristically piebald, although there is a complete range of variation from birds with no pure white feathers (thus resembling the wild type) to all-white birds with no colored feathers. While at first sight the piebald birds appear to be irregularly marked, this is not altogether the case. Birds with few white feathers tend to have them on the forehead and just under the beak and among the primaries. As their number increases, the white feathers tend to be distributed on the top of the head, down from under the beak onto the breast, on the belly and flanks and in the wings and tail, and there is often a little collar of white feathers across the back of the neck. There is a strong tendency for colored feathers to persist as eye-stripes, in a band across the lower breast (at the level where in the wild type the dark-brown breast feathers and the paler belly feathers meet) and another band ventrally behind the legs, and on the back, even in birds that are predominantly white. In addition to the variations in piedness,

there are factors affecting the pigment, where it occurs: the color may be either the wild-type dark brown or a rich fawn, fawn being recessive to brown, and it is also reported by aviculturalists that the intensity of the color may vary.

A characteristic feature of the estrildines is the occurrence of mouth markings in the nestlings. As this has been considered a most important taxonomic character (cf. Delacour, 1943; Wolters, 1957), it was interesting to find that the mouth markings are not stable in the Bengalese, but are disrupted in association with the disruption of the plumage color. The fundamental pattern in *L. striata* is illustrated in Figure 1, the clearest feature being the single horseshoe mark on the palate. Unfortunately, I did not make accurate drawings for the pur-

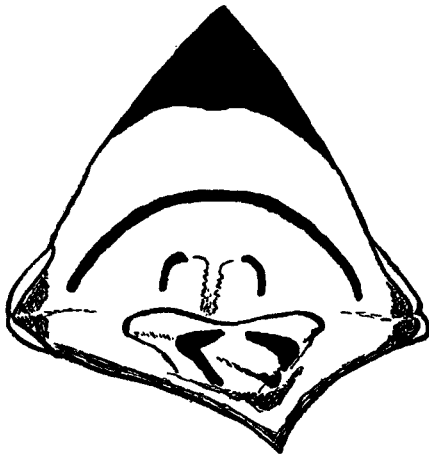


Figure 1. The mouth markings of *Lonchura striata*. This was drawn from a two-week-old "self colored" or wild-type Bengalese chick. The thickened edges of the gape corners are bright white, accentuated by the neighboring black skin. The ground color of the palate is bright yellow, making a strong contrast with the black markings. There is a horseshoe-shaped ridge running between the horseshoe and the pair of smaller marks below.

pose of providing an account of the variation in the markings. Only rough sketches were made of the markings at hatching of the chicks, for the purpose of recognizing the chicks individually; later, when the chicks' wing feathers grew (these are the first feathers to emerge, on about day 8 or 9), the distribution of white feathers among them was used for individual recognition. It has therefore been possible to compare my sketches of the mouth markings with the wing index of each chick, and this has confirmed my observation that it is possible to pre-

dict roughly from the mouth markings the future degree of piedness of the bird. For this purpose, I have classified the chicks into six groups according to the degree of disruption of the horseshoe mark at hatching, as follows (see Figure 2) :

1. Horseshoe complete and unbroken.
2. Horseshoe almost complete, a break being evident but the gap so small as not to appear as a distinct space: in these cases the gap usually disappeared altogether within a few days, leaving a complete horseshoe.
3. Horseshoe with one to three definite small gaps, the most frequent form of this being a symmetrical pattern with a central break and one on either side giving two dots at the peak of the horseshoe, the gaps being less broad than the dots. This and the subsequent patterns did not change appreciably as the chicks aged.
4. Horseshoe broken into sections by larger gaps than in (3).
5. Horseshoe represented only by a small stroke at each end, the center being entirely unmarked.

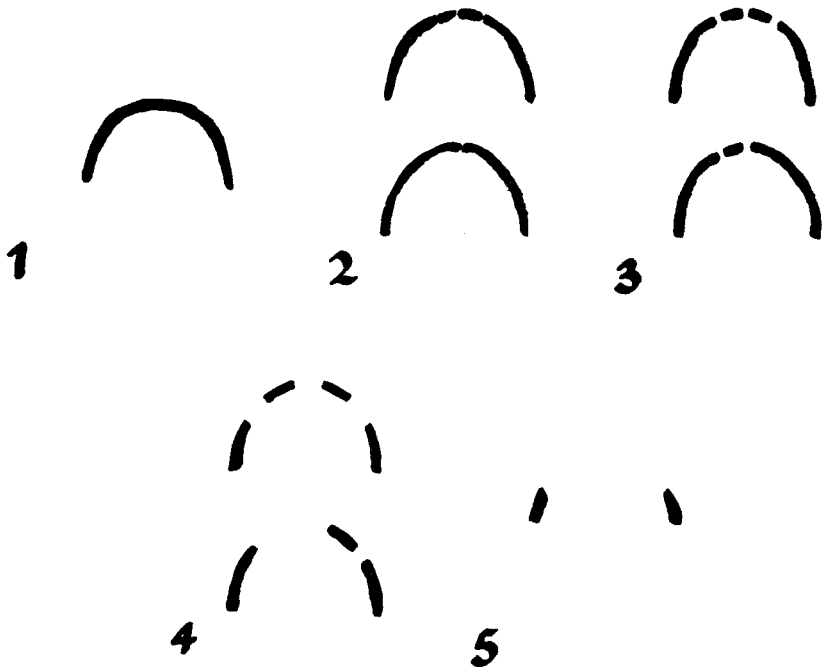


Figure 2. Indications of the way in which the variations of the horseshoe mouth mark were classified, and showing the types of disrupted patterns that occur.

6. Horseshoe completely absent.

Of course, the distinction between these groups was somewhat arbitrary, but most cases did fall clearly into one or the other. The wing indices that I recorded were the number of white feathers among the 9 primaries and 8 secondaries of each wing of the chick. I therefore averaged the number of white feathers among the primaries and secondaries (per wing) for each of the above six groups. The relationship existing between the mouth markings and the plumage is apparent from Table 1.

TABLE 1

<i>Mouth markings Group</i>	<i>Average number of white feathers in</i>		<i>Number of</i>
	<i>primaries</i>	<i>secondaries</i>	<i>chicks</i>
1	1.4	0.3	6
2	4.2	2.0	23
3	5.4	2.4	28
4	7.3	3.1	22
5	8.3	5.1	27
6	8.6	6.3	22

The birds in Group 1 would be classed as "self-colored" or wild-type birds, showing an almost negligible number of white feathers. Those of Group 6 in my stock did not approach the pure white form but had a substantial amount of colored plumage. Had I had a stock selected for whiteness, the number of white feathers in the wings for Group 6 would have been higher.

In addition to the connection of the disruption of the mouth markings with that of the plumage, the recessive fawn can also be distinguished in newly hatched chicks, for the pigment of the mouth markings and also of the eyeballs is fawn instead of near-black in such birds.

SEXING, MATURATION, AND SEXUAL BEHAVIOR

The original wild form, the Sharptailed Finch, is monomorphic, and although there is great individual variation among Bengalese Finches, it is impossible to sex them from their appearance. However, I have found that song is an altogether reliable guide to the sex of a Bengalese; an unknown adult male will very soon indicate its sex by singing, while I have never known a female to sing. Juveniles begin to molt into adult plumage about two months after hatching, and at the same time the young males begin to sing. At first the song is no more than a very quiet whispering, while the bird holds itself in a somewhat stretched upright position: there is not usually any very well-defined posturing,

and only rarely are the belly feathers ruffled or is the tail raised, as in the adult song posture. During the next weeks the song gradually becomes louder and a fuller tone is developed, while slowly the adult song posture is assumed and also courtship display may sometimes be seen. By the age of about three months these changes are complete, the molt is finished and the birds may be considered mature, although they do not yet appear to be full grown. Young birds that have not been known to sing by this age (assuming they have been observed sufficiently) may confidently be taken to be females. I have determined the sex of all my birds in this way and have never found myself in error: all my presumed females eventually laid eggs when they were paired.

The Bengalese Finch is certainly able to breed at an early age. Occasionally, I left juveniles together rather too long and then found that they had gone to nest. One bird who was herself hatched on 18 June hatched her own first chick on 24 September; another year, birds hatched about 9 June had young on 3 October. Thus the Bengalese may be considered mature at three months, for they are then in adult plumage and capable of breeding. Given suitable conditions, they then apparently remain in constant breeding condition; it seemed to me that no individual ever went temporarily out of reproductive condition and neither was it ever obvious that a bird was in molt. Presumably feathers were shed and replaced very gradually. This was in marked contrast to some of our wild-caught species of estrildine (*e.g.*, *L. castaneothorax*) in which the molt was very obvious. The breeding season of wild *L. striata* also tends to be prolonged, and may extend more or less throughout the year (*e.g.*, Baker, 1926; Betts, 1952; Henry, 1955).

When breeding pairs were needed, males and females were taken from the stock cages and put together. The males almost invariably courted within a few minutes and sometimes succeeded in forcing a copulation, but only rarely did the female show solicitation on this first encounter. During the following few days the female usually responded by soliciting whenever the male courted her. The courtship of the Bengalese Finch has been described by Morris (1958), and there are photographs of it in Morris (1958) and Eisner (1957). The male moves along the perch toward the female with a series of bowing and pivoting movements in characteristic posture, singing continuously. If the female is responsive, she assumes a forward position and quivers her tail in a vertical plane (solicitation: cf. Morris, 1954; Moynihan and Hall, 1954); otherwise she flies off. From a few observations on pairs

placed in larger aviaries, I believe this sequence would normally be preceded by a period of flying about and carrying nest material, as has been described for *L. punctulata* (Moynihan and Hall, 1954), but this was very much reduced in my small cages. Moynihan and Hall describe how, after this period of carrying nest material, the male Spicebird goes into the courtship display: he drops the nest material, beak-wipes, and then begins to display. Beak-wiping at this point is not usual in the Bengalese. The first movement of the display is normally a very deep bow, after which the bird mainly pivots in a horizontal plane as he moves up to the female before mounting her. Although my birds were in small cages, my observations on courtship agree with those of Morris (1958).

At the time the birds were put into the breeding cages, some hay was placed in the nest box, and more was scattered around the cage. Although the birds often began to build within a few minutes of being put together and continued to build during the next few days, the nest was most changed about two days before the first egg was laid. However, I made no attempt to study nest building carefully, mainly because the birds could be allowed only a small amount of nest material since a larger amount would have impeded my observations later.

THE INTERVAL BEFORE THE FIRST EGG IS LAID

The first egg was usually laid about 7–10 days after the pair was put together, but I was interested to find that this interval varied with the season of the year, tending to be longer in winter. Table 2 shows records for virgin birds and birds with breeding experience separately: virgin birds seem to take rather longer than experienced birds to go to nest, but I have rather few records for them. The data on birds with breeding experience are also shown graphically in Figure 3, in the form of bimonthly averages of this interval.

TABLE 2
INTERVAL BETWEEN PAIRING AND LAYING OF FIRST EGG

	<i>Date put together</i>	<i>Interval in days</i>
A) experienced birds	Jan. 6 1957	7, 10, 10, 11
	Feb. 11 1957	10, 11, 12, 21
	Mar. 8 1956	7, 8, 9
	Mar. 12 1958	9, 9, 10
	Mar. 26 1957	2, 6, 8
	Mar. 29 1957	1*
	Apr. 9 1956	3, 7, 7
	May 6 1958	7, 8, 10
	May 7 1957	7, 9, 14
	May 8 1956	3
	June 4 1957	6, 7, 7, 7
	July 24 1958	5, 10, 11
	Aug. 8 1956	6, 7, 7, 8
	Aug. 13 1958	7, 7, 8, 8
	Sept. 4 1955	6, 6
	Oct. 3 1957	8, 8, 9, 11
	Oct. 4 1955	8
	Oct. 15 1956	6, 6, 10, 16
	Oct. 27 1957	6, 7, 7, 9
	Dec. 6 1956	8, 8, 9, 17
Dec. 10 1957	7, 10, 18, 21 (66 cases)	
B) virgin birds	Jan. 15 1956	10
	May 8 1956	12
	June 11 1956	15, 20
	Sept. 6 1956	7, 8, 18, 20
	Sept. 9 1956	11, 17
	Oct. 4 1955	9

* In this very surprising case, where the first egg was found within 18 hours of the birds being put together, a normal clutch of eight eggs was laid on consecutive days. The whole clutch proved to be infertile, but this cannot be considered significant, as infertile clutches are not rare; among their several previous clutches the same pair had already had one entirely infertile clutch and also one entirely fertile clutch.

As most of the few records of virgin pairs were obtained during the summer months, I compared records obtained between the March and September equinoxes for virgin and experienced birds, using the appropriate form of the *t*-test. (The virgin bird sample was too small for the nonparametric χ^2 test to be used.) During the summer months, the mean interval before laying began was 6.9 days for the experienced birds and 14.2 days for the virgin pairs, and this difference is significant at 1 per cent ($t = 4.26$; 1 per cent value of $t = 3.32$). For comparison, the winter mean interval for the experienced birds was 10.0 days.

The records of the birds with breeding experience were divided at the solstices and the equinoxes, and comparisons were made using the χ^2 test. The records of the interval before laying began differed very

significantly as between summer and winter (equinoctial division: $X^2_{(2)} = 9.92, 0.01 > p > 0.005$). In contrast, division at the solstices produced no suggestion of difference of the records ($X^2_{(2)} = 0.16, 0.95 > p > 0.90$). This suggests that the interval before laying begins may be influenced by the absolute daylength but not by whether daylength is increasing or decreasing. I cannot, however, say definitely that daylength is the relevant influence, although it seems the most probable one. The birds were kept entirely at natural daylength, in which the variation was considerable; variations in temperature were smaller and were much less consistent, and the birds experienced no seasonal variation in diet.

CLUTCH SIZE

Five or six eggs are most commonly laid in a clutch, but clutch size ranges from two to nine. Single eggs are occasionally laid, but I have never known them to be incubated, while the two-egg clutches were incubated. No difference between virgin and experienced pairs was

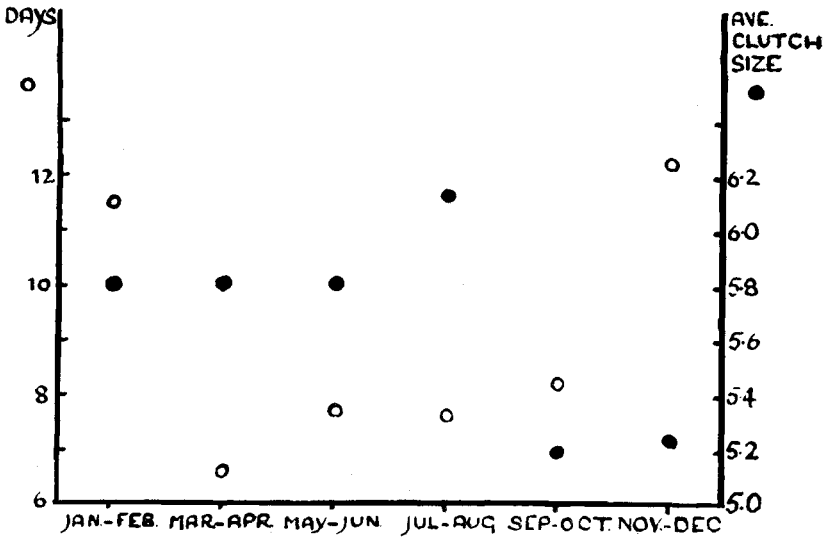


Figure 3. Seasonal variation in the interval before the first egg is laid (open circle) and in clutch size (solid circle). The points represent bi-monthly averages.

Note that the variations of the two measures are not in phase, clutch size being minimal from September to December, while the delay before the first egg is laid is greatest from December to February, probably indicating a differential sensitivity to photoperiod.

apparent, and I have not separated the records that are given in Table 3. Bimonthly clutch-size averages are presented graphically in Figure 3.

TABLE 3
CLUTCH SIZE

(In this table each month has been divided roughly into four "weeks." The markings indicate where the record was divided for testing.)

<i>Approx. date of 1st egg</i>		<i>Number in clutch</i>	<i>Approx. date of 1st egg</i>		<i>Number in clutch</i>
Jan.	2nd week	6	July	1st week	7, 9
	3rd "	2, 5, 8		4th "	5
	4th "	5	Aug.	1st week	6, 6
Feb.	2nd week	6		2nd "	5, 7
	3rd "	6		3rd "	5, 5, 6, 6, 6, 6, 6, 7
	4th "	6, 7, 7	Sept.	2nd week	5, 5, 5, 6
Mar.	1st week	6		3rd "	5
	3rd "	6, 6, 8		4th "	4, 4, 5, 6, 6
	4th "	4, 6, 7, 8	Oct.	1st week	5
Apr.	1st week	3, 5, 6, 9		2nd "	4, 4, 5, 5, 6, 6
	2nd "	4		3rd "	5, 7
	3rd "	2, 6, 7		4th "	6
May	2nd week	5, 6, 6, 7	Nov.	1st week	5, 5, 6, 7
	3rd "	5, 5, 7, 7, 7		2nd "	5
	4th "	2, 5		3rd "	5
June	1st week	5	Dec.	2nd week	6, 6
	2nd "	5, 6, 7, 7, 7		3rd "	3, 5, 5, 5, 6
	4th "	5, 6, 6, 6		4th "	3, 5, 6, 6
					(99 clutches)

For comparison, similar tests were performed on the records of clutch size as on the interval before laying began. When the records were divided at the equinoxes, no evidence of any difference in clutch size between summer and winter was found ($X^2_{(3)} = 3.77, 0.3 > p > 0.2$). But with division at the solstices, a significant difference was apparent ($X^2_{(3)} = 8.58, 0.05 > p > 0.025$). This suggests that clutch size is not influenced by the absolute daylength but may be affected by whether daylength is increasing or decreasing, larger clutches being more common in the springtime when daylength is increasing. It has, however, been suggested to me that, according to this interpretation, the high average for July-August is disturbing. That this value is higher than those of the preceding months is probably accidental, the samples not being large. That it is not lower, although the daylength is decreasing,

can be explained on the following grounds: however long the summer day, the birds habitually go to roost at about 6:00 P.M. (G.M.T.), while on the short, winter days they are constrained to roost at dusk. Thus the shortening of the days probably does not provide a significant stimulus until about the time of the September equinox, after which the birds are constrained to roost earlier than they would otherwise.

Frith and Tilt (1959) have found a comparable seasonal variation in clutch size in another estrildine, the Zebra Finch, in the wild. According to their data, the time of high average clutch size is the summer (November to March, in Australia). Thus, these data do not correspond with my findings, but it must be remembered that these wild birds are subject to a much wider range of potentially influential seasonal factors than were my captives.

Although no conclusion can safely be drawn until experiments under strictly controlled conditions have been carried out, the apparent contrast in the seasonal variations of the interval before laying begins and of clutch size is most interesting. If it is real, it suggests a high degree of specificity in the influence of photoperiod on the egg-laying mechanism. A physiological study under carefully controlled conditions would probably be very rewarding.

SEX RATIO

Another variable that appears to be influenced by the season of the year is the sex ratio of the young. The sex of my birds was determined at maturation, but as the postfledging mortality was negligible, the figures can be taken as the sex ratio at fledging. This means that there are two possible interpretations of the data: either the primary sex ratio (ratio at fertilization: Mayr, 1939; Landauer, 1957) may vary or the relative viability between fertilization and fledging may change. The first possibility seems the more likely to me. Although a large number of eggs failed to hatch (of 480 eggs laid and incubated, only 204 hatched), these eggs were almost always "clear" and showed no trace of an embryo, so that embryonic mortality except perhaps in the very earliest developmental stages must be ruled out. In addition, nestling mortality was not great. Table 4 shows the number of surviving young of the two sexes according to their approximate date of hatching: again, each month has been divided roughly into four "weeks." The markings indicate that the record was divided according to the season at which the birds were conceived, using a rough estimate of $2\frac{1}{2}$ weeks for the time between fertilization and hatching.

TABLE 4
SEX OF YOUNG BIRDS

<i>Approx. date of hatching</i>	<i>Number of males</i>	<i>Number of females</i>
Jan. 1st week	7	8
Feb. 1st week	1	2
2nd "	2	2
Mar. 2nd week	5	1
Apr. 2nd week	10	7
4th "	5	3
May 2nd week	7	2
June 1st week	3	3
2nd "	7	4
3rd "	3	3
4th "	0	1
July 3rd week	3	5
Aug.	none	
Sept. 1st week	8	6
Oct. 1st week	2	5
3rd "	1	4
4th "	2	2
Nov. 1st week	3	5
2nd "	5	10
3rd "	0	2
4th "	6	10
Dec. 1st week	1	0

(166 birds)

With an equinoctial division, the figures are suggestively but not significantly different ($X^2_{(1)} = 2.97, 0.1 > p > 0.05$). However, division at the solstices showed a significant difference between the months when daylength was increasing and those in which it was decreasing, more males being produced in the spring and more females in the autumn ($X^2_{(1)} = 6.24, 0.02 > p > 0.01$).

<i>Season of conception</i>	<i>Daylength</i>	<i>Males</i>	<i>Females</i>
Sept.-Mar.	short	33	46
Mar.-Sept.	long	48	39
Dec.-June	increasing	50	36
June-Dec.	decreasing	31	49

Division of the year into quarters is also interesting because it suggests how the sex ratio changes in the course of the year.

Dec.-Mar.	short, increasing	15	13
Mar.-June	long, increasing	35	23
June-Sept.	long, decreasing	13	16
Sept.-Dec.	short, decreasing	18	33

This suggests that both absolute daylength and daylength changes are influential, as apparently the sex ratio is balanced during two quarters and unbalanced in opposing directions in the other two quarters. These ratios were tested against the null hypothesis that males and females are produced in equal numbers, using the X^2 test with Yates' correction. The last category gave a significant difference ($X^2_{(1)} = 4.78, 0.05 > p > 0.02$), showing that during the autumn significantly more females than males were produced, but the ratio for March-June did not show a significant difference ($X^2_{(1)} = 2.09, 0.2 > p > 0.1$). The ratios in the other two categories were quite consistent with the null hypothesis ($X^2_{(1)} = .036, 0.9 > p > 0.8$ and $X^2_{(1)} = 0.14, p \approx 0.7$), indicating that there is no departure from an equal sex ratio in December-March and June-September. Comparison of the March-June and September-December records showed these were very significantly different ($X^2_{(1)} = 6.82, 0.01 > p > 0.005$).

LENGTH OF INCUBATION AND NESTLING PERIODS

The following convention was used: the day of beginning incubation, or of hatching, is called day 0, the following day is day 1, etc. Nests were normally inspected at about midday each day, although sometimes more frequently. Thus a 16-day chick is one that was found hatched on day 16 of incubation, making an incubation period of between 15 and 16 days.

In order to have broods in which the chicks were homogeneous in age, in many cases I replaced the eggs as they were laid by dummy eggs. These were in fact plastic model canary eggs, which are commercially available, and were therefore slightly larger than the eggs of the Bengalese Finch and pale blue instead of white but were none the less accepted immediately. The dummies were removed and the eggs replaced when the particular pair I wished to watch had five eggs, the other pairs at that time having perhaps one or two more or less. A difficulty commonly found in assessing the length of the incubation period is that of knowing precisely when the incubation of each egg began (cf. Swanberg, 1950). This difficulty was eliminated in those cases where the eggs had been replaced by dummies and no further eggs were laid after the clutch was returned to the nest (in which case regular incubation behavior was certainly established by this time). Seventy-one chicks were hatched from such clutches, and from these the incubation period may be estimated as 16 days (mean = 16.44 days, less half a day probable observational error). The distribution was as follows: 15 days—14 chicks; 16 days—28 chicks; 17 days—

15 chicks; 18 days—12 chicks; and 19 days—2 chicks. This sample represents fairly well my experience in all cases, in many of which the beginning of incubation was known with only very little less precision, except that it contains too many 15-day chicks. Of 59 chicks hatched from clutches in which one or two eggs were laid after the dummies were removed, only one was hatched at 15 days. Fifteen-day and 19-day incubation periods are definitely unusual. The records in which incubation periods were known exactly are given in Table 5; brackets enclose all the chicks from one clutch, and clutches incubated at the same time are shown together.

TABLE 5
LENGTH OF INCUBATION

<i>Date of beginning of incubation</i>	<i>Days of hatching</i>
Jan. 30 1956	(16, 16, 16, 17)
Feb. 26 1957	18
Mar. 21 1956	(17, 17, 17)
Apr. 8 1957	16; (16, 16, 17)
Apr. 20 1956	(18, 18, 19)
May 19 1956	17
Aug. 20 1956	(15, 15, 15, 17, 17); (16, 16, 17); (15, 15, 15, 18); (15, 15); (15, 15, 15, 15)
Sept. 15 1955	17
Oct. 1 1956	(16, 17)
Oct. 16 1957	(15, 16, 16)
Oct. 17 1955	18; (18, 18, 18)
Nov. 9 1957	(15, 16, 16, 16, 17); (16, 16, 17, 18); (16, 16, 16, 16, 16, 17)
Dec. 19 1956	17; (16, 16, 16, 18)
Dec. 20 1955	(18, 18, 19)
Dec. 22 1957	(16, 16, 16, 16)

These records suggest that variation in incubation periods is probably not caused mainly by a variability among the eggs, as the incubation period within a clutch tends to be fairly uniform and also separate clutches incubated at the same time tend to hatch simultaneously. This sample is too small to show the latter tendency reliably, but my other, less precise, records do confirm it. It therefore seems that the incubation period is influenced by some outside factor that can affect several pairs simultaneously, but it is not obvious what this factor may be as there is no suggestion of any seasonal trend. One might expect that development would be quicker in warm weather and slow when it is cold. However, only extreme outside temperatures really influenced the temperature at which the birds were kept. The rapid hatching of the clutches laid in late August 1956 certainly cannot be attributed to

unusual heat, while the weather was unusually cold during February 1956, but the clutch incubated at this time did not take long to hatch.

It is also of interest to see how hatching is spread when there has been no interference with the clutch, *viz.*, when dummies were not used. As the eggs are normally laid daily and my impression is that regular incubation usually begins with the antepenultimate egg, the majority of the chicks would be expected to hatch more or less simultaneously and the remaining two to hatch on the two following days. This expectation only approximately fits the observed facts. Only records where all or nearly all of the eggs in the clutch hatched are of interest in this context, and these are given below:

5 eggs laid	Apr. 3-7	chicks hatched	Apr. 21, 22, 22, 23, 25
6 " "	May 22-27	" "	June 9, 9, 10, 11, 12 (1 sterile egg)
3 " "	May 31-June 2	" "	June 18, 18, 18, 19, 20
	+2e. June 4-5		
5 " "	June 1-5	" "	June 19, 20, 20, 20 (1 sterile egg)
6 " "	Oct. 25-30	" "	Nov. 12, 12, 12, 13, 14 (1 sterile egg)
5 " "	Nov. 11-15	" "	Nov. 29, 30, 30, Dec. 1, 1.

My records of the time of fledging are less satisfactory. This is largely because fledging is not so well defined an event in estrildines as it is in most other groups of passerine birds. The chicks do not leave the nest once and finally, but instead frequently return to it and invariably roost in it. I define fledging in the Bengalese Finch as the first leaving of the nest without obvious provocation, and one is unlikely to determine this accurately without considerable observation of the nest as at first the chicks spend only very short periods outside it. I am convinced that the majority of broods fledge on day 24 or 25, while fledging on day 26 or 27 is not uncommon. If the chicks are underdeveloped, fledging may be delayed as long as the 30th day. I have no record of fledging before day 24: I think fledging on day 23 is possible but would be very unusual, and I consider it most unlikely that Bengalese could fledge normally before this age. In this I disagree with many of the avicultural books, and this disagreement can probably be explained because the young birds will leave the nest upon disturbance, and are capable of flying, considerably earlier—probably as early as day 19. The discrepancy between the usual published estimates of the incubation period and my data can perhaps be explained by the fact that the former may well have been measured from the time of laying of the last egg. Steinbacher and Wolters (1956), probably the most reliable of the avicultural books, gives the incubation period of the Bengalese Finch as 12–15 days and the age at fledging as 21–27 days. Perhaps another reason for the commonly accepted short estimates is

that my estimates would seem to be unusually long for an estrildine, both according to the published information and to our own experience with other species.

The fledgling Bengalese Finches begin to feed themselves about a week after they leave the nest, and can safely be separated from their parents within a fortnight of fledging. Indeed, the adults may begin to lay a new clutch as soon as 10 days after the young have fledged, and they then cease to feed the fledglings.

SUMMARY

This paper presents data accumulated during four years' study of the Bengalese Finch under fairly controlled conditions in captivity. A brief account of the management of the birds is given, after which the following main points are discussed:

1. The occurrence and form of nestling mouth markings has been thought of considerable importance in estrildine taxonomy. It is therefore of interest that the mouth markings of nestling Bengalese are not constant. The Bengalese is a domesticated piebald, and the variations in the nestling mouth markings are correlated with plumage variations.

2. There is seasonal variation both in the time from the introduction of a pair to the laying of the first egg, and in clutch size, but the variations in these two factors are not in phase. If, as seems most likely, these variations are responses to changes in photoperiod, this suggests a high degree of specificity in the influence of photoperiod changes upon reproductive mechanisms.

3. The sex ratio of the young also shows seasonal variation, more males being produced in spring and more females in autumn.

4. Data on the length of incubation and nestling periods are given.

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