

AGE-SPECIFIC CHANGES IN THE MAJOR BODY COMPONENTS AND CALORIC VALUES OF HERRING GULL CHICKS

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ABSTRACT.—Herring Gull chicks are relatively variable in body weight gain and fat content, but are more regular in linear skeletal growth. Developmental patterns of the internal organs of the semi-precocial gulls resemble those reported for altricial nestlings, but age-related changes in body fat and water content are more similar to those of precocial species. Increases in live-weight caloric values with age, from about 1.0 to 2.0 kcal/g, are related to increasing fat and decreasing water contents throughout the growing period.

Caloric content of tissues, major body components and relative sizes of body organs differ significantly between growing altricial and precocial birds (Norton 1970, Brisbin and Tally 1973, Ricklefs 1974, Dunn 1975a, Clay et al. 1979). Although semi-precocial chicks resemble precocial chicks in appearance and development of thermoregulation (Ricklefs 1974, Dunn 1976), their external growth patterns are intermediate between altricial and precocial extremes. The internal growth characteristics of semi-precocial species need to be documented in order to learn whether these features are also intermediate. Only limited data of this type are presently available (Koelink 1972, R. E. Ricklefs and S. C. White, unpubl. data).

We describe here age-related changes in the proportional sizes of some organs and body parts as well as caloric equivalents and water and fat components of growing semi-precocial Herring Gull chicks (*Larus argentatus*).

METHODS

The growth patterns of Herring Gull chicks in natural nests were studied by EHD in a portion of a gull colony on Appledore Island, New Hampshire, during the 1972 and 1973 breeding seasons. Chicks were individually marked with numbered plastic leg bands when one day old. Weights were recorded to the nearest 1.0 g with a Pesola spring balance. Chicks normally excreted and occasionally regurgitated before being weighed. Forearm and tarsus lengths of some of these birds were measured with a ruler held parallel to the bone, with the adjacent portions of the appendage being held at right angles to the bone being measured.

After measurement of metabolism (Dunn 1976), 13 chicks from the Appledore Island colony were killed and frozen for later analysis of body composition and internal development. Ages of seven of these chicks were not known exactly and were estimated by comparison of body weights and measurements with those

of known-aged chicks measured in the field. All birds of uncertain age were judged to be less than three weeks old, when estimation generally is accurate to ± 3 days (see Figs. 1 and 2). Carcasses were dissected while partially frozen in order to minimize loss of blood. Heart, liver and digestive tracts were each weighed to the nearest 0.1 g on a triple-beam balance, after blood was squeezed from the heart and the digestive tract was emptied. The weight of the digestive tract included the stomach and intestine with all attached organs and membranes. All body organs were then returned to the body before refreezing. The entire carcass was later homogenized in a blender and subsamples were either freeze-dried or dried in a vacuum oven at 50–60°C to constant weight. Lipid was extracted with petroleum ether in a Soxhlet apparatus. For 5 of the 13 Appledore birds, caloric determinations were made on four subsamples of the remaining lean dry residue with a Phillipson oxygen microbomb calorimeter. Live-weight caloric values were calculated by assuming a value of 9.0 kcal/g for extracted fat (Odum et al. 1965), adding it to the caloric value for the lean dry component and correcting for water content (Dunn 1975b). In the other eight cases, live-weight caloric values were calculated without calorimetry by using standard caloric conversion factors for extractable lipids (above) and 4.75 kcal/g for lean dry weight (Ricklefs 1974, this study). For both Dunn's and Brisbin's (see later) calorimetry samples, this indirect calculation gave live-weight caloric values which, on average, agreed within 5% ($n = 9$). Whenever possible, however, values presented here are calculated on the basis of actual caloric determinations of the lean dry component.

Analyses of major body components and caloric values were also conducted by ILB, on four birds collected as known-aged nestlings from the gull colony on Kent Island, Bay of Fundy, New Brunswick, Canada during the 1963 breeding season (Brisbin 1965). This colony is approximately 370 km to the northeast of Appledore Island, and both are within the area generally considered to be occupied by the New England Herring Gull population (Kadlec and Drury 1968).

Nestlings from the Kent Island colony were dried to a constant weight in a vacuum oven at 40°C after first opening up the carcass of each bird to facilitate drying, but without removing any organs or their contents and without carcass homogenization. Dried carcasses were then ground in a blender with 95% ethanol, followed by lipid extraction with petroleum ether. The remain-

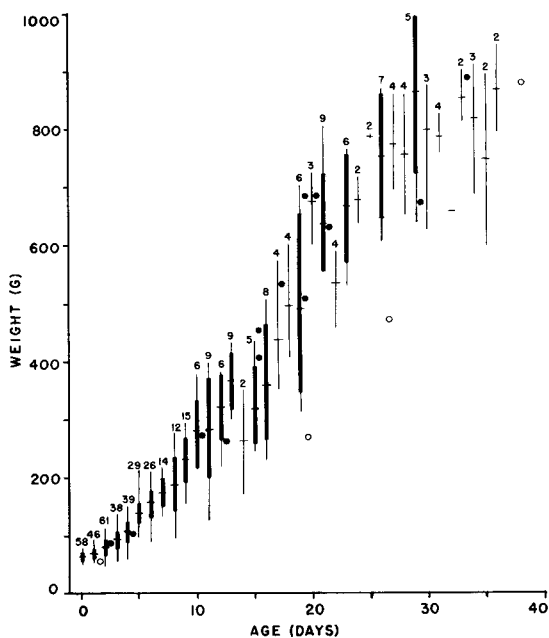


FIGURE 1. Body weights of Herring Gull chicks. Horizontal bars denote the mean weights of chicks from the Appledore Island, New Hampshire colony. Heavy vertical bars represent \pm one S.D. and thin vertical lines show the range. Numbers indicate sample sizes when more than one bird was measured. Weights of individual chicks killed for biomass analyses are indicated by solid and open circles, for birds from the Appledore Island and Kent Island colonies, respectively.

ing lean dry residue of each bird was ground in a Wiley Mill and the heat of combustion of a 0.6–1.0 g aliquot from each bird was determined using a Parr adiabatic oxygen bomb calorimeter. Live-weight caloric values were calculated for each of these individuals as described above. Differences between our methods should not be important, with the possible exception that Brisbin's method of lipid extraction, using ethanol as well as petroleum ether, may give a higher fat index than when petroleum ether is used alone.

RESULTS AND DISCUSSION

Body weights of the Herring Gull chicks are presented in Figure 1. The growth rate of chicks from Appledore was similar to that documented in more detailed studies (e.g., Kadlec et al. 1969). Although Kent Island chicks analyzed for caloric content weighed less than comparably aged chicks on Appledore, they apparently were as heavy as other wild chicks on Kent Island in the same year (Brisbin 1965).

Lengths of the forearm and tarsus of Appledore Island chicks (Fig. 2) show less overlap between ages than do body weights, and are useful in estimating ages of chicks, as has been demonstrated for several other semi-precocial species (Koelink 1972,

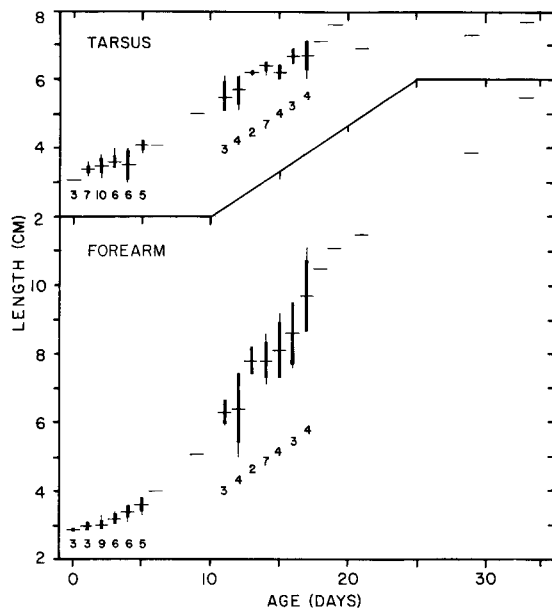


FIGURE 2. Tarsus and forearm measurements of Herring Gull chicks from Appledore Island. Symbols as in Figure 1.

LeCroy and Collins 1972, Dunn 1979). Although only a few data points are available, these data suggest that for the tarsus, at least, growth slows and nearly ceases several weeks before asymptotic body weight is attained.

Age-specific development of various internal organs (Fig. 3) previously were analyzed and compared with data for seven altricial and one precocial species (Dunn 1975a). This comparison suggests that internal development patterns of the Herring Gull are more similar to those of altricial species in which organs grow rapidly after hatching and slow later in the nestling period. In precocial species, organs grow slowly throughout development. More data are needed, however, for precocial and semi-precocial species.

Body water and lipid content change with age (Fig. 4). The proportion of body water decreases in nestlings of all avian species as they grow older, regardless of the growth pattern involved. Water indices of very young Herring Gull chicks, like those of comparably-aged precocial species (Norton 1970, Brisbin and Tally 1973, Clay et al. 1979), were considerably lower than corresponding values for altricial species (e.g., Ricklefs 1967). Water indices of 2.5 to 3.0 seem typical for most birds as they approach asymptotic weight (Brisbin and Tally 1973) and the Herring Gull is no exception, al-

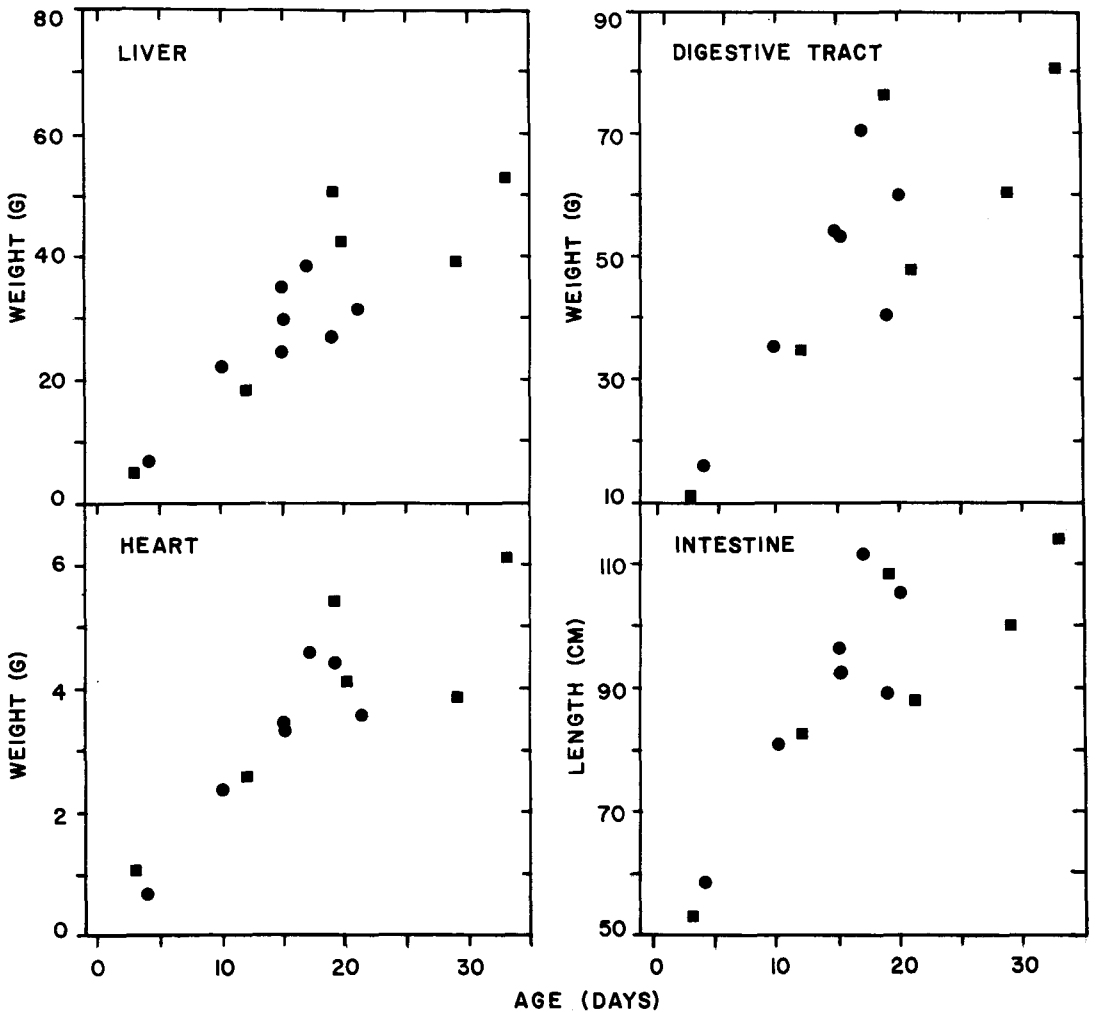


FIGURE 3. Weights and measurements of internal organs of Herring Gull chicks from Appledore Island. Each point represents a single bird. Circles indicate birds of known age, squares show chicks whose ages were estimated.

though a great deal of scatter was evident among the few data for older birds (Fig. 4). The water indices of the growing Herring Gulls were nearly identical throughout growth to those of the Pigeon Guillemot (*Cepphus columba*; Koelink 1972) and Common and Sooty terns (*Sterna hirundo* and *S. fuscata*; Ricklefs and White, unpubl. data).

The fat index of the youngest Herring Gull was quite high, probably due to the internal persistence of the yolk sac (Dunn 1975a); the fat content of chicks two or three days older was considerably lower and then it increased gradually in even older birds. This pattern is similar to that reported for precocial waterfowl (Sugden and Harris 1972, Clay et al. 1979) and altricial cormorants (Dunn 1975a). As the gulls approached asymptotic weight, their bodies tended to

contain more fat than those of altricial species of comparable relative ages (Ricklefs 1967, Dunn 1975a), and they also were higher than those of various species of tern chicks (Ricklefs and White, unpubl. data). Similarly elevated fat levels are shown by the Pigeon Guillemot (Koelink 1972). Fat content has also been shown to vary markedly between species in precocial chicks (Norton 1970, Brisbin and Tally 1973, Clay et al. 1979).

Live weight caloric value of the Herring Gull chicks rose from about 1.0 to 2.0 kcal/g, leveling off after about 20 days of age (Fig. 5). Our limited calorimetric data show that lean dry caloric value remains constant, averaging 4.74 kcal/g (S.D. = ± 0.51). The variability in live-weight caloric value must therefore be related to changes in the relative proportions of total body water and fat

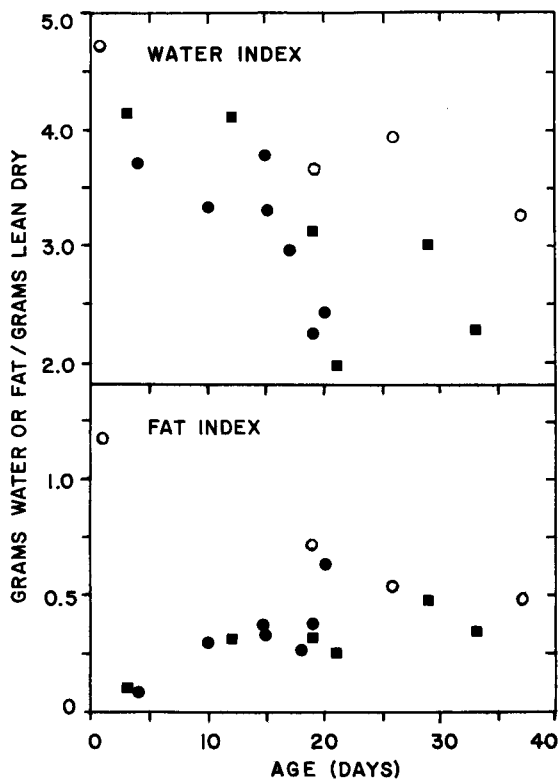


FIGURE 4. Water and fat indices of Herring Gull chicks. Solid symbols represent single birds from Appledore Island and open symbols represent chicks from Kent Island. Circles indicate birds of known age, squares represent chicks whose ages were estimated.

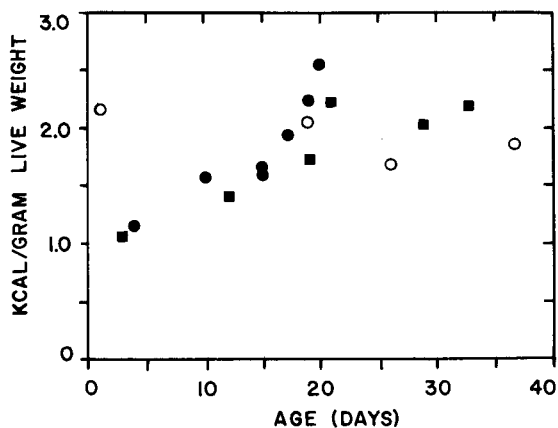


FIGURE 5. Caloric values of live-weight biomass of growing Herring Gull chicks. Symbols as in Figure 4.

(see also Brisbin 1969, Brisbin and Tally 1973, Dunn 1975a, Clay et al. 1979).

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