NESTLING DEVELOPMENT OF GREEN HERONS AT SAN BLAS, NAYARIT, MÉXICO

GONZALO GAVIÑO T.

Gabriel Mancera 511
Col. del Valle
México 12, D. F.

AND

ROBERT W. DICKERMAN[1]

Department of Microbiology
Cornell University Medical College
1300 York Avenue
New York, New York 10021

Although many recent papers have described methods for determining general age classes and growth rates of nestling birds, few have dealt with members of the order Ciconiiformes. Meyerriecks (*in* Palmer 1962) and Wheelock (1906) briefly presented some data on growth in nestling Green Herons (*Butorides virescens*) and Hindwood (1933) described the development of nestlings of *Butorides striatus* in Australia. Gross (1923) studied development of the Black-crowned Night Heron (*Nycticorax nycticorax*), and McClure et al. (1959) made extensive measurements of the growth of nestlings of that species as well as of Plumed and Little Egrets (*Egretta intermedia* and *E. garzetta*) in Japan. Lowe (1954) described the development of young Gray Herons (*Ardea cinerea*) and Kahl analyzed in detail growth rates of nestling Wood Storks (1962) and Marabou Storks (1966).

Because of the possible importance of age in susceptibility of birds in general to infection with arboviruses, i.e., viruses transmitted by mosquitoes (see reviews by Scherer 1963 and Stamm 1966), and because of the involvement of ciconiiform birds in the natural cycles of arboviruses, more accurate methods of aging birds are needed.

This report on the development in Green Herons is the second part of a study of the nesting biology of the species at San Blas in the state of Nayarit on the Pacific coast of México (for a description of the study area, see Dickerman and Gaviño 1969). The field work during the nesting season of July-September 1964 was largely carried out by Gaviño and formed the basis of his professional thesis submitted to the Facultad de Ciencias of the Universidad Nacional Autonoma de México (Gaviño 1966). The junior author provided the basic outline of the project and translated and amplified the manuscript.

PROCEDURE

The heron colony, 2.4 km ENE of San Blas, was visited almost daily during the months July to September. Nests were numbered, new eggs were marked as they were found, and as they hatched, the young were weighed and color marked with a dab of paint. The young were banded with U.S. Fish and Wildlife Service leg bands when large enough to retain them. On each visit to the colony, as many randomly selected, known-age young were measured and weighed as time permitted. Young became highly ambulatory at less than two weeks of age, and by two weeks would attempt to escape by jumping into the water. Beyond 15–16 days, young were increasingly difficult for a person working alone to catch, and the size of the samples from that age onwards dropped off sharply. They began flying from mangrove to mangrove at 21–25 days of age, and could then cover distances of up to 10 m.

Measurements taken were: weight in grams, and the lengths in millimeters of primaries 3 and 8, the tarsus, and the upper mandible from the tear duct and from the posterior edge of the nostril (fig. 1). Measurements for the upper mandible from the tear duct and of primary 3 were modeled after the study by McClure et al. (1959). Both primaries 3 and 8 were measured because of the doubt as to which feather McClure et al. referred. Later W. F. Scherer, one of the co-authors, informed us (pers. comm.) that in the Japanese study they measured the third large primary from the outside (i.e., primary 8). The blunt posterior edge of the nostril was selected rather than the more usual anterior edge, which is slit-like in the Green Heron, in order to have a better defined point from which to measure. Measurements were taken with vernier calipers reading to 0.1 mm. Weights of small young were made with an Ohaus triple-beam balance. Young of a few days and older were weighed in a plastic bag on an Ohaus spring scale read to the nearest gram. Numbers of young measured per age group were: day 1, 55; days 2–8, 33–49; days 9–12, 20–30; days 13–16, 12–14; days 15–21, 4–9; and days 22–41, 1–3.

The subspecies of Green Heron nesting at San Blas, Nayarit, is *Butorides virescens virescens*. This form occurs throughout México except the central plateau and northwestern part of the country, and ranges

[1] Requests for reprints should be sent to this address.

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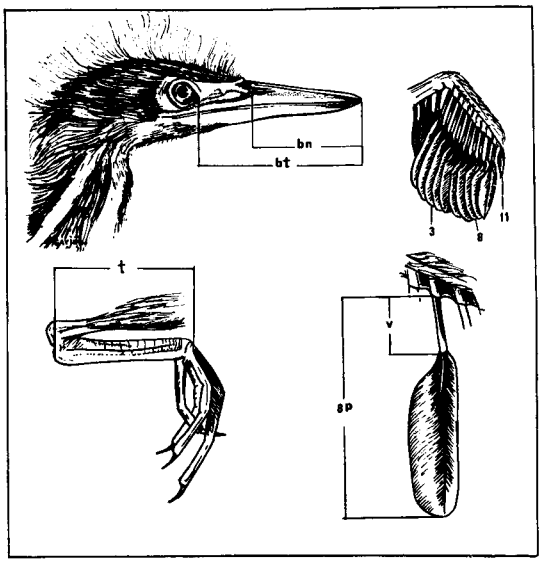

FIGURE 1. Structures measured during growth studies of Green Herons: bill from posterior edge of nostril (*bn*); bill from tear duct (*bt*); tarsus (*t*), primaries 3 and 8, and sheath (*v*).

south to the base of the Yucatán Peninsula, as well as covering the entire region of the conterminous United States east of central New Mexico (see map, Palmer 1962:418). Within this range there is no apparent significant geographic variation in size (Oberholser 1912).

In North American species of the family Ardeidae, there is relatively little sexual dimorphism in size, except in the American Bittern (*Botaurus lentiginosus*). In some forms of the Great Blue Heron (*Ardea herodias*) and the Louisiana Heron (*Egretta tricolor*) there may be 5–10 per cent variation in bill length. In bill measurements of all other species, and in the wing measurements of those two species, there is less than 5 per cent variation between series of the two sexes (from data in Palmer 1962). In *Butorides* sexual dimorphism in size is usually less than 3 per cent (Oberholser 1912). Thus, sexual variation within the series of nestling birds did not constitute a significant variable, and is ignored in the following growth curves and tables.

WEIGHT

Of the measurements taken in the field, weight exhibited by far the greatest variability, with 450 per cent variation between maximal and minimal weights in young of 6–7 days of age

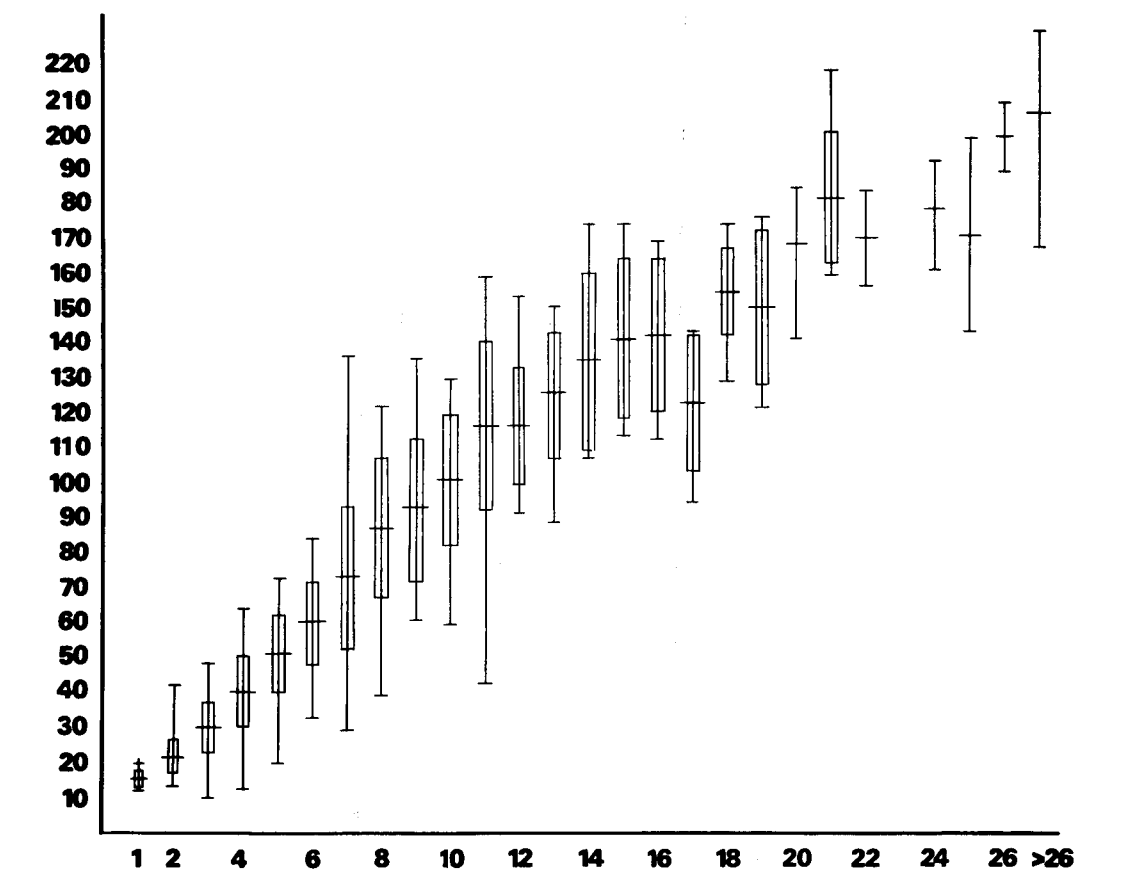

FIGURE 2. Weight (g, ordinate) of Green Heron nestlings as a function of age (days, abscissa, mean = horizontal lines; ranges = vertical lines; ± SD = rectangles.

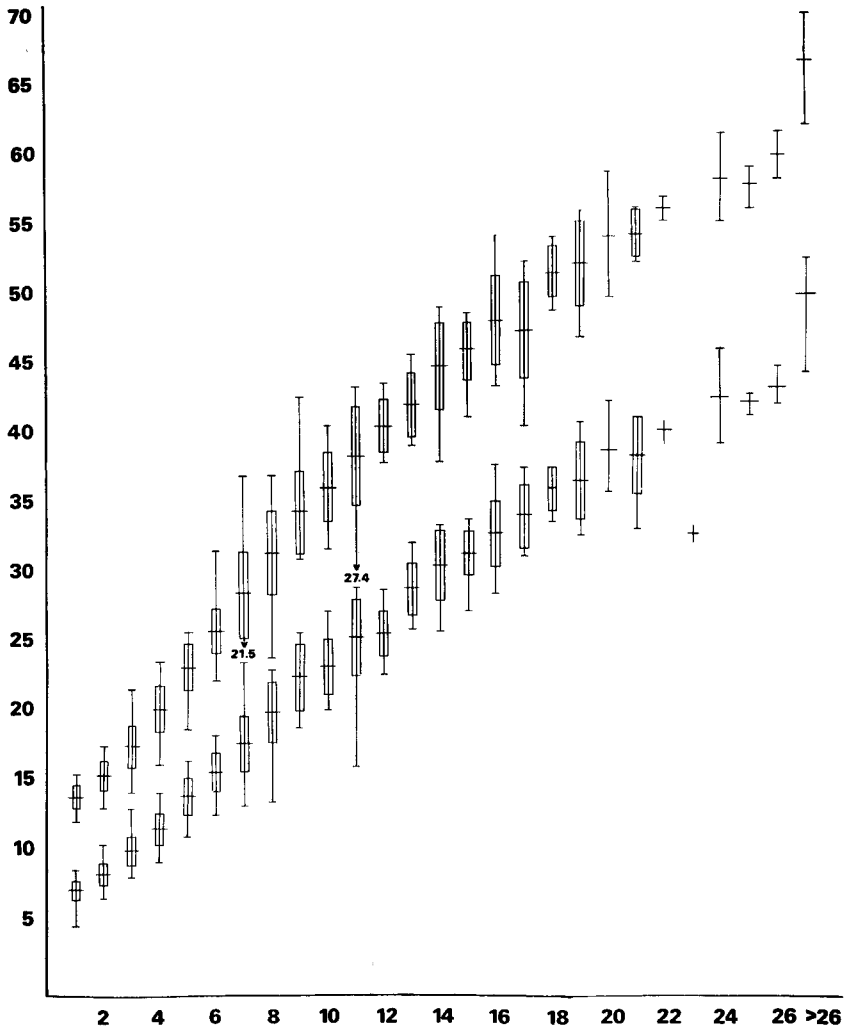

FIGURE 3. Bill length (mm, ordinate) of Green Heron nestlings as a function of age (days, abscissa). Upper data, length from tear duct; lower data, length from posterior edge of nostril; graphic representation as in figure 2.

and nearly 400 per cent variation among young of 10–11 days of age (fig. 2). This variation was due partly to the amount of food a bird had in its crop and stomach. Birds were usually weighed between 09:00 and 14:00, but the time varied from 08:00 to 18:00, and parents always had sufficient time to feed their young from one to several times in the day prior to the weighing of the young. Likewise the individual young varied greatly in their tendency to regurgitate their food while being handled. A nestling 3–4 days of age might cast up 15–20 g of fish, i.e., 50 per cent of the average body weight at that age. The more recent the meal, the more readily it was regurgitated, and it was not always feasible to attempt to extract all the food of the last feeding prior to weighing. The dip in weight and in culmen measured from the tear duct on day 17 (figs. 3, 4) can only be explained as due to random sampling error.

In the field Gaviño did not consider competition among siblings to be a major factor in weight variation when birds of a given age were being compared. Comparisons among nest mates show that even when one chick was smaller during its first week, development was normal, and during the second week the difference often leveled off. The retarded chick might have been the first, second, or last to hatch. In contrast, McClure et al. (1959:36) considered that competition among siblings probably caused the great variation they found among young of the same age.

The average weight of 194 freshly-laid eggs was 17.1 g. Twenty eggs weighed daily lost during the incubation period an average of about 1 g (Dickerman and Gaviño 1969).

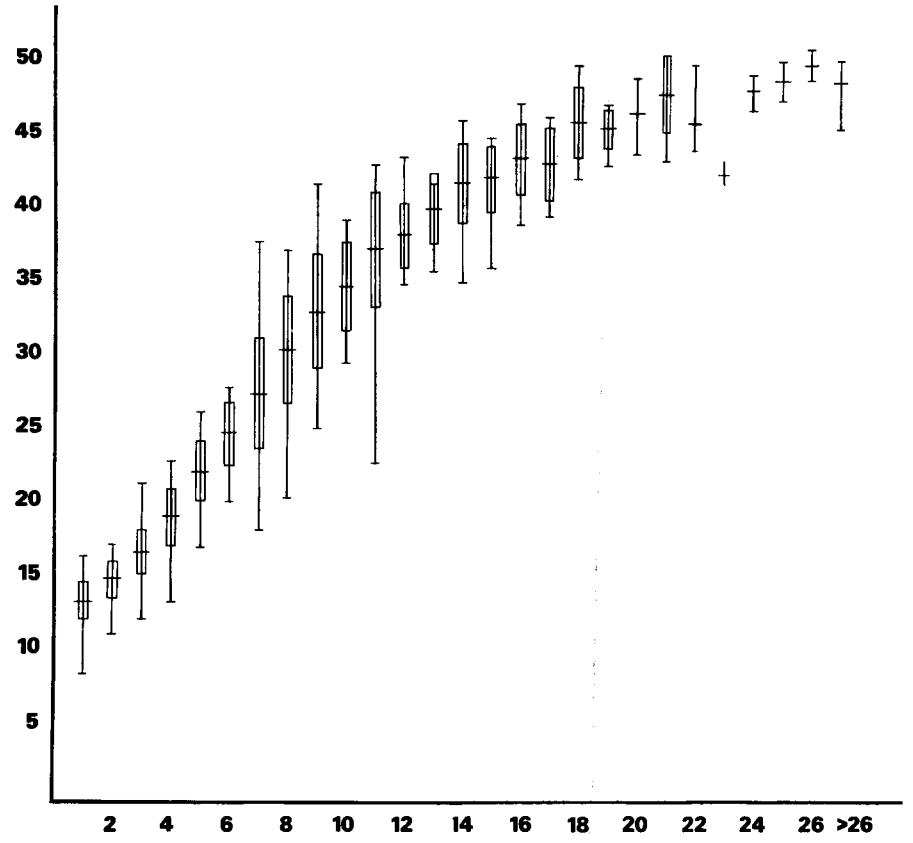

FIGURE 4. Length of tarsus (mm, ordinate) in Green Heron nestlings as a function of age (days, abscissa). Graphic representation as in figure 2.

The weight of 62 chicks on hatching and before receiving their first meal was 16.0 g. Hindwood (1933) reported young *Butorides striatus* immediately after hatching to weigh about 10 drachms (17.7 g), about two drachms (about 3.5 g) less than the freshly-laid eggs. Young grew at an almost constant rate throughout the first two weeks, with an average weight gain of about 8.4 g per day (fig. 3). This corresponds very closely with the growth rates of a single chick that gained 8.0 g per day for the first 14 days in New York (Meyerriecks *in* Palmer 1962:426). The chick weighed 11.5 g on hatching, 16.5 g at 2 days, 88.8 g at 7 days, 132.3 g at 14 days, and 173.5 g at 21 days. Wheelock (1906) found young Green Herons gained weight at a regular rate that did not depend on weather conditions. She found they gained 0.5 oz (14 g) per day for the first six days. At hatching they weighed ¾ oz (21.2 g) and at 7 days they weighed 3¾ oz (106.3 g). These weights are slightly heavier than the average for San Blas birds of comparable age, but fall well within the normal variations, especially considering the weighing errors involved with the avoirdupois system of weighing used by Wheelock.

Although by day 13–14 some young had reached minimal adult weight of about 160 g, average weight continued to increase at a steady rate until day 18–19, after which a slower increase and considerable individual variation was observed in the smaller series weighed.

BILL LENGTH

Measurements of the bill, both from the posterior edge of the nostril and from the tear duct, exhibited less daily variation than measurements of any other structure. Initially the basal portion of the bill grew relatively more rapidly than did the distal portion, as indicated by the slightly steeper curve for the bill as measured from the tear duct (fig. 3). The more rapid growth phase of the basal portion lasted until about day 12 or 13, at which time rates of both portions were about equal. Unlike the tarsus, whose growth curve leveled off sharply at day 16–17, the bill continued to grow for an extended period. Growth data for the several heron species studied by

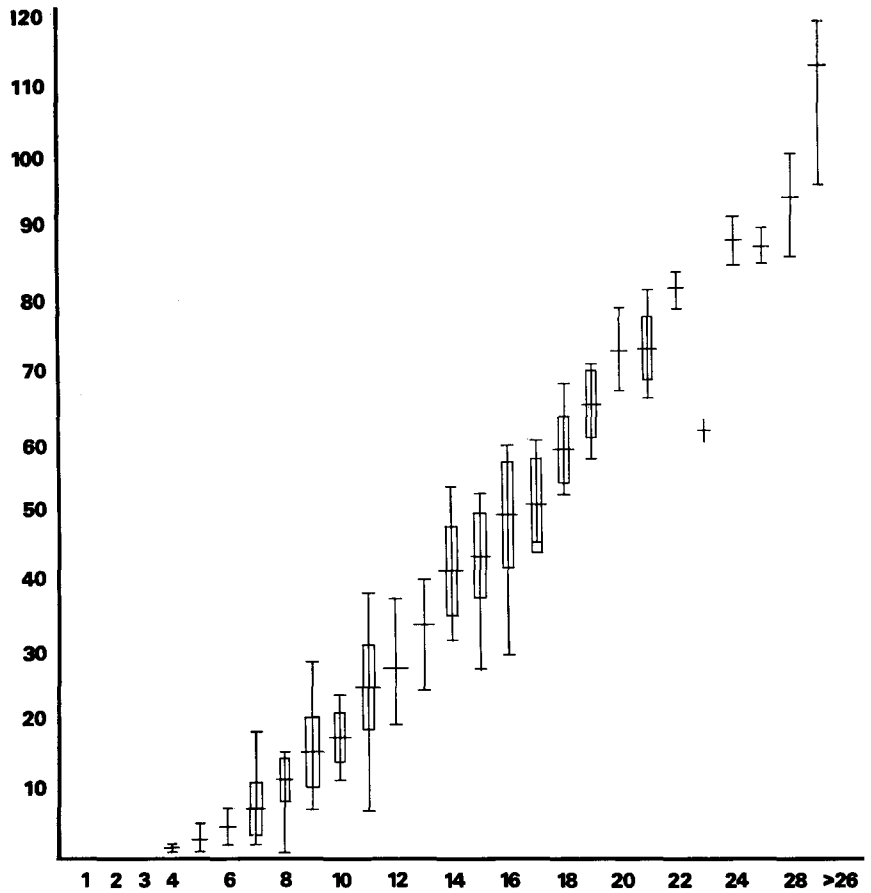

FIGURE 5. Length of primary 8 (mm, ordinate) in Green Heron nestlings as a function of age (days, abscissa). Graphic representation as in figure 2.

McClure et al. (1959) were graphed in larger increments than in this study, and comparisons are somewhat difficult to make. It would appear, however, that growth of the mandible of the Black-crowned Night Heron had essentially stopped by day 17–20. In the other two species, *Egretta intermedia* and *E. garzetta*, the growth curves show no leveling off through age 25–26 days, the oldest young included in their graphs, although this may be a factor of the smaller number of young of the older age groups.

TARSUS

Growth of the tarsus was rapid, even more so than the bill, with minimal adult measurements of 47.0 mm (Oberholser 1912) being reached by some young at day 16–17, and with growth beyond day 21 being exceedingly gradual (fig. 4). Tarsal length of nine young at day 17–18 averaged 46.2 mm, while the tarsi of 12 young over 26 days of age averaged but little more, 48.7 mm. However, the maximal tarsal length of young measured in this study (51.3 mm) was only equal to the average tarsal length for adult females (51.2) and less than that for males (53.0 mm) as presented by Oberholser (1912), indicating that full growth is not reached until after the young have become independent.

THIRD AND EIGHTH PRIMARIES

Because the rate of growth of primary 3 was similar to that of primary 8, and in order to present data more directly comparable to that of McClure et al., only the data for primary 8 were graphed. Primary 8 (3 of McClure et al.) erupts between the third and eighth day after hatching (fig. 5). It grew an average of slightly over 4 mm per day for the first four weeks, making it the most rapidly growing structure studied.

Following the format utilized by McClure et al. (1959), table 1 provides a scheme for aging nestling Green Herons utilizing measurements of the tarsus and primary 8. Some caution should be exercised in utilization of this table in that it is based on data from a

TABLE 1. Age of nestling Green Herons and the lengths (in mm) of primary 8 and the tarsus.

Primary 8	Tarsus	No. birds	Age (days)
	< 10	1	1
	10.6–15.5	93	1
	15.6–20.5	88	3
	20.6–25.5	7	4
1.0–5.5	15.6–20.5	6	4
	20.6–25.5	68	5
	25.6–30.5	18	6
5.6–10.5	20.6–25.5	4	7
	25.6–30.5	29	7
	30.6–35.5	4	8
10.6–15.5	25.6–30.5	4	9
	30.6–35.5	36	8
	35.6–40.5	2	8
15.6–20.5	30.6–35.5	12	10
	35.6–40.5	13	10
(Primary 8 > 26 mm: age > 10 days)			
20.6–25.5	30.6–35.5	3	12
	35.6–40.5	19	11
	40.6–45.5	1	9
25.6–30.5	35.6–40.5	23	12
	40.6–45.5	1	12
(Feather free of sheath > 10 mm, age > 12 days; < 10 mm, age < 14 days)			
30.6–35.5	30.6–35.5	1	14
	35.6–40.5	6	12
	40.6–46.5	5	13
35.6–40.5	35.6–40.5	2	13
	40.6–45.5	9	13
	45.6–50.5	1	14
40.6–45.5	35.6–40.5	1	17
	40.6–45.5	15	15
45.6–50.5	40.6–45.5	11	16
50.6–55.5	40.6–45.5	6	16
55.6–60.5	40.6–45.5	4	18
	45.6–50.5	7	17
60.6–65.5	40.6–45.5	2	21
	45.6–50.5	2	19
65.6–70.5	40.6–45.5	1	20
	45.6–50.5	7	19
70.6–75.5	40.6–45.5	1	21
	45.6–50.5	6	20
75.6–80.5	40.6–45.5	1	21
	45.6–50.5	2	21
80.6–85.5	40.6–45.5	1	22
	45.6–50.5	1	23
85.6–90.5	45.6–50.5	4	25
90.6–95.5	45.6–50.5	1	24
95.6–100.5	45.6–50.5	1	32
100.6–110.5	50.6–55.5	1	26
(Primary 8 < 95 mm, age < 26 days; > 95 mm, age > 26 days)			
(Feather without sheath > 110 mm, age > 33 days)			
(Bill from tear duct > 51 mm, age > 34 days)			
110.6–120.5	45.6–50.5	7	38

single nesting season. The extent of variation in growth rates from one year to the next, between one tropical situation and another, and especially between tropical and temperate regions cannot be evaluated until further comparable data are available.

PLUMAGE DEVELOPMENT

The natal down, wet and clinging to the body on hatching, became dry and fluffy within several hours. The down was grayish brown, longest on the head, forming a crest. It was paler (near white) on the belly. The down was less well developed on the wings. By the fourth day some pinfeathers began to show, with those of the primaries reaching a length of 2.4 mm in some individuals.

By days 5–6 the pinfeathers of the humeral tract were well developed, while those of the interscapular region of the spinal tract were slightly less prominent. The papillae of the pelvic region of the spinal tract were hardly visible, while those of the femoral tract were clearly visible. Only down was present on the head, neck, legs, and tail. The sheaths of the primaries and their coverts were about 5 mm long (to 7.5 mm), a little longer than those of the secondaries. The sheaths of the ventral tracts were visible on the fifth day.

On the seventh day the sheaths of feathers of the sides of the neck appeared.

The sheaths of the head region were distinguishable on days 10 and 11, looking like isolated spots on the coronal, frontal, and occipital regions (fig. 6). The tips of the feathers of the humeral tract were free of their sheaths, and those of the scapular region of the spinal and femoral tracts were just beginning to emerge from their sheaths. The pinfeathers of the tail were 2–3 mm long. The feathers of the ventral tracts were beginning to break free of the tips of their sheaths sufficient to determine their color. The most striking character of young 10–11 day olds was the primaries which were breaking free of their sheaths. Their coverts were still entirely encased in pinfeathers.

By day 13, the free vanes of the remigies measured about 6 mm, and their greater coverts had emerged sufficiently to show their color and the terminal white spot. The feathers of the alula measured about 5 mm. The feathers of the interscapular area and of the humeral tract were green and covered the midback. Feathers of the head, upper part of the neck, and lower back were just emerging from their sheaths, but these areas were still dominated by down. The feathers of the legs

FIGURE 6. Plumage development of Green Herons (ages, from left to right; 11 days, 20 days, 25 days, 37 days, and definitive plumage).

were breaking free of their sheaths to show color well. The sheaths of the rectrices measured about 7 mm, and on day 14 they and their upper coverts started to break free of their sheaths.

The rectrices on day 15 had about 10 mm of basal sheath with 2–4 mm of vane free at the tip. On days 17 and 18 the marginal coverts were breaking from their sheaths, the chestnut and white or buff stripes on the ventral side of the neck were clearly evident, and there were few vestiges of down on the tips of the feathers of the midback region, but more on the lower back. On the head only the feathers of the occipital region had begun to break from their sheaths. At day 20 there were still sheaths and abundant down on the frontal and occipital regions of the head (fig. 6).

By day 25 the entire head was feathered but there was abundant natal down clinging to these feathers and also to those of the rump. The tail measured about 40 mm. At day 23 only the head still retained natal down. The tail measured about 48 mm (fig. 6). The description of the juvenal plumage as presented by Palmer (1962:415–416) and Townsend (*in* Bent 1926:189) seems to correspond to birds of about 25 days of age.

By 37 days almost all feathers had lost their sheaths except those of the crown. The natal down had completely disappeared (fig. 6).

SOFT PART COLORS

At hatching, the legs and feet were pinkish with a slight orange cast, and the bill and lores were pinkish yellow, the same color as the surrounding skin areas. At three days, the feet were yellow-orange with the front of the tarsi and tops of the toes slightly more orange. At five days the lores took on a yellowish green cast, and the tarsi and toes became more bicolored with the fronts and upper surfaces grayish green and the bottom of the toes pale yellow.

The colors continued to darken, the bill changing from yellow to orange with a black tip and the lores becoming yellowish green, with areas of pale blue around the eyes. The legs and feet darkened in tone, greenish-blue-gray above and yellow below, the iris darkened to intense yellow. The general body skin was lightly greenish-yellow with the skin of the wings a medium bluish green. Hindwood (1933) described a similar change in the color of the skin and tarsi of young *Butorides striatus* from generally flesh-colored on hatching to green. In that species, the iris became yellowish, but apparently not as intensely so as in young *B. virescens*. With age the bill darkened with bands of black and dark gray, but the color of the legs and feet did not change greatly. At 18 days, the legs were uniformly grayish green with the bottom of the toes yellower.

SUMMARY

Nestling development of the Green Heron was studied at San Blas, Nayarit, México, July-September 1964. Daily measurements were made on marked young, including weight, and lengths of the culmen from nostril, culmen from tear duct, tarsus, and primaries 3 and 8. In *Butorides* sexual dimorphism in size is less than 3 per cent and did not constitute a significant variable. Weight measurements among

young of the same age varied by as much as nearly 400 per cent.

On hatching, young weighed about 16 g and gained an average of about 8 g per day during their first two weeks. Minimal adult weight of 160 g was reached by some young 13–14 days old. Bill measurements varied less within an age group than any other measurement. The basal portion of the bill grew more rapidly during the first 12–13 days, after which both portions grew at the same rate. The bill continued to grow steadily for an extended period, in contrast to the tarsus, the growth rate curve of which leveled off sharply at day 16–17. Minimal adult tarsal lengths were reached by some young by day 16–17; however, apparently slow tarsal growth continued beyond the age for which data were obtained. Growth of primaries 3 and 8 was similar. They erupted between the third and eighth day and grew an average of 4 mm per day for the first four weeks.

Based on these measurements, a table was compiled which will permit the aging of a nestling Green Heron within a range of two days. Caution should be used when applying these aging criteria because of variation in food supplies and/or other factors that affect growth rates from one area to another, especially between tropical and temperate climates.

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