OBSERVATIONS ON THE BREEDING BIOLOGY AND BEHAVIOR OF A NESTING POPULATION OF BELTED KINGFISHERS

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INTRODUCTION

A preliminary investigation of the Belted Kingfisher (*Megaceryle alcyon*) was initiated by Becker (MS) as part of the program of biological investigations carried on at the Lake Itasca Forestry and Biological Station of The University of Minnesota. Becker's original study was expanded by me, and field work was done from June through August, 1958, in an attempt to clarify the role of the Belted Kingfisher in the ecologic community at Itasca. The objectives of the field study of 1958 were: (1) to devise methods of trapping and marking the Itasca population of kingfishers; (2) to estimate the breeding population in Itasca Park; (3) to determine the daily range of nesting kingfishers; and (4) to obtain additional life history data.

The Lake Itasca Forestry and Biological Station is located on the eastern shore of Lake Itasca in Itasca State Park, Minnesota. The 50 square miles of Itasca Park contain northern conifer-hardwood forest, central hardwood forest, and prairie. Lakes, bogs, and ecotones are abundant. The study area consisted of 25 square miles in the eastern half of the park.

Intensive studies on the feeding habits of the Belted Kingfisher have been carried on in the maritime provinces of Canada (White, 1953) and in Michigan (Sayler and Lagler, 1949). Interesting accounts of this bird's habits and life history may be found in Barrows (1912), Bent (1940), Forbush (1927), and Roberts (1932). A review of the literature, however, reveals little information about the daily range of nesting kingfishers, their fishing territories, and their population dynamics. Furthermore, earlier studies on the Belted Kingfisher have dealt with the bird as a streamside occupant, whereas at Itasca it utilizes a lake shore habitat.

METHODS

The Belted Kingfisher usually selects a steep bank of bare ground for a nesting site. Since banks of this type seldom occur naturally in Itasca Park, it was not surprising that road cuts should serve as alternative nesting sites. Patrols were made of all roadways within or near the park, and shore-line patrols by boat and canoe were made of all large lakes in the area. Census routes were first run in mid-June and active nests were observed frequently thereafter.

Previous attempts at capturing Belted Kingfishers (White, 1953) involved trapping, shooting, nest destruction, and other methods equally disturbing to resident populations. I sought capturing techniques that would leave the bird unharmed and undisturbed so that it would remain in residence. Kingfishers were most vulnerable when entering and leaving the nest cavity, and several trapping methods proved to be effective. Nylon mist netting (2-inch mesh) was successfully employed as follows:

(1) A one hundred-foot length of netting was suspended from aluminum poles, 12 feet ¾ inch high. The set was made in the observed flight path of the approaching birds at a distance from the bank corresponding to that point where the kingfisher dipped for its "landing." Such a set varied with the individual nest and bird but was consistent for any one location.

(2) A more effective technique was developed for use when the bird was known to be in the nest cavity. Folds of netting were suspended over the entrance to the nest cavity in the form of a box with the inner edges pegged to the bank with clothespins. Females leaving the nest in the poor light of early morning were the most susceptible to capture by this arrangement.

(3) When young kingfishers depart from the nest, they move to a favored fishing site and there learn the techniques of food gathering. The entire family may be trapped in such a situation by a length of netting suspended on poles and angled out from shore about two feet above the surface of the water.

Each bird captured was marked so as to reveal age and nest site when the bird was observed on the wing. The breast and belly feathers of adults were tinted a brilliant orange. The underparts of juveniles were treated with methylene blue. Both dyes were in 70 per cent alcohol and remained visible for the five weeks during which observations were made. Birds from different nest sites were marked by painting the three outer primaries of both wings with various key colors of airplane "dope." These markings apparently did not handicap flight when applied with care, and they remained visible throughout the study. One disadvantage of airplane "dope" was the need to keep the painted primaries separated until they were dry.

LOCATION AND CONSTRUCTION OF NEST SITES

Belted Kingfishers nest almost exclusively in man-made cut-banks in Itasca Park. These cut-banks are usually formed by road projects or gravel pits. Of nine nests studied, only one was in what could be termed a natural site. Man-made banks may well be more a matter of necessity than choice for the kingfisher. The lakes of Itasca Park are characterized by low shorelines and/or densely vegetated embankments. The streams have not cut through high ground in forming a watercourse. Consequently, few favorable nesting sites of a natural type occur in the area studied.

Whenever possible, nests of Belted Kingfishers are constructed at least five feet above the ground level. Generally, the height of the embankment determines the elevation of the nest entrance. The birds start excavating 12 to 18 inches from the top of the embankment, near the bottom of the organic soil layer. One exception was a nest in a 15-foot sandbank. No soil horizon was evident, and nest construction was begun five feet below the upper rim of the embankment. Where a burrow was too low, or the soil was too rocky, the kingfisher would abandon a partly dug hole and begin anew elsewhere. Two such cases were observed along a roadway in the study area.

Sandy clay soil appeared to be the most suitable for nest sites. Probe holes in the vicinity of one nest showed where a kingfisher had tested the soil, perhaps to determine whether conditions were favorable for digging. Generally, the embankments used were either free, or nearly free, of vegetation. All but one of the nest sites had, within one hundred feet, a dead or dying tree for use as a perch site overlooking the nest. The exceptional nest was located in a county gravel pit where a telephone wire served as a perch site. Two nests were located directly over water, three were within five hundred feet of a lake, and four varied from 0.3 to 1.0 mile from a water source. Apparently, nearby water is not a critical factor in determining nesting sites.

I completely excavated, measured, and studied an abandoned nest cavity. The entrance was two and three-fourths inches in diameter and was 19 inches below the top of the embankment. It opened into a tunnel which extended into the bank for three feet. The tunnel slanted three inches downward from the horizontal and narrowed to two inches in diameter at a depth of three feet, where a twenty-degree bend to the right was evident. The tunnel extended another foot from the bend to where it terminated at the nest chamber. The nest chamber was six inches lower than the entrance to the nest site and was circular, having a diameter of eight inches. Undigested fish parts, the remains of disgorged pellets, lined the floor of the nest to a depth of one-half inch. Symetrically arranged on this debris lay seven eggs. Six of them, with their narrow ends pointing inward, formed a circle about the seventh.

POPULATION AND RANGE

Fourteen breeding pairs of Belted Kingfishers nested within the 25-square-mile census area, a density of one breeding pair per 1.8 square miles. The number of young produced and successfully fledged was not determined because nesting was still in progress when the field work was terminated.

White (1953) estimated the kingfisher population in the stream valleys of the maritime provinces to be ten birds, counting both adults and juveniles, per square mile of stream. His estimate exceeds that made at Lake Itasca, but there is no basis for a direct comparison of kingfisher populations from such diverse habitats. It would seem, from field observations, that the Itasca area could sustain a population greater than one pair of adult kingfishers per 1.8 square miles. Certainly, more nesting sites were available than were used. I believe that lack of fishing sites with fish populations adequate to support a kingfisher nesting effort may be the factor limiting the nesting population. Investigation of fish populations was not a part of this study.

The daily range of nesting adults was determined by observing the flight directions of marked birds and the distances they flew to the nearest body of water. Movements of kingfishers were plotted until their fishing sites were located.

Belted Kingfishers in Itasca Park were found to range from 0.5 to 5 miles from the nest site. Even when nesting over water, birds ranged away from the nest when in search of food. While fishing sites were most often within one mile of the nest, a daily flight of two miles was not uncommon. On one occasion, a male kingfisher was observed in a lakeshore snag five miles from the nest. Later in the day he was 0.5 miles from the nest at the fishing place most often visited.

FOOD AND FEEDING HABITS

The Belted Kingfisher's adeptness at catching fish is reflected in the stomach contents of 428 individuals captured on trout-rearing waters and studied by Sayler and Lagler (1949). These workers found that fish comprised 88.4 per cent of the total volume of food. Crayfish, insects, other invertebrates, and amphibians contributed a small share to the total food intake. Kingfishers taken from habitats other than trout-rearing waters consumed a lesser amount of fish, but in all cases fish comprised more than 50 per cent of the total stomach contents. Neither Skutch (1957) nor Moreau (1944) observed any food other than fish being fed the young of Amazon Kingfishers (*Chloroceryle amazona*) and Half-collared Kingfishers (*Alcedo semitorquata*), respectively. Fish were the only items of food taken by Belted Kingfishers under my observation in the Lake Itasca study area.

White (1937) made use of regurgitated pellets in his study of kingfisher food habits. Such pellets may be found at the base of trees used as perches in the vicinity of the nest (White, 1953). Unfortunately, no pellets were found during my study at Itasca. However, adults carrying fish to the young often dropped their cargo when caught in the mist net or sometimes they did so when merely striking the net. Thirteen small fish were secured in this manner and measured. This is the only sample known to me of fish taken for consumption by nestlings. Sayler and Lagler (1949) measured 729 fish found in stomachs of adult Belted Kingfishers and found a mean fish length of 72.4 mm. The mean length of fish in my sample (table 1) was 92.3 mm., suggesting a selectivity in favor of larger fish when young are being fed. Skutch (1957) observed that the fish brought to young Amazon Kingfishers increased in size as the young grew. Such an adaptation would necessitate fewer trips from fishing site to nest. To test this theory, the fish population available to parent kingfishers must be studied in its relation to the size and species of fish fed the young.

TABLE 1

FOOD FISHES TAKEN FROM TRAPPED BELTED KINGFISHERS

Species	Length (mm.)
Yellow perch (*Perca flavescens*)	115
	130
Common shiner (*Notropis cornutus*)	90
	90
	100
	50
	60
Short-nosed dace (*Rhinichthys atratulus*)	100
	90
	80
Horny-head chub (*Hybopsis biguttata*)	85
Mud minnow (*Umbra limi*)	110
	100

Adult Belted Kingfishers were noted as being active from 4:00 a.m., when a male arrived at the nest with a fish for the young, to 11:00 p.m. Bendire (*in* Bent, 1940:121) claims the kingfisher is nocturnal: "they are certainly fully as active throughout the night as in the daytime." During the present study, activity of kingfishers declined at dusk and ceased entirely for a minimum of five hours. Only one adult, usually the female, spends the night in the nest cavity. The male, according to Bendire (*ibid.*), roosts in nearby heavy cover. At three nest sites in my study area, the male kingfishers appeared to roost at night in nearby dense northern hardwood-conifer forest stands. I was unable to locate specific roost trees in the forest, but the males were often observed entering the forest in the deep dusk of late evening and leaving in the early morning. In the nests of the Amazon Kingfisher observed by Skutch (1957), the female incubated the eggs every night while the male roosted at an undetected site.

Morning was the period of greatest activity in feeding the young. Records for one nest show that the male on one occasion carried a fish to the young, stayed less than half a minute, and flew off to the Mississippi River, 0.7 miles distant. He was back 2.5 minutes later with another fish. This particular male made seven trips in two hours with fish for the young. White (1953) quotes Yeager as observing 16 fish being fed to six nestlings in one day.

During hot, sunny afternoons, the nests are usually not visited by the adults until feeding again commences about 4:00 p.m. However, on a cool, cloudy day, feeding took place throughout the day.

PREDATION, MORTALITY, AND DESERTION

Observed mortality from predation was slight among the kingfishers at Lake Itasca. Three juveniles were taken at one nest site by a Cooper Hawk (*Accipiter cooperii*). Another juvenile from a different nest site fell prey to a female Marsh Hawk (*Circus cyaneus*). The only adult mortality noted was that of a female killed by an automobile near her nest site in a roadside cut. An unsuccessful attempt to reach a clutch of eggs was made by a skunk. Predation does not appear to be a serious factor in the kingfisher population except at that critical period when the young-of-the-year leave the protection of the nest cavity. Both avian and terrestrial predators find the juvenal kingfishers susceptible prey at this time.

Nest desertion seemed to be a more important factor in the Lake Itasca area. King-

fishers responded unfavorably to any disturbance around the nest site. Desertions of nests in the study area were common. Six of the eight nests observed were deserted during the course of the study. Two of the desertions were attributed to disturbances resulting from trapping and marking. Children with air rifles and trucks loading gravel caused the desertion of a third nest. Another nest was abandoned because it was near a boat house and was subjected to constant disturbance. Unknown factors led to the desertion of the additional two nests.

BEHAVIOR

Several unusual behavioral mechanisms were noted in the course of the study. In the early morning trapping operations, adult Belted Kingfishers would often fly into the mist net with a fish to feed the young. Frequently the bird would not become entangled and if the fish was jarred from the bill upon impact, the kingfisher would immediately fly off to the fishing site and return with another fish. But if the fish was retained in the bill after impact with the net, the bird would make repeated efforts to fly into the nest cavity, even when apparently aware of the net obstruction. Moreau (1944) reports that only once in 440 observations was a parent seen leaving the nest entrance with a fish still in its bill. Perhaps the adult has to give up the fish before it is released from the drive to feed the young, even in the face of danger.

Two juvenal kingfishers, one male and one female, were taken from a deserted nest. In the laboratory, these birds displayed an unusual mode of backward locomotion resembling that of a mechanical toy soldier. A clicking sound was made on the table top by the callused tarsi. These calluses are present at hatching (Skutch, 1957) and probably protect the nestlings when moving back and forth frequently within the burrow. The backward shuffle could be initiated by any frontal threatening action, such as rapping on the table with a pencil. When pressure was applied to the rectrices of the backing bird, the movement ceased. Recalling the nature of the kingfisher's nest cavity, pressure on the tail feathers would seem to be an ideal stimulus for a cessation of the escape action.

The same two juvenal birds, during the time they were hand-reared, were housed in a darkened cardboard carton. Often, a sharp rapping could be heard on the carton wall. It was found that the birds rapped with their bills on the carton wall above the two corners being used as latrines. This may have been an attempt to knock "dirt" onto the excrement, thus keeping the "nest" sanitary. The hygienic value of such behavior in an eight-inch earthen chamber containing six or seven young kingfishers for several weeks cannot be discounted. Skutch (1957:225) states that "kingfishers . . . take no measures for the sanitation of their burrows." He comments, however, on the neatness and cleanliness of the young, saying that "they rise superior to their environment." He observed that one nest chamber had been enlarged and the earth dug or worn from the walls covered some of the filth. I opened two chambers containing young, and the strong odor of ammonia suggested decomposing nitrogenous wastes. Yet the nestlings and the chamber were surprisingly clean, although the litter of fish bones and scales gave the appearance of filth. Adult kingfishers probably take no sanitation measures, but I believe the nestlings do dig earth from the walls of the chamber as they apparently attempted to do in the carton.

ACKNOWLEDGMENTS

A stipend from the National Science Foundation and the Louis W. and Maud Hill Family Foundation made this study possible. I am indebted to Dr. William Marshall, Director, Lake Itasca Forestry and Biological Station of the University of Minnesota; to Dr. John Emlen and Mr. Alfred E. Eynon, both of the Department of Zoology, the

University of Wisconsin, for their technical assistance and guidance; and to Dr. George Hunt of the Department of Wildlife Managment, The University of Michigan, for his critical reading of the manuscript.

SUMMARY

Itasca State Park, Minnesota, offers a lake habitat favorable to nesting Belted Kingfishers (*Megaceryle alcyon*). A study of the Belted Kingfisher in this habitat is of significance, since other efforts have been restricted to streamside environments. Thirteen Belted Kingfishers were trapped and marked to facilitate field observations of territory, range, and fishing sites. An early summer adult population of Belted Kingfishers of one breeding pair per 1.8 square miles was determined by road and shoreline censuses. A daily range of 0.5 to 5.0 miles from the nest site for individual birds was recorded.

Nest cavities were usually about five feet above ground level in bare, man-made cut-banks along roads or in gravel pits. Sandy clay soil was most suitable for nest sites. Nearly all nest sites were near a dead or dying tree which could be used as a perch site. Two nests were located over water, three were 500 feet from the lake, and four were from 0.3 to 1.0 mile from water.

Adult kingfishers were active from 4:00 a.m. to 11:00 p.m.

Mortality from predation was slight among adult kingfishers in the study area. Juvenal kingfishers were susceptible prey when leaving the nest cavity. Three were taken by a Cooper Hawk and another was taken by a Marsh Hawk.

Belted Kingfishers are apt to desert the nest when disturbed. Six of eight nests in the study area were deserted in the course of the study. Two of the desertions were a result of trapping and marking of the birds. Other desertions were caused by children with air rifles and trucks loading gravel.

Captured juvenal kingfishers displayed a backward type of locomotion in the laboratory. Attempts by these same juveniles to keep a cardboard carton "nest" sanitary were noted.

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