

stantially built of coarse grass and was lined with fine grass, and a few long horse hairs. There was no depression in the ground under the nest. The half acre adjacent to the site was low and damp and covered with long grass. A prolonged drouth had no doubt driven the birds from their usual habitat on higher ground to this relatively damp spot. The parent birds did not assert their presence while the nest was being photographed.

A week later, and within 50 feet of the nest site, I flushed a Bachmans Sparrow which feigned crippledness as it fluttered off through the grass. A search revealed two young birds just learning to fly and which were captured. The one parent bird present remained near and most persistently endeavored to lure me away by fluttering through the grass, sometimes coming to within five feet of where I held the young in my hand.

Nashville, Tenn.

COMPARATIVE PERIODS OF NESTLING LIFE OF SOME NORTH AMERICAN NIDICOLÆ

BY FRANK L. BURNS

The term *Nidicolæ* (*Altrices*) as defined by Dr. Newton indicates the species or groups of birds having the young born in a more or less helpless condition, unable to leave the nest for some time and fed directly by the parent. Little reliance, however, can be placed upon the mere fact of direct feeding of the young by the parents as a diagnosis of *Nidicolæ*, since the young of many *præcocial* groups (the Grebes, Loons, Murrelets, Gulls, Terns, Flamingoes and Cranes) are also heterophagous; therefore the distinction is better expressed by Dr. Gadow: in a condition in which the development of the sense, tegumentary and locomotory organs are shifted on to the post-embryonic period; in distinction to *Nidifugæ* (*Præcoces*), in which the development of the same organs are far advanced, enabling the young to leave the nesting site almost immediately after birth.

Modern systematists place little reliance on the con-

dition of the young at birth as a taxonomic character, though in the past, unsuccessful efforts have been made to produce a satisfactory physiological arrangement of our birds based upon this peculiar state, grouped in accordance with external characters such as the shape of the bill and feet.

In the Water Birds there are some groups of Nidicolæ more nearly related in every essential character to the lower Nidifugæ, though the relatively higher group, the strictly Land Birds, are nearly all Nidicolæ, the exceptions being the Gallinaceous birds.

Nidificate species constructing elaborate nests or laboriously tunneling in the earth or wood, are all or nearly all nidicolous; while the nidifugous birds are essentially terrestrial and frequently deposit their eggs on the bare ground or rocks, with the exception of the Ducks, which heavily line their nests with feathers plucked from their own breasts; at best their nests are little more than rubbish heaps of earth, leaves or grasses. As a taxonomic character for groups, there are some inconsistencies; the *Alcide*, for instance, are not all nidicolous; according to recent observations the young of the Murrelets (at least the Ancient, Xantus's, and Craveri's Murrelets, all of which take to the sea in from one to three or four days), are nidifugous.

The higher types of Nidicolæ (young hatched in a blind or helpless and naked or semi-naked condition, never acquiring natal down, or acquiring natal down growing from the tips of the juvenal plumage) are characteristic of the higher, more specialized groups.

It has been thought not only that the ancestral type of our birds was nidifugous but that the protective aboreal nesting habits led to nidicolous young; a hypothesis not at all nullified by the fact of so many nidicolous species belonging to phylogenetically older groups and to groups having ground-nesting or near ground-nesting habits; for these species nest exclusively or almost exclusively in colonies and on islands affording protection from their natural enemies equal if not superior to the elevation of the arbor-

cal nester on the mainland, and the conditions of environment made further changes impossible.

The eminent anatomist Pycroft in his paper entitled "The Significance of the Condition of the Young at Birth," (*Popular Science Monthly*, *lxii*, 108 and further elaborated in "*The Infancy of Animals*,"), however, considers that birds were originally arboreal. He states that the structure of the feet of the *Archæopteryx* (the earliest bird known to science) would prove it strictly arboreal and suggests the conclusion that the reptilian stock from which the Aves are descended was probably also arboreal, and considers that we probably have in the arboreal South American Hoactzin (the young of which scrambles about the branches in a truly reptilian manner) a direct survival of the proavian type of nesting; the nidifugous young differing from other nidifugous young in the prehensile character of its wings. He claims that the facts justify the theory, (1) that birds were originally arboreal and their young nidifugous; (2) that the nidicolous habits and helplessness of young birds are specialized adaptations to an arboreal or gregarous mode of life, and (3) that the young of Gallinaceous birds form a link in the chain of evolution of nidifugous habits. The free finger tips and arrested development of the outer quill-feathers point to a prior arboreal habit, whilst the accelerated development of the inner quill-feathers indicates an adaptation to enable the young to escape from enemies surrounding a terrestrial nursery.

He believes that systematists attach too much importance to the diverse conditions presented by the young of different groups of birds at birth and that the significance of these conditions has been misunderstood. The real explanation seems to turn to expediency, designed to reduce infant mortality: (1) by depositing the egg upon the ground, or (2) curtailing the activity of the young. "One great disadvantage attendant on precocious development of the young whose nursery is in the tree tops is obvious—the nestling would be constantly in danger of falling to the ground, and a large number would indeed

meet with this fate . . . those species which, while retaining their arboreal nesting habits, have adopted the method of curtailing the activity of the young. This process was accomplished by reducing the food-yolk within the egg, and thus inducing an earlier hatching period. We may approximately measure the extent to which this reduction has been carried by the degree of helplessness displayed by the newly hatched bird, and by the nature and extent of its clothing. . . . The amount of food-yolk once reduced, a return to the older fashion of active young was impossible, and this explains why young of many species hatched upon the ground are as helpless as those reared in the topmost boughs of the highest trees."

Young reptiles are always active at birth, and there is little doubt that the nidifugous or precocious bird is the most primitive type. It is reasonable to suppose that the *Archæopteryx* (a possible progenitor of the Passeres) was nidifugous, but it cannot be known positively that it was arboreal as a breeder; in fact its beak seems poorly adapted for nest-building, (few, if any of our Passerines employ the feet to any extent in that capacity) and there are well known instances of arboricole species of North America (the Yellow-bellied Flycatcher, Black and White Warbler and Hermit Thrush, for instance) descending to the ground to nest.

With accurate knowledge of the condition and early life history of only a limited number of North American birds, it is perhaps somewhat presumptuous to offer serious objection to the Pycroft theories, but my investigations, however superficial and touching only a small angle of the subject, would seem to show here and there an invalid premise or an erroneous conclusion.

Confirmatory evidence of the theory that birds were originally arboreal, would seem to be lacking in the behavior of our birds. In the more than occasional deposition of the eggs of individuals of species normally ground-nesters (the Herring Gull, some Ducks and Geese) in nests high up in trees, and the habitual arboreal nesting of some species of typical terrestrial-nesting groups of nidi-

fugous birds (the Noddy, Wood Duck and Solitary Sandpiper) the inference might be that these species were returning to a former habit, but it seems more reasonable to think that they are governed by a stronger impulse, that of the perpetuation of race in the face of persecution. Many species of the Nidifugæ have been known to feed their young directly, and some species of the Gulls, Ducks and shore birds are capable of carrying or conducting their young safely to the ground. That it is not impossible for nidifugous young to move about freely in an arboreal nursery, is shown by Dr. Beebe in his recent study of the Hoactzin, in which he pictures the downy young climbing about somewhat in the manner of a quadruped. We have little ground for the belief that the elevated nesting habit is more fatal to nidifugous birds than ground-nesting; in fact the death rate of the few arboreal Nidifugæ would appear not conspicuously different from the latter.

On the other hand, brooding birds of species of more or less typical arboreal habits, when directly from their nests, will sometimes flush to the ground to feign a crippled condition, and in so doing would seem to indicate a former ground-nesting habit. There are a few ground-nesting species in many groups of arboreal nesters, and there are more or less instances where members of various arboreal species of remote relationship easily form or resume a ground-nesting habit (the Mourning Dove, Osprey, Long-eared Owl, many species of Sparrows, Brown Thrasher, Robin, and possibly the Flicker) especially where conditions are favorable and molestation at a minimum. Isolated colonies of some of our Egrets and Herons have apparently been ground-nesters for ages, while other colonies of the same species nest high in trees. Some groups as remote as the Sparrows and the Cormorants, Pelicans and Man-o-war, nest indifferently in bushes or on the ground.

On the whole, a careful study of the nesting habits of many species of North American birds, would seem at least to indicate a much more general ground-nesting habit at some former period and that a number of species later

sought an elevated situation to avoid molestation. In the *Alcina*, perhaps several species are in an active state of evolution from typical Nidifugæ to a condition of nidicolous habits. The great bulk of the Atlantic, California and Brunnich's Murres, and the Razor-billed Auk, first see light on narrow ledges far above the sea in almost inaccessible cliffs, positions doubtless chosen ages past by the species to avoid molestation; the result is the enforced helplessness of the young for a period of from 25 to 35 or 40 days, until half grown; though normally possessed of considerable strength and activity when only a few days old. Macgillivray gives instances of the extraordinary hardihood of some very small, unfledged young of the Murre, which were observed swimming about in the vicinity of the rocks; chicks that must have had comparatively easy access to the water.

There are no data from which to build a table of comparative values of the yolk in birds' eggs, but my study of the incubation periods of many North American birds, convinces me that the eggs of the Nidicolæ do not always show a relatively earlier hatching period in comparison to the Nidifugæ. Eggs of some species vary enormously in size. I have the shells of some eggs laid by a small domestic hen, averaging 2.92×2.26 in inches, comparable to the measurements of the eggs of some of the Megapodes. Some typical Nidifugæ lay eggs of normal size and it is probable that the yolk is proportionally as small as many of the Nidicolæ. It is possible that the egg of the Hummingbird contains yolk comparable in bulk proportional to that of the Murre (both species laying eggs of very large size in comparison to the bodies of the parents) yet there are none more naked and helpless than the newly hatched young of the former, while the nidifugous young of the latter would buffet the sea in a few days were they not literally shelved.

Is a return to nidifugous habits impossible? Who can say in the instance of the Nighthawk and Whip-poor-will, whose young are enabled to abandon the nesting site on the ground within a few hours after birth, whether they are not approaching typical nidifugous habits in the early use

of their feet in conjunction with almost immediate eyesight and the early development of the nervous system?

There can be no doubt that nidicolous habits are not only beneficial in many instances to an arboreal or insular existence, but that they are in time inevitable to that mode of life. However, it is not a special adaptation to a gregarious habit, since so many birds of nidifugous habits also nest in colonies.

It seems to me that a more logical conclusion to the nidicolous habits of so many terrestrial nesters would be attributable to a primitive habit of breeding on islets or cliffs, or in caves, crevices or burrows; insular or elevated situations of any kind chosen primarily for seclusion and found advantageous for the enforced confinement of the young until they became more robust to withstand the elements and avoid their enemies; in countless succeeding generations the temporary disuse of limbs and slower development of some of the sense organs would result in one thing, just as we now observe the beginning of the same phenomena in the enforced sedentary life of the young Murres and Auks. The individual or species unable or unwilling to carry food to their young, would have to conduct them to the feeding ground, seek a more accessible situation for their nests where the precocious young could feed and exercise, or perish. Therefore nearly all sea birds nesting exclusively on small islands are nidicolous. The exceptions include the Murrelets, possibly some of the Longipennes, and the Flamingoes; probably because of the situation of their nests in reference to accessibility to the sea or to a comparatively recent resort to insular breeding. On the other hand, we have documentary proof of the typically nidicolous Gannet nesting upon a rocky islet for upward of six or seven hundred years (*Cf. Gurney, The Gannet, p. 44*) and doubtless it has so nested for untold ages, since it has never been known to nest on the mainland.

Notwithstanding the diagnosis of the Nidicolæ and Nidifugæ by Dr. Newton and Dr. Gadow, the line of demarcation in some instances is exceedingly faint and re-

duced, at least as far as the tyro is concerned, to a question of the sealed or open eye-lids of the young immediately after it has hatched, and even this may prove unreliable in a few instances. It is well known that in most, if not all Nidifugæ, the eyelids separate shortly before the bird is hatched and are wide open almost immediately after birth. Mr. A. B. Howell informs me that according to his observations all sea birds, except the precocial ones, are hatched with their eyes closed, but that they open within a day or so; just how long he is unable to state.

The *Phaethontidæ*, *Fregatidæ*, *Ardeidæ* (at least the smaller species: Least Bittern and Green Heron); *Cathartidæ*, some of the smaller *Buteonidæ* (Marsh, Cooper's, Sharp-shinned and Broad-winged Hawks), Duck Hawk and Goatsucker, open their eyes wide within a day or two after birth. With most nidicolous birds, however, several days elapse between the separation of the eyelids and when they become wide open. In several instances, on the fourth or fifth day after birth, the eyes of the Mourning Dove, Cuckoo, Horned Lark, Brewer's Blackbird, Hooded Oriole, most Finches and Sparrows, Cedar Waxing, some Vireos, Wood Warblers, Mockers, Wrens, Hermit Thrush and Bluebird, are wide open. On the sixth or seventh day: Audubon's Caracara, some Hummingbirds, Pewee, Blue Jay, Red-eyed Vireo, Chickadee and Robin; eighth day, the Gannet, Belted Kingfisher and Crow; ninth day, the Purple Martin; tenth day, the Flicker; twelfth day, the Great Horned Owl and the fourteenth day the Chimney Swift.

Newton affirms that the young of nidicolous birds nesting on or near the ground in exposed situations, remain in the nest a relatively shorter time than those found nesting in less accessible situations. This in general seems to apply to our North American birds as far as known and would seem to infer only an earlier development of the sense of fear and of bipedal locomotion; for though the ground nestling may leave the nest at a relatively earlier age, precocity apparently does not extend to the wings or to the ability to care for itself exceptionally early. With some exceptions, fear develops almost immediately

after birth in our nidifugous young. Professor Herrick has intimated that the instinct of fear appears with comparative suddenness upon certain maturity of the nervous system, and while often premature, it is usually timed to correspond with a sufficiently advanced physical development to enable a retreat from threatened danger. It would seem impossible to discover the precise time of the acquisition of fear by the nestling, through the bungling methods, or rather lack of method, of the parent; for fear may be present and remain latent for hours or days before an abrupt movement of the observer or the extreme nervousness of the parent lead to its discovery with startling suddenness, and I believe it is always preceded by the acquisition of sight.

Instinctive fear has been shown on the fourth to the fifth day by some of the Cuckoos and Sparrows; on the fifth to the sixth day by the Least Bittern, Mockingbird and Wren-tit; seventh to eighth day: Green Heron, Long-eared Owl, some of the Vireos, Wood Warblers and Brown Thrashers; tenth day: Mourning and Ground Doves, Red-shouldered Hawk, Cowbird, Catbird, Chickadee, Wood, Hermit and Olive-backed Thrushes and Robin; eleventh day: Cedar Waxwing and Blue Jay; twelfth day: Marsh Hawk and Crested Flycatcher; fourteenth day: Turkey Vulture, some of the Hummingbirds, Bluebird; sixteenth day: Sharp-shinned Hawk; twentieth day: Crow; twenty-first day: Anhinga, California Vulture, Duck Hawk and Magpie; twenty-fifth day: Golden Eagle and Belted Kingfisher; twenty-eighth day: Broad-winged Hawk. The Yellow-billed Tropic-Bird, according to the experience of Mr. Gross, never showed fear at any time.

The production of more than one brood in a season is rather rare among the Nidifugæ, the Grebes, some of the Murrelets and Ducks, the Bob-whites and Scaled P'artidges, being among the few occasionally reproducing the second brood. With the Nidicolæ two or more families a season are much less uncommon, though perhaps not so regular as generally supposed; including, as far as known, some of our most abundant and widely distributed species;

among the *Oscines*, only those having an extended and continuous song period; and apparently only in the southern part of the breeding range of the Cuckoos and exceptional colonial species (the northern Cuckoo seldom produces a second brood though it often makes an attempt). The most productive species in point of families include the Tufted Puffin, Cassin's Auklet, Mourning and Ground Doves, Yellow-billed and Black-billed Cuckoos, Pewee, Say's and Black Phoebe, Horned Lark, English, Vesper, Chipping, Field, Song and Grasshopper Sparrow, Slate-colored Junco, Cardinal, Indigo Bunting, Mockingbird, Catbird, Brown Thrasher, House and Carolina Wrens, Robin and Bluebird. Apparently it does not occur to any extent among the lower orders, or the Birds of Prey, Woodpeckers, Kingfishers, Swifts or Hummingbirds, nor regularly in the *Passeres* among the Crows, Jays, Starlings, Grackles, Blackbirds, Orioles, Tanagers, Waxwings, Vireos, Warblers, Wagtails, Creepers, Nuthatches, Titmice or Kinglets.

That some species are more productive than others in the number of broods in a season, is of course due primarily to the prolonged duration of sexual instinct, or in other words, to a continuance of the peculiar physiological condition incident to reproduction, perhaps often repressed in the individual in the united movements of the colonial species, or more often lost for the season by the less dominant species through lessened vitality after a long period of waiting upon the young. The Land Birds included in the above list are birds with the requisite vitality and versatility to adapt themselves to environmental changes incident to civilization, and are among the most dominant species. They are all prompt, hardy nesters, therefore resident or only absent during the colder months, with the possible exception of the Indigo Bunting; all are more or less independent, especially for the earlier nesting site, of a camouflage of deciduous vegetation. For example, the Phoebe with no other advantage over other inornate-nesting Flycatchers, is enabled to produce two or more broods by beginning much earlier than other members of its family, and relining its nest for subsequent broods.

All multiple-brooded species have access to an abundant and unfailling food supply suitable for the young, or are adaptive to a varied and easily obtainable and seasonable diet. Most all feed upon seeds, insects or fruit as occasion requires and are consequently unaffected during seasonal scarcity of any one food. They are all builders of nests of simple construction. I know of no species in the northern part of the United States building an elaborate nest or tunneling in earth or wood for each clutch, regularly producing more than a single brood. They all have the effective assistance of the male, especially in taking charge of the offspring out of the first nest until they can shift for themselves. Finally, they have a brief nesting cycle. It is improbable that a nidicolous species incapable of confining the total period of nest building, deposition, incubation and nestling life to very much over six weeks, can regularly produce more than a single brood in Northern United States, also the nesting season must be brief or the parents will not be in a physiological condition to repeat.

Mr. Alfred C. Redfield carefully measured the work of a Belted Kingfisher nesting in a quarry at Radnor, Pa., April 2-18, 1908, and identified the sex of the excavator once as the female and once as the male.

Here are his notes:

1st day, hole just started
3rd day, about 8 inches deep.
5th day, about 15 inches deep.
6th day, 18 inches deep.
7th day, 23 inches deep.
8th day, 27 inches deep.
9th day, 36 inches deep.
10th day, 44 inches deep.
11th day, 47½ inches deep.
12th day, 51 inches deep.
13th day, 57½ inches deep.
14th day, 59 inches deep.
15th day, 59 inches deep.
16th day, 59 inches deep.

While there was no increase in depth on the last three

days, an accumulation of dirt made it certain that the birds had been working, probably in enlarging the end of the hole for the nest. With a nesting cycle of from two and one-half to three months, this species can hardly be other than single brooded.

Again to show the fine detailed work of some of our observers, I have assembled a table exhibiting day by day the increase in weight (in grams) of some nestlings taken in 1906 by the late John F. Ferry, Lake Forest, Ill. The Cedar Waxwing study (Aug. 20-28) is incomplete, but the development and length of nestling life of the Cowbird (June 11-22), Yellow Warbler (June 21-July 2) and Wood Thrush (June 11-22), exhibit a relatively slower growth, considering size, than the Catbird (June 13-24) and the Brown Thrasher (July 8-19).

	1st Day	2nd Day	3rd Day	4th Day	5th Day	6th Day	7th Day	8th Day	9th Day	10th Day	11th Day	12th Day
Cowbird				7.7	23.3		24.9		31.1	28.0		**
Cedar Waxwing	2.2	3.0	4.5	8.0	7.7				*			
	3.0	4.0	6.5	13.5	12.5	15.5	13.0		*			
	4.0	5.4	8.0	17.0	15.0	20.0			*			
	3.1	4.9	8.0	17.0	15.5	19.0	16.0		*			
Yellow Warbler				7.8	8.0	8.3	8.5					**
				6.2	7.2	8.3	7.3	7.7	9.4			**
Catbird		4.6			18.6	23.3	23.3	29.5	31.1	31.1	**	**
av. 3 young	3.1	6.2	15.5	15.5	15.5	22.0	25.2	27.2	28.5	**		
Brown Thrasher	6.0	7.5	9.0	12.0	17.5	21.2	25.5	40.5	51.5	47.5	49.5	**
	8.2	9.5	13.0	17.0	23.5	28.2	35.0	38.0	45.0	39.0	42.5	**
	6.5	8.5	11.0	15.5	22.0	27.5	34.0					**
Wood Thrush	3.1											
			6.2	18.6			24.9		37.3	34.2		**

* Found dead.

** Departed.

[TO BE CONTINUED]