MIGRATORY FEATURES OF THE INDIGO BUNTING IN JAMAICA AND FLORIDA

By David W. Johnston and Audrey C. Downer

Recent years have seen the accumulation of many useful quantitative and qualitative data pertaining to weight and fat in migratory birds. Most investigations of this nature have thus far dealt with birds breeding and overwintering on north temperate land masses, but few quantitative data pertaining to vernal weight and fat changes in birds of tropical regions are available. Even fewer studies have concentrated on both autumnal and vernal features of fat deposition in any one species that migrates from temperate zones to tropical islands for the winter. The recent discovery of Indigo Buntings (*Passerina cyanea*) wintering in large numbers along the north coast of Jamaica (Downer, 1963, 1965) prompted a study of weight changes, fat deposition, molt, and population movements in this species especially prior to its vernal departure from the island in northward migration. The occurrence of these North American migrants afforded an excellent opportunity to investigate premigratory changes in a reasonably stationary winter and spring population under insular conditions in a tropical region, chiefly because the birds overwintering at Montego Bay, Jamaica would necessarily have to incur premigratory changes at essentially the same site before an overwater flight to Cuba or the North American mainland. Our principal objectives in this study have been (1) to record and quantify the various premigratory changes in a banded population of buntings on Jamaica from the late winter through the spring months up to a rather precipitous departure from the island and (2) to compare and complement these vernal features with data obtained from some caged birds and those migrating through and wintering in Florida.

MIGRATION THROUGH FLORIDA

The Indigo Bunting breeds in suitable habitat from southeastern Canada to northern Florida and from the Atlantic seaboard to the eastern edge of the Great Plains. An up-to-date summary of this species' life history is found in the "Bent Life History Series" (Taber and Johnston, 1968), and its principal breeding and migratory characteristics in north Florida were presented in an earlier report (Johnston, 1965). Fall migration in at least the northern part of the range commences by late August and might continue through early November. Records of birds striking the WCTV television tower, near Tallahassee, Florida, indicate peak migration through or over western Florida to be in early October (Stoddard and Norris, 1967). Based upon data from netting operations, peak migration through the Gainesville, Florida region appears to be in the latter half of October. Both those birds killed at the television tower and most of those caught in mist nets in October in Florida

are generally described as having "heavy fat." Compared with spring migration, fall migration entails more flocking behavior and the occurrence of larger flocks. Between 18 October and 8 November, 1963, 72 buntings were netted and banded in one two-acre field at Gainesville. Because only seven birds repeated in the nets during that time, it appears that a rapid turn-over of buntings was occurring in that field. It is likely that many of the buntings passing through Gainesville did not stay around very long, but for the small number of repeating birds at Gainesville in October, the average length of stay was calculated to be 6.1 days. During the stay of these birds (2-11 days), all of them lost weight and fat (qualitatively assessed), a feature pointed out by Mueller and Berger (1966) for thrushes, possibly as a consequence of repeated handling of birds in nets.

Early in the field studies at Gainesville considerable difficulty was encountered in finding reliable criteria for distinguishing age groups in autumnal females. (First-year and adult males could be distinguished on the basis of their distinctive primary coverts.) Eventually, by utilizing birds of known sex and age killed at the WCTV tower, it became possible to establish differences between first-year and adult females on the basis of wing-bars, ventral streaking, and other more subtle features (Johnston, 1967). These differences have not proven to be reliable following autumnal migration.

A point of interest in these autumnal studies in north Florida pertained to the possibility of differential migration between the sex and age groups. We noticed, for example, that nearly every bunting caught in the nets at Gainesville in October was a first-year bird, but additional adult males could be seen in the vicinity of the nets which they frequently managed to avoid. These observations suggested that our netting operations were not yielding valid figures on the actual proportionate numbers of age and sex groups migrating through the area. To clarify this matter at least partially, data from the WCTV tower, though admittedly meager, have proven to be useful. In Table 1, numbers of buntings in the sex and age groups killed on single nights at the tower are presented.

TABLE 1. INDIGO BUNTINGS KILLED AT WCTV TELEVISION TOWER ON SINGLE NIGHTS

	Males		Females		Percent	Percent
	Adult	First-yr	Adult	First-yr	Adults	Males
27 September 1965	3	1	4	2	70	40
5 October 1965	6	1	9	10	58	27
6 October 1965	1	1	3	4	44	22
7 October 1966	8	2	12	1	87	43
18 October 1966	3	2	5	2	67	42

From late September until mid-October neither the proportion of adults nor males on a single night is strikingly different from values for immatures and females except that males never comprised more than 43 percent of the birds killed on a given night. Even though 67 percent of all birds were adults and 65 percent were females, these data in Table 1 suggest that males and females, adults and first-year birds tend to migrate together over north Florida. Murray (1966) presented evidence that adults and immatures of a number of other passerines tend to migrate at the same time in eastern North America.

Records from the tower show conclusively that buntings migrating over Florida in late September and early October weigh less than migrants taken in late October and early November (Johnston, 1965). For example the average weight of 53 first-year males taken on a median date of 6 October was 15.5 g; on a median date of 23 October, the average weight of 50 first-year males was 18.3 g. Weight data for the other sex-age classes, though more meager, showed a similar trend. The early migrants might represent birds from more southerly parts of the breeding range, that is, birds which had not yet completed sufficient fat deposition for a trans-Gulf flight. As an alternative explanation, the early migrants could have flown from more northerly parts of the breeding range and utilized some fat stores in transit overland before reaching Florida.

The species winters sparsely in the southeastern United States but commonly in south Florida. Farther south the principal wintering grounds include Cuba, southern Mexico, and Central America, from British Honduras south to Panama. Southbound migrants from the United States evidently utilize three principal pathways: (1) circum-Gulf via Mexico, (2) trans-Gulf to the Yucatan area, and (3) through peninsular Florida to Cuba and other islands in the western Caribbean region. A migratory route leading from the eastern United States to the Caribbean region is corroborated by the recovery on Jamaica of an Indigo Bunting banded in Pennsylvania (see discussion beyond).

HISTORY OF THE INDIGO BUNTING ON JAMAICA

Prior to the 1960's very few occurrences of Indigo Buntings on Jamaica had been reported. No reference is made to Indigo Buntings in any of the three books published on Jamaican birds—P. H. Gosse, 1847, *The Birds of Jamaica*; Lady Taylor, 1955, *Introduction to the Birds of Jamaica*; May Jeffrey-Smith, 1956, *Bird-Watching in Jamaica*. Jamaica is not mentioned in the range of this species by James Bond in his 1947 edition of *Birds of the West Indies*, although he does so in his 1947 edition of *Field Guide to Birds of the West Indies*.

Tordoff (1952) obtained an Indigo Bunting at Greenwood, St. James on 15 February 1947, one which he reported as being the first taken on Jamaica. Dr. Bernard Williams (1950) saw one in the same area on 25 March 1950. A male was found dead at Stony Hill, St. Andrew by Dr. Joyce Saward 21 February 1953; in her

report (1953) this bunting was referred to as a "rare bird." Observers with the Florida Audubon Society on their Caribbean tours reported occasional Indigo Buntings at various places on Jamaica between 1958 and 1963.

Since 1960 on Jamaica there has been a significant increase in the number of people observing and attracting birds by the establishment of feeding stations. Since the formation of the Gosse Bird Club on Jamaica in August 1963, reports of Indigo Buntings visiting feeders have come from many parts of the island. Whether Indigo Buntings have always wintered on Jamaica, unnoticed, or have recently extended their range or increased markedly in numbers is not known with certainty. The records strongly suggest a recent invasion of the island.

THE MONTEGO BAY STUDY AREA

In 1960, when observations were begun in the Montego Bay area, bird feeders were located in the Downer's garden, at a point 300 feet above sea level, atop a low range of limestone hills running parallel to the seacoast and about one mile from the Caribbean Sea. The hills here are interrupted by a valley running north to south, the sides of which drop steeply to the floor, about 30 feet above sea level. To the north on level ground between hills and the sea is located the Montego Bay airport.

The land atop the hills was known as "Paradise" until its subdivision for housing in 1950 at which time it was partially cleared and planted in guinea grass for grazing of cattle. This land, however, quickly reverted to scrub and bush with guinea grass filling in the gaps. Most of the large indigenous trees had not been removed. These consisted of red birch, bastard cedar, dogwood, Spanish elm, burnwood, logwood, naseberry, and pimento. In 1960 the Downer's house and garden were the last on the road, and the surrounding area was uncleared bush and forest.

The rainy season on the north coast generally embraces October but frequent "northers" bring rain until the end of December. When the rains end at least by January, the guinea grass produces seeds which provide food for seed-eating birds such as grassquits (*Tiaris* spp.), Saffron Finches (*Sicalis flaveola*), buntings, and other species. By about February the grass stalks have been stripped bare, and it is at this time that an influx of buntings and grassquits at the feeders in the area is most apparent. From February until April a dry season is experienced during which time strong northeast trade winds blow almost constantly. Most of the large trees shed their leaves, the grass withers, and the whole area assumes a burned and brown appearance. Buntings at this time have been observed eating seeds of trees such as logwood, dogwood, red birch, and casuarina.

Indigo Buntings were first noted at the Downers' garden in February 1961. In the 1961-62 winter season running water and bird-baths were attractive to buntings and other species until mid-March; during this time a small number of buntings visited the garden daily. In mid-March "budgerigar seed" was offered, in

TABLE 2. INDIGO BUNTINGS BANDED AT MONTEGO BAY, JAMAICA

	Number of new birds banded	Number returned from previous year	Number returned after two years	Number returned after three years	Number returned after four years
		Winter and Spring, 1963-1964			
Males	134				
Females	38				
Total	172				
		Winter and Spring, 1964-1965			
Ad. males	16	14			
First-yr. males	24	8			
Females	18	8			
Total	58	30			
		Winter and Spring, 196[illegible]-1966			
Ad. males	16	1	10		
First-yr. males	13	0	4		
Females	5	4	5		
Total	34	5	19*		
		Winter and Spring, 1966-1967			
Ad. males	5	1	0	6	
First-yr. males	18	1	0	3	
Females	15	0	1	2	
Total	38	2	1	11*	
		Winter and Spring, 1967-1968			
Ad. males	11	0	1	0	3
First-yr. males	22	2	0	0	3
Females	14	4	0	1	1
Total	47	6	1	1	7

*Some birds in these categories were not definitely recorded in 1964-1965 because at that time they were not color-banded.

mid-April, 30 buntings suddenly started to visit the feeder, and by the end of the month the number feeding at one time had risen to 60 just prior to their northward migration from the island.

The first bunting seen in the 1962-63 season appeared at the feeder on 29 November 1962. By the first week in February about 40 were present, the males outnumbering the females 4 to 1. By mid-April over 100 were feeding in the garden area but the northward migration left only two by 4 May. These two finally left on 10 May (Downer, 1963).

At the end of 1963 a banding program (involving aluminum, and, the next year, colored bands) was started and between 13 December 1963 and 27 April 1964, 172 Indigo Buntings were trapped and banded in the Montego Bay area (Table 2); 6 more were banded at Mona, St. Andrew. The usual method of capture involved the use of a drop-door trap placed on the feeding table and baited; no bait was used in the St. Andrew area located along a small stream. Subsequently, mist nets were deployed around the feeding area.

The number of buntings visiting the feeder in the 1964-65 season was noticeably less than in previous years, and a further decline was noted the following year.

In April 1964 another small flock of Indigo Buntings was located on the west side of Montego Bay along the road to Adelphi. Buntings were present at this site in 1965 and 1966, and although similar food was offered and no banding operations were carried out, a similar decline in numbers in the last two years was apparent. Many of the observers who reported Indigo Buntings in 1963 and 1964 failed to see any in 1965 (Downer, 1965) and 1966.

These observations as a whole suggest that this species is now a regular winter resident on the north coast of Jamaica, but the numbers in 1960-61 to 1963-64 were larger than in subsequent years. The feeding area apparently attracted these birds first when they were amassing fat stores before migration. Because Indigo Buntings utilize the same wintering areas year after year (Van Tyne, 1932; Loftin, 1963), many have returned to the Downer's garden since 1964.

SOME POPULATION MOVEMENTS

The color-banded buntings at Montego Bay have yielded interesting data especially on length of stay, influx of birds, and exodus late in the spring. In the spring of 1966, 51 buntings were caught more than once. Some birds repeated in the nets several times during a period of several months, and other individuals were clearly identified in the area by distinctive arrangement of the colored bands. The length of the stay of representative buntings is presented in Figure 1. Between 9 and 20 February a general influx of buntings occurred in the feeding station area.

Trapping and banding data indicate an exodus of some birds from the area in the last week of March. Because several of the birds at that time had been caught only a few days before their apparent

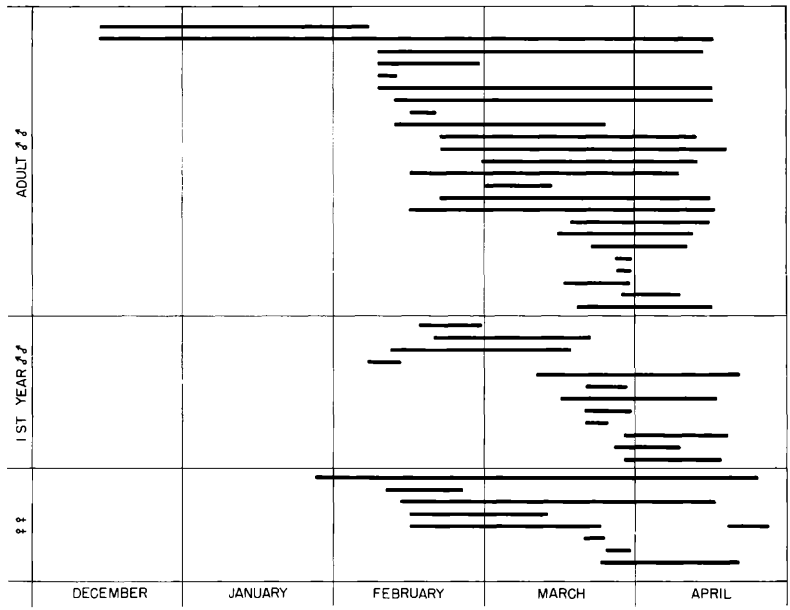

Figure 1. Length of stay of representative color-banded Indigo Buntings at Montego Bay, Jamaica in 1966.

departure from the area, we believe that these individuals were transients, arriving from other parts of the island, and probably leaving for the north in late March. General observations of bunting numbers lend additional support to this suggestion, because in the last week of March of every year a noticeable movement of buntings (birds caught and seen only once) through the Montego Bay area has been detected. Furthermore a number of new, unbanded buntings was trapped in late March, these birds generally remaining in the area for only 1 or 2 weeks (see Fig. 1).

Our recapture data and observations show that most buntings leave this north coast of Jamaica in mid-April (Figure 1). Although some banded and unbanded buntings probably remained in the area through the end of April, we have calculated the average departure date based upon the last date of trapping and observations of color-banded birds. Thus the average departure date was 16 April for males of both age groups and 23 April for females. From the north coast of Jamaica, therefore, females *on the average* migrated a week later than males, and, as a general rule, any birds lingering into the end of April and early May were females.

Interestingly enough, the majority of the repeating buntings departing in mid-April were those that had been in the area for at least two months, sometimes much longer. Indeed one adult male had been caught first on 19 December 1965, repeated frequently in the nets through January and February, and was last

seen at the feeding station on 17 April 1966. Similarly, one female was caught or seen many times between 28 January and 28 April.

In making these reports we are aware of possible adverse effects of netting and handling wild birds such as those reported by Mueller and Berger (1966). The extent to which banding operations frightened away buntings is unknown, but certainly the repeating of 51 birds in one season indicated that the operations were not disturbing to all the buntings. Nonetheless, individual buntings clearly became cognizant and wary of the nets because some color-banded birds learned to avoid the nets after their initial capture, but could still be clearly identified in the feeding area.

RETURNS OF BANDED BIRDS

In North America ever since the pioneer banding studies of Baldwin (1921), it has been known that passerine birds frequently return year after year to the same wintering grounds. It is now known that this homing to a wintering area occurs in some species migrating long distances over water or desert areas (Tree, 1965). Van Tyne (1932) reported the return of banded Indigo Buntings to the same wintering area of Guatemala in consecutive years, and Russell (1964) had similar returns in British Honduras. Considering the large number of Indigo Buntings banded at Montego Bay, it is not surprising to find so many returns (Table 2). Buntings caught in the 1963-64 season were not color-banded. Hence, an unknown number of birds bearing only aluminum bands seen but not caught in 1964-65 represented returning birds from the previous season. Taking this fact into account, we know that of the 172 birds banded in 1963-64, at least 30 (17.4 percent) definitely returned the following year, 19 (11.1 percent) returned in 1965-66, and 11 (6.3 percent)returned in 1966-67. Seven of these 11 buntings returning in 1966-67 had been caught or seen each year between 1963-64 and 1966-67; the other four individuals were not detected in 1964-65, probably because they were not color-banded at that time. Indigo Buntings, like some other passerines, also frequently return to the same breeding area. Mrs. R. E. Lynn (1963) reported 21 returns (from 91 banded birds) at Nashville, Tennessee between 1956 and 1962. For example, one adult male, banded there in 1958, was found dead nearby four years later.

The most startling discovery at Montego Bay was that of a foreign-banded bunting (Downer, 1966: Bell, 1966). On 17 April 1966 a female bunting appeared at the feeding station, the bird wearing only an aluminum band (as opposed to the many others present that were also color-banded). Attempts to catch this bird were unsuccessful, but the complete band number was read through a 20 X telescope. We later learned that this bunting had been banded on 29 September 1963 at Clarksville, Pennsylvania by R. K. Bell. Aside from the unusual way in which this recovery was recorded, it is noteworthy to reiterate this first long-distance recovery for the species, because it suggests a flight pathway for some Indigo Buntings to and from Jamaica.

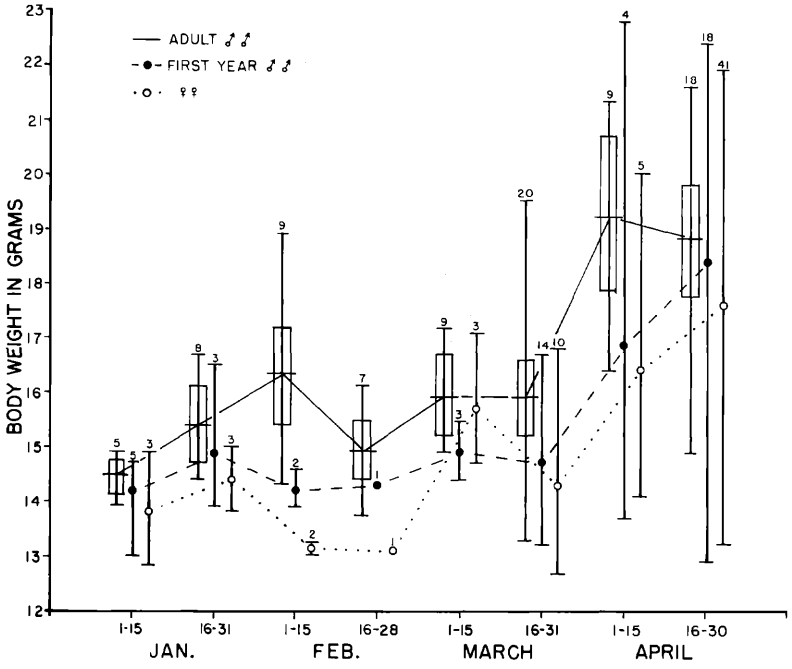

Figure 2. Weights of Indigo Buntings at Montego Bay, Jamaica. For each bi-monthly sample, vertical lines demark extremes, numbers at the top are sample sizes, horizontal bars and circles are means, open rectangles are twice the standard error of the means (for adult males only). Lines (solid and broken) joining means indicate seasonal trends.

The return of some banded buntings annually (Table 2) to the same feeding station and the evident increase in buntings in the 1960's raises interesting questions on population movements and homing. It is our belief, shared by Van Tyne (1932), that Indigo Buntings in Jamaica tend to winter as population units or flocks (40± birds). No buntings banded in the Downer's garden have ever appeared at any of the other feeding stations at Montego Bay, but Saffron Finches banded at the Downer's garden frequently turn up at other feeders nearby. Although every bunting might not remain in a given flock throughout the winter, observational data on color-banded birds at Montego Bay strongly suggest that the flocks remain more or less intact until the spring when, as pointed out above, an influx of new birds was noted and some evidently migrated from the island. Even so, some individuals banded much earlier in the season remained in the study area through April.

TABLE 3. SEASONAL AND HOURLY WEIGHTS OF ADULT MALE INDIGO BUNTINGS AT MONTEGO BAY, JAMAICA, 1964-1967. FIGURES REPRESENT SAMPLE SIZE, MEAN, AND EXTREME WEIGHTS IN GRAMS.

Time of Day	January	February	March		April	
			1–15	16–30	1–15	16–30
0600-0700	1:14.4			1:15.6	2:17.0 (16.4-17.6)	1:20.3
0700-0800	4:14.8 (14.5-15.6)	8:15.7 (13.7-16.7)	6:15.7 (15.2-16.3)	13:15.2 (13.3-18.8)	5:19.5 (18.1-20.2)	5:18.7 (15.5-20.8)
0800-0900	8:14.5 (13.0-16.2)	9:15.4 (14.3-18.9)	3:15.5 (14.9-15.9)	7:15.2 (13.4-16.5)	1:20.1	2:18.6 (18.5-18.7)
0900-1000	3:14.8 (14.7-14.9)	2:14.9 (14.3-15.5)		6:16.1 (14.5-16.6)	1:21.3	1.18:3
1000-1100	1:16.5	1:15.1		4:16.8 (14.2-19.5)		1:16.5
1100-1200	1:16.7					1:21.7
1200-1300						1:19.7
1300-1400						
1400-1500						2:20.0 (18.7-21.4)
1500-1600				1:14.4		1:21.4
1600-1700				1:15.4		
1700-1800				1:15.8		
1800-1900						1:14.9
Summaries—						
	18:14.8 (13.0-16.2)	20:15.5 (13.7-18.9)	9:15.6 (14.9-16.3)	20:14.9 (13.3-19.5)	9:19.2 (16.4-21.3)	16:19.0 (14.9-21.6)

VERNAL WEIGHT CHANGES

In the literature are numerous references to vernal weight changes in species of migrant birds, especially passerines in north temperate latitudes. Many of these birds are intracontinental migrants that initiate northward movements early in the spring in a lean condition and evidently amass fat deposits as they move overland. Other intracontinental migrants tend to leave later in the spring and with significant premigratory fat stores (Johnston, 1966). Migrants passing over extensive bodies of water (Odum, 1960) or inhospitable desert areas (Ward, 1963; Curry-Lindahl, 1963) necessarily amass sufficient fat stores to sustain lengthy nonstop flights. This pattern would seem to be the case for North American migrants wintering on tropical islands too. For example, in the Dickcissels (*Spiza americana*) wintering on Trinidad, ffrench (1967) states: ". . . it now seems clear that Dickcissels migrating from Trinidad start at the peak of fat deposition and gradually use up this fat on the journey."

Vernal weight data for the Indigo Bunting on Jamaica are summarized in Fig. 2 and Table 3. Several features of these weight data merit special comment. Except possibly in March and April, and even though our records late in the day are somewhat meager, there appear to be no significant diurnal weight changes at least

up to 10 a.m., such as those reported for other fringillids wintering at more northerly sites (Helms and Drury, 1960). Unfortunately few buntings visited the feeding station at Montego Bay during the heat of midday except during peak migration times. In some other fringillids there is clear evidence that the intensity of feeding is greater in early morning and late afternoon than during midday (Morton, 1967). Peak weights for the buntings, and probably peak fat deposition as well, were detected for males in the interval 1-15 April and for females, 16-30 April. If the average midwinter (January and February) weight of males is approximately 15 g., then at peak weight and fat conditions the males in April just prior to their exodus from the island would have experienced an approximate 30 percent increase in weight. Dickcissels on Trinidad, however, averaged a 56 percent increase in weight (ffrench, 1967). Also, Smith (1966) reported that some passerines in Nigeria showed vernal weight increases of between 36 and 59 percent. The 15-gram value for the midwinter buntings does not necessarily represent a lean weight, because Connell *et al.* (1960) gave a value of 13 g. as the fat-free weight of this species. Considering a lean weight, then, a given premigratory male Indigo Bunting could potentially increase its weight by at least 50 percent. The heaviest bunting that we have ever recorded was a bird in Florida that weighed 26 g. (Johnston, 1965); this individual likely experienced a 100 percent increase in body weight!

TABLE 4. VERNAL WEIGHT GAINS IN SELECTED RECAPTURED INDIGO BUNTINGS AT MONTEGO BAY

Dates between recaptures	Weight change	Weight change in g/day
7 Feb. - 10 Feb.	18.9 - 17.6	−0.40
11 Feb. - 12 Mar.	16.1 - 17.2	+0.04
20 Feb. - 16 Mar.	12.9 - 16.1	+0.12
20 Feb. - 23 Mar.	14.3 - 15.6	+0.04
11 Mar. - 12 Mar.	14.5 - 15.1	+0.60
12 Mar. - 16 Mar.	15.6 - 16.4	+0.20
17 Mar. - 20 Mar.	16.9 - 18.8	+0.63
11 Mar. - 16 Apr.	16.0 - 20.1	+0.16
20 Mar. - 13 Apr.	15.4 - 20.4	+0.22
29 Mar. - 6 Apr.	19.5 - 21.3	+0.22
29 Mar. - 19 Apr.	13.9 - 18.9	+0.24
31 Mar. - 16 Apr.	16.8 - 21.7	+0.29
6 Apr. - 19 Apr.	16.1 - 18.9	+0.21
13 Apr. - 20 Apr.	15.7 - 19.9	+0.60
15 Apr. - 18 Apr.	15.0 - 19.4	+1.50
15 Apr. - 19 Apr.	20.0 - 20.4	+0.10
18 Apr. - 23 Apr.	19.4 - 19.8	+0.08
20 Apr. - 25 Apr.	15.2 - 19.8	+0.92
21 Apr. - 22 Apr.	17.9 - 20.0	+2.10
16 Apr. - 19 Apr.	17.4 - 18.9	+0.50

NOTE—these data suggest two things: (1) the rate of weight increase is generally greater in April than earlier in the spring; (2) the rate of weight increase decreases in April as the birds get heavier because there appears to be a general maximum weight of 20 or 21 g.

From some recaptured buntings at Montego Bay, we have gleaned some information on the rate of weight gains in the spring (Table 4). The rate of weight increase is generally negligible in most birds until about 1 April. In April the rate might be large or small depending upon the initial body weight: if the bird weighs only about 15 g. in early April, its rate of weight increase thereafter would be quite large (approximately 1 g. per day). The greatest single rate of weight gain that we found was a bird that gained 2.1 g. in 24 hours in mid-April. Its rate of weight increase was 2.1 g. per day.

In comparison with vernal premigratory weights on Jamaica, average premigratory weights in autumn in north Florida are only slightly less than those in the vernal Jamaican birds. The average weight of 15 adult males at Gainesville, Florida, in October was 18.8 g., as compared with a vernal value of 19.2 g. for adult males on Jamaica in early April. That is to say, peak weights of those northbound and southbound migrants appear to be rather similar.

In Central America apparently Indigo Buntings in spring experience a different timing of weight increase. Rogers and Odum (1966) presented weight data for this species in British Honduras until 1 April at which time buntings in their sample weighed less than 15 g. These authors postulated that only buntings weighing at least 15 g. were "theoretically capable of an 800 mile flight" northward across the Gulf of Mexico. According to Johnston (1965) a flight distance of this magnitude would probably require a body weight of 18 g. Our weight data from Jamaica suggest that the birds weighed by Rogers and Odum had not yet attained peak weight and fat deposition. Either their buntings, we believe, would have remained longer at that site or nearby for additional fat deposition or the birds would have moved farther northward overland, achieving maximum fatness elsewhere in Central America before undertaking a trans-Gulf flight. In support of this belief we cite the data of Nickell (1967) who banded Indigo Buntings in British Honduras as late as 20 April and continued catching buntings (trans-Gulf migrants, probably) on the Mississippi Delta through mid-May.

Zimmerman (1965) noted that Dickcissels wintering in Panama decreased in body weight while undergoing prenuptial molt, but the Dickcissels studied by ffrench on Trinidad did not. Most male Indigo Buntings at Montego Bay were molting from January until early April (Fig. 3), and during this time in April weight increases were significant. Because of this prolonged prenuptial molt, clear correlations between weight changes and the time of molt are not evident.

In the spring months of 1965-1968, Mrs. E. J. Fisk caught, banded, and weighed approximately 200 Indigo Buntings at Homestead, Florida; weight data from many of these birds are presented in Table 5. A number of these birds were either repeats or returns, a fact indicating that the buntings at Homestead were winter residents at that location. Males (only moderately fat) at Homestead in early April had an average weight of only 16.2 g., whereas the very fat males at Montego Bay at the same time

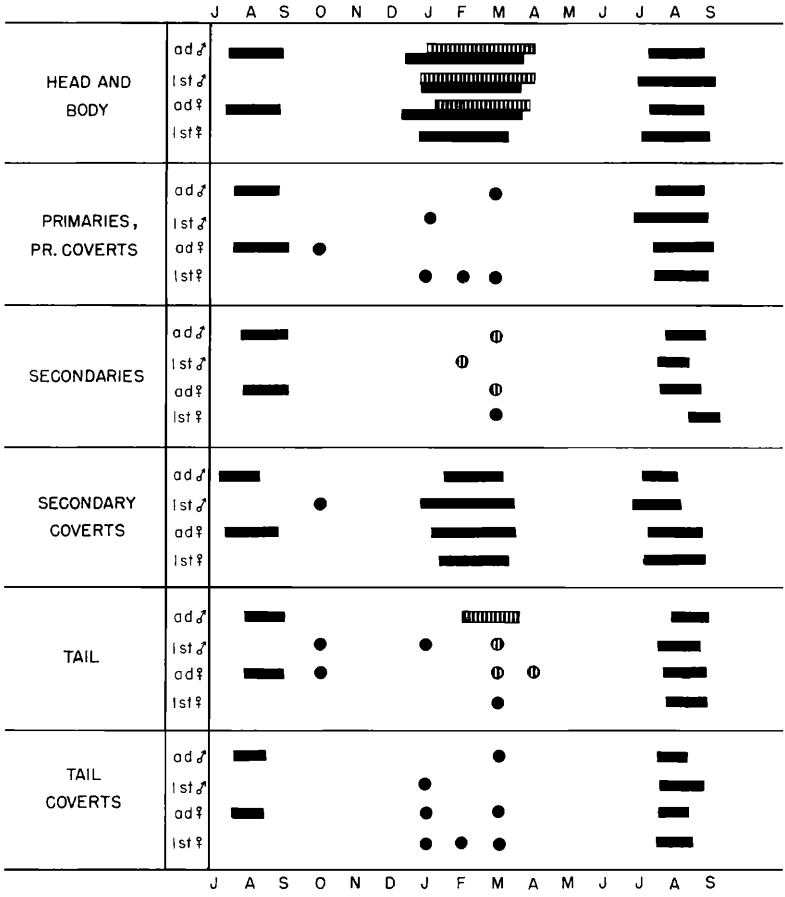

Figure 3. Summary of molting periods in captive and feral Indigo Buntings. Data for captives and feral birds from Florida are indicated by the solid bars; for birds from Jamaica, in cross-hatched bars.

TABLE 5. WEIGHTS OF INDIGO BUNTINGS AT HOMESTEAD, FLORIDA

	February	March	April 1 - 15	April 16 - 20
males	11*: 16.0 (14.3-7.6)	13: 15.7 (14.5-16.9)	26: 16.2 (14.0-18.9)	3: 17.2 (16.9-17.4)
females	13: 14.5 (13.1-16.6)	8: 14.3 (13.4-15.6)	14: 14.1 (14.3-16.2)	6: 16.6 (15.6-19.3)

*N: mean; extremes in parentheses.

averaged 19.2 g. in weight. These population differences in vernal weight and fat increases strongly suggest correlations with flights to be performed over water as versus over land.

MOLT

Few complete molt data are available for North American migrants wintering in the tropics, and, with the exception of a few statements in Dwight's report (1900), we have found no published details on molting Indigo Buntings during the winter and spring months. Because molt in buntings on Jamaica could be studied only from January through April and because an annual picture of this species' molt patterns is desirable, we include here data gleaned from other sources: 300 autumnal migrants at Gainesville, 200 migrants at the WCTV tower, and 35 captive birds. Of the birds obtained in September and October, only approximately 5 percent showed any molt whatsoever and that was a sparse body molt or the 9th primary still partly ensheathed. Thus, in Figure 3 where molt data for this species are summarized on an annual basis, blank areas in September and October represent times when essentially no molt was detected in the many birds examined. Also, for different periods of time ranging up to six years, 35 buntings have been kept in captivity at Gainesville on natural photoperiods at 25° C. These caged buntings, including all four sex and age groups, experienced molt which in its timing and intensity appeared to be normal. In the timing of molt these observations during migration in north Florida differ somewhat from data in the reports of Dwight (1900), who examined very few birds, and Emlen (1967) whose captive buntings molted ". . . between mid-August and early October."

The 20 vernal migrants killed at the WCTV tower were not molting, even though considerable variation in plumage among males was evident—some adults had immaculate blue plumage whereas others retained numerous brown body feathers interspersed among the new, blue ones. Observations on those birds, coupled with those from Jamaica, suggest that molt in the spring is essentially completed before the birds leave their winter quarters.

Extensive prenuptial molt was detected in captive and Jamaican buntings, especially the males, between January and early April. In fact, some individual captive birds were molting continuously from 21 January until 25 March. Areas of the birds' bodies most noticeably involved were the head, body, neck, and secondary coverts. The replacement of dull brown body feathers was clearly responsible for the acquisition of the nuptial plumage in males. Because so many birds, especially males, caught at Montego Bay in January were already in molt, we believe that the head and body molt (prenuptial) is initiated in December or even in November once the bunting has completed its autumnal migration.

Dwight (1900) reported prenuptial molt as occurring "chiefly in February and March." Both Dwight and Blake (1965) noted the replacement of a variable number of distal primaries in the first-year males. At one point Dwight indicated this replacement of

primaries as part of the postjuvenal molt, but later observed the renewal of some primaries in March. The inference from Blake's statistical study is that the replacement is postjuvenal. Of the many first-year males that we have handled in autumn migration at Gainesville and during the winter and spring months at Montego Bay, we have seen no birds actually molting primaries, although we can clearly distinguish the older, browner inner primaries from the newer, blacker outer ones. It seems quite likely that partial replacement of primaries in the first-year males occurs in August before migrants begin moving through the Gainesville area. "Five or six seems to be the usual number. . ." of primaries replaced in first-year males according to Dwight; Blake reported five as the most frequent number of replaced primaries. In our studies, replacement of primaries in first-year males had the following frequency distribution: 3 percent had replaced the outer 2 primaries; 19 percent, the outer 3; 55 percent, the outer 4; and 23 percent the outer 5.

ACKNOWLEDGEMENTS

This study was made possible by grants from the National Science Foundation (GB 2114), American Philosophical Society (Penrose Fund, 3765), and Graduate School of the University of Florida. Herbert L. Stoddard, Sr. and his colleagues at the Tall Timbers Research Station kindly provided us with specimens killed at the WCTV television tower, and Mrs. E. J. Fisk has permitted us to include unpublished weights from south Florida. Bertram G. Murray, Jr. read an earlier version of this paper and offered several helpful suggestions.

SUMMARY

On Jamaica Indigo Buntings were studied in late winter and spring with respect to population movements, returns of banded birds, weight changes, and molt. Supplemental data have been included from buntings in Florida and from captive birds.

Only in recent years have buntings been found in any numbers on Jamaica where, along the north coast, wintering groups appear to be reasonably stationary until at least the end of March. Some color-banded individuals were caught in the same garden not only in consecutive years but also repeatedly throughout the spring months, thus indicating homing and site-tenacity. Extensive prenuptial molt involving only body feathers was characteristic of this vernal period.

Although some buntings probably left the island in late March, the mean departure date for males was 16 April and for females, 23 April. Until about 1 April many of the males weighed 15-16 g., but by mid-April, their mean weight was 19.2 g., some individuals gaining as much as 1.5 g./day. By way of contrast buntings having wintered in south Florida weighed only about 16 g. in early April. The timing and intensity of vernal weight gains in different bunting populations is discussed and appears to be correlated with distance travelled over water or land.

LITERATURE CITED

BALDWIN, S. P. 1921. Recent returns from trapping and banding birds. *Auk*, **38**: 228-237.

BELL, RALPH K. 1966. A Bird Bander's Diary. *EBBA NEWS*, **29**(4): 183-185.

BLAKE, CHARLES H. 1965. Replaced primaries in first nuptial plumage of Passerina cyanea. *Bird-Banding*, **36**(4): 270.

CONNELL, C. E., E. P. ODUM, and H. KALE. 1960. Fat-free weights of birds. *Auk*, **77**: 1-9.

CURRY-LINDAHL, KAI. 1963. Molt, body weights, gonadal development, and migration in *Motacilla flava*. *Proc. XIII Intern. Ornith. Congr.*, 960-973.

DOWNER, AUDREY. 1963. Indigo Buntings in Montego Bay. *Broadsheet* No. 1 (Gosse Bird Club): 3-4.

DOWNER, AUDREY. 1965. Indigo Buntings at Montego Bay. *Broadsheet* No. 5 (Gosse Bird Club): 9-10.

DOWNER, AUDREY. 1966. "Recovery" — by Telescope. *Broadsheet* No. 7 (Gosse Bird Club): 2-3.

DWIGHT, JONATHAN, JR. 1900. The sequence of plumages and moults of the passerine birds of New York. *Annals N. Y. Acad. Sci.*, **8**: 73-360.

EMLEN, STEPHEN T. 1967. Migratory orientation in the Indigo Bunting, *Passerina cyanea*. *Auk*, **84**: 309-342.

FFRENCH, RICHARD P. 1967. The Dickcissel on its wintering grounds in Trinidad. *The Living Bird, Sixth Annual*, 123-140.

HELMS, CARL W., and W. H. DRURY, JR. 1960. Winter and migratory weight and fat field studies on some North American buntings. *Bird-Banding*, **31**: 1-40.

JOHNSTON, DAVID W. 1965. Ecology of the Indigo Bunting in Florida. *Quart. J. Fla. Acad. Sci.*, **28**(2): 199-211.

JOHNSTON, DAVID W. 1966. A review of the vernal fat deposition picture in overland migrant birds. *Bird-Banding*, **37**(3): 172-183.

JOHNSTON, DAVID W. 1967. The identification of autumnal Indigo Buntings. *Bird-Banding*, **38**: 211-214.

LOFTIN, HORACE. 1963. Notes on spring migrants in Panama (Aves). *Carib. J. Sci.*, **3**: 191-195.

LOFTIN, HORACE, DAVID T. ROGERS, JR., and DAVID L. HICKS. 1966. Repeats, returns and recoveries of North American migrant birds banded in Panama. *Bird-Banding*, **37**: 35-44.

LYNN, MRS. R. E. 1963. Indigo Bunting bandings and returns. *Inland Bird Banding News*, **35**(1): 17.

MORTON, MARTIN L. 1967. The effects of insolation on the diurnal feeding pattern of white-crowned sparrows (Zonotrichia leucophrys gambelii). *Ecology* **48**(4): 690-694.

MUELLER, H. C., and D. D. BERGER. 1966. Analysis of weight and fat variations in transient Swainson's Thrushes. *Bird-Banding*, **37**: 83-112.

MURRAY, BERTRAM G., JR. 1966. Migration of age and sex classes of passerines on the Atlantic coast in autumn. *Auk*, **83**: 352-360.

NICKELL, WALTER P. 1967. Four years of spring bird-banding at the Delta of the Mississippi. *Ontario Bird Banding*, **3**: 107-113.

OCUM, EUGENE P. 1960. Lipid deposition in nocturnal migrant birds. *Proc. XII Intern. Ornith. Congr.*, 563-576.

ROGERS, D. T., JR., and E. P. ODUM. 1966. A study of autumnal postmigrant weights and vernal fattening of North American migrants in the tropics. *Wilson Bull.*, **79**: 415-433.

RUSSELL, STEPHEN M. 1964. A distributional study of the birds of British Honduras. *Ornith. Mongr.*, No. 1: 1-195.

SAWARD, JOYCE. 1953. *Natural History Notes*, No. 59.

SMITH, V. W. 1966. Autumn and spring weights of some Palaearctic migrants in central Nigeria. *Ibis*, **108**(4): 492-512.

STODDARD, HERBERT L., SR., and ROBERT A. NORRIS. 1967. Bird casualties at a Leon County, Florida TV tower: an eleven-year study. *Bull. Tall Timbers Res. Sta.*, **8**: 1-104.

TABER, WENDELL, and DAVID W. JOHNSTON. 1968. Life history of the Indigo BUNTING. *In* Life histories of North American cardinals, grosbeaks, buntings, towhees, finches, sparrows, and allies. By A. C. Bent and collaborators. *U. S. Nat. Mus. Bull.*, **237**; Part I: 80-111.

TORDOFF, HARRISON B. 1952. Notes on birds of Jamaica. *Auk*, **69**(3): 320-322.

TREE, A. J. 1965. Return of Palaearctic birds to place of banding in Zambia. *Ostrich*, **36**(3): 144-145.

VAN TYNE, J. 1932. Winter returns of the Indigo Bunting in Guatemala. *Bird-Banding*, **3**: 110.

WARD, P. 1963. Lipid levels in birds preparing to cross the Sahara. *Ibis*, **105**: 109-111.

WILLIAMS, B. 1950. Apparance of migrants. *Natural History Notes*, No. 41.

ZIMMERMAN, J. L. 1965. Carcass analysis of wild and thermal-stressed Dickcissels. *Wilson Bull.*, **77**: 55-70.

Department of Zoology, University of Florida, Gainesville, Florida; Air Jamaica, Montego Bay, Jamaica.

Received May, 1968.

HABITAT DISTRIBUTION AND SURVIVAL IN THE FIELD SPARROW (*SPIZELLA PUSILLA*)

By STEVE FRETWELL

INTRODUCTION

In an earlier paper on the role of territorial behavior in Field Sparrows (Fretwell, ms, b), I found that the nesting success in a densely occupied habitat appeared to be lower than in a sparsely settled area. This implied that many individuals selected an overcrowded habitat to breed. Two explanations seemed plausible: firstly, the birds could be maladapted, and were unable to distribute properly (see Fretwell, ms, a). This explanation seemed reasonable because the habitats studied were pine plantations, habitats to which Field Sparrow populations can not have been long exposed. In developing an alternate explanation, however, it was noted that in 1964-1965 Field Sparrows wintered in the densely occupied habitat (✻1) but not in the sparsely occupied one (✻2). It was then proposed that breeding in the winter habitat provided an overwinter survival advantage which compensated for the lower nesting success. A study of Wynne-Edwards' ideas (1962) suggested a mechanism involving social behavior by which