BULLETIN NO. 97

The Eastern Belted Kingfisher in the Maritime Provinces

BY

H. C. WHITE

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CONTENTS

INTRODUCTION

THIS STUDY of the life history and food of the kingfisher (*Megaceryle alcyon alcyon* L.) in the "Maritimes", i.e. the provinces of New Brunswick, Nova Scotia and Prince Edward Island, is part of a general study of the relation of fish-eating birds to the production of salmon and trout and is based on observations and material collected over a period of many years.

We have received help from many of our co-workers and others and we wish to express special gratitude to A. W. H. Needler, C. J. Kerswill and D. G. Wilder of the Fisheries Research Board who have assisted in the progress of the work and preparation of the manuscript. Forrest Watson of the Department of Fisheries aided in the collection of material in the vicinity of Kentville in Nova Scotia. In 1935 Miss Edith Huntsman assisted in the rearing of young kingfishers. Throughout most of the work my wife, Ella, has given invaluable assistance in the collection of material and the hand-rearing of young birds.

The Maritimes jut out into the Atlantic Ocean and have a coastline of more than 3,000 miles (Figure 1). The streams are closely related to the sea, and thus anadromous fishes, as well as the catadromous eel, are an important part of the fauna of most of the fresh waters.

The geological formations of the Maritimes are largely neo-Permian, Carboniferous, Devonian and pre-Cambrian, and the fertility and faunae of the streams and lakes are associated with their location in one or more of these formations. Ecologically the area is Canadian, but there are small areas which are Transitional in character. These include an area more than 100 miles in length along the lower part of the Saint John River, the western part of the south coast of Nova Scotia and the valley of the Annapolis River.

The fish species in most of the waters are probably those of the invasions into the newly forming watersheds after the Ice Age, although a few intentional or accidental introductions have recently been made (Table I). The richest watershed, in number of species, is that of the large Saint John River which has tributaries reaching deeper into the continent than the other streams. In general, the number of species of fishes and other truly aquatic organisms is greater in the streams of the interior than in those of the Maritimes, where some streams are devoid of all fishes except those which were able to reach them by passing through sea water. This applies to all the streams of Prince Edward Island and streams in some areas around the Bay of Fundy. We have found only one species of crayfish, (*Cambarus bartoni* Fabr.), in parts of three large adjacent watersheds, the Saint John, the Restigouche and the Miramichi, but we have failed to find it in the lower tidal tributaries of these or in any of the smaller nearby coastal streams.

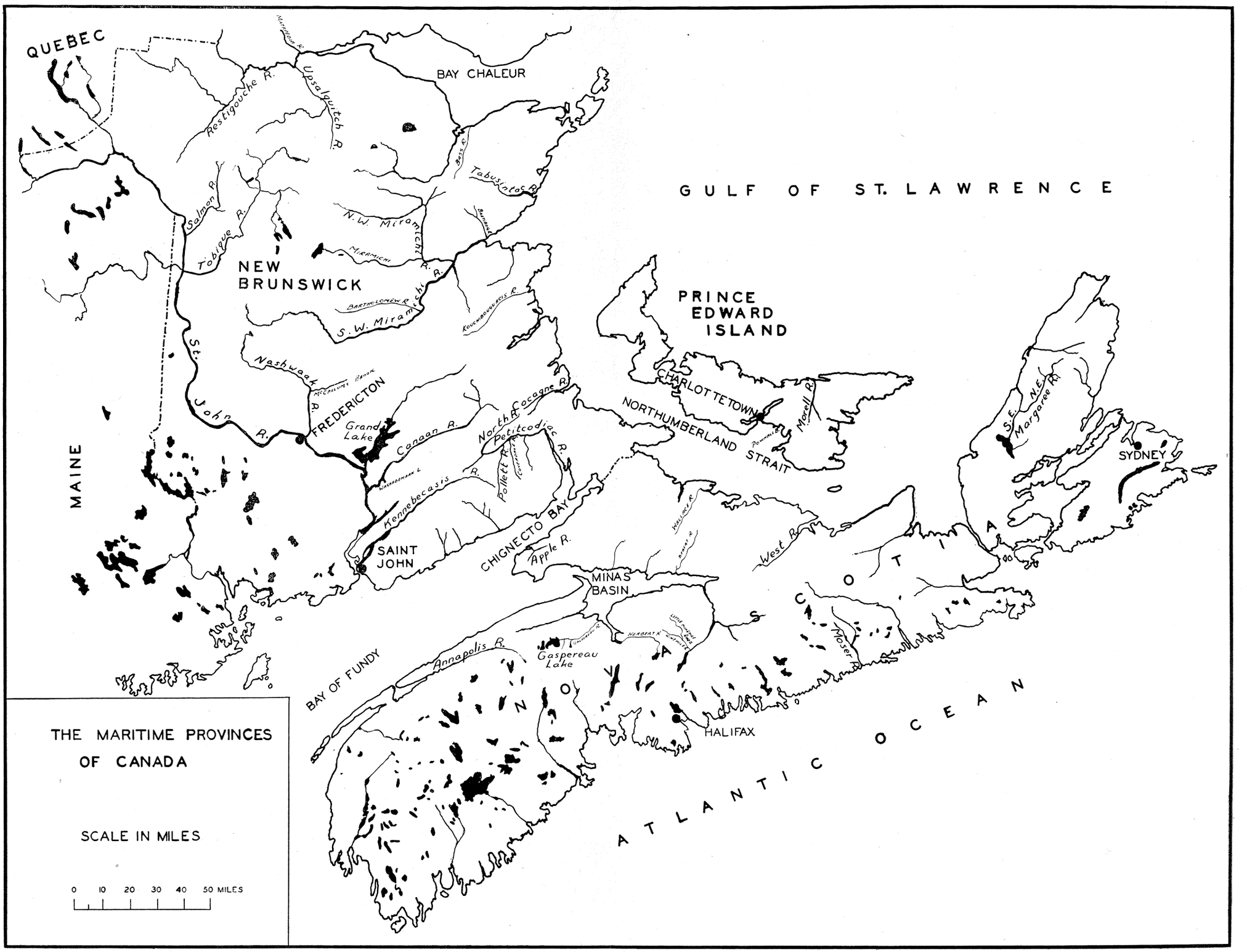

FIGURE 1. The Maritime Provinces of Canada, showing streams and lakes mentioned in the text.

birds would sit most of the time among the leaves of alders or other stream-side bushes and call when hungry, and it was necessary to go to the young to feed them. If a bird were perched too high to be reached it could be coaxed down by showing it a fish. At such times it would utter a plaintive little chatter. By the third day they would respond to the call by flying along the stream to get the food and would plunge and get dead or wounded fish which were thrown into the water beneath low perches.

That the instinct to catch fish is present early in the young was shown by the behaviour of these hand-reared birds. For some days before they were able to fly they would become very interested in minnows swimming in a pan of water and when a young bird was placed on a perch above the pan it would make a rather ludicrous attempt to dive for the minnows. By the fourth or fifth day they were attempting to catch fish by diving from low perches and by the

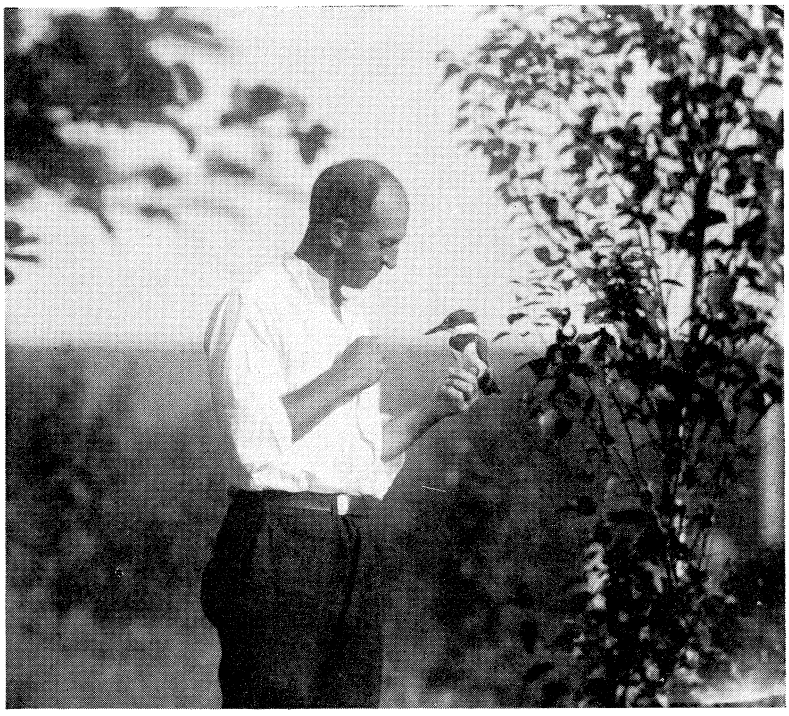

FIGURE 2. The author with tame kingfisher called from river to get fish concealed in right hand.

seventh or eighth day would be catching some small fishes. At this time the birds would come to the house or tent when called, and for the first two weeks seemed to be always within calling distance. Throughout the summer and early fall the birds would usually answer when called, come and alight on an outstretched hand (Figure 2) or nearby perch. All our birds were nervous when strangers were near and were suspicious even of us when we wore clothes with which

they were not familiar. At dusk they would disappear and would not answer our call but at the break of day they would start calling. We never discovered their night roosts.

Recaptures of wild banded nestlings indicate a dispersal of the young birds within a month after taking flight, but our tame birds remained near their "home" area until early in September. One bird which we raised at Prince Edward Island disappeared on September 14, but on the 29th we heard kingfishers overhead and looking up we saw three kingfishers circling at a height of several hundred feet. We gave the call to which our bird had been accustomed and instantly one bird made an almost vertical drop with partly closed wings and alighted on a nearby stream-side perch. It chattered in response to our talk but soon flew down the stream. We believe that the circling was a pre-migrational flight for it was the last time that we saw this bird.

LIFE HISTORY

In our studies of life histories we take as our premise that, when within their power, organisms tend to behave in a manner which will favour the survival of the species. From this point of view in this study we have attempted to rationalize not only our own observations but also some of those reported by others.

Migration, Flights and Dispersal

In the spring of the year the first kingfisher may reach the Maritimes during the first week in April, but the main migration occurs during the last ten days of the month, and soon after their arrival pairs are along the streams in the vicinity of their nesting banks.

Early in the season it is not unusual to see three or more kingfishers several hundred feet in the air circling and chasing one another and uttering shrill cries as well as their ordinary rattle. This behaviour is not unlike the courtship of several other birds and is the only behaviour we have seen which might be interpreted as courtship. It could, however, be associated with a dispute over territory, as similar sounds are heard when one kingfisher is driving another from a feeding range.

In connection with the bird-control experiment on the Pollett River, we wished to know whether or not the supply of kingfishers, mostly juvenals (young birds of the year in their first full plumage), was coming only from other parts of the Petitcodiac River system. In 1948 to determine this we banded 110 nestling birds. A few of these were banded on the Petitcodiac system, but most of them were on adjacent watersheds. Thirteen recaptured on the Pollett River showed that juvenals were coming from both the Petitcodiac system and overland from adjacent watersheds. One of the banded juvenals was taken on the Miramichi River, more than 90 air miles north.

These records indicate that there is a wide midsummer dispersal of the juvenals. Three of the birds banded on an adjacent watershed were retaken as

adults on the Pollett in the spring of 1949, indicating a return to the general locality of their nativity.

In the autumn the number of kingfishers is decreasing by mid-September but a few may linger until late in October.

We have no record of a kingfisher surviving a winter in the Maritimes, but on Prince Edward Island, where large springs and some small spring streams are open throughout the winter, one was seen to survive until early in January in each of two winters. We found the feathers of one where it had been eaten near a spring which it had frequented, and the other disappeared from its usual haunts. The island springs have a restricted fauna and could scarcely support a kingfisher throughout a winter.

Distribution

The kingfisher is common over the entire Maritime Provinces, except around the shores of the Bay of Fundy where its occurence is rare. In the more fertile parts of the Maritimes the kingfishers utilize nearly all the feeding territories along the seashore and the fresh waters including small streams, and are much more abundant than casual observations would indicate. Along the stream valleys of the agricultural districts, the population of young and adult often approaches ten birds per mile. In the stoney and rocky areas and in some of the poorly-drained areas of central New Brunswick they are not abundant during the nesting period, but when the young birds disperse the waters in these areas are used as feeding grounds.

Along the Bay of Fundy, kingfishers are virtually absent at all times around the muddy waters of Chignecto Bay and Minas Basin and are scare around other parts of the Bay. On the quiet bays and estuaries of the outer coast of Nova Scotia kingfishers occur in small numbers. On the Gulf of St. Lawrence shores of the Maritimes they seldom frequent the wave-swept parts, but after the nesting season young birds congregate around the numerous shallow, protected bays where small shore fishes are available and abundant, and many nest in such localities.

On the streams, kingfishers prefer the larger and more open parts, and use the smaller branches which are completely over-shadowed by trees only when fishing conditions are unfavourable in the larger parts.

Nesting Sites

The ideal location for the kingfisher's burrow along its feeding area would seem to be a well-drained sand bank having a vertical or slightly overhanging face of sufficient height so that the mouth of the burrow can be about two feet below the top of the bank and yet high enough from the base to be beyond the reach of any local bird-eating mammals (Figure 3). When available, a kingfisher generally selects the place having these qualities, but good nesting sites are often lacking near good feeding areas or are in the feeding territory of other kingfishers and therefore not available; so in order to nest the birds are

forced to use inferior or vulnerable sites. In the Maritimes the availability of nesting sites limits the abundance of kingfishers.

When searching for burrows along one good kingfisher stream, it was found that numerous good nesting banks occurred for nearly a mile but in the entire area there was but one occupied nest. In the next mile there was no favourable bank, but a pair of birds was patrolling this area. After much searching the burrow was finally found in a bank so low that a weasel or mink could walk into it. The young in this nest were only a few days old, while in the adjacent area the young were within a day or two of taking flight. We have noticed that in other inferior locations the young have generally been less advanced than in the favourable places.

FIGURE 3. Ideal site for kingfisher's burrow, an alluvial sand bank beside a fertile stream.

Such observations seem to indicate that nesting has been delayed by the search for an available nesting site. That there is in the Maritimes a scarcity of available nesting sites is further indicated by the fact that when a nest and the female have been destroyed in the bird-control experiments, even late in the nesting season, the site has been quickly occupied by another female.

When suitable banks are not present near feeding grounds or are in the territory of another pair, kingfishers may resort to unusual nesting sites. Beyer (1908) reports that in the gum-swamps of Louisiana they nest in the open tops of decayed stumps. Forbush (1927) and Sutton (1928) have reported instances where they have constructed burrows in decayed trees.

In a wooded rocky section of Nova Scotia we found a burrow made in a low mound of soft earth where the wheels of lumbermen's wagons had cut a face in the mound (Figure 4). In a boggy area a burrow was found in a layer of marl-like earth adhering to the roots of a large uprooted tree. Taverner (1934)

has reported similar nesting. In an area where there were no cut banks we found a pair of kingfishers occupying a burrow which they had started in a ten-inch face of earth on a sloping bed-rock surface. The tunnel slanted upwards into deeper soil.

FIGURE 4. Along this road, in the pre-Cambrian area, lumbermen's wagons had cut a low face in some soft earth and kingfishers had utilized the place for a burrow. Photo by A. G. Huntsman.

That they do not all succeed in nesting was brought to our attention at Moser River in Nova Scotia. This is a rocky, stoney area (Figure 5). On the lower part of the River there was a single pair of kingfishers which first attempted to establish a burrow in a small sand pit in a pasture field where someone had removed a few yards of earth, but cattle crushed their burrow. Then they made a number of burrows in the cut face of a sawdust pile but this proved to be too wet. Next they moved to a long road cutting having a sloping bank composed of clay and stones, and it was the first week of July before they abandoned their attempts in this bank where they had made numerous burrows from three inches to one foot deep. This pair of birds came to our house 100 yards from the

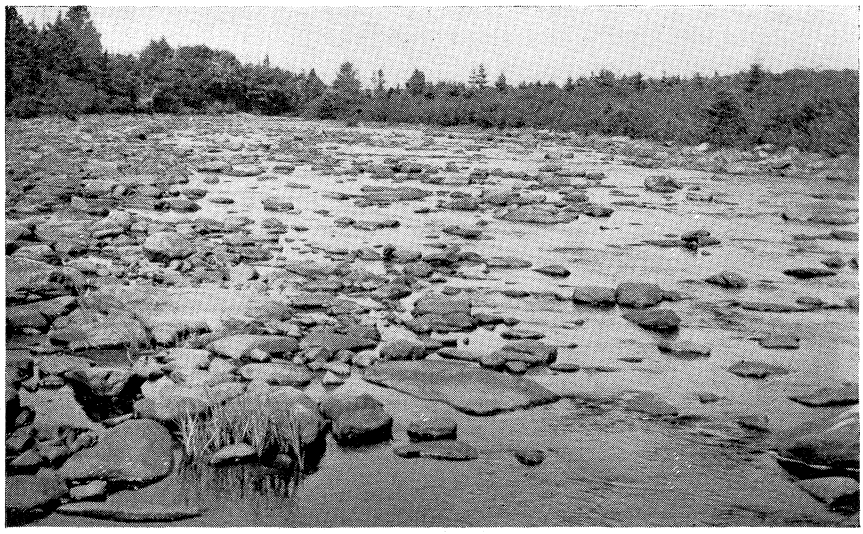

FIGURE 5. Moser River, Nova Scotia. In such rocky areas there are no good nesting banks for kingfishers, but they sometimes find places for make-shift burrows. Photo by A. G. Huntsman.

river in response to the calls of a young kingfisher which we had brought from another area. They also flew along the river carrying fish in their bills and called loudly. These actions were probably a respone to their thwarted parental instincts.

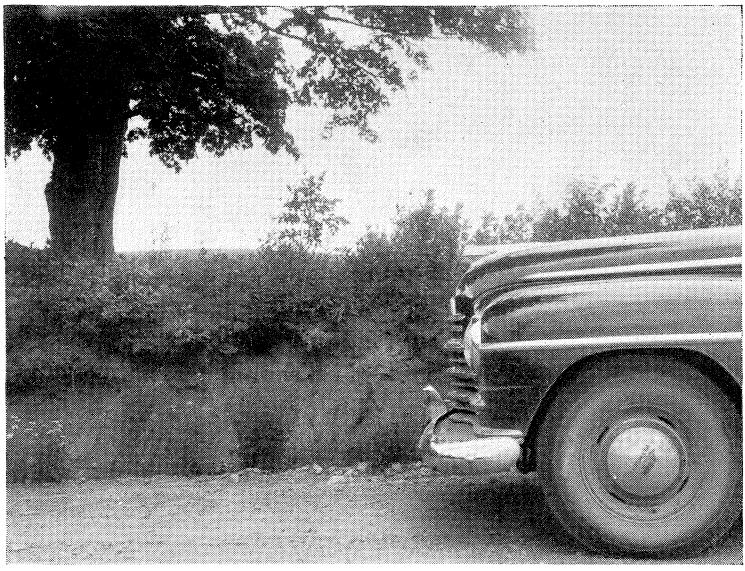

FIGURE 6. One of the kingfisher burrows along Highway No. 14 in Albert County, New Brunswick. Over much of the Maritimes their reproduction depends upon man-made nesting sites.

If kingfishers were dependent on natural sites they would be entirely absent from large areas of good fishing grounds. In most parts of the Carboniferous areas of southeastern New Brunswick and northeastern Nova Scotia there are good stream banks where kingfishers nest, but over most of the Maritimes they are nearly or entirely dependent upon man-made earthworks such as sand or gravel pits, railroad or highway cuttings (Figure 6) and the banks of ditches. Thus in the Maritimes, instead of being an enemy of the kingfisher, man is its benefactor, and we believe that this is true for other large areas of its range.

In this connection, our observations are that in parts of southern Ontario, where we have seen the changes of fifty years, the draining of swamps, clearing of the forest and intensive agriculture have been responsible for the conversion of many clear-running streams into dry stream beds or series of muddy pools. There the work of man has provided nesting banks but has largely ruined many of the kingfisher's feeding streams.

Making the Burrow

When selecting a place in a bank for its burrow a kingfisher will often try many places which can be readily identified by the shape of the marks left in the bank. We believe that the bird must fly against the bank, probably from a hovering position nearby, and strike with considerable force, for the individual marks left by the bill in a fairly hard bank appear to be much too deep to be made by any other method.

In soft earth a pair of kingfishers will complete a burrow in a few days. During experimental bird control we have destroyed the burrows and within a week have found fresh burrows completed near the same places. Bendire (1895) states that a pair completed a burrow "in a rather friable clay bank" in a little over three days.

We believe that the method of digging the burrow has been accurately reported in the *observations* of Miss Frances Densmore and reported by Roberts (1932). In part Miss Densmore stated "They both dug taking turn and turn about . . . One would go in and work for two or three minutes . . . No dirt ever came out with the bird that had been digging but when the other went in there was a veritable fountain spurting out for nearly a minute after it entered". To loosen the earth the kingfisher uses its bill and to move the loose earth a very rapid backward kicking of the feet. Our young hand-reared birds were surprisingly expert at kicking a shower of sand behind them and no doubt the adult birds could kick out a "veritable fountain" from the burrow. It is logical also that with the tunnel partly filled it would be difficult for the bird to back out and kick earth from the mouth of the tunnel but easy for a bird when entering.

When digging a tunnel they have a perch to which they fly to rest between digging periods. This perch is generally almost directly out from the tunnel, and many times we have noted that it is covered with fresh earth from the feet of the birds. Our interest in locating the resting perches has been the collection, for food studies, of the disgorged stomach pellets beneath the perches.

The length of the burrows that we have examined has varied from three to seven feet, the extremes occurring in hard and soft banks respectively. The shortest burrow was in a bank of sand, gravel and clay mixture at the edge of a gravel pit. From the mouth of the burrow to the extreme end of the nest chamber was barely three feet. In the nest we found the female with freshly laid eggs. The tip of this female's bill was so badly worn that it was an ineffective tool for further digging. This observation seems to indicate that the blunting of the bill limits the depth to which the birds can dig in hard soils. In sawdust piles they often burrow in 12 feet or more but we have no record of a brood having been raised in such a place.

Generally the mouth of the burrow is not more than two feet from the top of the bank, but in a high bank along the Margaree River we found a nest in a layer of fine sand about 25 feet below the top. In clean soft soil the tunnel is generally straight and horizontal, with the chamber at the end and with the nest below the level of the tunnel (Figure 7). The tunnel may be bent if, when digging, the birds have encountered large stones or roots. In 1948 two of 20 burrows which we opened while banding young birds were bent so that the nest chamber was less than two feet from the face of the bank. One of these was in gravelly soil, but the other was in a clear sand layer in clayey soil. The latter may have been bent to keep within the drier sand near the face of the bank.

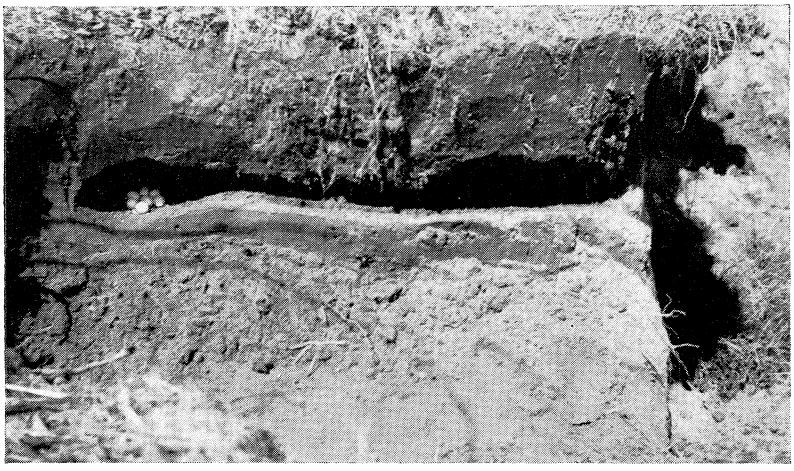

FIGURE 7. Longitudinal section of a kingfisher's burrow and nest chamber. Top of outer part of tunnel broken away during our excavation.

NEST CAVITY AND NEST

When newly made the nest cavity is usually nearly spherical or ovoid, and somewhat flattened in the bottom (Figure 8). The five to seven eggs, seven being not only the maximum but the usual number in the Maritimes, are laid on the bare earth. The fish-bone nests often mentioned by others are made from the accumulated pellets of the sitting birds. They undoubtedly form an insulating

material for the eggs, as when a sufficient quantity of bones has accumulated we have found the eggs resting on a circular layer of dry bones about one-quarter inch in thickness over a layer mixed with sand about one-half inch thick. We have used such bones in our studies of the food of the adult birds. The stage of incubation can be estimated by the quantity of bones present in the nest. We have never found any nesting material other than the bones. In a newly-made deserted burrow we found dry moss and leaves, but careful examination revealed that when completing the chamber the kingfisher had broken into the nest chamber of some small mammal, probably that of a chipmunk.

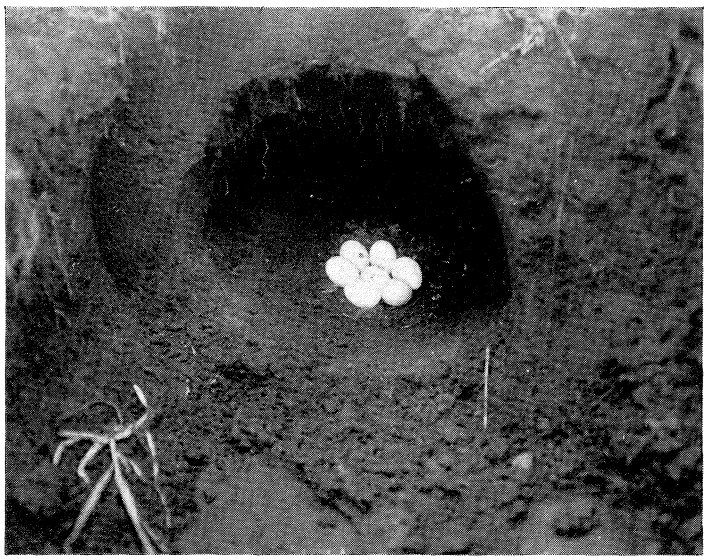

FIGURE 8. A nest cavity with eggs in early stage of incubation. Eggs were resting on only a few disgorged fish bones.

INCUBATION AND NESTLINGS

We believe that the female generally does the incubating, for, with one exception, when eggs have been present we have found the female in the burrow. In the one case where we found the male in the nest, the eggs were warm, and although we remained at the nest site for more than a half hour we saw no other kingfisher. Since kingfishers were being killed at our bird-control experiment less than a mile from the nest, it is possible that the female had been killed and the male had taken over the incubation.

Bent (1940) gives the incubation period as 23 or 24 days and Wheelock (1905) states that the young remained for 28 days in a nest she had under observation. She believed also that at first the young were fed by regurgitation.

Unlike most other birds the young kingfisher is hatched naked with no trace of down or hair-like covering. Since most of the food which is brought

to it is slimy, any such covering would certainly become fouled and would be worse than useless. The feathers grow and are retained in their elongating sheaths until the end of the bird's third week in the nest when the sheaths of the primaries are more than three-quarters inch in length. The tips of the primaries and tail feathers are the first to break through the sheaths. In a period of about three days all the feathers break from their sheaths, and then for both sexes the juvenal plumage is, with only minor differences, like that of the adult female.

Sayler (1946) suggests that "in the initial stages of feeding the nestlings, the parent birds present them with small and delicate fish which disintegrate easily". We have no data on the earliest food of the nestling, but we have examined the stomach contents of nestlings taken in 1937 along the Margaree River (White, 1938) as well as some taken since that time. The youngest we have examined were from a brood we judged to be a week or ten days old and weighed an average of 2 oz. It is interesting to note that even these small birds had been fed fish up to 4 inches in length, and that young of two other broods averaging less than 4 oz. in weight contained some fish about 5 inches in length. All the fishes found in them were salmon parr and trout, although sticklebacks, small fish readily if not preferably taken by adults and immature birds, were abundant and available much nearer one of the burrows than were the salmonids. In 1937 on the Pollett River a brood of six nestlings judged to be about two weeks old had been fed 16 fishes, including two 5-inch trout. The shortest fish in the stomachs of this brood was a sculpin (*C. cognatus*) 2½ inches long but a relatively bulky fish. The suckers and the single minnow were about 3½ inches each. The smallest trout was 2¾ inches.

Regarding the size of fishes fed to the young when 14 days old, Wheelock (1905) states, "On this day one of the adults brought seven fish possibly four

FIGURE 9. Young kingfisher seven to ten days old, showing parts of two fish taken from its stomach, i.e. gullet, proventriculus and gizzard. Old birds feed them relatively large fish.

inches long". In reference to the food carried to the nest Carey (1909) has said, "It not infrequently happens that one of these fish is too large to be carried by the parent bird into the narrow passage".

The kingfisher sometimes nests at a long distance from water, and the young require their weight in fish every day (White, 1936). Since the parents carry a single fish at a time it would seem impossible for them to rear a brood at any distance from water unless they carry relatively large fishes to the young. We have noticed also that kingfishers which have a nest of young, unlike many other parent birds, are never hurried in their work of feeding. The data, we believe, indicate that when catching fish for the young the parent birds tend to select fish of such sizes that from one to three will fill the stomach of a single nestling (Figure 9). Selection for size may possibly account for their feeding small trout and salmon parr when smaller species are present.

In our examination of the stomach contents we have noted that, although the young readily digest the bones of fishes, fish eyes and the chitinous parts of insects from the stomachs of the fishes which they have eaten tend to collect in the stomachs of the nestlings (White, 1938).

Activities in Nest

After the first eggs are laid in the nest the kingfishers throw no more soil from the mouth of the burrow. Sometimes in very soft soil the outer lip of the tunnel will break off or wear down but that is accidental. When searching for burrows containing young for banding, we have found that there is little use looking at the freshness of the soil beneath the burrow as this seldom gives any indication of an occupied burrow; the freshness of the tracks in the mouth of the tunnel is the best criterion (Figure 10). The probable advantage of not kicking soil from the chamber during nesting is that such soil carrying the odour of the birds might reveal the location of the nest to enemies.

We have made no observations on the very young nestlings, but before the young are half grown they start hammering at the walls of the nest chamber and building up the level of the bottom. They can modify the shape or even change its location, being limited in their activities by the hardness of the soil and the volume of the original nest chamber. We do not know whether the parent birds assist in such work. It seems that the young are especially active at this work during the last week that they are in the nest. In burrows in sandy soil containing the feathered young, we have found the chamber broad and with recesses around the edge, and the floor so close to the ceiling that there was barely room for the young birds to shuffle about. This increased activity in fresh clean earth is probably responsible for the immaculate condition in which they keep their new feathers. A nestling reared in an experimental burrow spent much of its time pecking at the walls of the burrow, pulling at rootlets, kicking sand and going forwards and backwards in the tunnel. When frightened at the mouth of the burrow it would quickly shuffle backwards into the nest chamber.

We have repeatedly noticed that the nest cavity when containing young is much larger than a new cavity containing eggs, and the nests containing the

more advanced young appear to have the largest cavities. Sayler (1946) has reported that "females were repeatedly seen during the day to carry off a bolus or pellett of waste or undigested food remains from the nest". Since the young seem to be unable to digest chitin, and the adults often feed the young upon crayfish, it may have been the disgorged shells of the crayfish which Sayler saw the females carrying, or it may have been in part manure-soaked earth pellets. If the latter, it would account for the increased size of the nest chamber.

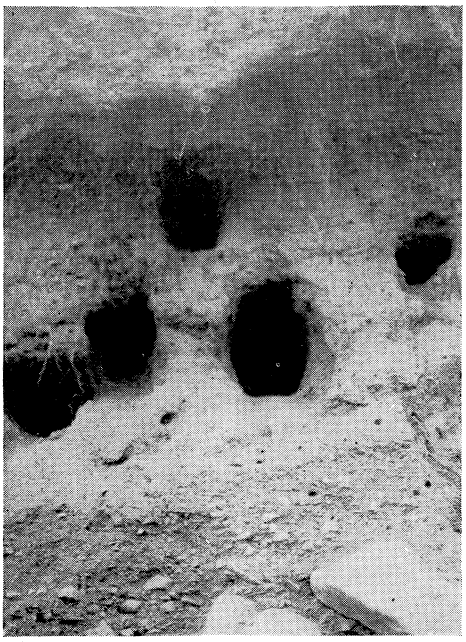

FIGURE 10. Kingfishers often nest along with sand martins. The freshness of the foot marks at right and left on bottom edge of entrance often indicates whether or not the burrow is occupied.

SANITATION

When passing their faeces kingfisher nestlings do not form mucous sacs as is common with many birds but pass them in liquid form and eject them with some force. To keep young birds clean when hand-rearing them, we have used cardboard cartons with a layer of dry sawdust in the bottom. In the carton a nestling would shuffle backwards to the side, elevate the anus and eject the faeces as high as possible against the side of the carton. It would then turn and hammer with its bill at a spot as high as it could reach over or on the area where the faeces had been ejected. The manner of hammering is not like the peck of a hen but like that of a woodpecker and young nestlings can vibrate the head with considerable rapidity.

The tip of the bill, including both mandibles, of the nestlings is hardened and of a special shape for protection against injury to the bill and for aid in

digging in the nest chamber (Figure 11). This structure is not the temporary "egg-horn" but persists, although it becomes smaller, up to the time of the breaking of the feather sheaths when the whole bill becomes hardened.

Our young birds hammered at times other than just after evacuation. Whenever the sawdust became soiled enough to give off an odour they would start hammering at the carton and keep it up for long periods until the carton was changed or cleaned and supplied with fresh sawdust. We saw in this behaviour the method by which the nest chamber is kept clean even though large quantities of fish are consumed daily by the young. However we wished to get further proof by rearing a young bird in a cavity in a bank.

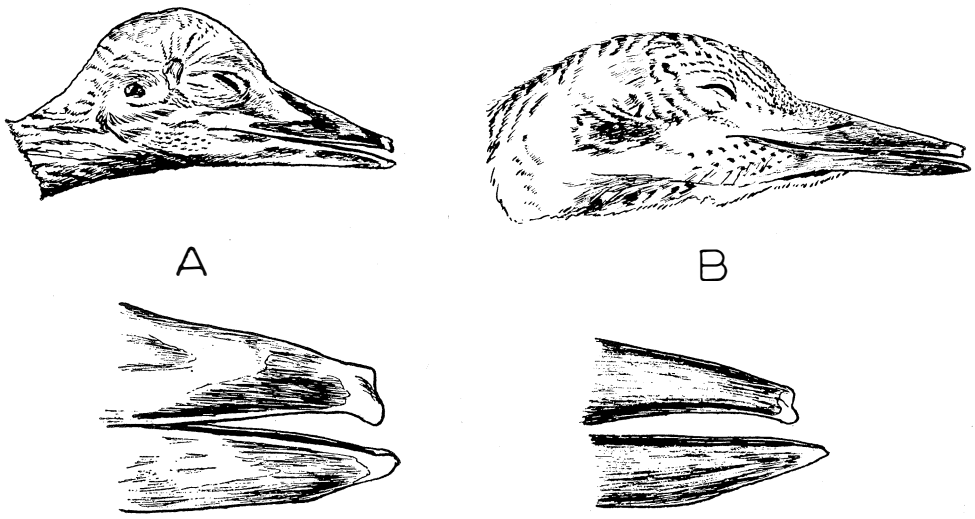

FIGURE 11. Heads of young (A) and older (B) nestlings, and (*below*) enlarged drawings showing structure of the hardened tips. Drawing by C. J. Kerswill.

Near our camp on the Margaree River in 1937 there was a low cut sand bank along the road and in this we constructed an artificial tunnel and nest cavity. At the top of the nest cavity we constructed a window covered with glass and a large piece of opaque cloth. We then transferred a nestling which we had been rearing to the cavity and continued feeding it there. The young birds nearly always evacuate immediately after feeding and this behaviour simplified our problem. After feeding the bird we would make observations through the glass. The hammering and other behaviour was similar to that which we had observed in the carton but in this cavity the bird was able to knock sand loose and cover the faeces. For the two weeks previous to flying this bird kept its nest chamber clean. Even when it had not recently passed faeces it would from time to time hammer at the walls, and in the two weeks it had altered the shape of the cavity. We also observed it in the act of kicking sand with its feet at which it was very adept.

Some observers have reported finding the nest chamber in a foul condition,

but of the many nests we have opened we have never found one containing filth or any unpleasant odour. We have repeatedly noticed a warm body odour not differing from that of a nest of any other young birds and sometimes a slight odour of fish but not that of stale fish. A handful of earth from the bottom of the nest has only a clean earthy odour. However, our observations have been made in districts where the burrows have been in dry sand or sandy gravel and it may be that in places where the ground gets damp or in very firm soil it would be impossible for them to maintain such excellent sanitary conditions as we have found.

Bendire (1895) has stated that the burrow is kept rather clean and that the excrement is promptly removed. This could be done by the adult birds only if they carry away pellets of the soiled earth, as suggested by Sayler's observations.

Another provision for sanitation is the persistence of the long pin-feather sheaths. These keep the young nestlings from getting their new feathers fouled with fish slime or fresh faeces as the pin feathers and bodies are easily cleaned with the dry soil in the nest.

Enemies

In their northern breeding areas kingfishers have fewer enemies than most other birds, but there must be a heavy mortality between the time that they leave the north and their return in the spring. They successfully rear large broods and their abundance is much greater every fall than when they return the following year.

Bent (1940) considers "the selfish fisherman" who shoots kingfishers and "the proprietor of a trout hatchery" who will not bother to screen his pools as "the most serious enemies of the kingfisher". In our Maritime Provinces we know of no fisherman who habitually shoots kingfishers. There are a number of government salmon and trout hatcheries where some kingfishers are killed but the number is a small fraction of the general kingfisher population.

The kingfishers seldom have success when they attempt to nest in the banks of sand or gravel pits where children are in the habit of playing, as the children in their efforts to satisfy their curiosity about the occupants of the hole generally render the burrow unfit for nesting. The birds will generally make a number of attempts to establish a nest. For reasons we have explained under the heading "Nesting Sites" in Eastern Canada and probably in a large part of its breeding range, man is a benefactor of the kingfisher rather than its enemy.

When banding kingfishers in 1948 we found a burrow in a six-foot vertical bank of alluvial sand with the mouth of the burrow about 18 inches below the overhanging top. On a mass of fish bones in the nest chamber there was a single egg containing a nearly full-grown embryo which had been dead only a short time. No young birds had occupied the nest and the old had deserted it. There were no claw marks around the mouth of the burrow but the familiar foot marks of the parent birds were so indistinctly shown that on finding the burrow we had doubted that it was an occupied nest. Near the nest a red squirrel had been feeding on the cones of a large spruce tree from which a dead limb hung over

the stream in such a position that a squirrel could jump a distance of two and a half feet into the mouth of the burrow. Red squirrels are well-known nest robbers, and the only explanation for the failure of this nest seemed to be that it had been robbed by a squirrel.

There is evidence that skunks may sometimes rob the nests. In 1948, while searching for kingfisher nests for the purpose of banding the young, we found two nests where skunks, identified by their tracks in the sand, had started to dig down to the nest cavities. At one place the skunk had made a cone-shaped pit fully a foot deep directly over the nest, but had quit digging when about three inches of soft sand separated it from the nest. This nest contained eggs and the female bird. At another place a skunk had dug a cavity about five inches deep and the nest chamber was some 12 inches directly below. At several other places we have found old nests into which a skunk or some other animal of similar size had broken.

Bent (1940) states that skunks or minks might crawl into the burrow when the parent birds are away but that "it would seem that the formidable beak of the kingfisher, if at home, would prove to be an effective weapon of defence". We think that he underrates the members of the weasel family or overrates the formidable qualities of the kingfisher's beak. We have frequently captured an adult kingfisher in our bare hand when reaching into a burrow, but we would not attempt to capture a member of the weasel family in a similar manner.

Along banks where the sheer face was not high we have found where some animal larger than a mink or skunk had reached up and pulled out sand martins' nests and had left claw marks around a kingfisher's burrow but had made no serious attempt to dig into the nest. This is probably the work of the raccoon.

We believe that the Sharp-shinned and Cooper's hawks in this country are the most important enemies of the kingfisher. On several occasions in the woods near streams we have found where a kingfisher had been plucked and no bones left, and have thought that this was the work of one of the above hawks.

It is probable that either the Sharp-shinned or Cooper's hawk is capable of capturing kingfishers in straight flight, but the behaviour of the kingfisher is adjusted to lessen the chances of its being caught. When travelling over land kingfishers generally keep well above the haunts of these hawks and when near water they fly either over the water or near enough so that if attacked they can make a plunge into it. When they alight they usually select perches which give them a chance to make a dive to the water at an angle of not less than 45 degrees. The exceptions to this are where their resting perch is situated not far from water and gives them a clear view in all directions or, when making their burrow, the perch, though perhaps far from water, is situated so that they have a clear view of the mouth of the burrow. This latter point may be significant. At all times, except for its night roost, the kingfisher prefers a perch which gives it a clear view and a chance for a quick get-away.

A number of observers have described the behaviour of the kingfisher when pursued over water by a hawk. We have never seen this, but Mr. Fred D. White

of Aylmer, Ontario, a keen observer who had never heard of this behaviour, told me about his experience. His attention was attracted by a kingfisher splashing into his pond and then he noticed "a small hawk not much bigger than the kingfisher" ascend into the air in the opposite direction from which the kingfisher emerged from the water. The kingfisher gave its call and the hawk turned and overtook it, but just as Mr. White thought the kingfisher would surely be caught it dived into the water with a great splash and the hawk flew up and beyond it. The kingfisher came out of the water going in the opposite direction. This performance was repeated ten or a dozen times and then the hawk flew across the pond and alighted in a tree overhanging the water. The kingfisher, calling loudly, alighted on the opposite side of the pond. After a short rest, much to Mr. White's surprise, the kingfisher flew across the pond to the hawk and started the performance over again. This time, however, the hawk made only a couple of trials and then went on its way. In 1947 Dr. P. F. Elson and Mr. H. W. Coates witnessed similar behaviour on Fenton Pond in Albert Co., N.B.

While carrying on investigations at Apple River in Nova Scotia we saw two kingfishers performing this hawk-kingfisher behaviour with first one and then the other taking the role of the hawk. From their flight we thought that they were young birds which had come from a nearby nest about a week before. The play of young animals generally, if not always, serves as practice for some behaviour connected with their survival.

Regarding these unsuccessful attacks by the hawk, Bent states, "The Cooper's and Sharp-shinned hawks often pursue it, perhaps largely for sport . . . it even seems as if the kingfisher enjoyed the sport, judged by its derisive 'laughter' at the defeat of the hawk". It is possible that the kingfishers may enjoy it, but we believe that this behaviour is of the same nature as the broken-wing ruse of many birds and is done to save the lives of their young.

The young are not strong fliers, and regarding this Carey (1909) has remarked, "They are a sombre looking lot, as for several days they sit tamely about the wharfs or venture on short, erratic flights, which makes one feel that they have not yet got used to the light after their long imprisonment underground". Since the young are weak fliers, a whole brood occurring in the hunting ground of a hawk could easily be destroyed. But when the old birds have discouraged the hawk in its attempts to catch kingfishers and have continued to utter their rattling challenge in the area, the young which have plumage like that of the parents and utter the same challenging call are probably safe from attack by any hawk which has been discouraged.

Sayler (1946) has noted that "During the first three or four days the parents generally perch on dead trees or exposed branches and the young on nearby dogwood, alder or other shrubs where they are somewhat hidden". Regarding their behaviour when alarmed he states, "The cries of the parents seem to rally the flock together and to keep it concentrated generally within a 100-yard stretch along the margin of the water area". We have noted (White, 1937) that the family moves along the stream in a leisurely fashion with the individuals within calling distance of one another, and have termed it a "loose

flock". This behaviour seems to be a further protection against hawks. The old birds, ready to be chased by any hawk which may appear, perch where they are easily seen, while the young birds are inconspicuous.

Night Roosts

The kingfisher is diurnal and goes silently to its night roost at twilight. During our investigations we have by accident found three of their night roosts. White faecal splashes on the ground and undergrowth first attracted our attention, and closer examination revealed the presence of numerous fish-bone stomach pellets which definitely established that the roosts were used by kingfishers.

One of these along the Margaree River of Nova Scotia was at the base of a steep hill among large sugar maples, and the position of the pellets indicated that the bird had roosted about 25 feet from the ground among the smaller branches where these overlapped from two of the trees. The roost was less than 100 feet from the water's edge. Along the Restigouche River in New Brunswick the bird or birds had roosted on the small branches of maples among spruce trees. The trees were about 50 feet up on the valley hillside, and here also the distance from the water was about 100 feet. A third, and larger, roosting area along the Nashwaak River was in a thick growth of small trees on the valley floor and was about 200 feet from the water. Here the birds had roosted near the tips of small horizontal branches of maples sheltered by fir trees and about 20 feet from the ground. The distribution of numerous pellets and faecal splashes showed that they had roosted on various branches of several different trees but in a small area.

When alighting during the day a kingfisher tends to select rather large limbs for its perches, but at night it roosts on small supple limbs. This behaviour was noted by Brewster (1937) who made observations on a kingfisher roosting in "a tall slender Paper Birch . . . near the end of a long branch, about thirty feet from the ground".

The night roosts selected by the kingfisher are places where, near the tips of slender branches, it is safe from carnivorous mammals and, among the leaves of deciduous trees, inconspicuous to owls.

Feeding

When feeding, the kingfishers dive from a perch over or near the edge of the water or from a hovering position 20 to 50 feet in the air. Most of the fish which they catch are taken in water less than two feet in depth, and even in deep water we doubt whether they ever catch fish more than two feet below the surface. They often catch fish or crayfish in water only a few inches deep and they apparently strike with considerable force. Under these conditions, the impact on the bill is partially relieved by allowing the belly and partly closed wings to strike the water as the bill strikes the bottom. At times in such shallow water they sometimes stand on the bottom a few seconds before taking flight with their prey.

The dive may be at an angle or nearly vertical, and the kingfisher may change direction during the dive. One of our tame birds made a dive from a perch about ten feet above the water to strike at a trout fingerling which we could see clearly. When the bird was about four feet from the water, the trout darted, and instantly the bird changed direction and struck the water some four feet from the point where it had first taken aim. We were able to notice that the bird struck ahead of the trout, apparently to allow for the speed of the fish, but it failed to catch it. Generally the young catch only very small fishes.

The point of aim at most fishes is just in front of the dorsal fin, and we believe that in most cases the fish is caught before it has had time to move, but sometimes the fish is caught well back toward the tail or missed. After a capture, the bird flies to a perch where it generally pounds the fish against the perch by a sidewise movement of the head. Although the musculature of the large bill is relatively weak the sharp edges converging to the point make the bill an effective structure for holding a fish. The pounding serves several purposes: If large, the fish may be stunned; also this is the bird's method of turning the fish so that it may be swallowed head first. Sometimes the pounding serves to break the tips or turn back the extended paired spines of such fishes as sticklebacks and bullheads. Our tame birds would not infrequently swallow sticklebacks with the spines unbroken and locked in their extended position.

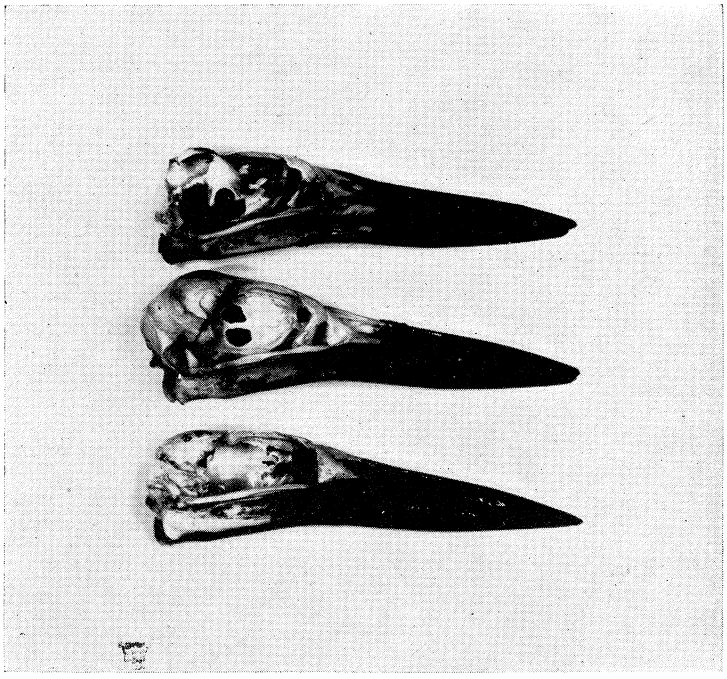

FIGURE 12. Head skeletons of two juvenal kingfishers (*above*) and one adult (*below*). From repeatedly striking bottom when catching small fish in shallow water, the juvenals wear off the tips of their bills. Even greater wearing occurs when adults dig burrows in hard soil.

They are careful not to loose their grasp on a fish, and we believe them incapable of such acrobatics as the tossing of a fish into the air and catching it so that it can be swallowed head first, as reported by Brailliar (1922) and Bent (1940). A crayfish is hammered against a perch or boulder, and often the large claws are knocked off and it is swallowed tail first but with the tail bent under the body.

When the young birds begin to catch fish, they dive from very low perches and frequently, in stoney country, from boulders only one or two feet above the water. As they feed upon very small fishes, often less than two inches in length, they make many plunges into shallow water and when feeding over a hard bottom the tips of their bills become worn (Figure 12).

ANALYSES OF PELLETS AND STOMACH CONTENTS

Material

In our studies of the kingfisher's food we have depended largely upon disgorged stomach pellets, but we have also used stomach contents from birds shot or trapped during bird-control experiments. For food studies we consider the pellets of more value than the stomachs from an equal number of dead birds. A pellet nearly always represents the remains of a full meal, whereas the stomach of a bird either shot or trapped may be empty except for a few bones which may be useless for specific identifications, or it may contain a pellet or partly digested fish remains. When using pellets for the food studies, one is not limited by the number of birds or even their presence or absence along the waters at the time the material is being collected. Pellets may remain unharmed for months beneath the perches, and by careful observations on the condition of a pellet at time of collection, an estimation of the time of its deposition may be made. Newly deposited pellets are slightly bile-stained and often intact when the dried mucus holds the bones together (Figure 13). Other stages which give clues to its age are the breaking down of the pellet, bleaching, and later a staining from the substratum. When very old, the bones may become brittle. We have collected and used pellets which have been exposed to the weather for a full year.

When collecting pellets, one seldom sees a kingfisher using the perches under which the pellets are collected, but by becoming familiar with their perching habits the perches may be easily recognized along any body of water. These often overhang the water and pellets beneath them are thus not available to the collector.

To locate perches under which pellets may be collected the collector should stand at the water's edge and look along the shore, selecting for examination the dead or bare limbs, especially the larger ones from which a kingfisher's plunge to the water would be at an angle of forty-five degrees or steeper.

When the perch has been used recently, the white faecal splashes near it will often indicate to what extent it has been used. Pellets are generally found directly beneath the spot where the birds perch. The faeces are ejected away

from the perch, but by allowing for this the position of the pellets may often be determined.

If the perch be high and over thick ground vegetation, it is sometimes difficult to locate the pellets. Under these circumstances we have used a longe light line with about six ounces of lead attached to the end. By casting the lead over the perch and lowering it to the ground we have generally found the pellets close to the lead.

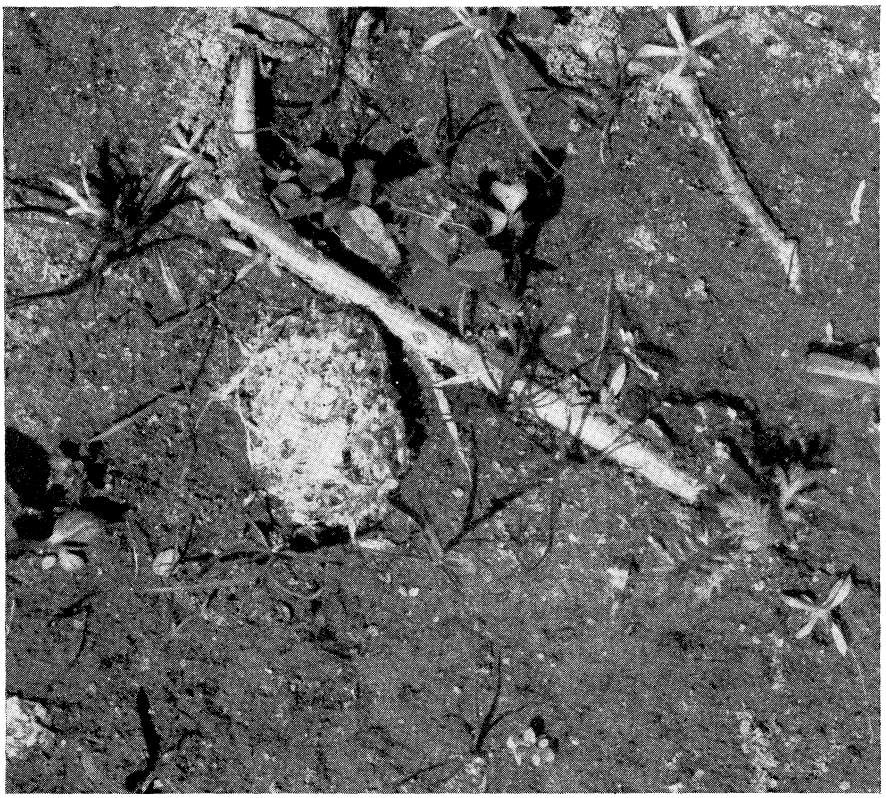

FIGURE 13. A fairly fresh disgorged stomach pellet *in situ* on a damp sand beach. Later such a pellet would break apart forming a small pile of bones. For analysis of this pellet see next figure.

ANALYSES

Pellet analyses have been made by using a dissecting binocular microscope when sorting out the specific bones from the pellet (Figure 14). When stomach contents have been used, the undigested flesh has been artificially digested and the bones washed to provide clean bone specimens such as are found in the pellet.

For identification of the fishes in the pellets we have used a reference collection of bones from identified specimens (Figure 15). Except for a few which are rare, this collection includes all the freshwater fishes of the Maritimes and also those seashore fishes which are ordinarily taken by kingfishers. Crayfish and the large insects which are caught by kingfishers have been identified by their chitinous parts. The pellets contain also the chitinous parts of small insects and the cases of caddice flies (Figure 14) which we have disregarded in our analyses. Some investigators (Sayler, 1946) have listed as the food of the kingfisher, minute adult and larval aquatic insects and other small forms which are undoubtedly from the ruptured stomachs of the ingested fishes.

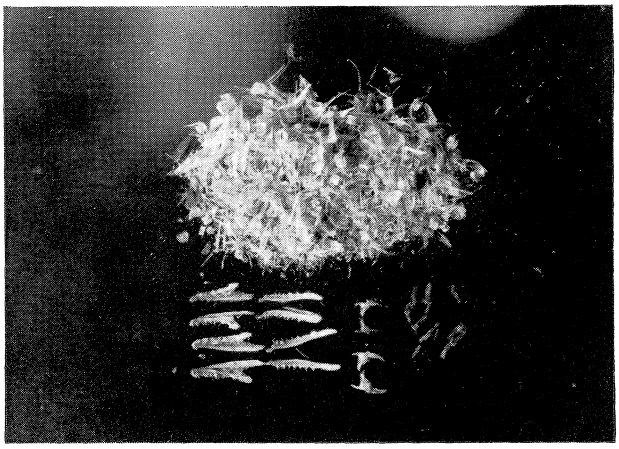

FIGURE 14. Specific bones have been picked out of this pellet and arranged below loose bones. Two sets of jaw bones of Eastern Speckled Trout, two sets of opercular bones of sculpin (*Cottus cognatus*), show what the kingfisher had eaten for one meal. Indistinctly shown to the right of the sculpin bones are caddice-worm cases from the stomachs of the fishes eaten.

Bones from the head and shoulder girdle of the fishes have been used for estimating the lengths of the fishes represented in the pellets. However, length estimates made in this manner are subject to considerable error, and volumes calculated from such estimates may have a large error (Figure 16). From two branches of the Petitcodiac River, minnows which differed by 50 per cent in volume, determined by displacement, were found to have head and shoulder bones of approximately the same measurements. Even in the same stream there may be considerable variation in relative size of head bones. Such differences have been used as a check on scale reading to determine the age of salmon parr and smolts (White, 1936). Since we are primarily concerned with the numbers of valuable fishes taken by the kingfisher, we have given in the tables the numbers and numerical percentages for the various organisms with comments in the text on the comparative volumetric proportions for some of the fishes.

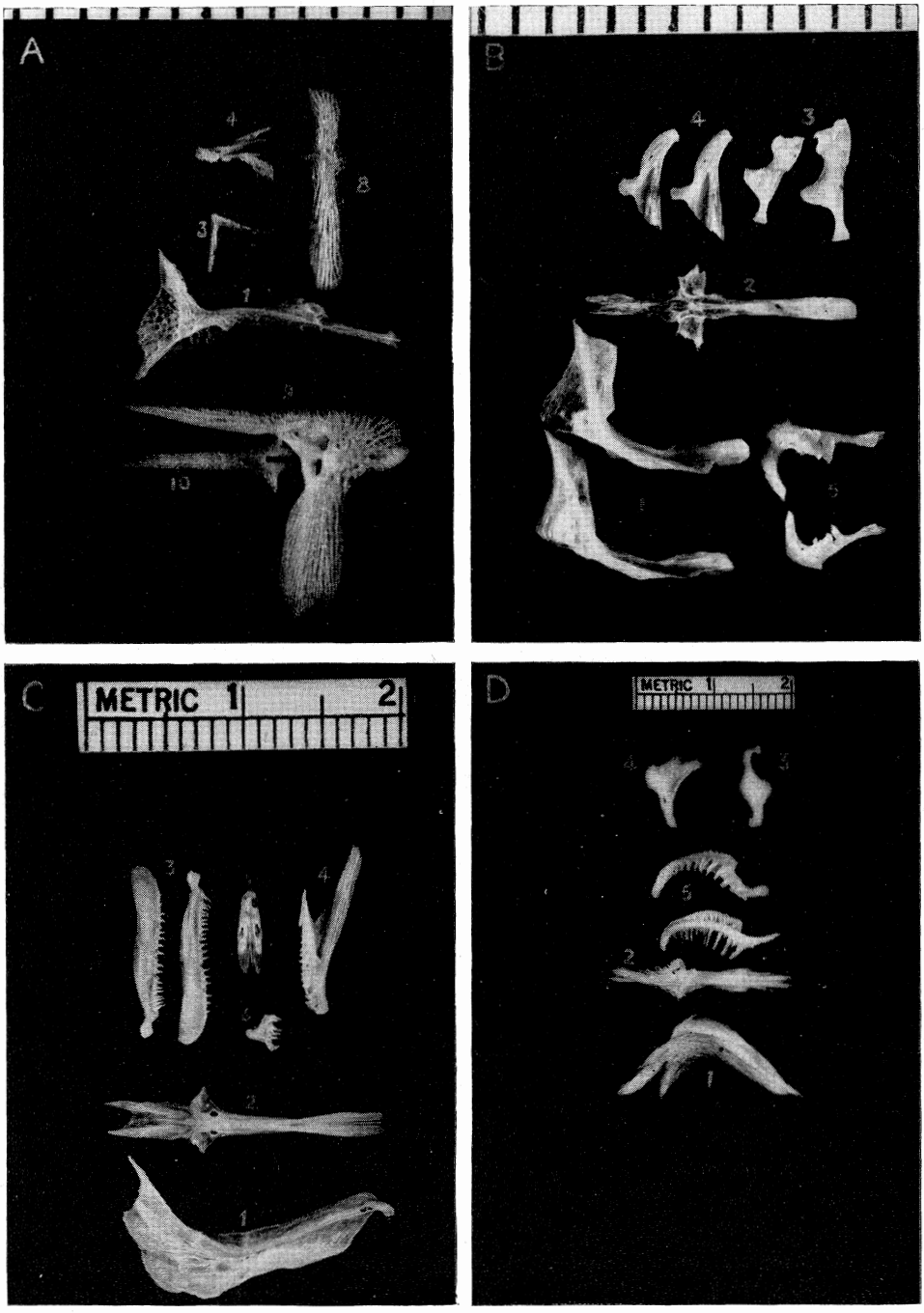

FIGURE 15. Photomicrographs of specific bones of four common food fishes (scale in millimetres). Photographs by G. F. M. Smith.

A. Threespine stickleback—*Gasterosteus aculeatus*
B. Blacknose dace—*Rhinichthys atratulus*
C. Atlantic salmon parr—*Salmo salar*
D. White sucker—*Catostomus commersoni*

1. clavicle 2. parasphenoid 3. maxilla 4. dentary 5. pharyngeal arch 6. premaxilla 7. basihyal 8. dermal plate 9. innominate 10. pelvic spine

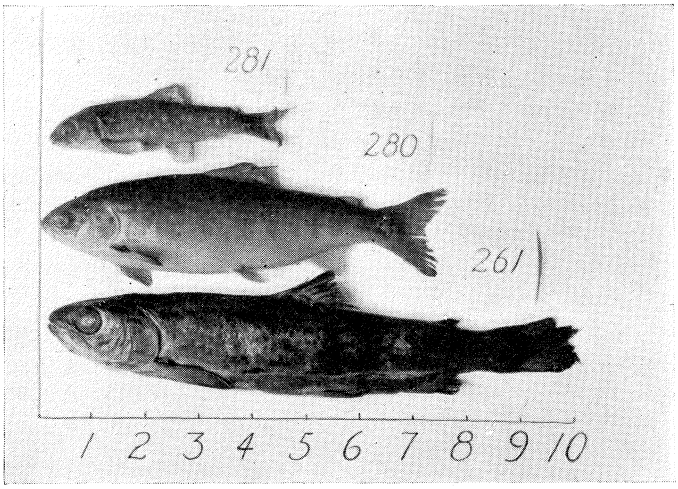

FIGURE 16. Three salmon parr with lengths shown in inches below. Within a species considerable variation occurs in body proportions. Accurate volumes are not ascertainable from bone specimens found in pellets or stomachs. Photo by D. G. Wilder.

FOOD

Regarding the food of the kingfisher, Bendire (1895) reports that it feeds largely upon fish, but that it eats also crustacea, insects, frogs and lizards.

Bent (1940) gives a list of food organisms, including young birds, mice and "even berries", and he states that "on the seacoast, it has been known to feed on clams and oysters, which sometimes results disastrously for the bird". Sayler (1946) has found the kingfisher feeding upon many species of fishes, salamanders, crayfishes and insects, with mice as an unusual item. He has stated that flying insects constitute the first food caught by the young birds. As an example of unusual food, we have found a water shrew (*Sorex palustris*) in the stomach of an adult male kingfisher (White, 1939a).

The above references give some idea of the diversity of the food reported for the kingfisher. Of the items mentioned above, we would take special exception to the inclusion of large clams and oysters, as the musculature for the kingfisher's bill is relatively weak, and we cannot believe that it is capable of extracting these organisms from their shells. Moreover, such behaviour seems foreign to the feeding habits of this bird. The fact that a kingfisher is sometimes found with its bill held fast by the shell of a clam or oyster is not proof of its feeding upon these shellfish, but rather is evidence of an accident when the bird has dived at some other food organism and its bill has struck between the open valves of the shellfish which has instantly closed its shell. By using a sharpened stick we have often fished freshwater mussels in this manner.

Bent (1940) has rightly stated, "The kingfisher is a fish eater and an expert fisherman, well deserving its name. It evidently prefers fish to any other food and would probably live on fish exclusively if it were always able to secure all it needed". In the Maritimes fishes are abundant and available to the kingfisher

in nearly all the waters and thus fish is the main food. The exception to this is in streams which contain crayfish and even in these we have found that crayfish predominate in the food only in those parts where mergansers have reduced the fish population.

In our previous food studies we have reported only those made on the Margaree and Apple Rivers of Nova Scotia (White, 1936, 1937, 1938, 1939 a and b). In the summer of 1948 pellets were collected from a wide variety of habitats over most of the Maritimes, and along with the analyses of these we have included those made incidentally to fisheries work in restricted areas. Our study of the food is based on more than 1,300 pellet and stomach analyses.

Table I gives the scientific and common names of the fishes occurring in the fresh waters of the Maritime Provinces.

TABLE I. Fishes reported as occurring in fresh waters of the Maritime Provinces. (Presence recently verified ×; reported present +; anadromous form present *.)

	New Brunswick	Nova Scotia	Prince Edward Island	Anadromous	Remarks
Petromyzon marinus, Sea lamprey	×	×		*	
Dorosoma cepedianum, Gizzard shad	+				
Pomolobus pseudoharengus, Alewife	×	×	×	*	
Alosa sapidissima, American shad	×	×		*	
Osmerus mordax, American smelt	×	×	×	*	
Prosopium cylindraceum, Round whitefish	+	×			
Coregonus clupeaformis, Lake whitefish	×	×		?	
Salmo salar, Atlantic salmon	×	×	×	*	
Salmo salar sebago, Sebago salmon	×	×			
Salmo gairdneri, Rainbow trout	×	+	×	*	Introduced
Salmo trutta, Brown trout	×	×		*	Introduced
Salvelinus fontinalis, Eastern brook trout	×	×	×	*	
Salvelinus alpinus, Arctic charr	×				Rare
Cristivomer namaycush, Lake trout	×				
Catostomus commersoni, White sucker	×	×			
Catostomus catostomus, Longnose sucker	×				Rare
Semotilus corporalis, Fallfish	×				
Semotilus atromaculatus, Creek chub	×	×			
Margariscus margarita nachtriebi, Pearl dace	×	×			Rare
Couesius plumbeus, Lake chub	×	×			
Rhinichthys atratulus, Blacknose dace	×	×			
Pfrille neogaea, Finescale dace	×				Rare
Chrosomus eos, Redbelly dace	×	×			
Notemigonus crysoleucas, Golden shiner	×	×	×		Introduced P.E.I.
Notropis cornutus, Common shiner	×	×			
Notropis heterolepis, Blacknose shiner	×	×			
Ameiurus nebulosus, Brown bullhead	×	×			
Esox niger, Chain pickerel	×	+			Introduced N.S.
Anguilla bostoniensis, American eel	×	×	×		
Fundulus diaphanus, Banded killifish	×	×	×		
Roccus saxatilis, Striped bass	×	×		+	
Morone americana, White perch	×	×	×	+	
Perca flavescens, Yellow perch	×	×			
Stizostedion canadense, Sauger	+				Doubtful
Micropterus dolomieui, Smallmouth bass	×	×			Introduced
Lepomis gibbosus, Pumpkinseed	×	×			
Lepomis auritus, Yellowbelly sunfish	×				Rare
Cottus cognatus, Freshwater sculpin	×				
Pungitius pungitius, Ninespine stickleback	×	×	×		
Eucalia inconstans, Brook stickleback	×				Rare
Gasterosteus aculeatus, Threespine stickleback	×	×	×		
Apeltes quadracus, Fourspine stickleback	×	×	×		
Lota lota, Burbot	×				

Trout-Rearing Streams

For the purpose of this account we define trout-rearing streams as those streams or branches where trout spawn and where many remain to complete their life cycle. There is a considerable variety in the fish life of such streams and corresponding differences in the kingfisher's food when feeding on them.

Headwater streams with trout and sculpins predominating

In this class there is Jardin Brook, a headwater, alder-bordered spring brook of the Restigouche River system, and similar parts of the Caraquet and Pokemouche Rivers. Thirteen pellets collected along these brooks contained remains of 32 trout, 30 sculpins, 5 threespine sticklebacks and one unidentified minnow. The sticklebacks were probably taken from backwaters. In these streams trout formed numerically 47 per cent of the fishes taken, but would be a much higher percentage by volume, as bone measurements show that some of the trout were about 14 cm. in length, whereas the other fishes ranged below 8 cm. (Table II).

Table II. Food in trout-rearing streams.

	Upper Kennebecasis River, N.B.		Jardin Brook, Upper Caraquet and Pokemouche Rivers, N.B.		Clark's Brook, Forbe's Brook, P.E.I.		Morell River, P.E.I.	
Food organisms	In 61 pellets		In 13 pellets		In 15 pellets		In 9 pellets	
	No.	%	*No.*	%	*No.*	%	*No.*	%
Osmerus mordax					13	39.4	4	13.3
Salmo salar	8	2.8					9	30.0
Salvelinus fontinalis	54	18.8	32	47.1	1	3.0	2	6.7
Catostomus commersoni	5	1.7						
Semotilus atromaculatus	6	2.1						
Couesius plumbeus	4	1.4						
Rhinichthys atratulus	13	4.5						
Notropis cornutus	6	2.1						
Cyprinidae			1	1.5				
Fundulus diaphanus					1	3.0	1	3.3
Fundulus heteroclitus					1	3.0	1	3.3
Cottus cognatus	101	35.2	30	44.1				
Pungitius pungitius					1			
Gasterosteus aculeatus	90	31.4	5	7.4	16	48.5	10	33.3
Gasterosteus bispinosus					1	3.0	1	3.3
Apeltes quadracus					1	3.0	1	3.3
Odonata (nymph)							1	3.3
Totals	287		68		34		30	

Streams populated largely by trout

Around the Bay of Funday there are small streams which contain only those fishes which could reach them through salt water. Some of these streams are well populated with stunted trout which may mature when less than 13 cm. in length. They sometimes contain a few stunted salmon parr and small eels. Two small branches of Apple River in Cumberland County, Nova Scotia, are of this character. Fourteen pellets collected along these streams contained remains of 22 trout, constituting 100 per cent of the food (White, 1937).

As an example of the food taken by kingfishers in a trout stream during a spawning migration of other species, we refer to our previous work at Trout Brook of the Margaree River system where pellets were collected in 1935 (White, 1936). Large numbers of a local variety of threespine sticklebacks ascend the lower part of this stream in a spawning migration, and kingfishers congregate in the area and feed upon them. There were masses of pellets beneath all the available fishing perches. Analysis of 37 pellets from this area contained the remains of 135 fishes, of which 95 per cent were sticklebacks and 5 per cent salmon and trout.

On the same stream, half a mile above the area where sticklebacks were spawning, six pellets contained 10 trout and 4 salmon, but only 4 sticklebacks.

In Prince Edward Island all streams are trout-rearing streams, but from mid-April to June they may contain great numbers of spawning smelt in the lower parts. On June 17, when pellets were collected along Clark's and Forbes' Brooks, many small male smelts were lingering in the streams and many trout of suitable sizes for kingfishers were present in the same areas. Fifteen pellets contained the bones of 34 fishes which consisted of 13 smelt, 1 trout, 2 killifish and 18 sticklebacks (Table II). Smelt, which are easily available at spawning time, had formed the greater volume of the food and trout, the least available, the smallest. As usual in Prince Edward Island waters, sticklebacks were taken in largest numbers (Figure 17) (White, 1927).

A third example of this condition is indicated by a New Brunswick trout stream, Indiantown Brook, of the Miramichi River system. Three pellets collected

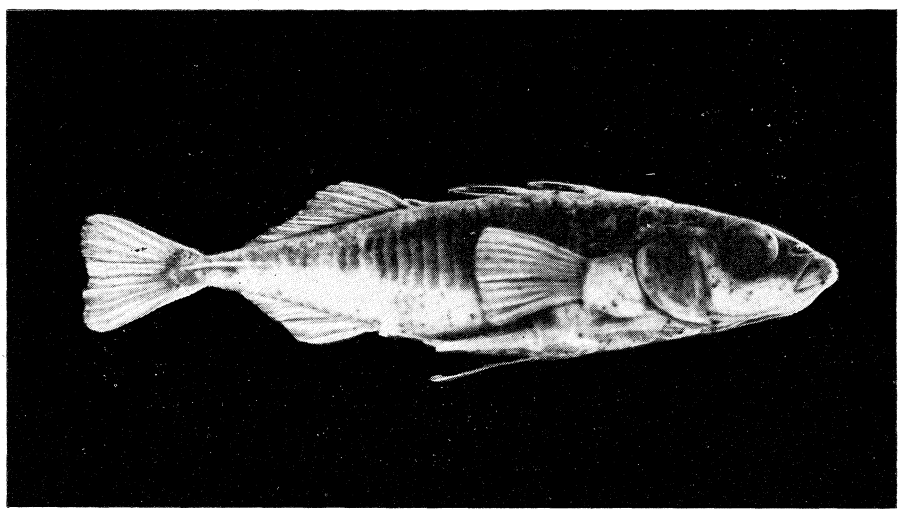

FIGURE 17. The Threespine Stickleback (*Gasterosteus aculeatus*). The kingfisher does not hesitate to swallow very rough food organisms. This fish has armour plates on body and strong sharp spines which can be extended and locked at right angles to the body, yet it is a principal item in the food of kingfishers.

there beneath a fishing perch on June 15 near the end of the smelt run contained bones of six smelts only, while two pellets collected at the same perch on August 27 contained crayfish remains only.

STREAMS CONTAINING SCULPINS, MINNOWS AND OTHER FISHES

Some trout-rearing streams contain a considerable number of fish species. Two branches of the Kennebecasis River, the South and Portage branches, contain trout, salmon, suckers, four species of minnows, sculpins, young burbot, eels and threespine sticklebacks. These streams are clear, largely gravel-bottomed and spring-fed throughout their length but at times they are flood-swept by water from the fertile wooded hills of southern New Brunswick. Since they are near our station for salmon investigations, sample seinings and collections by electrical methods have been made in them and their fauna is known better than that of most of the waters along which we have collected pellets. Numerous springs provide excellent spawning grounds for trout and the fry are produced in great numbers. In the fall large salmon spawn in these streams and maintain a fairly good stock of salmon parr. Although these two streams are persistently angled, natural reproduction is able to maintain a heavy population of trout.

Large suckers are present in all the larger pools, but young suckers are scarce. Blacknose dace are common, the young in backwaters and the adults in the rapids. Common shiners, lake chub and creek chub are present in small numbers. Sculpins are fairly abundant, but seek the colder parts late in the summer. Young burbot occur in small numbers where flat stones are present, but have not been found in the upper parts. The threespine stickleback is present in all the backwaters which contain vegetation.

Although these streams are not of the type which one would associate with eels, fishing with electrical apparatus has shown that the stoney or coarse gravel rapids are well populated with eels up to 30 cm. in length. It is evident that the small elvers make good growth in these rich food-producing areas.

On the Portage branch we have found occupied kingfisher nests spaced at approximately one per stream mile. Sixty-one pellets collected along the two branches contained the bones of 287 fishes as follows: 8 salmon, 54 trout, 5 suckers, 29 minnows, 101 sculpins and 90 sticklebacks. The numerical percentages for species are given in Table II. Sculpins and sticklebacks are apparently among the most available and eels the least available to the kingfisher. Other species were taken in numbers fairly close to their relative abundance.

Small Salmon-Rearing Streams

POLLETT RIVER

The Pollett River is a small salmon-rearing stream, and salmon spawn in that part of the river below the Glades where a dam stops their upward migration.

Above the dam for 11 miles is the experimental section of the stream where an attempt is being made to assess the production of salmon smolts from various plantings of hatchery-reared salmon fingerlings (Elson, 1950).

Since assessments of the fish populations have been carried out on the

experimental section, the food of the kingfisher in that part of the stream is of special interest. Control of fish-eating birds, as part of the experiment, has interfered with the normal life of the kingfisher, but has created conditions which have given us data regarding them. Kingfisher control has not been thorough in the early part of the seasons, as at that time the smolt traps and the counting and marking of the descending smolts have largely occupied the time of the staff. Every year, during this interval, from one to three pairs of kingfishers have established nests along the experimental section.

During the summer of 1946, the year previous to bird control, 32 pellets were collected along the experimental section. In 1947, the first year of bird control, a brood of young was taken from a burrow and used for stomach analyses. In 1948 pellets were collected from nests containing eggs. A number of the birds killed during bird control were secured, and 29 of these contained enough food for analyses. In 1949 another collection of pellets was taken from a nest in which there were eggs. The analyses of the pellets and stomach contents are given in Table III.

TABLE III. Food in the experimental area of the Pollett River.

Food organisms	32 pellets July 19 to Sept. 30, 1946		*ca.* 30 pellets from nests June 2, 1948 to June 1, 1949		29 stomachs May 13 to Oct. 9, 1948		6 stomachs from nestlings June 26, 1947	
	No.	%	*No.*	%	*No.*	%	*No.*	%
Salmo salar	14	16.1	26	24.1	4	2.7		
Salvelinus fontinalis	1	1.2	18	16.7	1	0.7	12	75.0
Catostomus commersoni	27	31.0	5	4.6	34	22.8	2	12.5
Semotilus atromaculatus	3	3.4	3	2.8	3	2.0		
Couesius plumbeus	33	38.0	26	24.1	87	58.4	1	6.2
Rhinichthys atratulus	4	4.6	23	21.3	14	9.4		
Anguilla bostoniensis	2	2.3						
Fundulus diaphanus					1	0.7		
Cottus cognatus	1	1.2	5	4.6			1	6.2
Apeltes quadracus	1	1.2						
Gasterosteus aculeatus	1	1.2	2	1.9	4	2.7		
Odonata nymph					1	0.7		
Totals	87		108		149		16	

In 1946, before bird control, salmon parr of one year or older were relatively scarce, yet the 32 pellets collected that year contained remains of 14 parr being numerically 16.1 per cent of the food organisms.

Early in the seasons of 1948 and 1949, with yearling parr abundant, 30 pellets of adult nesting birds contained 26 parr, constituting 24.1 per cent of the food organisms.

In comparison with the above, the stomachs of 29 kingfishers killed in 1948 in the same area contained only one parr and three of the recently planted salmon fingerlings about 45 mm. in length. The single salmon parr was from the stomach of one of two adult birds killed on May 13, that is, during the nesting season. The fingerlings were from birds killed between August 10 and October 9. Only one of the birds examined between these dates was an adult.

Every year the adult birds have fed to a considerable extent upon the salmon parr but the juvenals have fed almost entirely upon young suckers and the smaller minnows.

MOSER RIVER

From 1939 to 1943 Moser River was our base for salmon investigations and during that time some observations were made on the life history and food of the kingfisher. This river is in the pre-Cambrian area, and its water is reddish in colour and slightly acid. Owing to its extremely stoney bed, the stream has so few areas suitable for the spawning of salmon that we considered spawning as a factor limiting its production of salmon. This river is fairly typical of many of the smaller salmon streams of southern Nova Scotia. The watershed is a rocky area with a shallow layer of stoney soil, and thus even inferior nesting sites for kingfishers are scarce.

Only two nesting sites, both inferior, were known to us, and in two of the five seasons when observations were made the kingfishers on the lower part of the river failed to bring out young. We believe that in any nesting season not more than three broods are successfully reared on the entire river system.

In this area a study of the kingfisher's food was possible only by the use of pellets, as the birds were too scarce to supply material for sufficient stomach analyses. Pellets were collected in 1940–41 and 1941–42 on the lower four miles of the river and on Mill Lake which is about 150 yards from the river. Forty-four pellets were collected along the river and 15 along the lake.

The pellets from the river contained the remains of 192 fishes and two *Odonata* nymphs (*Hagenius brevistylus*). Young gaspereau, which descend the river in great numbers, were the dominant food. Of these there were 104, being numerically 53.6 per cent of the food organisms. The numbers and percentages for other organisms were as follows: salmon parr, 10–5.2 per cent; trout, 4–2.1 per cent; suckers, 8–4.1 per cent; minnows (including 1 lake chub, 9 common shiners and 13 golden shiners) constituted 11.9 per cent; killifish, 24–12.4 per cent; sticklebacks, 10–5.2 per cent; eels, 6–3.1 per cent; three miscellaneous fishes and two insects constituted 2.5 per cent. The food taken from Mill Lake, which is shallow and weedy, consisted largely of the ninespine stickleback and the banded killifish and was similar to that which we have reported for other Nova Scotia lakes and ponds.

SALMON RIVER

In New Brunswick there are a number of streams named Salmon River, but the one with which we are dealing is a branch of the Saint John River in the northern part of the Province. This is a clear, spring-fed, but also flood-swept, gravelly stream and, unlike any of the small salmon streams listed above, it contains crayfish. It has the physical properties of a good salmon-rearing stream, and young salmon appeared to be fairly abundant. Eight pellets collected about five miles above the mouth of the stream contained 26 food items as follows: 14 salmon (2 fry and 12 parr), 3 lake chub, 5 sculpins and 4 crayfish. This is a

small collection of pellets, but is similar regarding its salmon content to collections from such a good salmon-rearing stream as the Margaree River.

BARNABY RIVER

The Barnaby is a small branch entering the tidal part of the Southwest Miramichi. In contrast to Salmon River it is broader, shallower, and flows over considerable bed rock and broken shale and has few gravel areas for the spawning of salmon. The water is slightly red in colour and, at least in the lower part, becomes fairly warm.

At the time pellets were collected along this stream, young salmon were scarce, but crayfish were fairly abundant. A few minnows and young suckers were present in the pools. Since mergansers are abundant on the Miramichi system it is probable that, earlier in the season, they had thoroughly fished this area. Thirty pellets collected here contained the remains of 1 salmon parr, 1 sucker and 34 crayfish. The preponderance of crayfish in the food is similar to that found on the lower waters of the Restigouche system.

MORELL RIVER

The Morell River of Prince Edward Island is a small salmon-rearing stream and also a noted trout stream. It is in a neo-Permian area and so is of a very different type from the streams of the mainland. This is a rich stream containing masses of long trailing pond weeds (*Potomageton*) and water buttercup, and is one stream of the Maritimes where aquatic vegetation might interfere to some extent with the feeding of the kingfisher. It has a good stock of both young salmon and trout.

On June 19, 1948, nine pellets were collected along the stream and these contained remains of 30 fishes as follows: 9 salmon parr, 2 trout, 4 smelt, 2 killifish, 12 sticklebacks and 1 dragonfly nymph (Table II).

In this small collection, salmon parr averaged one per pellet which would mean at least three per day for each adult kingfisher feeding on the stream. Sticklebacks were taken in largest number, but their volume would be much smaller than that of the salmon.

Although the pellets were taken on trout-rearing waters and small trout were abundant, only two occurred in the pellets, which may indicate that the trout were not as readily available as the other species. The smelts represent food taken during the smelt spawning run.

MISCELLANEOUS STREAMS

In 1948 pellets were collected in the Carboniferous and Devonian areas along a number of small salmon-rearing streams which are sufficiently alike to be treated together. These streams include: West, Herbert, Gaspereau, Debert, Bass and Wallace Rivers of Nova Scotia, and in New Brunswick the Coverdale of the Petitcodiac system, Cascabac Creek of the Lower Saint John, the upper Kouchibouguacis, Bartibog of the Lower Miramichi, and the lower part of Bartholomew of the Southwest Miramichi.

During ordinary water levels, the parts of these streams where pellets were collected range from 20 to 80 feet in width and are sufficiently cool to support trout throughout much of the summer. All contain minnows, suckers and sticklebacks. We have not found the freshwater sculpin (*Cottus cognatus*) or the fallfish (*Semotilus corporalis*) in Nova Scotia, but they occur in many of the New Brunswick streams.

Eighty-one pellets collected along these comparatively small streams contained the remains of 295 fishes and 4 large insects (2 water beetles and 2 dragonfly nymphs) (Table IV). Salmon constituted numerically 20.1 per cent of the organisms, trout 6.0 per cent, suckers 9.7 per cent, minnows 40.4 per cent, sticklebacks 12.7 per cent, other fishes 9.7 per cent and insects 1.3 per cent. Since many of the salmon were smolts or large parr, which have individually several times the volume of the average fish taken, the volumetric percentage of salmon would be several times higher than the numerical.

TABLE IV. Food in small salmon-rearing streams of the Carboniferous and Devonian areas.

Stream	Number of pellets	*Salmo salar*	*Salvelinus fontinalis*	*Catostomus commersoni*	*Leucosomus corporalis*	*Semotilus atromaculatus*	*Couesius plumbeus*	*Rhinichthys atratulus*	*Chrosomus eos*	*Notropis cornutus*	Cyprinidae	*Anguilla bostoniensis*	*Fundulus diaphanus*	*Fundulus heteroclitus* *	*Cottus cognatus*	*Pungitius pungitius*	*Gasterosteus aculeatus*	Insecta
Nova Scotia																		
West	2	8					2											
Herbert	1		1	5		4	6											
Gaspereau	2		7				1					1	5					
Debert	1		1														3	
Bass	8	9	1				1							2	5		16	
Wallace	5	3	5					1		3							4	
New Brunswick																		
Coverdale	34	27	2	7			29	15	10			1			6		2	
Bartibog	6	3	1	1		2		1			1					8	4	2
Upper Richibucto	2	4																
Upper Kouchibouguacis	1	1		1						1								
Bartholomew	11	1		14	2		4			19					2	1		1
Cascabac	8	4		1			2	15		2		7						1
Totals	81	60	18	29	2	6	45	32	10	25	1	9	5	2	13	9	29	4
Numerical percentages		20.1	6.0	9.7	0.7	2.0	15.0	10.7	3.3	8.4	0.3	3.0	1.7	0.7	4.3	3.0	9.7	1.3

*From estuarial part of stream.

MEDIUM AND LARGE SALMON RIVERS

Pellets have been collected along parts of some of the medium and large salmon rivers of Nova Scotia and New Brunswick, but there has been no attempt

to make a detailed study of the food of the kingfisher over any large area of these streams such as has been done for the Northeast Margaree. The studies on the Margaree have shown how the food of the kingfisher in the different parts of the stream varies with the composition of the fish populations on the different parts (White, 1937). In the tidal part of this stream young salmon were scarce, young trout not present, but a number of other fishes plentiful, and there the salmon constituted only 5.2 per cent of the kingfisher's food. Some 15 miles upstream, in a good salmon-rearing area and with trout present but other species scarce, salmon composed 87 per cent of the food. Above this area fishes other than salmon and trout became progressively less abundant, and 25 miles above the estuary salmon and trout constituted the entire food of the kingfisher. In this latter part it was shown that there was a positive correlation between the percentage of trout in the food and the water height (White, 1938). This appears to be associated with the fact that when rivers rise salmon stay closer to their original positions related to the bottom than do trout which rise more freely.

Since our recent collections of pellets on the various salmon rivers were made along relatively short areas or at only a few stations along the streams, the foods taken in these areas are not to be interpreted as representing all the kinds or percentages of the different items taken by the kingfisher on the entire river or on parts differing from those where pellets were collected.

NORTHWEST MIRAMICHI RIVER

The Northwest Miramichi is a good salmon-angling stream. We are unacquainted with the upper parts, but the lower 20 miles where pellets were collected is an excellent salmon-rearing area. There are good nesting banks for

TABLE V. Food in medium and large salmon rivers.

Food organism	29 pellets Northwest Miramichi		14 pellets Southwest Miramichi		33 pellets Tobique		27 pellets Nashwaak		188 pellets Restigouche, Upsalquitch and Matapedia	
	No.	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%
Salmo salar	42	24.1	5	6.5	20	16.0	25	39.1	13	5.2
Salvelinus fontinalis	12	6.9			3	2.4			4	1.6
Pomolobus pseudoharengus					8	6.4				
Clupeidae sp.									9	3.6
Catostomus commersoni	35	20.1	14	18.2	14	11.2	3	4.7	6	2.4
Leucosomus corporalis	1	0.6	5	6.5	4	3.2				
Semotilus atromaculatus	9	5.2	4	5.2			2	3.1		
Couesius plumbeus	18	10.3	4	5.2	7	5.6			1	0.4
Rhinichthys atratulus	15	8.6	22	28.6	21	16.8	14	21.9		
Notemigonus crysoleucas	1	0.6								
Notropis cornutus	19	10.9	5	6.5	18	14.4	9	14.0	1	0.4
Cyprinidae	1	0.6								
Fundulus diaphanus							1	1.6		
Cottus cognatus					11	8.8	1	1.6	5	2.0
Pungitius pungitius	9	5.2					1	1.6		
Gasterosteus aculeatus	5	2.9	9	11.7			2	3.1	1	0.4
Cambarus bartoni			7	9.1	15	12.0	6	9.4	212	84.1
Rana sp.			1	1.3	1	0.8				
Insecta	7	4.0	1	1.3	3	2.4				
Totals	174		77		125		64		252	

kingfishers along most of this part, and in other physical characters it is similar to the Northeast Margaree but differs from the Margaree in having more species of fishes. Being a clear, flood-swept stream it is subject to heavy predation by broods of mergansers.

Twenty-nine pellets were collected along this stream, 5 on June 21, 1946, and 24 on August 26, 1948. These pellets contained the remains of 167 fishes and 7 large insects. Twenty-four per cent of the food organisms were salmon, 7 per cent trout, 20 per cent suckers, 24 per cent minnows, 8 per cent sticklebacks and 4 per cent insects. The species and detailed percentages are shown in Table V.

Because a smaller percentage of salmon was found in the food of the kingfisher on the Northwest Miramichi than was taken by this bird on the Northeast Margaree it does not necessarily follow that its feeding on the Miramichi is less effective in reducing the salmon population.

SOUTHWEST MIRAMICHI RIVER

The Southwest Miramichi is one of the larger salmon rivers and its drainage basin occupies a large part of central New Brunswick. The main Southwest is slower and deeper than the Northwest and in some places is broken into several channels. Although this part of the river produces salmon parr in fair numbers it has not, in our opinion, such good salmon-rearing areas as the Northwest Miramichi. It has large areas of good habitats for the non-salmonid fishes, and crayfishes occur along the shores. The valley is fertile, and heavy vegetation borders the shores. We found no stream-side banks suitable for the nesting of kingfishers, but on August 28, the date of pellet-collecting on this stream, kingfishers were seen along all parts examined. The combination of very high perches and heavy ground vegetation rendered pellet collecting difficult. Only 14 pellets were collected at various places over a 15-mile length of stream about 25 miles above the head of tidal influence.

The pellets contained remains of 77 organisms including 5 salmon, 14 suckers, 40 minnows, 9 sticklebacks, 7 crayfish, 1 frog and 1 dragonfly nymph. For species and percentages see Table V. In this collection of pellets the relatively large number of minnows, especially the small blacknose dace, of which there were 22, may be accounted for by the size selectivity of young kingfishers. One pellet, evidently that of a young bird, contained remains of nine dace. The food taken is of the character that would be expected from such a habitat.

TOBIQUE RIVER

The Tobique, a branch of the Saint John River, is one of the best of the medium-sized salmon rivers. It is a fertile stream and has extensive areas of spawning and rearing grounds for salmon. Many mergansers rear their brood on this stream. Nesting banks for kingfishers are scarce along the main river but man-made banks are available, and the feeding territories near the settled parts are used by kingfishers.

On September 10, 1948, 33 pellets were collected along a section of stream from 5 to 20 miles above the mouth. These pellets contained remains of 125

food organisms which consisted of 20 salmon, 3 trout, 14 suckers, 50 minnows, 11 sculpins, 15 crayfish and 12 miscellaneous. This is one of the few areas of the Maritimes where no sticklebacks were found in the pellets. The creek chub and golden shiner were also lacking. All of these are present in the Saint John River. The scarcity of weedy backwaters in the area where pellets were collected may account for their absence in the pellets. The percentages and species found in the pellets are shown in Table V.

NASHWAAK RIVER

The Nashwaak is another medium-sized salmon stream of the Saint John River system and enters that river about 100 miles below the mouth of the Tobique. In parts it is broad and shallow and becomes warmer than the Tobique.

Twenty-seven pellets were collected along the river near the mouth of McCallum Brook, a cold branch, thus some of the food may have come from this stream. Sixty-four organisms, fish and crayfish, were represented in the pellets with an average of 2.4 per pellet. This low average and the large size of the fishes indicates that the pellets were mostly from adult birds—two of the pellets were from a riverside perch and 25 from a night roost in the woods along the river.

The pellets from the night roost averaged one parr per pellet, which we regard as a high average for such a stream as the Nashwaak. Since salmon parr often move into shallow water at twilight, the high incidence of parr might be interpreted as indicating that the salmon were more available to the kingfishers just before roosting time. In the entire collection of pellets salmon constituted the highest percentage—39.1 per cent. Blacknose dace, common shiners and crayfish occurred in significant numbers. Ten fishes of six other species were represented but no trout, although they occurred in McCallum Brook. The presence of one sculpin probably represents food from the brook. Numbers and species of the food organisms are shown in Table V.

RESTIGOUCHE SYSTEM

The Restigouche River and its tributaries, the Upsalquitch and Matapedia, are large salmon streams of northern New Brunswick.

No kingfisher pellets were collected along the upper reaches of these streams but we have made analyses of 188 from the lower parts. On September 11 and 12, 1948, when pellets were collected, a few salmon parr and fry were found, but all small fishes were apparently scarce. Crayfish, however, were plentiful in shallow water along the edge of the streams and constituted 84 per cent of the food organisms with an incidence of one per pellet.

Salmon parr and fry were second in the food but were only 5.2 per cent. A few other fishes which were taken are shown in Table V.

We saw no nesting sites for kingfishers on the lower parts of the Restigouche, but at the time pellets were collected many kingfishers were present. Apparently most of these were juvenals, as they occurred in groups of several birds. Large numbers of disgorged crayfish remains were found beneath perches along the

shores. The kingfishers had evidently been feeding upon the crayfish for some time, for many of the chitinous remains were well bleached.

The dominance of crayfish in the food may be due to the feeding of the juvenals, for Sayler (1946) has reported that, in Michigan, crayfish are readily taken by the juvenals before they start to catch fish.

Marginal Salmon Waters

In the agricultural areas of Nova Scotia and New Brunswick there are areas of certain streams, generally the lower parts, which nearly every year become too warm for young salmon. Some of the salmon survive in such places by finding spring seepages or other cooler water in which they congregate during the critical periods. The headwaters and feeders of these streams often contain trout and have small areas which are favourable for salmon. Trout from the feeder streams migrate into the larger parts late in the fall or early in the spring but return to cool waters when the river water becomes warm. These warm streams generally contain an abundance of fish of a number of species and are excellent feeding grounds for kingfishers. The common fishes found are shown in Table VI.

NORTH RIVER

The North River, a branch of the Petitcodiac, flows mostly through agricultural land and is marginal salmon water.

In 1944 and 1945, 41 pellets were collected along the lower four miles of this stream. These pellets contained the remains of 222 fishes, 1 frog and 2 large insects (Table VI). Spawning salmon have access to this stream and hatchery fry have been planted in it, but only 5 salmon parr and 4 trout were among the

Table VI. Food in marginal salmon waters (warm lower parts of streams).

Food organism	41 pellets North River, Petitcodiac system		27 pellets Cocagne and Bass Rivers, N.B., Nine-mile River, N.S.		9 pellets Canaan River, N.B.	
	No.	%	*No.*	%	*No.*	%
Salmo salar	5	2.2	4	3.7	1	6.2
Salvelinus fontinalis	4	1.8				
Osmerus mordax			4	3.7		
Catostomus commersoni	54	24.0	24	22.2	2	12.5
Leucosomus corporalis					6	37.5
Semotilus atromaculatus	6	2.7	4	3.7		
Couesius plumbeus	49	21.8	1	0.9		
Rhinichthys atratulus	16	7.1	10	9.3		
Chrosomus eos	12	5.3	1	0.9		
Notropis cornutus			6	5.5	1	6.2
Notropis heterolepis	2	0.9				
Esox niger					5	31.2
Anguilla bostoniensis	7	3.1	1	0.9		
Fundulus diaphanus	42	18.7	6	5.5	1	6.2
Pungitius pungitius			5	4.6		
Gasterosteus aculeatus	22	9.8	39	36.1		
Apeltes quadracus	3	1.3				
Rana sp.	1	0.4	1	0.9		
Insecta	2	0.9	2	1.9		
Totals	225		108		16	

food remains in the pellets. The pellets containing trout were found near the mouths of cooler streams. Young suckers were dominant in the food, with the lake chub and banded killifish occurring in somewhat smaller numbers. Sticklebacks formed an important part of the food from this stream. A few redbelly dace and blacknose shiner occurred in pellets collected near weedy backwaters.

COCAGNE, BASS AND NINE-MILE RIVERS

The Cocagne River discharges into Northumberland Strait, the Bass into Bay Chaleur and the Nine-mile is a branch of the Shubenacadie River of Nova Scotia. They are all small rivers, and during the summer the lower parts become too warm for young salmon.

Twenty-seven pellets which were collected on the lower parts of these streams contained remains of 105 fishes, 1 frog and 2 insects (Table VI). Sticklebacks, especially the threespine stickleback, were the dominant fishes in the food. Suckers and blacknose dace were second and third in numbers. Four salmon and 4 smelt occurred in the pellets from the Cocagne River. The smelt were taken during their spawning run.

CANAAN RIVER

The Canaan River is a branch of the lower Saint John and is larger than the other marginal salmon waters mentioned above. It differs from most other streams in the composition of its fish fauna since, besides the common forms, it contains the fallfish, yellow perch and chain pickerel. Although a considerable number of species occur, it has a scanty population of fish of the sizes taken by kingfishers, but the small alder-fringed branches have an abundance of such fish. The condition in the main stream is probably due to the presence of the voracious pickerel and possibly the perch and large fallfish, and the main stream is also heavily fished by mergansers.

Pellets were scarce along the river and only nine were obtained. These contained the remains of only 16 fishes (Table VI). The pellets were evidently from adult birds, as the fishes were larger than those taken by juvenals. Five of the fishes were pickerel ranging from four to nearly seven inches in length, and six were fallfish. Salmon were represented by a single specimen which was probably a smolt taken during migration.

LAKES AND PONDS

The lakes and ponds of the Maritimes are largely of two characters according to the geological formation in which they occur.

In the Carboniferous areas of the mainland and the neo-Permian of Prince Edward Island there are comparatively few lakes, but most of these are calciferous and fertile. Some of these, especially those of Prince Edward Island, are very rich and produce an abundance of fishes. In the Carboniferous and parts of the Devonian areas much of the land has been opened to farming and, with road improvement, cut banks have been made along the roads and sand and gravel deposits have been opened, making suitable banks for kingfishers'

nests. Thus nearly every pond or lake in these areas has a nesting site near enough so that the water may be used as a feeding place for the nesting birds.

In the pre-Cambrian area of Nova Scotia, and in some of the Devonian granite areas where there are many lakes, the country is wooded or barren and the waters are largely acid in character and have a low productivity. These areas are rocky or extremely stoney and there are few nesting sites for kingfishers. In these areas of the central part of western Nova Scotia many of the lakes are used as storage reservoirs for power plants. The alternate flooding and lowering of these probably increases the fertility, for they produce fairly good populations of the smaller fishes which can tolerate these waters. We have not found the threespine stickleback in any waters of these areas, but its place is taken by the ninespine stickleback which sometimes occurs in abundance.

GASPEREAU LAKE

Gaspereau Lake is one of the larger lakes of the Devonian area of Nova Scotia and is used as a storage basin. Dams and embankments have been made and at high-water level the storage basin covers much land which was originally marsh or forest. As its name implies, it is a spawning and rearing area for alewives or gaspereau which now enter the lake through a fishway. The young remain in the lake for several months before descending to the sea.

On July 25 the lake was full, and no pellets could be collected along shore as many dead trees provided numerous fishing perches over the water. At this time, however, 12 pellets were collected at resting perches in a nearby gravel pit where kingfishers had nested. These pellets had been dropped in late April or early May when the birds were constructing their burrows. On September 24, after the water had been lowered to the level of the original basin, 24 pellets were collected along the lake.

TABLE VII. Food in ponds and lakes.

Food organism	36 pellets Gaspereau Lake, King's Co., N.S.		17 pellets Small ponds and lakes of central N.S.		7 pellets Grand and Washademoak Lakes, N.B.	
	No.	%	*No.*	%	*No.*	%
Pomolobus pseudoharengus	47	15.0				
Catostomus commersoni	9	2.9	5	4.2	1	5
Semotilus atromaculatus			3	2.5		
Couesius plumbeus			1	0.8		
Rhinichthys atratulus					1	5
Notropis cornutus					1	5
Notemigonus crysoleucas	9	2.9	3	2.5	7	35
Ameiurus nebulosus	5	1.6			1	5
Esox niger					3	15
Anguilla bostoniensis					1	5
Pungitius pungitius	139	44.4	94	78.3		
Fundulus diaphanus	33	10.5	4	3.3	1	5
Morone americana	19	6.1	2	1.7		
Perca flavescens	50	16.0	6	5.0	4	20
Rana sp.	1	0.3				
Insecta (*Odonata*)	1	0.3	2	1.7		
Totals	313		120		20	

The pellets from the nesting site, being pellets of adult birds, contained mostly large food fishes and averaged less than two fish per pellet. All but two of the pellets from the lake shore were pellets from juvenals and averaged 12 fish per pellet.

The 36 pellets contained remains of 311 fish, 1 frog and 1 dragonfly nymph. The ninespine stickleback was the dominant food and constituted numerically 44.4 per cent. Young of the yellow perch and alewife and the banded killifish were major food fishes. Other fishes as shown in Table VII were taken in smaller numbers.

GRAND AND WASHADEMOAK LAKES

Grand and Washademoak are two large lakes of the lower Saint John system and are situated in fertile parts of the Carboniferous area. We found kingfishers scarce in this area and this condition was correlated with a scarcity of small fishes around the shores. These lakes contain chain pickerel, small-mouth bass and burbot, and the presence of these undoubtedly accounts for the scarcity of small shore fishes. Much searching beneath good kingfisher perches yielded only seven pellets.

These pellets contained remains of only 20 fish of nine species (Table VII).

Here, as in the Canaan River where pickerel were present, the pellets show that the kingfishers fed rather readily upon the advanced young of this fish.

SMALL LAKES AND PONDS

A collection of 17 pellets was made along several small lakes and ponds of the Devonian part of central Nova Scotia. Unlike Gaspereau Lake, these waters had no run of alewives entering them. Some of these contained trout but no remains occurred in the pellets.

The food found in the pellets consisted of 118 fish and 2 dragonfly nymphs. Of these organisms 94 or 78.3 per cent were ninespine sticklebacks. Except for alewives, the composition of the food is similar in character to that found at Gaspereau Lake.

SEA SHORE

Along the extensive shoreline of the Maritimes there is a variety of habitats. Kingfishers seldom feed along the rocky shores or wave-swept beaches or along the shore of the Bay of Fundy where, on account of the great tides, there is an extremely wide intertidal zone. Many feed along the quiet bays and estuaries and the salt-water marshes of other parts of the coast, especially after the juvenals have started fishing. We have divided the area of our most extensive collecting into three zones, but as shown by the analyses (Table VIII) there are only minor differences in the food taken in the different zones. We have picked up miscellaneous pellets at various places along the shore, and the food in these has been essentially the same as that from areas where we have made the larger collections.

Sticklebacks, especially the threespine stickleback, *Gasterosteus aculeatus*, and its close relative, *G. bispinosus*, form the greater part of the kingfisher's

food on most of the salt-water habitats. In the southern part of Northumberland Strait, i.e. the Nova Scotia–Prince Edward Island part, the percentage of sticklebacks was exceeded by mummichogs (*Fundulus heteroclitus*). The ninespine stickleback occurs in the food in all weedy brackish-water habitats.

Pellets collected along Pownal Bay, P. E. I., contained two trout fingerlings but these were evidently from nearby freshwater springs and are not to be classed as sea food. A salmon from the Tabusintac estuary collection was probably a smolt taken from estuarial waters.

Silversides (*Menidia notata*) occur in great numbers around the Gulf of St. Lawrence, but are taken by the kingfisher mostly around wharves and other places where they are forced close to the surface by predacious fishes. A few flounders, sculpins and other fishes as well as crustaceans are occasionally taken.

TABLE VIII. Food at sea shore.

Food organism	46 pellets Northumberland Strait, N.S., and P.E.I.		27 pellets Northumberland Strait, N.B.		33 pellets Tabusintac River estuary, N.B.	
	No.	%	*No.*	%	*No.*	%
Salmo salar					1	0.7
Salvelinus fontinalis	2	1.7				
Osmerus mordax	3	2.5				
Fundulus heteroclitus	74	62.7	26	19.6	48	32.4
Fundulus diaphanus			1	0.8		
Pseudopleuronectes americanus	1	0.8	2	1.5		
Pungitius pungitius	5	4.2	13	9.8	9	6.1
Apeltes quadracus			1	0.8	1	0.7
Gasterosteus aculeatus	16	13.5	45	33.8	73	49.3
Gasterosteus bispinosus	11	9.3	23	17.3	15	10.1
Menidia notata	1	0.8	19	14.3		
Myoxocephalus sp.	4	3.4	1	0.8		
Teleostei unidentified	1	0.8	2	1.5		
Brachyura unidentified					1	0.7
Totals	118		133		148	

ECONOMIC STATUS

The economic status of fish-eating birds has long been a controversial subject and, as pointed out by Vladykov (1943), the reason for the controversy is often that those holding divergent opinions have generalized from specific cases. He has also given examples of some of the complexities of the fish-bird problem. Others have realized that conclusions must be based on extensive investigations. Taverner (1934) has stated, "The Belted Kingfisher lives upon small fishes and whether or not this constitutes a grave economic offence is a question that cannot be answered off-hand". Sayler and Lagler (1946) have made a comprehensive study of the food of the kingfisher, and have concluded that in Michigan most of the kingfisher's feeding is innocuous, that it is undesirable about fish hatcheries and rearing stations, and that general control on natural waters is not biologically justified.

In defence of the kingfisher, it has been stated by several authors that trout (and we presume that these authors would include salmon) are not as easily caught by the kingfisher as are the so-called "coarse-fishes". Bent (1940) has stated, ". . . wild trout are not so easily caught, for as every trout fisherman knows, the trout are seldom seen in the open places except when darting swiftly across them, but spend their time hiding under overhanging banks or under logs or stones and only dashing out occasionally to capture their prey". Certainly this behaviour would not protect them from their aquatic enemies, but could be protection only from some enemy which attacks them from above, and might well be interpreted as indicating that the only trout surviving are those which have been able to find and use such shelters against the attacks of kingfishers and other fish-eating birds.

In the Maritimes both trout and salmon may be seen in open clean pools and rapids and, when the adult kingfishers are feeding their young, both the salmon (White, 1938) and the trout (Pollett River, Table III) may be selected as food for the young. At other times, however, except when they select for size, they apparently take those fishes which are most abundant and in shallow water.

Our investigations, especially those on the upper Kennebecasis River, have indicated that although the kingfisher may take large numbers of trout from some naturally overstocked trout streams, this may be beneficial. However, they also take large numbers of freshwater sculpins (*Cottus cognatus*, Table II) from some of the overstocked streams. The sculpins are said to feed upon trout fry (Bent, 1940). The thinning of the trout population might be more efficiently done by the sculpins taking the small fry than by the kingfishers taking the fingerlings. Also the sculpins are readily eaten by the larger trout. Thus instead of the kingfisher benefiting the trout by taking sculpins, as suggested by Bent, this may actually be detrimental. We give this example as one of the complexities of the problem which can be solved only by careful investigation.

The economic importance of non-migratory trout of the stream depends upon the food capacity of the stream to produce large trout, as only those which grow to a catchable size are of value to the angler. For the salmon the case is different, since they remain in the stream for only two or three years and then make their great growth in the sea. Since one in eight or ten of the descending smolts may return as adult salmon, the removal of the advanced salmon parr may constitute a real economic loss.

In most, if not all of our good salmon-rearing streams of the Maritimes, mergansers reduce the population of young salmon and other fishes far below the carrying capacity of the streams. This has been well demonstrated by the recent experiment in bird control on the Pollett River and by numerous field observations on other streams (Elson, 1950). The mergansers generally leave the salmon-rearing areas after they have reduced the fish population to a low level, but kingfishers, by their different method of fishing, are able to feed over these areas and further reduce the number of young salmon. Under these conditions their feeding is undoubtedly detrimental. However, the bird-control experiment has also demonstrated that, when mergansers are kept from the

stream, minnows and suckers increase, and the juvenal kingfishers feed almost exclusively upon the small minnows and suckers which compete to some extent with the salmon. Under these conditions the feeding by the young kingfishers is probably beneficial.

In areas where young salmon and trout are scarce because of limited spawning areas, the feeding of the kingfisher may greatly reduce the population of these fishes and be detrimental.

In the Maritimes much, if not most, of the feeding of the kingfisher is done in areas which are not frequented by commercially important fishes, and in these waters their feeding is harmless. In many, and perhaps most cases, kingfishers are harmless to the production of desired species and in some cases may be beneficial. In particular cases where salmon and trout are not abundant but are still predominant in the population, kingfishers may be harmful to those species. Even in streams in which the salmonids predominate, kingfishers do not appear in general to be nearly as harmful as mergansers, and there are believed to be few cases in which organized destruction of kingfishers would be economically justified.

The kingfisher has a greater aesthetic value than many other birds and we see no reason why it should not have the same protection afforded other migratory species. However, since man has been responsible for greatly increasing the kingfisher population of the Maritimes he should be justified in exercising control over them at fish-rearing establishments or other places where adequate investigations have shown that their feeding is harmful to the fishing interests.

REFERENCES

BENDIRE, CHARLES EMIL. Life histories of North American birds. *U.S. Nat. Mus., Spec. Bull.*, No. 3, 1895.

BENT, ARTHUR CLEVELAND. Life histories of North American cuckoos, goatsuckers, humming birds, and their allies. *U.S. Nat. Mus. Bull.*, No. 176, pp. 111–129, 1940.

BEYER, GEORGE EUGENE, ANDREW ALLISON AND HENRY HAZLITT KOPMAN. List of the birds of Louisiana, Part 5, *Auk*, **25**, 439–448.

BRALLIAR, FLOYD. Knowing birds through stories. Frank and Wagnalls, N.Y. 1922.

BREWSTER, WM. The birds of the Lake Umbagog region of Maine, Part 3. *Bull. Mus. Comp. Zool.*, **66**, 409–415, 1937a.

CAREY, HENRY REGINALD. Remarks on the habits of the kingfisher on the New Hampshire sea-coast. *Bird-Lore*, **11**, 161–164, 1909.

ELSON, P. F. Increasing salmon stocks by control of mergansers and kingfishers. *Fish. Res. Bd. Canada, Prog. Rep. Atl.*, No. 51, Note No. 116, pp. 12–16, 1950.

FORBUSH, EDWARD HOWE. Birds of Massachusetts and other New England States, Part 2. Mass. Dept. Agric., Boston, 1927.

ROBERTS, THOMAS SADLER. The Birds of Minnesota, Vol. 1. Mus. of Nat. Hist., Univ. of Minnesota, 1932.

SAYLER, J. CLARK II, AND KARL F. LAGLER. The eastern belted kingfisher, *Megacerye alcyon alcyon* (Linnaeus) in relation to fish management. *Trans Amer. Fish. Soc.*, **76**, 97–117, 1946.

SUTTON, GEORGE MIKSCH. Notes on the flight of the chimney swift. *Cardinal*, **2**, 85–92, 1928.

TAVERNER, P. A. Birds of Canada. *Nat. Mus. Canada Bull.*, No. 72, *Biol. Series*, No. 19, 1934.

VLADYKOV, VADIM D. Relation between fish and fish-eating birds. *Can. Field Nat.*, **57**, 124–132, 1943.

WHEELOCK, IRENE GROSVENOR. Regurgitative feeding of nestlings. *Auk*, **22**, 54–70, 1905.

WHITE, H. C. A preliminary report on trout investigations in Forbes Brook in 1925 and 1926. *Contr. Can. Biol. and Fisheries*, N.S. **3**(15), 365–375, 1927.

The food of kingfishers and mergansers on the Margaree River, Nova Scotia. *J. Biol. Bd. Canada*, **2**(3), 299–309, 1936.

Local feeding of kingfishers and mergansers. *Ibid.*, **3**(4), 323–338, 1937.

The feeding of kingfishers: Food of nestlings and effect of water height. *J. Fish. Res. Bd. Canada*, **4**(1), 48–52, 1938.

Bird control to increase the Margaree River salmon. *Bull. Fish. Res. Bd. Canada*, No. 58, 1939a.

Change in gastric digestion of kingfishers with development. *Amer. Naturalist*, **73**, 188–190, 1939b.