

- HOLLOM, P. A. D., and H. G. BROWNLOW. 1955. Trapping methods for bird ringers. (Rev. edition) *British Trust for Ornithology, Field Guide No. 1*, 56 pp.
- HUSSELL, D. J. T., and JAMES WOODFORD. 1961. The use of a Heligoland trap and mist-nets at Long Point, Ontario. (in this issue)
- LINCOLN, F. C., and S. P. BALDWIN. 1929. Manual for bird banders. U. S. Dept. of Agriculture, Misc. Publ. No. 58; 1-112.
- LOCKLEY, R. M., and R. RUSSELL. 1953. *Bird-Ringing*. Crosby, Lockwood and son.
- MACKINTOSH, J. R. 1956. Planting your garden for wild birds. Audubon Society of Canada, Toronto.
- MATHER, J. R. 1960. An alternative to the sleeve used on catching boxes. *The Ringers' Bulletin*, 1 (8): [10-11, unpagel].
- SPENCER, ROBERT. 1959. Progress and prospects in ringing. *Ibis*, 101: 416-424.
- TERRES, JOHN K. 1953. Songbirds in your garden. Cromwell.
- WEIGOLD, HUGO. 1956. How we began ringing on Heligoland. *The Ring*, 8: 159-162.
- [WHITTLE, CHARLES L.] C.L.W. 1930. ["Der Vogelzug," a new ornithological journal.] Review in *Bird-Banding*, 1: 83.
- WILLIAMSON, KENNETH. 1957. Mist-nets versus Heligoland traps. *Bird-Banding*, 28: 213-222.
- WOODFORD, J. 1959. The use of mist-nets and a Heligoland trap at Point Pelee. *Bird-Banding*, 30: 38-46.

Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario, Canada; 17 Farnsworth Drive, Weston, Ontario, Canada.

Received February, 1961

ARTIFICIAL INCUBATION OF EGGS OF VARIOUS BIRD SPECIES AND SOME ATTRIBUTES OF NEONATES

By DAVID KENNETH WETHERBEE and NANCY S. WETHERBEE

Introduction. In connection with a study of the morphology of just-hatched birds we have accumulated collateral data that may be of some general value to ornithologists. More than 2,000 specimens of 83 species were hatched in incubators. No species tried in adequate samples failed to be amenable to artificial incubation. Incubation data determined in the laboratory where conditions can be standardized are basic to an understanding of the biological problems of natural incubation studied by ecologists.

Evans (1891 and 1892) in Scotland and Heinroth (1908 and 1922) in Germany first and most extensively hatched out Old World species. Baldwin and Kendeigh (1932), Kendeigh (1940), and Graber (1955) investigated artificial incubation of wild birds' eggs in America. Present manuscript was completed in 1957.

Acknowledgments. Grateful acknowledgment is made to the many people who helped search for nests. Dr. Kay T. Rogers encouraged the use of artificial incubation in 1951 when science foundations spurned the practicality of artificial incubation of wild birds' eggs.

Dr. Richard Graber kindly contributed several specimens hatched in his incubator. Incubators were made available by Dr. Rudolph F. Nunnemacher at Worcester, Massachusetts, Dr. Bradley M. Patten at Ann Arbor, Michigan, Dr. Hugh Clark at Storrs, Connecticut, and the late Dr. Charles S. Johnson at Nashville, Tennessee. Dr. Oliver L. Austin, Jr. and others kindly made many suggestions that were adopted in improving the manuscript; responsibility for the accuracy and organization of the final draft however is entirely our own.

Methods. All the eggs of each clutch found were collected, whether or not the clutch was complete. Date, time, locality, number of eggs in the clutch, degree of certainty of species identification, and data on the incubation attendance of the parent were recorded. A separate data sheet for each egg was kept. At the incubator a clutch- and egg-number was brushed on each egg. The length of time and conditions of transportation from the field were recorded. Each egg was measured or weighed, put in water to determine buoyancy, and candled before being put into the incubator. Efforts were made over the 6-year period to obtain as many eggs as possible.

Artificial incubation was aimed at 37.8°C. and 64 percent relative humidity. Most of the eggs were incubated in forced draft, 600-chicken-egg capacity, American-Lincoln cabinets. The eggs, rolled twice daily, were held in open, partitioned petri dishes lined with gauze. To determine volumes, most of the eggs were weighed daily until they reached specific gravity of unity as determined by buoyancy in water at 37°C. At this point egg weights in grams equal their volumes in cubic centimeters. The comparison of volumes is more significant than comparison of weights of fresh eggs (or at least is more amenable to standardization) because for practical purposes there is no such thing as a "fresh egg" in nature. Balances could be read to at least four digits and were sensitive to at least three decimal places. Thin-shelled eggs, such as those of swallows, were dried completely by blotters before being returned to the incubator. When volumes were not determined in the manner just described most other eggs were measured to greatest length and width by vernier calipers.

Infertile and addled eggs were discarded as soon as detected. Dead embryos were examined for anomalies. The times of first peeping from the egg and of the first pipping of the shell were noted. Efforts were made to preserve the hatchling at, or as near the moment of, hatching as possible, as this was critical to the central study (Wetherbee, 1959). This time was recorded as plus or minus the nearest hour, one-half the interim between incubator tendings. The partitions of the petri dishes isolated each "altricial" chick and its numbered shell from other hatchings; with "precocial" (in the strict ornithological sense) species each egg was individually bagged.

Each chick was weighed, described as to behavior, color of skin, mouth-lining and down, and often compared to other species hatched simultaneously. Each chick was labelled, tied in a gauze bag, and preserved in 10 percent neutral formalin or 75 percent ethyl alcohol. Specimens were later transferred to 95 percent alcohol in individual snap-cap vials. The shells were collected and put into dry storage for reference in case of curatorial errors. This work attempts to establish

a standard for data on incubation under standardized conditions. Such measurements may allow for more accurate and more significant interspecific comparisons, for there should be (ideally) very little intraspecific variation. Embryological development and incubation periods in the wild, however, vary greatly as parental attentiveness, environmental temperature, moisture, etc. are conditions which cannot be measured accurately.

Definitions of terms. Incubation period is defined as the longest time it takes any egg of the given species to hatch spontaneously under artificial incubation in forced air incubator aimed at 37.8°C., 64 percent relative humidity. Such standardization is necessary, because, as every commercial hatcher knows, embryological development is sensitive to slight differences in temperature or humidity (Huggins, 1941). Ideally, experimental work may some day establish the optimum temperature for incubation of each species (Baldwin and Kendeigh, 1932, and Graber, 1955). Incubation periods given here are the longest that we recorded and are not necessarily entire maximum potential incubation periods, though most are probably representative. Incubation period data were not used when the chick required aid in emerging from the shell. Egg clutches of larger species had greater variability in total emergence than egg clutches of smaller species. Mortality statistics for artificial incubation have no bearing on incubation mortality rate in the wild.

The expression of temperature in 0.1°C. rather than 1°F. is advocated in the interests of establishing a standard of high critical rigor sorely needed for comparative purposes in this type of ornithological work. We have purposely expressed time duration in hours rather than days-and-hours. We believe that the sad state in which the literature of incubation finds itself can be rectified if ornithologists will use consistently the primary units of temporal embryology—hours. Even when we made a conscious effort to record to the nearest hour we often came up with a hatching time “plus or minus 10 hr.”; we can't help but wonder what the margins of error are in statements in the literature recorded and expressed in days. What is worse, ornithologists often get confused as to whether or not to count the first day; or they limit the meaning of day to calendar day; or they record incubation time in days and estimated fractions, then later convert to hours.

Interim between hatchings. As eggs may undergo some development in the nest due to variable, warm environmental temperature, even though the eggs are not incubated by the parent, the interim between hatching used as an indication of the relative time of the onset of parental incubation is of most value when expressed as the minimum interim observed in several complete clutches all of which hatch, rather than as the maximum interim.

Clutch weight. Clutch weights were reported only from actual clutches known to be complete by virtue of a hatching time in the incubator considerably less than known incubation periods. These data should be distinguished from clutch weights determined from calculations and extrapolations.

Weights. Averages were determined from segregated clutch averages,

not arithmetic summation of individuals, unless otherwise stated in the text. Neonatal weights were taken of specimens that had just dried, after being taken directly from the constant humidity of the incubator. Many chicks were observed to defecate after hatching; this probably accounts for most disparities between volume of egg and neonatal weight within a species.

Data.

Green Heron *Butorides virescens*. A complete clutch of 5 eggs weighed 80.39 g. 3 days before hatching; these eggs av. 39.3 mm. x 28.7 mm. and 16.08 g. (15.47 g. to 16.73 g.). The chicks at hatching av. 13.05 g. (12.66 g. to 13.55 g.). The 5 hatched a total of 72 ± 20 hr. apart. Skin was tawny, bill was tipped gray, eyes were open and light olive, down was gray above and white below.

Black-crowned Night Heron *Nycticorax nycticorax*. A complete clutch of 3 eggs weighed 111.2 g. 5 days before hatching; av. 52.3 mm. x 37.8 mm. and 37.06 g. (35.18 g. to 39.33 g.). Another nearly fresh clutch of 3 eggs weighed 104.53 g.; av. 34.84 g. (34.34 g. to 35.26 g.). Dimensions av. 52.5 mm x 34.6 mm. The embryos showed that natural incubation commenced with the laying of the first egg. Av. clutch wt. was 107.9 g., av. egg wt. 35.95 g. Pectination was not in evidence on the toenail at hatching.

American Bittern *Botaurus lentiginosus*. Two chicks from a complete clutch of 3 hatched 44 ± 15 hr. apart. The hatchling's loose skin was pink with a yellowish epidermis, bill flesh color with black tip, mouth light pink, eyes open and light olive, down yellowish olive slightly darker above. They uttered low harsh squawks and sometimes reached out to gape; the lower mandible was soft and spread laterally when opened. The chicks clutched and released with their toes independent of leg movements. Attempts at sitting and raising the head were feeble. The apical digit of the wing was noticeable.

Wood Duck *Aix sponsa*. A complete clutch of 9 eggs weighed 315.7 g. 16 days before hatching. These av. 35.08 g (31.90 g. to 38.55 g.). Four ducklings hatched a total of 27 ± 2 hr. apart and av. 23.53 g. (21.55 g to 25.66 g.). Respiration rate of one at incubator temperature was 42 times per minute. When one was put in water it tried to swim but sank and drowned. The down was sheathed for some hours after hatching, the rectrices (or their coverts?) were decurved, perhaps to hold an air bubble for greater buoyancy. We found no particularly developed nail at the tip of the bill, although such an aid to climbing from the nesting cavity has frequently been ascribed in Forbush's and Kortright's standard works. The legs and feet were black except for a cream stripe down lateral side of leg and on areas between joints; upper mandible black except for cream tip, egg-tooth tan, lower mandible cream, iris olive. The natal down freed of its investing sheathes was blackish olive above and buffy yellow below; no loral stripe was present, the facial markings surrounded a cream cheek patch. The texture of the down was coarse; the tips of barbs on upper parts were elongate and smooth like mammalian guard hairs.

Black Vulture *Coragyps atratus*. A complete clutch of 2 eggs weighed 196.5 g. 2 days before hatching; these eggs av. 81.0 mm. x 51.8 mm. and weighed 96.54 g. and 100.0 g. The chicks at hatching weighed 75 ± 7 g. and hatched 16.6 hr. apart. Dark gray down 10 mm. long covered the body except the mid-ventral apertium and the blackish-gray face. Behind the olive open eye was a crescent of 1 mm. natal down. The pale gray legs and feet were thick and fleshy, reminiscent of the oedema-like swelling of neonatal flamingos as described by Baruel (1954). The chicks stood weakly, trembled and uttered soft hissing noises. Their tongues were curious, thin, trough-like folds, opening when protruded and closing when withdrawn.

Red-shouldered Hawk *Buteo lineatus*. The bill of the chick was black, contrasting with the light color of cere; toe nails gray. The natal down, 10 to 15 mm. long was at first completely sheathed as in other hawks, but soon fluffed

out to cover the body with light buffy brown plumage, darkest on the scapular and alar tracts.

Broad-winged Hawk *Buteo platypterus*. One egg, advanced in incubation when received, weighed 40.60 g. 22 days before hatching, had a volume of 39.17 cc., and reached 1.0 sp. gr. 16 days before hatching; neonatal wt. 29.63 g. The chick cheeped continually and was covered with short, dirty white down; bill was black, cere flesh-colored, talons gray. Its eyes were closed and the feet apparently could not grip.

Sparrow Hawk *Falco sparverius*. Three eggs from a complete set of 5 av. 14.93 g. 6 days before hatching. Two of the 5 that hatched weighed 11.37 g. and 12.30 g. and hatched a total of 60 ± 5 hr. apart. The chick was as helpless as a neonatal songbird, with pink skin and silvery white down covering all the body. The eyes were open, especially when the bird whined or gaped. Unlike the neonatal Broad-winged Hawk these chicks could grasp with their feet. The notch and tooth characteristic of the genus was already developed at hatching.

Ruffed Grouse *Bonasa umbellus*. Typical egg wt. from a complete clutch of 13 was 14.45 g. 7 days before hatching. Nine that hatched av. 13.98 g. (11.46 to 16.48 g.). These hatched over an interim of 9 ± 6 hr. apart. One that hatched in 534 ± 8 hr. from an incomplete clutch of 8 weighed 17.60 g. as a fresh egg, 14.36 g. the day before hatching, and 12.26 g. as a neonate. The black eyes were open, bill and weak legs pinkish yellow. The flight feathers were remarkably developed. The chicks uttered notes of 4 syllables. The down, finely variegated on the upper parts with buffy yellow, golden brown and black was buffy yellow on the underparts and extended down each side of the tarso-metatarsus. The culmen lacked the black mark of the Greater Prairie Chicken and the black ear-stripe was more prominent but the black of the variegation was much less extensive.

Greater Prairie Chicken *Tympanuchus cupido*. The cream bill of the chick was black on the culmen. Down extended the length of the legs even onto the toes. The upper parts were variegated buffy yellow, black and brownish red; the face and under parts tawny. Four black spots behind the eye and about the ear were noticeable. The quills of the primaries were well started.

Bobwhite *Colinus virginianus*. Seven fresh eggs (from penned birds) av. 31.5 mm. x 24.8 mm. and 10.32 g. (9.50 g. to 11.29 g.). The neonates hatched at 559 ± 7 hr. and av. 7.52 g. (6.77 g. to 8.60 g.). Six eggs each of the blonde and Red Tennessee breeds did not differ significantly in any of these characters. The down was striped chestnut, buffy yellow and blackish-brown. On the back were 2 buffy yellow stripes, not 3 stripes as in Gambel's Quail and California Quail. There was a black stripe over the ear, the underparts were light gray.

California Quail *Lophortyx californicus*. Six fresh eggs (from penned birds) av. 30.7 mm. x 23.5 mm. and 8.55 g. (8.07 to 9.50 g.). Incubation lasted 559 ± 7 hr.; 2 chicks weighed 6.28 g and 7:00 g. The plumage was like that of the Bobwhite except for 3 buffy stripes on the back.

Gambel's Quail *Lophortyx gambelii*. Six fresh eggs (from penned birds) av. 29.9 mm. x 24.5 mm. and 9.66 g. (9.00 g. to 10.34 g.). Incubation lasted 559 ± 7 hr.; 3 chicks ranged from 6.67 g. to 8:00 g. We could not distinguish this species from California Quail in natal plumage.

Common Coturnix *Coturnix coturnix*. Eight fresh eggs (from penned Japanese birds) av. 32.0 mm. x 24.9 mm. and 10.68 g. (9.47 g. to 12.16 g.). Incubation periods were puzzlingly variable. Fifty fresh eggs received in February took 460 ± 0 hr., in March 414 ± 5 hr., and 100 in July 395 ± 15 hr.; the latter was nearest the claims of commercial breeders. Three of these incredibly prolific birds with such short incubation periods commenced laying unfertilized eggs themselves in my pens at 4 weeks (April 10, 1957) of age. Neonatal wt. of 6 chicks av. 8.03 g. (7.05 g. to 8.90 g.).

Ring-necked Pheasant *Phasianus colchicus*. Twelve fresh eggs av. 32.47 g. (30.06 g. to 35.56 g.). Nine of these av. 46.7 mm. x 36.8 mm.; 4 had vol. 27.93 cc. to 30.17 cc., and reached 1.0 sp. gr. 9 to 15 days before hatching. The longest incubation recorded was 550 ± 0 hr. Neonatal wt. of 5 chicks av. 23.28 g. (20.91 g. to 25.40 g.). The culmen was dark gray, the bill, legs and feet were cream. The down was indistinctly striped blackish brown and buffy brown, the underparts were buffy yellow, there was a black spot in front and behind each ear. Down did not extend onto the legs, as it did in the Ruffed Grouse.

Red Jungle Fowl *Gallus gallus*. Eighteen fresh eggs av. 51.1 mm. x 36.8 mm. had av. wt. 37.54 g. (31.05 g. to 40.02 g.). Ten of these eggs produced chicks with av. wt. 26.01 g. (21.28 g. to 29.70 g.). The incubation lasted 504 ± 0 hr. Three "large" eggs of the common chicken, Columbian breed, av. vol. 48.41 cc. produced chicks 37.15 g. av. wt.

Virginia Rail *Rallus limicola*. Two eggs from a complete clutch of 10 weighed 8.51 g. and 8.53 g. 5 days before hatching. Four that were allowed to hatch av. 5.58 g. neonatal wt. and emerged within 11 hr. of each other. The chick, unable to stand, was a pitiful looking thing, quivering and raking its long witch-like digits as a barnacle combing the water. It explored crevices with its black-tipped bill and made feeding movements with the bill and throat. While the eyes were already developed enough to open occasionally, they were kept closed for the most part. The alula seemed inordinately long, the occiput bulged as in "altricial" young. The natal down was black, but 2 chicks of the 5 had a patch of white down below the wings suggestive of a species-dimorphism.

Killdeer *Charadrius vociferus*. A complete clutch of 4 eggs weighed 46.42 g. 3 days before hatching with av. wt. 11.61 g. (11.19 g. to 12.09 g.). The neonates av. 9.29 (9.03 g to 9.68 g.). These eggs hatched a total of 0 ± 7 hr. apart. Another fresh clutch of 4 eggs, probably complete, weighed 55.48 g. 15 days before hatching, with the av. 13.87 g. (14.30 g. to 13.00 g.) Av. dimensions were 39.5 mm. x 27.4 mm. The neonates av. 10.49 g. (10.30 g. to 10.74 g.). The chicks emerged a total of 22 ± 11 hr. apart. The clutches av. 50.59 g. total wt., 12.74 g. egg wt., and 9.89 g. neonatal wt. Color of soft parts: iris olive, bill black except light tips, feet and legs light straw yellow with poorly defined gray zones at joints, toe nails black, skin of apteria and of the wings buffy brown. The pattern of the down was accented by jet black borders between the pure white areas and velvet-like brown areas; it was most strikingly conspicuous as a black ring around the neck. Down of the frontal region, throat and nape-ring, distal wing segments and all of under-wing areas and underparts was white. Crown, infra-orbital stripe and dorsum, olive with black mid-dorsal patch. The short olive tufts (3 to 5 mm.) of the upper parts had longer black tips presenting an exquisite plush. The downs of the upper tail-coverts were 10 to 15 mm. long and banded black and buffy yellow; the rectrices fully 40 mm. long were black and like a tuft of cut pile. The white of the under parts was suffused tawny about the femoral region and under tail-coverts.

American Woodcock *Philohela minor*. A complete clutch of 3 eggs weighed 46.63 g. 2 days before hatching, av. 15.5 g. egg wt. (12.16 g. to 17.56 g.). The chick from the smallest egg had trouble hatching, the membranes dried in the pipped shell and part of the yolk-sac did not retract. The other 2 hatched 0 ± 5 h. apart and weighed 13.06 g. and 13.13 g. They squatted, uttered slight peeps, walked with poor balance and had their eyes open. At hatching the woodcock already had the bill shaped like a blunt probe and the robust toes were longer than either of the leg segments. The spine of the thoracic vertebrae was peculiarly hunched. This species did not have the long tail characteristic of the Killdeer and Spotted Sandpiper. The down was not dense and was golden blackish brown alternating in stripes of tawny yellow.

Spotted Sandpiper *Actitis macularia*. The skin was very dark, becoming lighter with spots on the tibio-tarsus and fading out on the absurdly long legs and feet. The down of the upper parts was golden brown and black, under parts white save a black patch on the lower neck. A prominent black line in front of the eye. The long tail was like a tuft of cut pile and patterned a fine black and golden agouti.

Herring Gull *Larus argentatus*. Four neonatal chicks av. 60.6 g. (52.3 g. to 67.7 g.). The physical strength of these eggs was incredible; added eggs built up tremendous gas pressure which was ultimately released by explosion. The mandibles were buffy brown with smoke gray tips; legs, feet and toe nails were buffy brown. The down was at first completely sheathed (as in many other birds), but later fluffed out to form a long dense nap with the texture of beaver fur. The pattern of alternation of buff and blackish brown areas was complexly variegated with tawny suffusion over the fore.

Common Tern *Sterna hirundo*. Two eggs av. 18.86 g. 12 days before hatching, had vol. 21.41 cc. and 17.66 cc. and reached 1.0 sp. gr. 11 days before hatching. Five neonates av. 12.09 g. (10.67 g. to 13.58 g.). The mandibles were black tipped, the down of the upper parts was variegated light tawny and black, the tawny predominating and the underparts were white save the chin and throat which were blackish brown.

Rock Dove *Columba livia*. Five eggs from 5 clutches of feral doves av. 16.87 g. (15.18 g. to 18.76 g.), and 39.5 mm. x 28.7 mm. Five neonatal squabs av. 12.22 g. (11.02 g. to 13.30 g.). Very pale gray wooly down 15 mm. long sparsely covered the body but was noticeably absent over the ventral apterium and face. Skin light, in contrast to that of Mourning Dove. Prognathous, tips of mandibles white, bill relatively long, longer than head, with bulging nasal shields. The huge eyes still-closed showed dark bluish through the skin and projected over the crown like those of a frog. An egg from a loft of a large white breed of unknown identity weighed 22.09 g., vol. 21.15 cc., reached 1.0 sp. gr. 9 days before hatching, had an incubation period 414 ± 5 hr. and produced a neonatal squab weighing 15.2 g.

Mourning Dove *Zenaidura macroura*. A complete clutch of 2 eggs weighed 15.03 g. 11 days before hatching, egg wt. 7.80 and 7.23 g., neonatal wt. 5.35 g. and 4.95 g. These hatched 27 ± 2 hr. apart, commensurate with the observed differences in development of the very early candled embryos. Respiration rate at incubation temp. was 72 times per minute. They uttered a faint weep. The buffy yellow down was wooly in texture; it covered the chick except the ventral apterium, legs and feet, lower eyelid, ear and chin. The skin of the helpless squab was olive, like a rotten fruit, the closed eyes showed black through the skin; the bill was black except for the swollen region at the nares and at the tips in front of the egg teeth; the mouth was the same color as the bill externally. A very large crop was noticed.

Domestic Parakeet *Melopsittacus undulatus*. Ten fresh eggs from the same hen av. 2.39 g. (2.07 g. to 2.54 g.) and 18.0 mm. x 15.7 mm. Neonatal wt. of 3 ranged from 1.65 to 1.70 g. Incubation periods were 405 ± 4 hr. The hen started incubation immediately after the first egg was laid. Except for a white chenille down 1 to 2 mm. long over the dorsum lateral to the broad ephippial apterium, the chicks were bare. The cere and the embryo-like overshot upper jaw, retained in the adult, and yoke-toes were already in evidence. The upper neck muscles were enormously developed.

Common Nighthawk *Chordeiles minor*. A complete clutch of 2 partly incubated eggs, characteristically covered with a powdery bloom, was artificially incubated for 11 days; 65 hr. after the first chick had hatched, the second was taken alive from a piped shell. The upper parts were variegated black and buffy yellow; the under parts pale gray. The down covering the body was shaggy but rather thin on the dorsum. The shaggy longer down of the head and throat obscured the shape of the chick. The external nares, situated near the tip of the bill, were flared like those of a goldfish.

Black-billed Cuckoo *Coccyzus erythrophthalmus*. Two nestlings about 3 days old had 10 symmetrically arranged pustules on the roof of the mouth and on the tongue, "guide marks for parental feeding" of some authors. The tongue was edged with black at its tip. This species and three passerines: Catbird, Horned Lark and Blue-gray Gnatcatcher were the only North American birds noted to have actual markings in the mouth. We have seen African weaver finches

among the spirit collections of museums that have this trait elaborately developed with markings having a metallic luster. The legs, feet and bill were slate-blue.

Great Horned Owl *Bubo virginianus*. Down on a just-hatched bird was white and fluffy over the entire body, including the toes. The bill and toe nails were dark olive.

Ruby-throated Hummingbird *Archilochus colubris*. Two chicks, naturally incubated, were noted to hatch 17 ± 17 hr. apart. The skin was pigmented dark gray, contrasting with the buffy yellow down. The distended crop was full of small spiders, their first food. The chick's toe nails seemed disproportionately long.

Belted Kingfisher *Megaceryle alcyon*. A complete clutch of 8 eggs was brought through the last 10 days of incubation. The neonates weighed an av. 9.33 g. (8.46 g. to 10.36 g.), and hatched a total of 33 ± 4 hr. apart. The chick was duck-like and without down and with pink skin through which the vertebrae showed clearly. It walked hunched. Although its eyes were still closed, they could be forced open. The chicks were positively thigmotropic, and when two came in contact they seemed to lock necks by contact stimulus. They stood on feet and heels without touching the abdomen as they uttered cheeps; they did not gape. The prognathous bill was black without the rictal swellings of cavity-nesting passerines, the mouth lining was flesh-color. The alular claw was conspicuously white, toe nails gray.

Yellow-shafted Flicker *Colaptes auratus*. Six neonates from a heavily incubated, complete clutch of 8 eggs av. 4.80 g. (4.20 g. to 5.12 g.) and hatched a total of 7 ± 5 hr. apart. Of the remaining 2 eggs, 1, rather larger than the rest, seemed to be infertile while the other, a runt (5.81 g.), was just showing embryonic development when the clutch was hatching, but it soon died. Another clutch had the following history: one egg was always left in the nest and the others removed on the day of laying. Eggs *a*, *b*, *c*, *d*, and *e* were laid on successive days; then 2 days elapsed before egg *f* was laid; then 2 more eggless days elapsed before *g* and *h* were laid on successive days; 2 more eggless days elapsed before *i*, a small egg with marbled texture was laid. The female attended the nest 5 more days before she and the egg disappeared. The eggs of this clutch av. 7.21 g., none was successfully incubated by us. These observations seem to contradict the indeterminate-laying reputation of this species. Another complete clutch of 4 eggs av. 28.5 mm x 22.9 mm. and hatched a total of 8 ± 6 hr. apart. The flesh-colored chicks were without natal down and without contrasting color of the mouth lining. The rictal flanges of the strongly prognathous mandible were curiously situated on the sides of the lower mandible, not at the angle of the jaw. A probable epigenetic significance of this fact is that the lower mandible is indeed prognathous in an absolute sense. Another strange feature of these reptile-like hatchlings was the swollen heel pads covered with friction ridges of papillae. The external auditory meatus was oblique to the surface of the head and was difficult to see, giving the erroneous impression that woodpeckers have no ears at hatching.

Downy Woodpecker *Dendrocopos pubescens*. A complete clutch of 4 eggs weighed 8.32 g. 4 days before hatching; the eggs av. 2.08 g. (1.95 g. and 2.22 g.). The neonates av. 1.67 g. (1.55 g. to 1.77 g.) and hatched a total of 5 ± 3 hr. apart. The naked, prognathous pinkish chicks rendered a chattering call not unlike that of an adult Barn Swallow and also a higher pitched, short peep. The open mouths were without special coloration and like the flicker, the heels had friction pads.

Eastern Kingbird *Tyrannus tyrannus*. A complete clutch of 3 eggs weighed 10.10 g. 13 days before hatching; the eggs av. 3.37 g. (3.21 g. to 3.54 g.), had av. vol. 3.27 cc. (3.13 cc. to 3.41 cc.), and reached 1.0 sp. gr. 11 days before hatching. The hatchlings weighed 2.43 g. each and emerged a total of 0 ± 5 hr. apart. Another egg constituting a complete clutch in itself was a giant that weighed 4.71 g. 11 days before hatching. The egg was left undisturbed in the

nest for 2 days after discovery and the nest checked again 2 days after our robbery to determine whether more would be laid. It remained the only egg. Its vol. was 4.40 cc. and it did not reach 1.0 sp. gr. until the day before hatching out a 3.71 g. chick. Some natural incubation obviously had taken place in the nest as it hatched in our incubator after only 265 ± 2 hr. Length of incubation period in chickens is not affected by wt. of egg according to Hays (1941), but "each increase of one gram in egg wt. delayed hatching 3.73 minutes" in chickens (D. W. MacLaury, pers. comm.). A third clutch of 4 eggs that was probably complete and nearly fresh had av. dimensions 23.1 mm. x 16.4 mm. and hatched a total of 13 ± 7 hr. apart, with an incubation period of 366 ± 7 hr. The skin and mouth of the chick were orange-yellow, the down white.

Eastern Phoebe *Sayornis phoebe*. Av. complete clutch wt. of 5 clutches was 9.04 g. (9.90 g. for a clutch of 5 eggs 8 days before hatching and 7.68 g. for a clutch of 4 eggs 10 days before hatching). Av. egg wt. per clutch in 11 clutches was 2.06 g. (1.86 g. to 2.27 g.). Thirty-four individual eggs ranged from 1.75 g. to 2.38 g. Av. egg vol. per clutch in 7 clutches was 2.03 cc. (1.86 cc. to 2.21 cc.). Eighteen individual eggs ranged from 1.75 cc. to 2.29 cc. Most eggs reached 1.0 sp. gr. 9 days before hatching. Av. neonatal wt. per clutch in 12 clutches was 1.50 g. (1.29 g. to 1.88 g.). Thirty-three individual chicks ranged from 1.25 g. to 1.88 g. Longest incubation period was 375 ± 0 hr. Several other eggs closely approached this time and it is believed to be representative. In 4 clutches in which all eggs hatched, the maximum time for total clutch emergence was 11 ± 0 hr. In a clutch in which 3 or 4 hatched, the 3 emerged a total of 0 ± 4 hr. apart. As that clutch was transported more than a hundred miles the day before hatching this may have caused the relatively synchronous hatching. In one clutch that contained a cowbird's egg 2 of 4 chicks that hatched emerged a total of 32 ± 5 hr. apart, not considering the parasite. Our interpretation is that the phoebe was stimulated to commence incubation early when the cowbird's egg completed her stimulus threshold number. It is noteworthy that she laid the additional egg nevertheless. Two phoebe eggs substituted in a Tree Swallow nest failed to hatch. The flesh-colored neonate had medium gray down above and white below and had yellow bill, mouth, feet and posterior parts. The long toe nails were gray, the yellow rictal region was only slightly flanged. Heads of neonatal flycatchers were noted to be fully as large as the bodies.

Great Crested Flycatcher *Myiarchus crinitus*. A nestful of 6 recently hatched young showed noticeable differences in size (probably because of age). The down was dark gray becoming lighter gray on the alar and femoral pterygiae; the body was dark flesh color; the mouth lining was dull orange-yellow and the relatively broad rictal flanges were cream.

Least Flycatcher *Empidonax minimus*. Two fresh eggs measuring 16.0 mm. x 13.0 mm. hatched in 322 ± 5 hr. The chicks had very small yellow mouths without rictal flanges and their down was light gray. Another nest in which the first egg was laid June 2 and the second egg June 3 (or June 4) had no additional egg June 5, when the 2 were taken and 2 Tree Swallow's eggs put in their place. On June 6 the swallow's eggs had disappeared. The artificially incubated Least Flycatcher eggs died during early development.

Horned Lark *Eremophila alpestris*. A probably incomplete clutch of 3 eggs av. 2.75 g. (2.49 g. to 2.89 g.). These had av. vol. 2.63 cc. (2.35 cc. to 2.78 cc.). They reached 1.0 sp. gr. 7 days before hatching. Neonatal wt. of 2 chicks was 1.70 g. from the smallest egg and 2.47 g. from the largest. Their incubation was 253 ± 4 hr. while in our cabinet. The chicks' skins were black above, but orange below; the down was buffy yellow. The inside of the mouth was orange, especially the median part, with arresting black mouth markings distributed as follows: a spot on the inside tip of the upper and of the lower mandibles, one at the tip of the tongue and a spot at each postero-lateral corner of the tongue. The rictus was light yellow.

Tree Swallow *Iridoprocne bicolor*. Our data on this species cannot be analysed by clutches because our early techniques were inadequate. Av. egg wt. of 26 eggs was 1.80 g. (1.54 g. and 2.28 g.); av. vol. of 20 eggs was 1.72 cc. (1.50 cc.

to 1.96 cc.); they reached 1.0 sp. gr. 7 days before hatching. Neonatal wt. of 18 chicks av. 1.34 g. (1.08 g. to 1.55 g.). The longest incubation periods recorded were 346 ± 0 hr. and 340 ± 0 hr. In 2 cases that were checked the hen laid a fifth egg the day after the incomplete clutch of 4 was robbed. One hen laid a fifth egg, after the first 3 and the fourth egg had been robbed on successive days. We planted Tree Swallow eggs in an Eastern Phoebe's nest and also in a Barn Swallow's nest successfully; the foster parents hatched and fledged the young swallows. All species of swallows in the neonatal condition were noted to have a pallor compared to young of species of other groups. Tree Swallows compared to Bank Swallows were larger and lighter (not so pink) in skin color; the mandibles lacked the gray tip; the hatchlings were more lethargic; the mouth was very pale yellow, not flesh-color; the swollen, white rictal flanges contrasted with the narrower flesh-color flanges of the Bank Swallow. Tree Swallows compared to Barn Swallows were of about equal size but lighter in color, the mouth less yellow, down whiter and rictal flanges swollen to form more of a sigmoid outline. The latter observation may be a demonstration of the utility of the flanges in cavity nesters.

Bank Swallow *Riparia riparia*. Av. complete clutch wt. of 2 clutches was 7.79 g. (7.57 g. for a clutch of 5 eggs 6 days before hatching, and 8.02 g. for a clutch of 6 eggs 9 days before hatching. Av. egg wt. per clutch in 8 clutches was 1.47 g. (1.32 g. to 1.64 g.); 37 individual eggs ranged from 1.22 to 1.95 g. Av. egg vol. per clutch in 6 clutches was 1.41 cc. (1.26 cc. to 1.62 cc.); 21 eggs ranged individually from 1.17 cc. to 1.78 cc. They reached 1.0 sp. gr. 7 days before hatching. Av. neonatal wt. per clutch in 5 clutches was 1.04 g. (0.86 g. to 1.16 g.); 18 chicks ranged from 0.79 g. to 1.23 g. None of the clutches was fresh enough to span the entire incubation period in the incubator; however 1 clutch was successfully hatched after 10 days, a gratifying performance for this difficult-to-incubate species. The only complete clutch of 100 percent success was a clutch of 5 eggs that hatched a total of 36 ± 9 hr. apart. Data from less successful clutches support the view that this span is representative of the time elapsing from deposition of the first egg to initiation of incubation. Neonatal Bank Swallows were very active and crawled long distances. Their skin was pink, down light gray, bill gray or black at tip, mouth lining and rictal flanges were light flesh-color, toe nails white. Compared to the Cliff Swallow this species had darker pink skin, a smaller, narrower mouth and rictal flanges, and darker gray down.

Rough-winged Swallow *Stelgidopteryx ruficollis*. Av. egg wt. per clutch in 6 clutches was 1.84 g. (1.60 g. to 2.02 g.); 29 individual eggs ranged from 1.49 to 2.08 g. Av. egg vol. per clutch in these 6 clutches was 1.77 cc. (1.52 cc. to 1.98 cc.); 21 individual eggs ranged from 1.44 cc. to 2.02 cc. The number of days before hatching that eggs reached 1.0 sp. gr. varied from 3 to 10. Av. neonatal wt. per clutch in 3 clutches was 1.29 g. (1.12 g. to 1.56 g.); longest incubation period 367 ± 4 hr. and 366 ± 0 hr. in different clutches. In no clutch did all eggs hatch, but in one in which 2 of 7 hatched the interim between was 36 ± 8 hr. In one instance a sixth cold egg was found in the nest the morning after the first 5 had been removed. All eggs were laid on successive mornings. The neonates crawled as actively as did those of the Bank Swallow. Compared with a Barn Swallow that hatched simultaneously, the Rough-winged Swallow was smaller, had darker tips of the mandibles and had paler rictal flanges.

Barn Swallow *Hirundo rustica*. Av. egg wt. per clutch in 5 clutches 1.95 g. (1.82 g. to 2.16 g.); 16 individual eggs ranged from 1.70 g. to 2.27 g.; av. egg vol. per clutch in these 5 clutches was 1.88 cc. (1.74 cc. to 2.11 cc.); 15 individual eggs ranged from 1.64 cc. to 2.19 cc. Sp. gr. of 1.0 was reached 5 to 9 days before hatching. The extremely thin shells of all species of swallows probably presents for them a delicate problem in water conservation. Longest incubation period was 364 ± 0 hr. with the next closest 358 ± 4 hr. Av. neonatal wt. per clutch in 4 clutches was 1.47 g. (1.39 g. to 1.61 g.); 13 chicks ranged from 1.32 g. to 1.69 g. One complete clutch of 5 eggs hatched over an interim of 48 ± 10 hr. Another clutch with only 4 eggs hatched over an interim of 42 ± 6 h. Barn Swallows seemed very weak on hatching. One pair of Barn

Swallows hatched and raised 2 Tree Swallows which had been experimentally substituted into the clutch. However, in another instance all the eggs including those of the host were found out of the nest the day after introduction.

Cliff Swallow *Petrochelidon pyrrhonota*. Our data on this species cannot be analyzed by clutches because of the inadequacy of our early techniques. Av. individual egg wt. for 18 eggs 2.14 g. (1.89 g. to 2.53 g.); av. individual vol. for these long eggs 2.07 cc. (1.82 cc. to 2.46 cc.); they reached 1.0 sp. gr. on the average 7 days before hatching. Av. individual neonatal wt. of 8 chicks was 1.62 g. (1.45 g. to 1.86 g.). Our longest incubation record 314 ± 0 hr. was undoubtedly short, the egg having gone through some natural incubation before collection. The young were noted to use their heads to butt objects within touching distance; their foot movements seemed to comb at their wings. Their skin was light pink, bill and mouth showed no special coloring, the rectal flanges were pale; down light gray, toe nails white.

Blue Jay *Cyanocitta cristata*. Av. egg wt. per clutch in 4 clutches 6.47 g. (5.95 g. to 7.15 g.); 9 individual eggs ranged from 5.95 g. to 7.38 g. Av. egg vol. per clutch in these 4 clutches was 6.16 cc. (5.66 cc. to 6.76 cc.); individual egg vol. ranged from 5.66 cc. to 6.97 cc. They reached 1.0 sp. gr. on the av. 8 days before hatching. Av. neonatal wt. per clutch in 5 clutches was 4.99 g. (4.70 g. to 4.91 g.); 13 individual chicks ranged from 4.59 g. to 5.28 g. Longest incubation period was 406 ± 0 hr., second longest was 392 ± 5 hr. Parental incubation undoubtedly begins before the clutch is complete for a probably incomplete clutch of 2 eggs hatched 13 ± 5 hr. apart and a complete clutch of 5 eggs, 4 of which hatched, hatched over a span of 44 ± 7 hr. In a nest kept under observation, the third egg was laid between 10 A.M. and 6 P.M. The neonate was without natal down; its back was gray, belly pink; the hooked toe nails white, mouth light salmon. The rectal region had no flanges. The lower mandible was shorter than the upper at least in one specimen.

Common Crow *Corvus brachyrhynchos*. Four eggs from a complete clutch of 5 av. 18.61 g.; 3 of these had av. vol. 18.15 cc. (17.47 cc. to 18.63 cc.). Sp. gr. of 1.0 was reached 11 days before hatching.

Black-capped Chickadee *Parus atricapillus*. The eggs of this species were difficult to bring all the way through the incubation period; those we hatched successfully were collected 5 days before hatching. Av. egg wt. per clutch in 3 clutches 1.20 g. (1.08 g. to 1.27 g.); av. egg vol. per clutch in 2 clutches 1.16 cc., with individual eggs ranging from 1.15 cc. to 1.23 cc. Neonatal wt. of 1 clutch av. 0.85 g. (0.71 g. to 0.93 g.); one from another clutch was 0.70 g. In 1 clutch 6 of 7 eggs hatched successfully over a period of 61 ± 10 hr. One clutch that contained 10 eggs failed to develop; these were covered by nesting material when found. Neonatal chickadees had a glaucous pallor like the young of swallows; their mouths were very pale yellow and the large rectal flanges were white. They uttered pipping sounds, used their wings to aid in crawling, and begged for food very actively.

Carolina Chickadee *Parus carolinensis*. A complete clutch of 5 eggs weighed 4.96 g. the day before hatching; av. egg wt. per clutch in 4 clutches was 1.04 g. (0.96 g. to 1.16 g.); 19 individual eggs ranged from 0.90 g. to 1.21 g. Av. neonatal wt. of 5 chicks from the same clutch 0.79 g. (0.75 g. to 0.86 g.). This clutch hatched 0 ± 10 hr. apart in contrast to the staggered incubation noted in a single clutch of Black-capped Chickadee, however our samples of each species are probably inadequate. The neonates had dark gray down, light yellow mouth and large white rectal flanges.

White-breasted Nuthatch *Sitta carolinensis*. Av. egg wt. per clutch in 2 clutches was 2.23 g. (2.15 g. to 2.31 g.); av. vol. per clutch of these 2.17 cc. (2.03 cc. to 2.31 cc.); 9 individual eggs had vol. 1.86 cc. to 2.34 cc. and reached 1.0 sp. gr. on the av. 8 days before hatching. Av. neonatal wt. per clutch 1.63 g. (1.54 g. to 1.71 g.); 9 individual chicks had wt. 1.52 g. to 1.80 g. Longest incubation period was 351 ± 5 hr., recorded for 3 eggs hatched from a clutch

of 7 eggs that we believed were fresh; these hatched over a span of 0 ± 5 hr. The other clutch, from which 5 of 9 hatched, opened over a span of 46 ± 16 hr. The neonate was light pink but not as light as a just-hatched Tree Swallow. The mouth was cream bordered by a yellow-edged bill and rictal flanges. Some chicks seemed weak and lethargic, others crawled well and uttered peeps.

House Wren *Troglodytes aedon*. Av. egg wt. per clutch in 4 clutches was 1.41 g. (1.06 g. to 1.67 g.); 11 individual eggs ranged from 1.02 g. to 1.71 g. Av. egg vol. per clutch in these 4 clutches 1.44 cc. (1.02 cc. to 1.85 cc.); 11 individual eggs ranged from 0.98 cc. to 1.62 cc. and reached 1.0 sp. gr. 6 to 9 days before hatching. Neonatal wt. of 3 chicks ranged from 1.04 g. to 1.17 g. Longest incubation period for 2 eggs that we believed were fresh and that were from different clutches was 350 ± 5 hr. The skin of the neonate was very dark gray; the legs, feet, and mouth were slightly yellow, the rictal flanges white, down dark gray.

Bewick's Wren *Thryomanes bewickii*. Av. egg wt. per clutch in 2 clutches was 1.36 g. (1.32 g. to 1.40 g.); 11 individual eggs ranged from 1.23 g. to 1.44 g. Av. dimensions, by clutches, were 15.7 mm. x 12.3 mm. Clutch wt. was 9.78 g. 6 days before hatching. Neonatal wt. of 3 chicks (2 clutches) av. 1.11 g. (1.00 g. to 1.15 g.). Longest incubation period was 350 ± 10 hr. for a fresh egg from a probably incomplete clutch of 4 eggs. While Bewick's Wrens' eggs seemed difficult to incubate artificially, a clutch in nature was noted to hatch only 3 of 6; one of these showed no development, another died when about half incubated, and the third died in the pipped shell.

Carolina Wren *Thryothorus ludovicianus*. One complete clutch of 5 eggs weighed 13.64 g. 9 days before hatching. Av. egg wt. was 2.73 g. (2.64 g. to 2.92 g.). Av. dimensions were 2.05 mm. x 1.56 mm. The 3 hatchlings av. 2.09 g. (1.90 g. to 2.20 g.). These 3 emerged over a span of 0 ± 10 hr. The neonates were not darkly pigmented like those of the House Wren. The mouth was yellow, the rictal flanges pale yellow, the bill was tipped with dark gray, the down was dark gray. The neck seemed comparatively thick.

Mockingbird *Mimus polyglottos*. Av. egg wt. per clutch in 3 clutches was 4.60 g. (4.49 g. to 4.69 g.); av. dimensions 24.5 mm. x 18.6 mm.; 6 individual eggs ranged from 4.28 g. to 4.80 g. Av. neonatal wt. per clutch in 2 clutches that were incomplete was 3.50 g.; 5 individual chicks ranged from 3.28 g. to 3.84 g. Longest incubation periods for eggs known to be fresh when collected were 298 ± 9 hr. and 293 ± 10 hr. Neonates were olive with yellow mouths and extremities, the bill was tipped with dark gray. The light yellow rictal flanges were broad, almost as prominent as those of the neonatal Starling (the flange of which is supposed to demonstrate cavity-nesting adaptation).

Catbird *Dumetella carolinensis*. Complete clutch wt. in 2 clutches was 14.61 g. in 1 clutch of 4 eggs 1 day before hatching, and 16.25 g. in another clutch of 4 eggs 7 days before hatching. Av. egg wt. per clutch in 8 clutches was 3.87 g. (3.65 g. to 4.18 g.); 21 individual eggs ranged from 3.40 g. to 4.26 g. Av. egg vol. per clutch in 7 clutches was 3.74 cc. (3.43 cc. to 4.02 cc.); 16 individual eggs ranged from 3.43 cc. to 4.13 cc. They reached 1.0 sp. gr. 7 days before hatching. Av. neonatal wt. per clutch in 9 clutches was 2.85 g. (2.57 g. to 3.17 g.); 24 individual chicks ranged from 2.52 g. to 3.41 g. Longest incubation period for an egg known to be fresh when collected was 317 ± 3 hr.; the next longest 316 ± 5 hr. Shortest interim between total hatch in a clutch of 4 eggs was 12 ± 5 hr.; others were 25 ± 0 hr., 36 ± 5 hr. and in a complete clutch of 3 eggs 33 ± 15 hr. The skin of the neonate was dark gray, similar to that of the House Wren, the down was black, toe nails (variably) and tips of the sharp bill dark gray, mouth yellow, rictal flanges white, and peculiarly, the tip of the tongue was variably black.

Brown Thrasher *Toxostoma rufum*. A neonate weighed 4.70 g. In a complete clutch of 4 eggs 3 hatched over a span of 24 ± 12 hr. The skin was dark gray especially on the dorsum and the down was black; the mouth cream laterally becoming orange in center, rictal flanges white.

Robin *Turdus migratorius*. Av. complete clutch wt. of 4 clutches was 21.20 g. (18.71 g. for a clutch of 3 eggs 8 days before hatching and 23.62 g. for a clutch of 4 eggs 5 days before hatching). Av. egg wt. per clutch in 10 clutches was 6.39 g. (5.74 g. to 7.05 g.); 25 individual eggs ranged from 5.50 g. to 7.37 g. Av. egg vol. per clutch in 8 clutches was 6.29 cc. (5.92 cc. to 6.73 cc.); 13 individual eggs ranged from 5.75 cc. to 6.92 cc. and reached 1.0 sp. gr. relatively early, 5 days before hatching. Ave. neonatal wt. per clutch in 13 clutches was 5.02 g. (4.56 g. to 5.80 g.); 29 individual neonates ranged from 4.33 g. to 6.05 g. Longest incubation period was 295 ± 1 hr.; the next longest was 289 ± 0 hr. from a fresh egg, first one laid in the clutch. Shortest interim between first and last hatching in a complete clutch of 4 eggs was 43 ± 10 hr.; others recorded were 48 ± 15 hr. for a complete clutch of 4 eggs and 49 ± 5 hr. for a complete clutch of 3 eggs. The neonate was light pink with long light salmon down, darker at tips. The mouth was yellow becoming orange medially; the rectal flanges were whitish. Surprisingly, for an "altricial" bird, the eyes opened when the bird gaped. One chick from a clutch that had accidentally been chilled for 5 hr. on the sixth day before hatching had very short down; however, another of the same clutch, that hatched several hr. later than the odd one, was normal. Red-winged Blackbird eggs substituted for incubated Robin eggs were missing the day after they were introduced.

Wood Thrush *Hylocichla mustelina*. Av. complete clutch wt. of 3 clutches with 3 eggs each was 14.90 g. (14.36 g. in 1 clutch 10 days before hatching and 15.23 g. in another 8 days before hatching). Av. egg wt. per clutch in 4 clutches was 5.26 g. (4.77 g. to 1.14 g.); 10 individual eggs ranged from 4.46 g. to 6.14 g. Av. egg vol. per clutch in 3 clutches was 5.17 cc., ranging for 5 individual eggs 4.70 cc. to 5.78 cc. The only egg determined reached 1.0 sp. gr. 9 days before hatching. Av. neonatal wt. per clutch in 4 clutches 3.46 g. ranging for 7 individual eggs 2.86 g. to 4.00 g. Longest incubation period was 335 ± 3 hr., for an egg that hatched at the small end. This egg was believed to be almost fresh though it was taken from a clutch of 3 eggs from under the hen at 4 p.m. Another egg from this clutch hatched with a relatively large unretracted yolk sac. It is noteworthy that this rare observation was recorded also in another just-hatched Wood Thrush. The shortest interim for total hatching of a clutch was 16 ± 6 hr.; another 38 ± 9 hr. and a third, from which only 2 of 3 eggs hatched, 32 ± 5 hr. The neonate had a yellow-orange mouth with pale yellow rectal flanges. The bill, anterior to the nares, was gray. One chick at incubation temperature respired 24 times per minute. Three eggs of a Catbird substituted for the 3 incubated eggs of a Wood Thrush were missing the next day. An egg of the Wood Thrush was found on the ground May 26; no nest in the vicinity could be found. This fresh egg underwent some development in the incubator then died.

Eastern Bluebird *Sialia sialis*. Clutch wt. of 1 complete clutch of 5 eggs 5 days before hatching was 14.27 g. Av. egg wt. per clutch in 3 clutches was 2.92 g. (2.79 g. to 3.12 g.); 12 individual eggs ranged from 2.56 g. to 3.21 g. Egg vol. from 1 clutch only av. 2.94 cc. (2.88 cc. to 3.05 cc.). Av. neonatal wt. per clutch in 4 clutches 2.17 g. (2.05 g. to 2.28 g.); 12 individual chicks ranged from 2.00 g. to 2.42 g. Longest incubation period was 329 ± 6 hr. with another from the same clutch of 4 eggs 323 ± 0 hr.; another single fresh egg hatched in 322 ± 6 hr. Interim between first and last hatchings was 14 ± 13 hr. for a complete clutch of 5 eggs, 4 of which hatched. In another clutch 3 of 5 eggs hatched over an interim of 11 ± 9 hr. The neonate was on the yellow side rather than the pink side of flesh-color with decidedly yellow color on the legs, toe nails and bill. The eyeballs were comparatively large presenting chunkier conformation of the head than that of non-turdids. The down was black.

Blue-gray Gnatcatcher *Polioptila caerulea*. Two complete clutches of 5 eggs respectively weighed 5.21 g. 7 days before hatching and 4.89 g. 5 days before hatching. Av. egg wt. per clutch of 6 clutches was 1.02 g. (0.95 g. to 1.14 g.); 20 individual eggs ranged from 0.91 g. to 1.18 g. Av. egg dimensions per clutch for 6 clutches were 1.47 mm. x 1.16 mm. Av. neonatal wt. per clutch in 5 clutches was 0.75 g. (0.69 g. to 0.79 g.). One chick weighed 0.63 g., another 0.87 g. Longest incubation periods were 320 ± 6 hr. and 312 ± 0 hr. While

no clutch hatched completely, data on the incomplete hatchings indicate that 8 hr. is about the normal span of opening of the whole clutch. A nest under observation was completed fully a week before the first egg was laid. After the removal of the first 2 eggs no more were laid. The neonate was unusual in two respects: there was absolutely no down and the very pale cream mouth was marked by a pair of contrasting black spots on the tongue. The skin of the head and back was dark gray as was also the tip of the otherwise flesh-color upper mandible.

Cedar Waxwing *Bombycilla cedrorum*. Four chicks from a clutch of 5 eggs hatched over a span of 57 ± 3 hr. The neonate was pink and with no down. The red mouth was bordered by thin light yellow of the horny bill, the gape was comparatively wide but without rictal flanges. The observation of Saunders (1956) that the just-hatched waxwing has violet-blue lines in the mouth should be further investigated. We observed no such lines and suspect the report may have resulted from fruits eaten by the young.

Loggerhead Shrike *Lanius ludovicianus*. A clutch of 5 fresh eggs av. 4.56 g. (4.33 g. to 4.71 g.). Av. dimensions were 24.5 mm. x 18.1 mm. A single chick hatched in 308 ± 0 hr. and weighed 3.33 g. The parent of that chick laid egg c the day after a and b were removed; eggs d and e respectively were also laid in the emptied nest. The neonate had light gray skin, a pair of black spots on either side of the egg tooth, and a yellow mouth with buffy yellow rictal margin. There was some short white down on the rectrices, secondary coverts and abdominal ventral region only.

Starling *Sturnus vulgaris*. Av. complete clutch wt. of 4 clutches was 37.77 g. A clutch of 4 eggs weighed 27.65 g., a clutch of 5 eggs 40.69 g. and 2 clutches of 6 eggs 48.48 g. and 34.24 g. The latter was weighed 1 day before hatching, the others 8 days. Av. egg wt. per clutch in 8 clutches was 7.10 g. (5.71 g. to 8.14 g.); 34 individual eggs ranged from 5.44 g. to 8.39 g. Av. egg vol. per clutch in 8 clutches was 6.88 cc. (5.60 cc. to 7.75 cc.); 23 individual eggs ranged from 5.44 cc. to 7.89 cc. Eggs were also widely variable, independent of size, in the number of days before hatching in reaching 1.0 sp. gr., 8 to 2 days. Av. neonatal wt. per clutch in 6 clutches was 5.27 g. (4.07 g. to 6.30 g.); 18 individual neonates ranged from 3.82 g. to 6.43 g., the differences supposedly accounted for by unassimilated (but retracted) yolk, rather than by bodily development. Halbersleben and Mussehl (1921-22) found that chick wt. in *Gallus* was 64 percent of egg wt. regardless of differences in egg wt. (See also Heinroth, 1922: 72.) At 35 days these wt. differences had disappeared. Our data do not yield any reasonably long incubation period record. However, 2 complete clutches of 6 eggs each hatched over a span of 16 ± 5 hr. and 23 ± 9 hr. The skin of the neonate was orange-pink, the down gray in front and white posteriorly, the toenails white. The rictal flanges were enormous and bright yellow like the inside of the mouth.

White-eyed Vireo *Vireo griseus*. Two fresh eggs weighed 1.80 g. and 1.69 g. and had av. dimensions of 17.9 mm. x 13.5 mm. The neonates weighed 1.35 g. and 1.31 g. respectively. Both hatched in 350 ± 7 hr. The skin was flesh-color, the mouth and small rictal flanges light yellow, the tip of the upper mandible gray.

Red-eyed Vireo *Vireo olivaceus*. Av. egg wt. per clutch in 2 clutches was 2.36 g.; 5 individual eggs ranged from 2.21 g. to 2.43 g. Vol. of 1 egg 2.25 cc. Neonatal siblings weighed 1.60 g. and 1.91 g. Another complete clutch of 3 eggs (exclusive of a cowbird egg) took 35 ± 9 hr. to open from first to last. It is noteworthy that the most advanced embryo in a clutch candled very early in development was overtaken 9 ± 6 h. in hatching by the next-to-most advanced. It is a common belief among aviculturists that "the older the germ the longer the incubation." "One (each ?) day of storage delayed hatching 50 minutes" in chickens (D. W. MacLaury, pers. comm.). The neonate was yellow-orange including the inside of the mouth. The vireo's eyes were large, like those of the Eastern Bluebird.

Philadelphia Vireo *Vireo philadelphicus*. One that had just hatched under natural incubation had light yellow-orange body and bill with toe nails noticeably white. Inside of the mouth was yellow, the short natal down light gray.

Warbling Vireo *Vireo gilvus*. Three eggs from a complete clutch of 4 eggs av. 1.65 g. (1.53 g. to 1.77 g.). One of these eggs had vol. 1.75 cc. and reached 1.0 sp. gr. 8 days before hatching. Av. neonatal wt. of 3 chicks was 1.23 g. (1.13 g. to 1.32 g.). These hatched 1 each day, totaling 43 ± 18 hr. interim. Their skins were yellow-orange.

Yellow Warbler *Dendroica petechia*. A complete clutch of 5 eggs weighed 7.85 g. 9 days before hatching. Av. egg wt. of these eggs was 1.57 g. (1.52 g. to 1.63 g.). Av. vol. was 1.54 cc. (1.50 cc. to 1.57 cc.) and reached 1.0 sp. gr. 5 days before hatching. Neonatal wt. of 3 chicks from 2 clutches av. 1.14 g. (1.05 g. to 1.20 g.). Two eggs that hatched successfully from a clutch of 5 opened 21 ± 5 hr. apart. The skin was yellow-orange and the down white. Longest incubation period of 267 ± 2 hr. seemed too short to be representative when compared to non-parulids, but there was every reason to believe that the egg was fresh when collected. That fact is emphasized because the skeletons of these warblers are remarkably advanced for 270-hr.-old avian embryos.

Chestnut-sided Warbler *Dendroica pennsylvanica*. Four eggs from a clutch of 4 (exclusive of a cowbird egg) av. 1.41 g. (1.32 g. to 1.57 g.). Av. vol. of 3 eggs 1.41 cc. (1.29 cc. to 1.54 cc.). The single neonate that hatched successfully weighed 0.97 g. Longest incubation period was 268 ± 4 hr.

Prairie Warbler *Dendroica discolor*. A complete clutch of 4 eggs weighed 5.51 g. 9 days before hatching (1.35 g. to 1.41 g.). Two neonates weighed 1.00 g., another 0.94 g. The skin was yellow-orange with a blood vessel on the right side of the neck showing conspicuously red, the mouth was light yellow with paler rictal flanges, down dark gray.

Ovenbird *Seiurus aurocapillus*. Clutch wt. respectively 11.24 g. for a complete clutch of 5 eggs 4 days before hatching and 11.01 g. for a clutch of 4 eggs 8 days before hatching. Av. egg wt. per clutch for 2 clutches was 2.50 g. (2.25 g. to 2.75 g.); 9 individual eggs ranged from 2.12 g. to 2.89 g. Vol. of 1 egg 2.65 cc. Av. neonatal wt. per clutch for 3 clutches was 1.88 g. (1.70 g. to 2.09 g.); 12 individual chicks ranged from 1.45 g. to 2.19 g. A complete clutch of 5 eggs hatched within 16 ± 0 hr. from first to last egg; a complete clutch of 4 eggs hatched within 24 ± 8 hr. The neonate had a yellow bill and rictal flanges, the mouth red, down medium gray but darker on the head.

Yellowthroat *Geothlypis trichas*. Av. egg wt. of 4 individual eggs from 2 clutches was 1.86 g. (1.78 g. to 1.93 g.). Av. vol. of 4 eggs was 1.82 cc. (1.75 cc. to 1.89 cc.); they reached 1.0 sp. gr. 8 days before hatching. The eggs of this species seemed disproportionately large for the size of the adult; av. egg dimensions 1.45 mm. x 1.93 mm. Av. neonatal wt. of 6 chicks from 4 clutches 1.24 g. (0.90 g. to 1.14 g.). Longest incubation period was 256 ± 12 hr. A set of 3 (exclusive of a cowbird egg) had a total hatching span of 16 ± 5 hr.; another complete clutch of 4 eggs 22 ± 19 hr. The neonate was light orange with dark gray down. The teleoptile remiges (or the greater coverts?) already showed through the skin as pigment spot. The mouth was light reddish orange, bordered by the yellow edge of the bill; the rictal flanges which were noted to be very rounded were yellow, as were also the toe nails.

House Sparrow *Passer domesticus*. Av. complete clutch wt. for 5 clutches was 14.33 g. (12.55 g. for a clutch of 4 eggs 4 days before hatching and 17.73 g. for a clutch of 6 eggs 11 days before hatching). Av. egg wt. per clutch for 30 clutches was 2.78 g. (2.27 g. to 3.34 g.); 85 individual eggs ranged from 1.87 g. to 3.36 g. Av. egg vol. per clutch for 27 clutches was 2.63 cc. (2.15 cc. to 3.15 cc.); 76 individual eggs ranged from 1.75 cc. to 3.16 cc. Sp. gr. of 1.0 was reached on the av. 5 days before hatching but varied from 1 day to 9 days before hatching. Av. neonatal wt. per clutch for 30 clutches was 2.02 g. (1.73 g. to 2.74 g.); 58 individual chicks ranged from 1.58 g. to 2.83 g. Longest incubation period was

282 \pm 3 hr. with many other records closely crowding this one. The interim between first and last egg hatching was variable. Where all eggs of the clutch hatched successfully the interval in one clutch with 4 eggs was 10 \pm 3 hr.; in another 36 \pm 6 hr. For complete clutches of 5 eggs 1 clutch in which 4 hatched successfully all chicks emerged in 0 \pm 7 hr.; in another of the same success, 10 \pm 5 hr. In a complete clutch of 6 eggs 5 hatched in 58 \pm 8 hr. One clutch that was deposited after the "rookery" had been twice thoroughly robbed had 2 light colored eggs and 3 that were completely white. We think that the rapidly repeated layings exhausted available pigment. These pale eggs showed normal hatchability. Another clutch with exceedingly narrow, elongated eggs hatched without singularity. A chick that was noted to be unusually small (1.66 g.) and with blanched skin was hatched in proper time from an egg not noticeably abnormal in any respect. The neonates were naked and the skin was light gray especially on head and dorsum. The mouth was red and contrasted with the bright yellow rictal flanges which were broad and thick in this species.

Red-winged Blackbird *Agelaius phoeniceus*. Av. clutch wt. of 4 clutches of 4 eggs each was 14.76 g. (12.14 g. 8 days before hatching and 16.53 g. 10 days before hatching). Av. egg wt. per clutch for 14 clutches 3.98 g. (3.04 g. to 4.66 g.); 37 individual eggs ranged from 2.80 g. to 5.39 g. Av. egg vol. per clutch for 10 clutches 3.85 cc. (3.02 cc. to 4.24 cc.); 28 individual eggs ranged from 2.80 cc. to 4.32 cc. They reached 1.0 sp. gr. on the av. 6 days before hatching but ranged from 4 to 9 days. Av. neonatal wt. per clutch for 12 clutches was 2.75 g. (2.14 g. to 3.21 g.); 29 individual neonates ranged from 1.83 g. to 3.32 g. Longest incubation recorded 263 \pm 1 hr.; this seemed too short to be representative. Two complete clutches of 4 eggs each in which all eggs hatched successfully hatched over a span of 23 \pm 9 hr. All other complete clutches, in which hatching was less successful, hatched in less time than the above except 2 clutches, 40 \pm 6 hr. and 33 \pm 9 hr. The neonate was bright orange-red. It is noteworthy that the yolk of the Red-winged Blackbird egg is of this same color, probably xanthophyl determined and derived from phytophagus insect larvae.

Baltimore Oriole *Icterus galbula*. The youngest of 5 nestlings thought to be just-hatched weighed 2.63 g.; the others showed the probable progression in staggered hatching, 4.26 g., 6.91 g., 7.86 g. and 7.85 g. The skin and mouth were orange-pink, toe nails yellow, down light buffy yellow. The underside of the flat, unswollen rictal flanges was bright red. We were unable to determine whether this coloring, noted in several other species, was from underlying blood vessels or was a pigment deposition; probably the former. (See discussion under Field Sparrow.) This chick uttered no sound.

Common Grackle *Quiscalus quiscula*. Av. egg wt. per clutch of 4 clutches was 6.76 g. (5.57 g. to 9.20 g.); 14 individual eggs ranged from 5.26 g. to 9.93 g. Av. egg vol. per clutch of 4 clutches 6.57 cc. (5.32 cc. to 8.96 cc.); 12 individual eggs ranged from 5.16 cc. to 9.40 cc. They reached 1.0 sp. gr. on the av. 8 days before hatching with a range from 5 to 10 days before hatching. Av. neonatal wt. per clutch from 5 clutches 4.96 g. (3.50 g. to 6.58 g.); 14 individual chicks ranged from 3.50 g. to 7.03 g. Longest incubation period recorded was 310 \pm 0 hr.; the clutch was possibly complete. The last chick hatched 21 \pm 0 hr. after the first. In 1 clutch of 5 eggs of which 4 hatched successfully all chicks emerged within 6 hr. of one another. A clutch of 5 eggs had 3 hatch over a 30 \pm 4 hr. span. The neonate had a red mouth with white, moderately flared rictal flanges. The down was black, toe nails white, tip of upper mandible medium gray.

Brown-headed Cowbird *Molothrus ater*. Av. egg wt. for 10 eggs was 3.03 g. (2.63 g. to 3.36 g.). Av. vol. of 7 eggs 2.75 cc. (2.22 cc. to 3.15 cc.); these reached 1.0 sp. gr. 5 to 8 days before hatching. Av. neonatal wt. of 9 chicks 2.22 g. (1.85 g. to 2.68 g.). Longest incubation period recorded was 297 \pm 6 hr. The neonate had a red mouth with moderately flared, pale rictal flanges; the bill was slightly prognathous. The down was light buffy yellow becoming white posteriorly. It may be coincidental but only 1 of 10 cowbird eggs incubated artificially was found newly hatched at a time other than early morning; the

hatching of the hosts' eggs of the same clutches was evenly distributed over the night and day.

The immediate biological effects of the introduction of the cowbird egg are great and probably underestimated by most observers. Much of the damage is done long before the egg is hatched. When our data were segregated as to cowbirds that hatched in our incubator successfully on the one hand and unsuccessfully on the other, the 6 unsuccessful eggs were in hosts' clutches that were also almost totally unsuccessful in hatching; while the successful cowbird eggs were in successful hosts' clutches. Our interpretation is that these unsuccessful clutches were deserted. Inconspicuous physical damage to at least some of the hosts' eggs was detected in most instances by the candler. In addition it was often suspected that some hosts' eggs were removed and never found by us. It is the instinctive habit of chickens to eat an egg that is cracked or dented and the same habit may be applicable to cowbird hosts.

Following are some detailed case histories: *A.* Eastern Phoebe; 2 of 4 of the host's eggs failed to hatch. The cowbird egg hatched 64 ± 4 hr. before the first phoebe egg and 192 ± 99 hr. before the last. The relatively long incubation period of the phoebe may deter successful cowbird parasitism. *B.* Eastern Phoebe; 2 of the host's eggs were pierced, the third never developed; the cowbird egg also did not develop. *C.* Eastern Phoebe; no eggs save the cowbird egg were found. It did not develop. *D.* Red-eyed Vireo; 2 of the host's eggs were cracked and the third embryo eventually died. The cowbird egg hatched. *E.* Red-eyed Vireo; 1 egg was laid by a cowbird but destroyed by human agency before the vireo commenced to lay. The second cowbird egg hatched 17 ± 15 hr. before the first vireo's egg and 52 ± 16 hr. before the last (third) vireo's egg. *F.* Red-eyed Vireo; 1 of the host's eggs hatched; the other 3 died in the shell. The cowbird egg did not hatch. *G.* Black-and-white Warbler; 3 of the host's eggs hatched under natural incubation before we found the nest. This was 6 full days before the cowbird egg hatched in our incubator. One of the host's eggs was found pierced and a foot away from the nest. *H.* Yellow Warbler; the first egg of the host was punctured; the second was missing and a cowbird egg was in its place; the next day the host laid another egg, then the clutch was collected. The cowbird egg hatched 11 ± 8 hr. before the host's third egg. *I.* Chestnut-sided Warbler; 1 of the 4 host's eggs hatched; the cowbird egg did not. *J.* Ovenbird; the cowbird egg hatched 8 ± 7 hr. before the first Ovenbird's egg and 34 ± 8 hr. before the third (last) Ovenbird's egg. *K.* Yellowthroat; of the 2 host's eggs 1 had 2 tiny holes and failed to hatch; the other hatched 22 ± 20 hr. after the cowbird egg. *L.* Yellowthroat; the cowbird egg hatched within 0 ± 5 hr. of 2 of the host's eggs and 16 ± 5 hr. before the third (last) egg. *M.* Red-winged Blackbird; neither the 1 blackbird's egg nor the cowbird egg hatched. *N.* Rufous-sided Towhee; 1 of the 2 towhee embryos died in the shell. The cowbird egg hatched 16 ± 7 hr. before the successful towhee's egg. *O.* Rufous-sided Towhee; 1 towhee egg was broken; the other did not hatch. The cowbird egg hatched. *P.* Song Sparrow; neither the host's 4 eggs nor the cowbird egg hatched. *Q.* Two eggs believed to be of the cowbird were found together on a wood path May 30; no nest could be found in the vicinity. The eggs failed to develop.

Scarlet Tanager *Piranga olivacea*. Av. egg wt. per clutch for 2 clutches was 3.38 g. with 5 individual eggs ranging from 3.10 g. to 3.65 g. Av. egg vol. for 3 eggs of 1 clutch 3.40 cc. (3.34 cc. to 3.47 cc.). These reached 1.0 sp. gr. 4 days before hatching. Neonatal wt. of 2 siblings was 2.70 g. They hatched 2 hr. apart; the third egg of the clutch did not hatch. Artificial incubation for this clutch was 264 ± 0 hr., but the eggs were probably not fresh. The neonate had a pink mouth and silvery gray down.

Cardinal *Richmondia cardinalis*. Av. complete clutch wt. in 5 clutches of 3 eggs each was 12.62 g. (11.82 g. to 13.76 g.). Av. egg wt. per clutch in 6 clutches 4.27 g. (3.94 g. to 4.59 g.); 12 individual eggs ranged from 3.65 g. to 4.87 g. Av. dimensions per clutch 24.7 mm. x 17.9 mm. The skin of the neonate was orange, the mouth red with cream rictal flanges, the bill already cardueline in shape. The down was black, contrary to my previous belief (Wetherbee, 1957) that cardueline finches have white natal down. Inexplicably, of 17 eggs of this species incubated artificially under standard conditions, only 1 hatched. The incubation period was 298 ± 9 hr.

Rose-breasted Grosbeak *Pheucticus ludovicianus*. Clutch wt. on a complete clutch of 4 eggs was 16.92 g. 10 days before hatching. Av. egg wt. per clutch for 3 clutches was 3.94 g. (3.38 g. to 4.23 g.); 9 individual eggs ranged from 3.14 g. to 4.39 g. Av. egg vol. in 1 clutch of 4 eggs was 4.07 cc. (3.96 cc. to 4.24 cc.). They reached 1.0 sp. gr. 5 days before hatching. Neonatal wt. of 3 individuals ranged from 2.82 g. to 3.29 g. (av. 3.10 g.). Longest incubation period recorded was 294 ± 5 hr. In one complete clutch of 4 eggs in which only 3 hatched the span between first and last hatching was in excess of 58 hr. An incomplete clutch of 3 eggs hatched 25 ± 11 hr. from first to last. As 2 of these hatched simultaneously, incubation probably commenced with the second egg. If it can be assumed that at least 4 eggs composed the potential clutch and that 1 egg is laid each day in the morning, then the longest incubation period given above plus about 12 hr. represents the true period for this species. In chickens, however, afternoon laying becomes more frequent as the hen's age increases; therefore morning laying is not always a safe assumption. The skin of the neonate was orange like that of the Red-winged Blackbird; the down was white except on the head where it was gray. The mouth, especially the tongue, was reddish orange and was bordered by the yellow of the edge of the mandibles; the pale yellow rictal flanges were only slightly flared; the toe nails were white.

Indigo Bunting *Passerina cyanea*. One egg, which had been laid shortly after the first 2 had been removed by a predator, weighed 2.01 g.

Purple Finch *Carpodacus purpureus*. Three eggs from 2 clutches weighed 1.86 g. to 2.09 g. (av. 2.00 g.); vol. ranged from 1.76 cc. to 2.04 cc. (av. 1.92 cc.). None of these eggs hatched successfully; longest embryonic life was 274 ± 0 hr.

Rufous-sided Towhee *Pipilo erythrophthalmus*. Weights of 3 eggs from 2 clutches ranged from 3.60 g. (just before hatching) to 3.98 g. (av. 3.28 g.). Neonatal wt. of 2 chicks from different clutches were 3.05 g. and 3.08 g. The mouth of the neonate was red in sharp contrast to the bordering yellow bill.

Chipping Sparrow *Spizella passerina*. Av. egg wt. per clutch in 4 clutches was 1.54 g. with 10 individual eggs ranging from 1.35 g. to 1.66 g. Av. vol. of 4 eggs from 3 clutches was 1.50 cc. (1.39 cc. to 1.58 cc.). These reached 1.0 sp. gr. 6 days before hatching. Av. neonatal wt. per clutch in 3 clutches was 1.09 g. with 8 individual chicks ranging from 0.98 g. to 1.27 g. Longest incubation period recorded was 274 ± 10 hr. The interim between first and last hatching in a complete clutch of 4 was 22 ± 16 hr., probably nearer 22 ± 6 hr., one chick having died before the incubator was tended. A third egg in one instance was laid after the first 2 eggs had been robbed. The neonate was dull orange with dark gray down. The tip of the bill was gray, the toe nails white. The mouth was reddish bordered by the yellow of the edge of the bill; the rictal flanges were light yellow.

Field Sparrow *Spizella pusilla*. Av. complete clutch wt. of 4 clutches of 4 eggs each was 6.51 g. with extremes respectively of 6.01 g. 8 days before hatching and 7.14 g. 7 days before hatching. Av. egg weight per clutch in 7 clutches was 1.67 g. (1.55 g. to 1.86 g.); 24 individual eggs ranged from 1.42 g. to 1.92 g. Av. vol. for 5 eggs from 2 clutches was 1.66 cc. (1.43 cc. to 1.86 cc.). Sp. gr. of 1.0 was reached 7 days before hatching. Av. egg dimensions per clutch were 17.8 mm. x 13.2 mm. Av. neonatal wt. per clutch for 5 clutches was 1.23 g. (1.09 g. to 1.41 g.); 11 individual chicks ranged from 1.05 g. to 1.41 g. As 231 ± 0 hr. was the longest incubation period recorded, we believe that further work is indicated. The interim between hatching of the first and last chick in a complete clutch of 4 eggs was 24 ± 8 hr. Eggs were laid daily. The neonate was light orange with down that varied from light to dark gray. The upper mandible was gray on the anterior half; the mouth was bright red and the rictal flanges light yellow.

In the Field Sparrow as in some other species, the color of the mouth is dark in the preserved specimen, while in other species the mouth coloration disappears upon preservation of the specimen. This dark color is presumably caused by vascularity and therefore suggests that some oxygen exchange may take place in the nestling's mouth. This interpretation of mouth color is especially favored by Daniel's (1957) contention that the early respiratory activity of "altricial" birds

is relatively inefficient because of incomplete fusion of the para-bronchi of the lungs.

Swamp Sparrow *Melospiza georgiana*. Clutch wt. of a complete clutch of 4 eggs 10 days before hatching was 8.25 g.; av. egg wt. 2.06 g. (1.85 g. to 2.15 g.). Av. neonatal wt. of 3 of these chicks was 1.46 g. (1.37 g. to 1.55 g.). Av. dimensions of 5 eggs in 2 clutches were 19.8 mm. x 15.0 mm. Three of a clutch of 4 hatched over an interim of 12 ± 8 hr. The neonates were described in detail elsewhere (Wetherbee, *in Bent*, ms.). Their skin was pink and the down dark gray; mouth pink with pale yellow border.

Song Sparrow *Melospiza melodia*. Four eggs from a partly incubated clutch av. 2.35 g. Three young that hatched successfully from a clutch of 4 eggs emerged over a span of 39 ± 10 hr. The mouth of the neonate was salmon color.

Summary. The artificial incubation of eggs of 83 species of wild birds is described. Determinations of magnitudes are reported for egg weights, clutch weights, egg volumes, incubation periods, interims between hatchings within clutches, and number of days before hatching during which eggs float. Colors of natal down and soft parts, especially of mouth linings are given. Extent of development judged by behavior is noted. This paper attempts to establish procedural standards under standardized conditions that may allow for more accurate and more significant interspecific comparisons of incubation and neonatal condition independent of parental attentiveness in incubation and of other environmental variables.

LITERATURE CITED

- BALDWIN, S. P., and S. C. KENDEIGH. 1932. Physiology of the temperature of birds. Sci. Publ. Cleveland Mus. Nat. Hist., 3, 196 pp.
- BARRUEL. 1954. Birds of the world. Oxford University Press.
- DANIEL, J. C., JR. 1957. An embryological comparison of the domestic fowl and the Red-winged Blackbird. *Auk*, **74**: 340-358.
- EVANS, W. 1891. On the periods occupied by birds in the incubation of their eggs. *Ibis*, 52-93 [33], 1891.
- . 1982. Score further notes on the periods occupied by birds in the incubation of their eggs. *Ibis*, 55-58 [34], 1892.
- GRABER, R. R. 1955. Artificial incubation of some non-galliform eggs. *Wilson Bull.*, **67**: 100-109.
- HALBERSLEBEN, D. L. and F. E. MUSSEHL. 1921-22. Relation of egg weight to chick weight at hatching. *Poultry Science*, **1**: 143-144.
- HAYS, F. A. 1941. The importance of length of incubation period in Rhode Island Reds. Massachusetts Ag. Exp. Sta. Bull., 348.
- HEINROTH, O. 1908. Trachtigkeits—und Brutdauer. *Zool. Beob.*, **49**: 14-25.
- . 1922. Die Beziehungen zwischen Vogelgewicht, Eigewicht, Gelegegewicht und Brutdauer. *Jour. f. Ornith.*, **70**: 172-285.
- HUGGINS, R. A. 1941. Egg temperature of wild birds under natural conditions. *Ecology*, **22**: 148-157.
- KENDEIGH, S. C. 1940. Factors affecting length of incubation. *Auk*, **57**: 499-513.
- SAUNDERS, A. A. 1956. Descriptions of newly-hatched passerine birds. *Bird-Banding*, **27**: 121-128.
- WETHERBEE, D. K. 1957. Natal plumages and downy pteryloses of passerine birds of North America. *Bull. American Mus. Nat. Hist.*, **113**: 339-436.
- . 1959. Comparative phylembryogenetic dimensionality of neonatal birds. University Microfilms, Ann Arbor, Michigan, 260 pp.

Massachusetts Cooperative Wildlife Research Unit, Dept. of Poultry Science, University of Mass., Amherst, Mass.

Received 1958