

Brief details on these records follow. Those from Louisiana are cited in Lowery 1974, Louisiana birds, third ed., Baton Rouge, Louisiana State Univ. Press, and those from Alabama in Imhof 1976, Alabama birds, second ed. University, Alabama, Univ. Alabama Press. Some of them also appeared in Audubon Field Notes and Amer. Birds, as cited below.

1958.—Most of July; specimen 30 July to Univ. Alabama from Mobile Pilot Ship, 7 miles south of Dauphin Island, Alabama, J. C. Gray and M. W. Gaillard (identification verified by R. C. Laybourne). 1964.—16 July, 2, Chandeleur Islands, Louisiana, L. E. Williams (Stewart 1964, A. F. N. 18: 513). 1966.—29 September, a dying bird not preserved, Dauphin Island, tropical storm Debbie, W. T. Siebols. 1970.—7 May, off Santa Rosa Island, Florida, J. M. Stevenson (Imhof 1970, A. F. N. 24: 616). 21 and 23 May, 3, 1½ miles off Panama City, Florida, M. A. Olson (Imhof 1970, A. F. N. 24: 616). 4 and 5 September, 2 on 4th, 35 miles off South Pass, Louisiana, R. J. Newman. 1971.—11 August, 35 miles off South Pass, R. J. Newman. 1972.—3 May, 20 miles off South Pass, R. J. Newman. 1973.—July through September, up to 16, off Dauphin Island, T. Walker and many (Purrrington 1974, Amer. Birds 28: 64). 1974.—4 July, off Dauphin Island, F. E. Bowers (Purrrington 1975, Amer. Birds 29: 69). 30 July, specimen, Florida State Museum, off Shired Island, Dixie County, Florida, D. W. Johnston. 1 September, 1 probable; 11 November, 27 probables, off Panama City, Florida, S. Stedman and J. Harbison (Purrrington 1975, Amer. Birds 29: 69).

In my experience on the Alabama coast, shearwaters, storm-petrels, gannets, boobies, tropicbirds, frigatebirds, phalaropes, jaegers, and pelagic gulls and terns generally feed 30 or more miles offshore when the wind is northerly (offshore). With southerly onshore winds, which are usual during storms, these birds are often seen from land and even enter bays. The Magnificent Frigatebird (*Fregata magnificens*) is a conspicuous example of this type of feeding pattern. In 1973 Greater Shearwaters entered Mississippi Sound, Alabama on southerly winds of 5–10 knots and provided opportunities for excellent photography by T. Walker, J. V. Peavy, and H. H. Kittinger (Imhof 1973, Alabama Birdlife 21 (3–4): 6–7; 1976, Alabama birds, second ed.).—THOMAS A. IMHOF, 1036 Pike Road, Birmingham, Alabama 35218. Accepted 3 Oct. 75.

**Differential growth of body parts in the White Ibis.**—Patterns of growth and the development of final structure size in birds, like other characteristics of reproduction, are the results of adaptation to the varying environmental demands on both adults and young. Ricklefs (1973) demonstrated how patterns of biomass growth relate to varying adaptive strategies. To elucidate the adaptive processes of growth, it is also important to consider the patterns of growth of characters other than biomass and to compare such patterns within a single species. Ricklefs (1975) suggested that differences in growth rates reflect differences in the rate at which mature function is achieved. If so, differing growth rates of various body parts must have differing adaptive values relative to the biology of each species. Ricklefs (1975) discussed differential growth rates of body components in a passerine. A number of other studies have measured the growth of various body parts in birds and Kahl (1962, 1966), Siegfried (1972) and Gavino and Dickerman (1972) have done the same for various ciconiiforms. Siegfried (1966), Karhu (1973) and Dunn (1976) noted the occurrence of differential growth of body parts. These studies gave little consideration to the adaptive aspects of the growth patterns they found. In this paper I discuss the growth of seven body components of the White Ibis (*Eudocimus albus*) and comment on the adaptive value of differing growth patterns.

Birds were taken as piped eggs from nesting colonies in southern Florida and individually maintained in small containers at 30°C. Each hour they were fed all they would consume of a ground mixture of two parts shrimp (*Penaues duorarum*) and one part sardine (*Harengula pensacolae*) by weight to which was added 20 ml of water and 1 g vitamin and mineral supplement per 100 g of food. After 2 weeks they were placed in larger cages within a screened enclosure under ambient southern Florida temperature and fed shelled shrimp and anchovies (*Anchoa mitchilli*). At 3 weeks they were moved to outdoor cages, 0.5 × 0.5 × 1.1 m.

Birds were weighed and the middle toe, tarsus, primary VIII, wing arc, innermost left retriix, and the bill were measured daily before their first meal. Mean sizes and ranges were calculated based on 5 birds from day 1 to 20 and on one male and one female from day 20 to 130. My concurrent measurements of the biomass growth of wild nestling White Ibis showed that the biomass growth of the captive nestlings was slower. The discrepancy between wild and captive nestlings does not bias the results of the present paper, which concerns only the relative growth among body parts. The patterns of growth described were also apparent in the wild nestlings studied. A detailed consideration of the differences in growth between wild and captive ibis will be presented elsewhere (Kushlan ms.). In the present paper, captive birds were used to facilitate daily measurements and to follow growth beyond the usual nesting period.

Growth curves were compared using Ricklefs' (1967) method of curve fitting. The growth curve parameters compared were the asymptotic size (the calculated size approached by the growth curve, which bears

no consistent relation to either adult size or size of the character at the end of the nesting period), the growth constant (K), the growth rate calculated as the time to grow between 10% and 90% of final size, the day on which 90% of final size was reached, and the day near which the adult size was reached. In this study the asymptotic sizes of various characters calculated by Ricklefs' method were the same or within 5% of adult size except weight, which was 79% of adult size. The mean clutch size of White Ibis in southern Florida is 2.33 with a brood reduction to about one nestling by the time of fledging. Incubation is 21 days, and newly hatched nestlings averaged 35.1 g. Wild birds fledged around 40 days but captive birds did not reach a similar stage of development until around day 50, which is taken as fledging for this paper.

Body parts developed at different rates (Fig. 1, Table 1). Leg structures grew fastest and wing and tail were the next fastest, reaching 90% of their final size in 35 to 40 days. The tail did not begin growth until day 18, but then grew at the fastest overall rate and reached 90% of its final size only 17 days later. The bill was the slowest growing structure measured.

At fledging time, only toes and tarsi were approximately adult size. The bill, only 68% of adult size at fledging, required a total of 72 days to reach the 90% growth stage and 112 days to reach adult size. The primary and tail feathers reached adult size around 55 days, although fraying caused a decrease in size thereafter. Of most significance in terms of energy requirements was that the weight at fledging averaged only 79% of adult weight. The single captive individual followed reached adult weight at 630 days, 31 months after hatching.

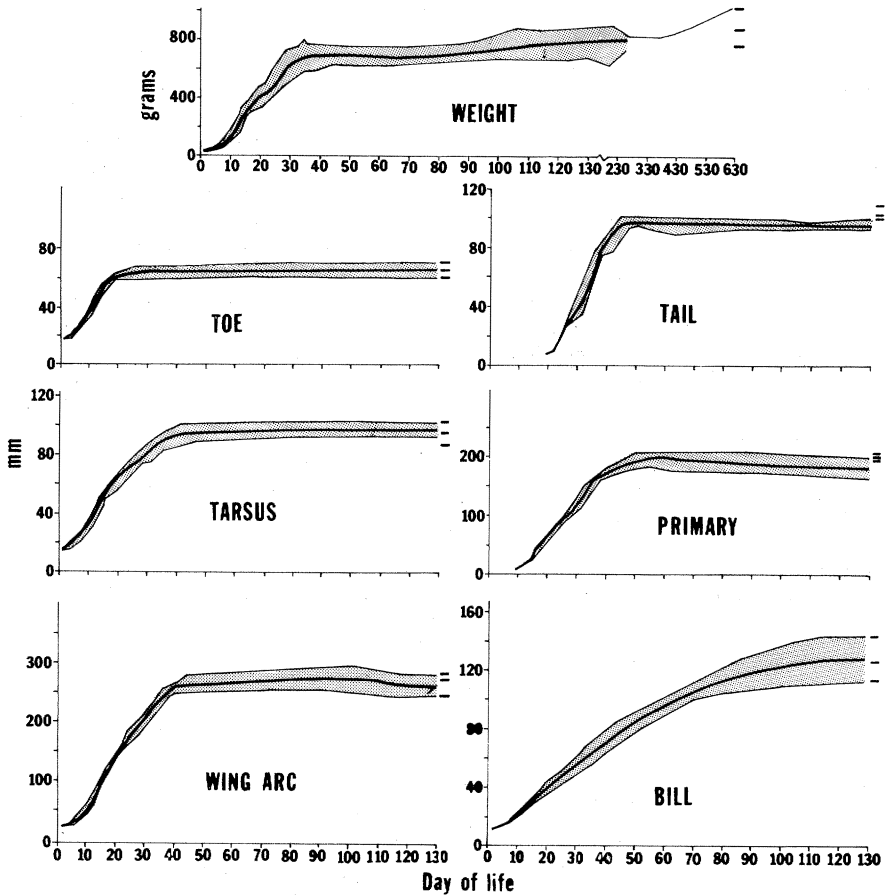


Fig. 1. Growth curves of body parts of White Ibis. Shaded zones are ranges. Solid lines within the range are the mean size for each day of life. Mean sizes of adult White Ibis collected in southern Florida are indicated by horizontal slashes at the right of each plot, top slash males, middle overall mean, bottom females.

TABLE 1  
GROWTH PARAMETERS OF NESTLING WHITE IBISES

| Character    | Growth constant (K) | Asymptotic size (mm or g) | Growth rate <sup>a</sup> | Day of life when 90% final size | Ratio of size at fledging to adult size | Day of life when adult size |
|--------------|---------------------|---------------------------|--------------------------|---------------------------------|---|-----------------------------|
| Middle toe   | .171 <sup>b</sup>   | 66                        | 18 <sup>c</sup>          | 18                              | 1.00                                    | 29                          |
| Tarsus       | .180 <sup>b</sup>   | 94.5                      | 25 <sup>c</sup>          | 25                              | .98                                     | 52                          |
| Tail         | .020 <sup>c</sup>   | 95                        | 17                       | 35                              | .92                                     | ca. 55                      |
| Primary VIII | .249 <sup>d</sup>   | 198                       | 27                       | 35                              | .93                                     | 54                          |
| Wing arc     | .123 <sup>b</sup>   | 278                       | 35                       | 40                              | .94                                     | 74                          |
| Bill         | .043 <sup>d</sup>   | 125.5                     | 70                       | 72                              | .68                                     | 112                         |
| Weight       | .185 <sup>b</sup>   | 7000                      | 23                       | 30                              | .79                                     | 630                         |

<sup>a</sup> Days needed to grow from 10% to 90% of final size.

<sup>b-d</sup> Curve fitted to logistic equation (b), Von Bertalanffy equation (c), Gompertz equation (d).

<sup>c</sup> Because toe and tarsus were 30% and 17% respectively of their final sizes at hatching, data for these structures are from day 1 to 90% of final size.

White Ibis growth is characterized by the relatively rapid increase in size expected for altricial water birds of their size (Fig. 10 of Ricklefs 1973), but at fledging most measurements are less than those of adult birds. Only feet and legs reached adult size by fledging, at which time other characters were between 68% and 94% of adult size. The initial rapid growth of feet and legs enables nestling ibis to perch, walk, climb, and cling at an early age. Thus they are able to remain securely near the nest or move in trees or on land to follow their parents, avoid predators, and later to gather in prefledging groups on the top of trees. Such precocial development of leg structures is also found in other birds (Ricklefs pers. comm.) including ciconiiforms, as McVaugh (1973) illustrated. As the White Ibis forages by walking and probing, full development of walking structures at fledging is obviously adaptive. Conversely a bird with a foraging strategy involving walking does not depend on the rapid maturation of flight structure to the same extent as a species that feeds on the wing. Thus the flight structures, remix, retrix, and wing arc, were 6 to 8% below adult size at fledging and reached adult size around 2 months of age.

The underdevelopment of the bill and low body weight at fledging are the most ecologically significant aspects of differential development in the White Ibis. A low body weight through the early period of life results in considerable metabolic savings by requiring a lower daily food intake than that of adult-sized birds. This would be selectively advantageous if the ability of young birds to obtain food was not so great as that of adults. Perhaps a smaller, more slowly developing bill through the first one-third year of life is similarly adaptive, permitting an ibis gradually to increase foraging proficiency as the bill increases in size.

The pattern and rate of growth of seven parameters of body size were analyzed in the White Ibis. Structures associated with terrestrial locomotion were fastest growing and were the only structures measured that achieved adult size at fledging. Structures associated with flight developed more slowly in this ground-feeding species. Body weight and bill were the slowest components to develop. Lowered body weight over the first 1.7 years of life probably results in significant metabolic savings. Slow bill development may be related to a gradual increase in foraging proficiency.

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**Variation in size and quality of the Starling egg.**—The size of eggs varies within populations and, to a lesser extent, within clutches of birds. In several species large egg size results in increases in size of chick, rate of growth, and survivorship (Halberson and Mussehl 1922, Wiley 1950, Skogland *et al.* 1952, Parsons 1970, Schifferli 1973). Amounts of protein and lipid vary in direct proportion to egg size in domestic fowl (Romanoff and Romanoff 1949) and the Herring Gull, *Larus argentatus* (Parsons 1970), but the relationship between egg size and composition has yet to be determined for any species of bird with altricial development. Furthermore, proportions of egg constituents may vary as a function of egg size, resulting in eggs of different quality. Romanoff and Romanoff (1949: 116) have shown for the leghorn chicken that as egg weight increases the proportion of albumen in the egg increases slightly and the proportion of yolk decreases slightly. Parson's (1970) data on Herring Gulls similarly indicate a decrease in the proportion of yolk with increasing egg size, but with no corresponding change in the proportion of lipid in the eggs.

This note reports on the relationship between egg composition and weight in the Starling (*Sturnus vulgaris*). I collected 12 eggs on 23 April 1973 from incomplete clutches in nest boxes near Kennett Square, southeastern Pennsylvania, taking 1 egg from each of 8 boxes and 2 eggs from each of 2 boxes. Egg contents were analyzed the same day. Amounts of water, lipid, and nonlipid dry matter were determined separately for shell, albumen, and yolk. Components were dried in a vacuum oven at 50°C. Lipids were extracted in a 5:1 mixture of petroleum ether and chloroform.

The sample of eggs had an average weight of 7.20 g (range, 6.3 to 8.0 g) with a standard deviation of 0.53 g and coefficient of variation of 7.36%. The eggs contained  $12.5 \pm 1.2\%$  (mean  $\pm$  SD) shell (undried, including shell membranes),  $17.0 \pm 1.7\%$  yolk, and  $70.6 \pm 2.0\%$  albumen; the yolk contained  $57.0 \pm 0.9\%$  water,  $27.2 \pm 2.6\%$  lipid, and  $15.9 \pm 2.4\%$  nonlipid dry matter; the albumen contained  $89.4 \pm 0.6\%$  water,  $0.8 \pm 0.6\%$  lipid (or other ether extractible material), and  $9.7 \pm 0.6\%$  nonlipid dry material.

I calculated product moment correlations and regression statistics for each component as a function of egg weight. Albumen weight and shell weight both increased as egg weight increased (correlation coefficients,  $r = 0.95$  and  $0.89$ ,  $P < 0.01$ ) but yolk weight did not vary with respect to egg weight ( $r = 0.25$ ,  $P > 0.05$ ). Because the slope of the regression of albumen weight on egg weight  $b = 0.79$  g albumen/g egg weight) was greater than the average albumen content of the eggs (0.71 g/g), the proportion of albumen in the eggs increased as egg weight increased, but not significantly ( $r = 0.30$ ,  $P > 0.05$ ). The proportion of shell remained constant ( $r = -0.10$ ). The proportion of yolk in the egg decreased significantly with increasing size ( $r = -0.52$ ,  $P < 0.05$ ,  $b = -1.68\%/g$  egg weight). Proportions of water, lipid, and nonlipid dry matter did not change significantly in either yolk or albumen. Because the proportion of yolk varies inversely to the proportion of albumen, the level of nonlipid dry matter in the egg as a whole (yolk plus albumen) did not vary significantly with egg weight ( $r = 0.19$ ). The level of lipid in the egg as a whole decreased with increasing egg weight, but not significantly ( $r = -0.41$ ,  $b = -0.6\%/g$  egg weight).

Although coefficients of variation in yolk weight (8.60%) and albumen weight (8.58%) were similar to the coefficient of variation in egg weight (7.36%), only albumen weight was correlated with egg weight. Egg size in the Starling apparently depends on the amount of albumen laid down, which has been related to the weight of the oviduct (Ricklefs 1976). Because yolk size is not related to egg size, growth of Starling young may be independent of egg weight, in contrast to findings on the Great Tit, *Parus major* (Schifferli 1973). Growth parameters of the Starling (asymptote and growth rate constant of logistic equations fitted to growth curves) are, in fact, unrelated to egg size (MS). This is not to say that growth is not influenced by the size of the yolk, only that yolk size and growth are both unrelated to egg weight.

The relationship between proportion of yolk and egg weight in the chicken (Romanoff and Romanoff 1949: Fig. 57) has a slope of  $-0.176\%/g$ ; the same relationship in the Starling has a slope of  $-1.68\%/g$ . These slopes may be normalized for comparison by relating the decrease in proportion of yolk to the