THE LIFE HISTORY OF THE AMERICAN CROW

CORVUS BRACHYRHYNCHOS BREHM

DISSERTATION

Presented in Partial Fulfillment of the Requirements
for the Degree Doctor of Philosophy in the
Graduate School of The Ohio State
University

By

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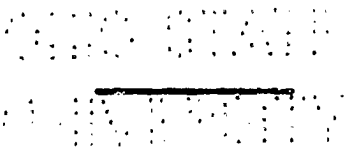

The Ohio State University

1952

Approved by:

Charles A. Dambach

Adviser

ACKNOWLEDGMENTS

This report is not mine alone, but has been made possible by the host of people who have contributed their time and knowledge and whose interest has provided stimulation and encouragement. Though they are too many to mention individually, and many probably are unaware of the extent of their contribution, may they know that I am appreciative.

Dr. Charles A. Dambach acted as adviser from the beginning of this study and I am deeply grateful for his many valuable suggestions and helpful encouragement. Dr. E.H.Dustman, through the Ohio Cooperative Wildlife Research Unit, gave financial assistance and furnished equipment without which much of the data would have been enormously more difficult, if not impossible, to obtain. Dr. Milton B. Trautman provided information and suggestions and his interest and enthusiasm have been of great help.

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The personnel of the Ohio Division of Wildlife helped in many ways. They furnished information about roost locations, flight lines, and crow hunters. They furnished specimens and some equipment, and

were helpful in every way possible.

H. ALbert Hochbaum and Lyle K. Sowles of the Delta Waterfowl Research Station in Manitoba were most helpful during my brief visit there. To all of the many people who took the time and trouble to respond to the questionnaires which were sent, I take this opportunity to express my appreciation.

My wife Tommy has typed and retyped the manuscript, has helped with proof reading and has endured the many minor hardships and inconveniences which have been her lot during the preparation of this report. To her belongs a considerable share of the credit.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Although the American crow is a common or abundant bird over large portions of the United States, relatively little recent investigation has been made of its life history other than its food habits. There are conspicuous gaps in the information available in the literature. The crow is reputed to be of great economic importance to farmers and sportsmen, and although this importance is controversial it is desirable to re-examine its status in the light of current agricultural practices and the present range and abundance of the birds. This study brings together current knowledge of the bird and permits its re-evaluation in the light of more life history data than has heretofore been available.

Probably few birds in the United States are familiar to so many people as is the American crow. Big, black and conspicuous, subject of story and fable, it is present over most of our area where man and his activities are found. The crow is not a popular bird. The name to most men signifies sly cunning and treachery, the robbing of crop fields, and the destruction of wildlife. This reputation is based in part upon fact, but superstition, erroneous observation, and mistaken opinion have also contributed to its development.

The color of the crow in itself almost forbade any widespread popularity for the bird. Black was associated for centuries with witchcraft, evil, and disaster, and black animals were looked upon with suspicion, if not with fear. We believe today that we have outgrown these old superstitions, but black is still a hue with certain

fearful or unpleasant associations and few people have special fondness for it.

The crow is more or less closely associated with man's activities. It followed and prospered with our ancestors through the wilderness. This is not an ingratiating characteristic in a wild animal, and we have always dealt harshly with those who attempt to profit by our enterprise.

In spite of its bad reputation the crow has long been an interesting and integral part of the rural American scene. The long evening flight lines in fall and winter, although perhaps not consciously appreciated, would probably be sorely missed if they disappeared. The woodlot nests and the unmelodious but expressive voice of the bird are other familiar and interesting features of crow country. Thoreau said, "This bird sees the white man come and the Indian withdraw, but it withdraws not. Its untamed voice is still heard above the tinkling of the forge. It sees a race pass away, but it passes not away. It remains to remind us of aboriginal nature."

Certain specific traits of the crow give rise to its questionable economic status. Its close association with agricultural enterprise, its omnivorous food habits, and its characteristic flocking habits in fall and winter contribute to its unpopular relationship with man. On the other hand, careful observation and investigation reveal much to be said on the credit side for the crow.

This paper is the result of such an investigation. It includes the results of more than one thousand hours of field observation and

many more hours of library work. It reveals some weaknesses of men as well as some of crows, and points out some ways in which it is believed that the relationship between the two might be improved. It is not anticipated that this work will settle the old controversy, but rather will point out the futility of it and make clear the efficacy of dealing with each problem separately and on the basis of the specific factors and conditions pertaining to it.

For the purposes of this paper the assumption is made that our knowledge of the ecology and behavior of man exceeds that available for the crow, and is sufficient for the objectives of this problem. In order to examine the relationship of crows to men and to other organisms in their environment, here is first recorded what is known of crows.

METHODS

Systematic field observations of the habits of crows were begun in 1948 while the writer was operating a farm in northwestern Ohio. After an examination of the literature indicated that further investigation would be worth while, this study was initiated and field work consisting of detailed observations of crows at all seasons was conducted through 1949, 1950, and 1951. Special emphasis was devoted to collecting data during the nesting period and during the time the birds were in fall and winter flocks. Throughout this study the writer was employed as an instructor in the Department of Zoology and Entomology at the University, and thus vacations, week-ends, evenings and week-day periods when class schedules permitted, could be devoted to field work. Several students were assigned special field problems covering certain aspects of the crow's life history. Seven such studies were carried out. Twenty-six young crows were banded where it was anticipated that they could be observed in subsequent seasons. Three broods of young from nests on the University farm at Columbus were color banded in 1951. No opportunity has yet been afforded to locate and make further studies of these birds. Observations covering periods of a week or more were made at each of eight nests, and more limited data were collected from more than a hundred nests. During 1949 and 1950 ten young crows were taken from nests and reared in captivity to enable observation of their reactions under controlled conditions.

Specimens were collected at roosts where sportsmen and conservation workers had shot the birds. Fellow students organized crow hunts and contributed the birds shot whenever timely information was required. The writer solicited aid of this kind from friends and coached them in the technique of correctly aging crows, so that considerably more information was gathered than could have been collected by one man working alone. About 650 dead specimens were examined during the period from October 1948 to June 1950.

Observations at nests were made from blinds or other places of concealment in the vicinity of the nest tree. Seven-power binoculars and a 15 power telescope were used in making the observations. In several instances it was possible to park an automobile within two or three hundred yards of a nest. At that distance the crows did not appear to be disturbed by the observer as long as he remained in the car, and general observations could be made by using good binoculars or a telescope.

A blind was placed adjacent to a garbage dump near Columbus during June and July of 1950. In this manner flocks of yearling birds and family groups of adults and fledglings were closely observed.

Nest observations were facilitated by the use of climbing irons, a 32-foot magnesium extension ladder, and a 15-foot bamboo pole with a mirror attached at the tip. This equipment was somewhat cumbersome to transport, but was indispensible in determining the contents of high nests.

Egg sets in the United States National Museum, the Ohio State Museum, and the collection of Homer Price of Payne, Ohio were examined during 1948 and 1949. Measurements were taken and data collected from the accompanying records.

Studies were made of the banding records and food habits data in the files of the U.S. Fish and Wildlife Service up to August, 1951.

In June of 1949 the writer attended the National Crow Shooting Contest in Wood County, Ohio, and the 201 birds killed were examined to determine age and sex. A trip was made during June of 1950 to the Delta Waterfowl Research Station in Manitoba and through parts of the Aspen Parklands and pot-hole regions of that province to observe the behavior of crows in waterfowl breeding areas.

Letters and questionnaires (pp. 7-8) were submitted to game protectors in each county in the state during the 1948-49 and 1950-51 seasons, in order to locate winter concentrations of crows in Ohio. This same questionnaire was sent to game protectors in Indiana during the 1948-49 season. Another letter and questionnaire (pp. 9-10) were sent to amateur and professional ornithologists in marginal crow range and in other areas in the United States and Canada where additional information on the status of the bird appeared to be desirable. The response was good and supplied needed information for eighteen states and three Canadian provinces.

Considerable time was spent in the field watching the behavior of crows at their roosts and in flight to and from their feeding areas. Most of the roost observations were made in central Ohio.

Ohio Cooperative Wildlife Research Unit
The Ohio State University
Columbus 10, Ohio

Dear Sir:

A survey is again being made of the winter crow population in Ohio. This is to request your further cooperation. Will you please fill out the attached form and return it in the enclosed self-addressed and stamped envelope.

In filling out the evening flight portion of the questionnaire, report only good sized flocks of crows observed late in the afternoon and most certainly headed for the evening roost. Please check or underline the direction which approximates that in which the crows were observed to fly. For location, please state the county, and in which part of the county the observation was made.

Very truly yours,

E. E. Good

E. E. Good, Assistant Leader
Ohio Wildlife Research Unit

EEG:jv
Enclosure

Questionnaire to County Game Protectors

1. Location of any crow roosts in your own or adjacent states (Give county, distance and direction from nearest town, main highway etc.)

2. Direction of evening crow flights in your locality or elsewhere in your state. (If you have observed evening flights in several locations, give separate data for each.)

North
N. East
East
S. East
South
S. West
West
N. West

Location: _____

_____

_____

_____

2. Direction of evening crow flights in your locality or elsewhere in your state. (If you have observed evening flights in several locations, give separate data for each.)

North
N. East
East
S. East
South
S. West
West
N. West

Location: _____

_____

_____

_____

North
N. East
East
S. East
South
S. West
West
N. West

Location: _____

_____

_____

_____

North
N. East
East
S. East
South
S. West
West
N. West

Location: _____

_____

_____

_____

Columbus, Ohio
December, 1950

Dear Sir:

As part of a study dealing with the life history and ecology of the crow, we are seeking the cooperation of persons in a number of localities over its range. Any information which you can furnish will be greatly appreciated.

Enclosed is a form which we are requesting you to fill out and return in the self-addressed envelope. If the space allotted on the form is insufficient please use the reverse side to complete your answers or for any other comments or information which you care to contribute. Observations other than those covered by the form are most welcome as are names and addresses of persons who might be able and willing to furnish additional information.

Thank you for your cooperation.

Very truly yours,

E. E. Good

EEG:jr

Enclosure

Questionnaire to Ornithologists

Suitable blanks in the table below should be filled with numbers selected from the following lists. (Estimate to the best of your ability)

In Summer Crows nest in the various parts of your state in which of the following concentrations.

1. 5 or more nests per square mile
2. 1 to 5 nests per square mile
3. 1 nest per 2 or 3 square miles
4. 1 nest per 4 or 5 square miles
5. Nests are uncommon or rare
6. Absent

In Winter in an average day afield you would expect to see which of the following numbers of crows in the various parts of your state

1. Thousands
2. Hundreds
3. Dozens
4. Several
5. Few if any
6. None

Portion of your state	Summer	Winter
North		
South		
East		
West		
N.East		
S.East		
N.West		
S.West		

Use only the blanks which apply. If crows are absent all across the northern part of your state in winter but are present in small numbers in the south, mark the north-winter space 6 and the south winter space 4 or 5 whichever applies leaving other spaces blank.

If the distribution is not uniform and the reason is apparent please state what it is. (Example: No forest growth, Desert over part of state, etc.)

If a subspecies other than the eastern crow is present please state its approximate range in your state.

your state	Summer	Winter
North		
South		
East		
West		
N.East		
S.East		
N.West		
S.West		

Use only the blanks which apply. If crows are absent all across the northern part of your state in winter but are present in small numbers in the south, mark the north-winter space 6 and the south winter space 4 or 5 whichever applies leaving other spaces blank.

If the distribution is not uniform and the reason is apparent please state what it is. (Example: No forest growth, Desert over part of state, etc.)

If a subspecies other than the eastern crow is present please state its approximate range in your state.

If the crow reaches the limit of its range in your state please indicate on a rough map or by counties the approximate boundary of such range.(Use other side of sheet if necessary)

If you know or believe the status of the crow to have changed or to be changing in your part of the country please state briefly the nature of such change. (Examples: Extending range, increasing or decreasing in abundance)

Some difficulty was encountered in locating roosts within the time available for field work. Preliminary observations included the plotting of the direction of flight lines observed throughout the region. This enabled a rough approximation of the location of roosts, but it was found that in practice they could not be located as readily as had been anticipated.

All observations pertaining to flight lines and the size of feeding area covered by the birds from a single roost have been based upon afternoon and evening field work. Since most crows leave the roost before daybreak in the morning it is virtually impossible to follow their movements at that time. The return flight begins in late afternoon and it is possible to follow flights across country to the roosts before dark. This can be done by automobile in flat country where roads occur at regular intervals, but even under favorable conditions it is easy to lose sight of the birds and probably more such attempts fail than succeed. It is nearly essential to have two persons in the car, one to drive and one to observe and map the route.

The writer made several attempts to follow crows and locate roosts by using light planes. Most of these failed for one cause or another, but after several attempts some of the difficulties were overcome and a flock was successfully followed from feeding ground to roost. The flock would mill about and disperse when disturbed by the plane, so it was necessary to fly at altitudes above 1000 feet to avoid frightening the birds. This caused difficulty in keeping them

in sight at all times, particularly when the flock was small. A 7 power binocular was found to be helpful for this purpose. A Piper Cub proved to be the best plane tried. Its relatively slow speed and high wing afforded excellent visibility, especially when the side of the cockpit was opened. Even such a slow plane as this traveled much faster than the crows and it was necessary to constantly circle above them to keep them in sight. The planes were used over intensively farmed land and it is believed that such a method would not prove feasible in areas with a high per-centage of forest cover. The crows were almost invariably lost to view when they entered or flew over a woodlot. Where these areas were small and widely separated, the birds could generally be relocated as they passed through or over the woodlot to open land again. Where such cover occurred in large blocks or strips, the birds would be invisible for such long periods that they would be lost. Crows do not always fly the shortest route to their roost, as is popularly believed, and to lose sight of a flock for more than a few seconds often means failure for the attempt.

No adequate method for determining crow populations has been developed. Winter populations of crows can be estimated more readily than summer because fairly good estimates of the numbers occupying winter roosts can often be made. When the roosts are very large the problem of estimating numbers becomes enormously more difficult. Aldous (1944 p.292) gives an excellent description of the arrival of birds at a large roost. He estimated that 200,000 crows used

this particular roost. He says, "Quite accurate counts were made of the arriving birds until about 40,000 had entered, after which they came so fast that counting was impossible. They approached in a solid bank from three-fourths of the horizon and from as far as field glasses could reach. A rough estimate was of 25,000 in view at one time and they continued to arrive at that rate for 45 minutes." Under such circumstances only estimates can be made.

Attempts were made to determine the breeding crow population on an area of farm land in central Ohio which was about four square miles in extent. The results were far from satisfactory. Counts of birds in the area reveal little about the breeding population for the number of non-breeding birds is not known. In the area where this count was attempted it was discovered that a flock of unmated birds, which varied in size from 35 to 75 individuals, was present much of the time. The flock dispersed somewhat through the day and it was impossible to determine its size except on rare occasions. The results, as indicated above, were so variable that they were of no value in attempting to calculate percentages.

An attempt to count all of the occupied nests in the area was likewise unsuccessful. It was originally believed that little difficulty would be experienced in spotting new nests in April before the leaves appeared. It is possible for an experienced observer to do this, but on a large area the task is time-consuming and laborious. Many nests are quite conspicuous early in the season, but others will be overlooked by all but the most meticulous workers. Since

crow nests are so well constructed, many will last through several seasons without disintegration apparent from the ground. The use of binoculars is helpful in determining the age of nests. The mere fact that a nest is new is no proof that it represents a nesting pair. The nest destruction by predators was found to be extremely high in Ohio, while this study was being conducted, and in many areas a majority of the nests had been destroyed before the nest was located. This could generally not be determined from the ground. It is not known how much renesting may occur, but it is known that nests destroyed early in the season result in second attempts by the breeding pairs. This being true, it then becomes necessary to climb to every nest. This is an almost impossible task if the sample is at all adequate. In areas where few crows are present, the occupied nest count might be feasible.

TAXONOMY AND DISTRIBUTION

Taxonomy

The Passerine family Corvidae, which includes the crows, ravens, magpies and jays, is worldwide in its distribution, only a few islands being without representatives. The subfamily Corvinae, to which the crows belong, is also widely distributed, but in the western hemisphere does not extend south of Jamaica and Central Mexica. This subfamily includes the largest of the Oscines or singing birds. The crow is not often thought of as a "singing" bird, but the structure of the vocal organs clearly shows its association with this group.

The genus Corvus is represented by five species in continental North America north of Mexico. These include the raven, Corvus corax Linnaeus, the white-necked raven, Corvus cryptoleucos Couch, the common crow, Corvus brachyrhynchos Brehm, the northwestern crow, Corvus caurinus Baird, and the fish crow, Corvus ossifragus Wilson. All of these occur in the United States.

The raven is much larger than the crow and is widely distributed in the less-developed sections of the country. In the East it is found in the northern forests and south in the mountains to Georgia, and it occurs over most of the West, especially in the arid regions. The white-necked raven is a crow-sized bird whose range includes arid portions of Texas, New Mexico, Arizona, Colorado, and Oklahoma; except for a small area in southwestern Oklahoma its range does not overlap that of the crow. The fish crow is a coastal

species found along the Atlantic and Gulf coasts from Massachusetts to Texas. The northwestern crow is another coastal species occurring from the Alaska peninsula and Kodiak Island south to the Puget Sound region of Washington.

Four subspecies of the common crow have been described. The eastern crow, Corvus b. brachyrhynchos Brehm, occurs from southern Alaska, northern Mackenzie, southern Keewatin, southern Quebec, and Newfoundland, south to Maryland and the northern portions of the Gulf states, and west to the Great Plains.

The southern crow, Corvus b. paulus Howell, is somewhat smaller than the eastern crow and the bill is shorter and more slender. Measurements of the subspecies are given in Table 1. The southern crow ranges south from the District of Columbia, central Tennessee, and southern Illinois. There is considerable overlapping of the ranges of this subspecies and the preceding one.

The Florida crow, Corvus b. pascuus Coues, is smaller than the eastern crow, but somewhat larger than the southern form. Its feet and bill are especially large and heavy. Its range includes most of peninsular Florida and a portion of southeastern Georgia. It intergrades with the southern crow in Georgia and in the northwestern part of the Florida peninsula.

The western crow, Corvus b. hesperis Ridgway, is the form found west of the Great Plains. It is smaller than the eastern subspecies and has a smaller bill. Its range includes southern British Columbia, southern Saskatchewan, and Montana, south to

TABLE 1

AVERAGE MEASUREMENTS OF THE SUBSPECIES OF CORVUS BRACHYRHYNCHOS BREHM

Sex	Subspecies	Wing	Tail	Exposed Culmen	Depth at Nostril	Tarsus	Middle Toe
Male	brachyrhynchos	321	182	51.5	19.5	62	38
Male	pascuus	304	175	51.5	19.	62.5	38
Male	hesperis	302.5	171	47.5	16.5	57.5	35.5
Male	paulus	290	170	51	17.5	60	33.9
Female	brachyrhynchos	305	177	48	18	57.5	35.
Female	pascuus	304	169	51	19	62	38.
Female	hesperis	295	169.5	45.5	16	55.5	34
Female	paulus	283	167	47	16.3	59	33

Data from Howell (1913)

northern Lower California and central New Mexico. This range in the south is rather well separated from that of both the southern and eastern subspecies by territory where few or no crows breed. Approximate boundaries of the ranges of the various subspecies are outlined in Figure 1. These are of necessity indefinite, for much more work must be done before they can be outlined with any degree of certainty. This is especially true of those nesting far to the north in the central part of the continent; there the ranges of the eastern and western forms are undefined.

The differences between these subspecies are small and cannot be relied upon for field identification. Minor differences in behavior observed appear to be largely imposed by environmental conditions rather than by genetic differences in the birds. This should not be construed to mean that such differences do not exist, but few are known at present.

The field work for this study was confined almost entirely to the eastern subspecies. Only casual observations were made in range occupied by forms other than Corvus b. brachyrhynchos.

Distribution and Abundance

The common crow, with which this report is concerned, occurs throughout most of the United States and Canada, from the Gulf of Mexico north practically to the tree line. Figures 2 and 3 show the summer and winter ranges of the species. The stippling indicates the bird's relative abundance in the various parts of its range.

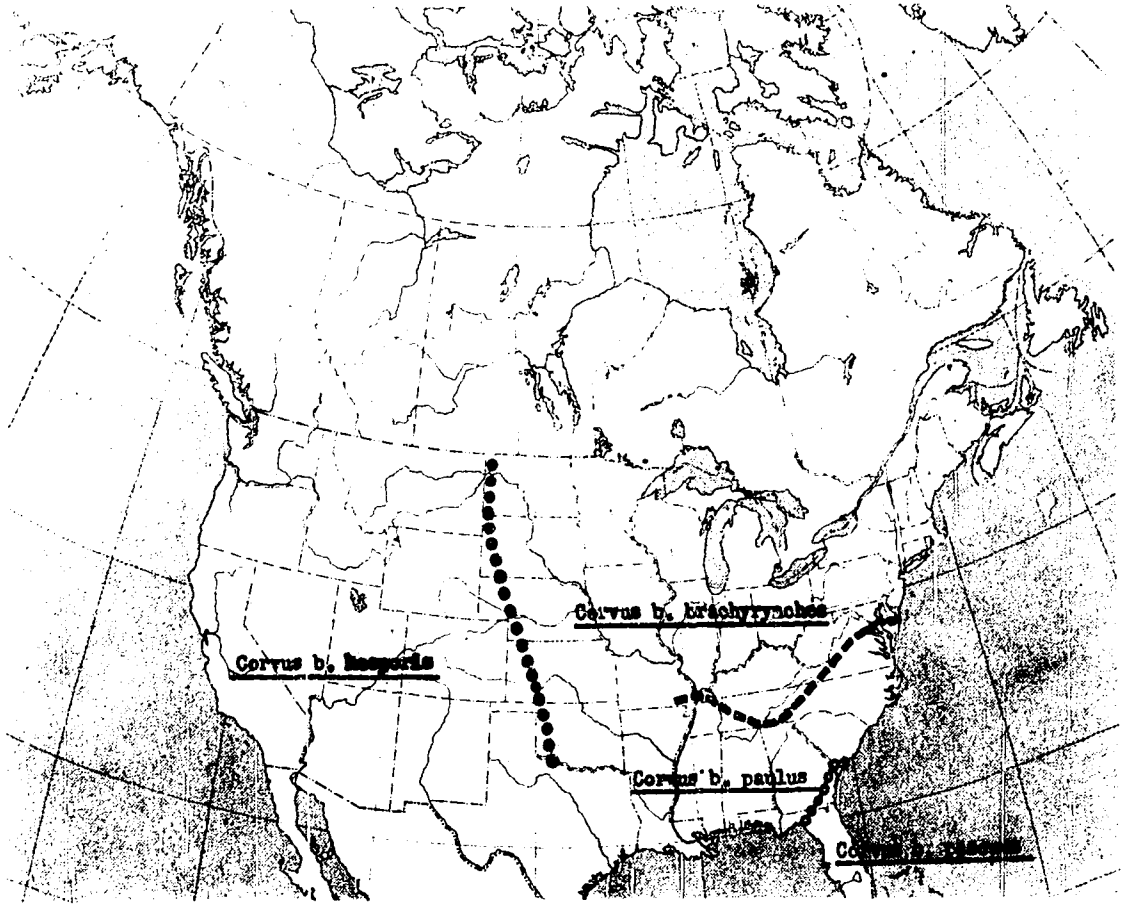


FIGURE 1

Ranges of the subspecies of Corvus brachyrhynchos

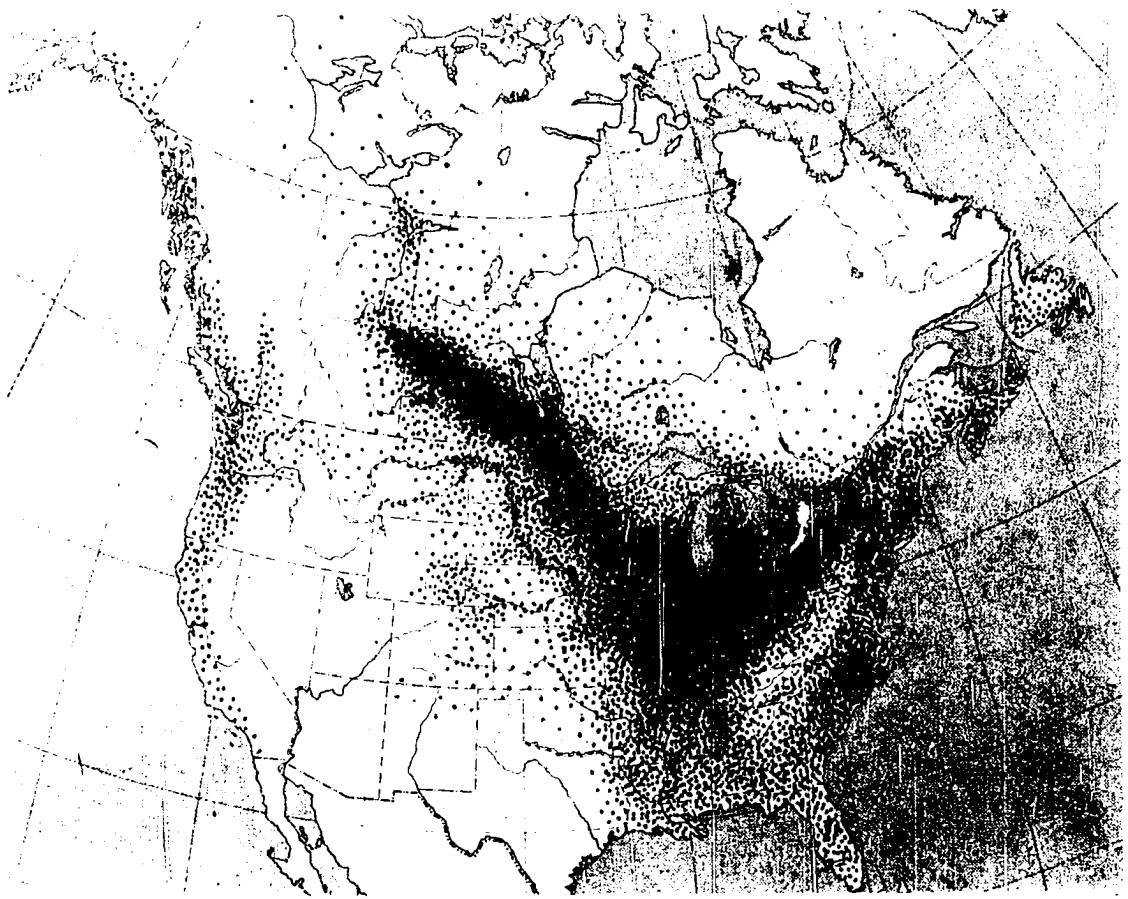


FIGURE 2

Breeding Range of the American Crow

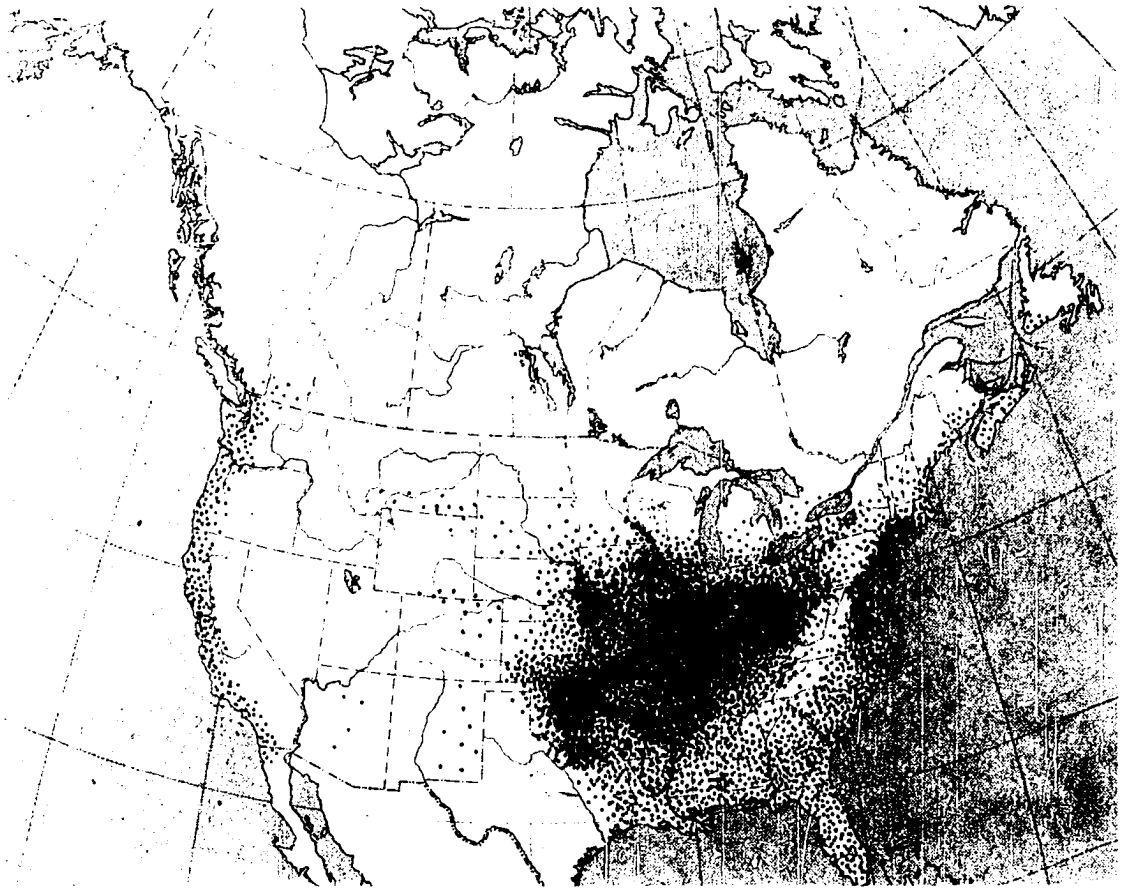


FIGURE 3

Wintering Range of the American Crow

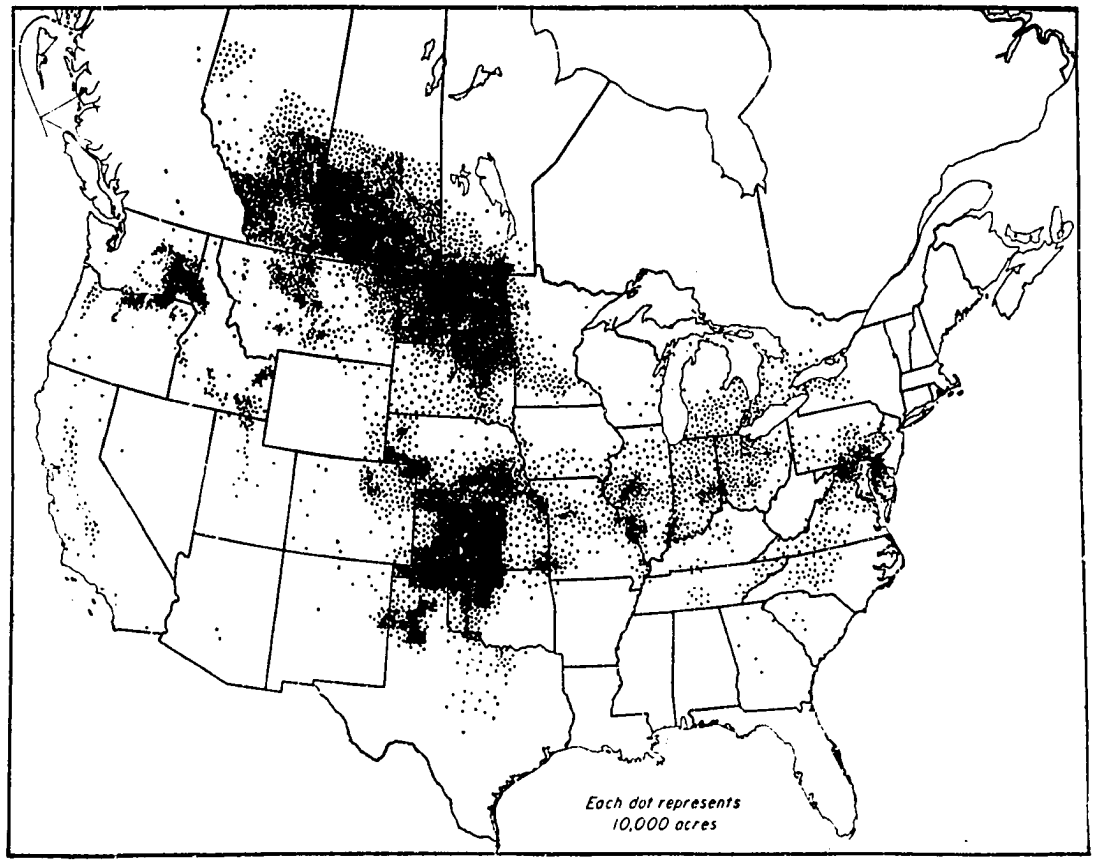
The crow has increased greatly in numbers since the coming of agriculture, but it is doubtful if any great extensions of range have occurred. However, tremendous population increases have taken place in some areas and are presumably still occurring as agriculture pushes northward. Increases also may occur locally when changes in farming practices make conditions more favorable for these birds. The most spectacular changes probably have occurred in the prairie states and provinces. There farming operations provided an abundant food supply and, as Schorger (1941, p.105) points out, permitted the growth of trees where these had previously been kept out.

That the crow was not common in early times over those portions of its range where it is now most abundant, is attested by many early writings. Schorger (1941), investigating the history of the crow in Wisconsin, found that in general it was scarce over the state in 1855, became common in the southern portion by 1875, and abundant by 1890. The crow was not a common bird in Ohio and Wheaton (1882) quoted Wilson as saying that it was entirely supplanted by the raven on the south shore of Lake Erie. In northwestern Ohio even yet there are men who can remember when crows were less abundant and the raven still was frequently seen. Apparently this was not true over all of the state for Goslin (1950) records the bones of the crow 43 times from the site of a prehistoric Indian village in south central Ohio. The bones of the raven were found but 3 times.

The crow is not a forest bird as the raven is, nor is it a prairie species, but it thrives best where there are trees for

nesting and roosting, and open fields where food can be gathered. Such conditions were limited in primeval North America, yet the crow apparently found and utilized them wherever they did occur, as along streams and prairie borders. This small and scattered population furnished the seed stock from which has sprung our present-day abundance of crows. More still continue to scatter through the wild, unsettled country to the north. These will no doubt multiply rapidly if man's activities are extended and provide an abundant food supply there.

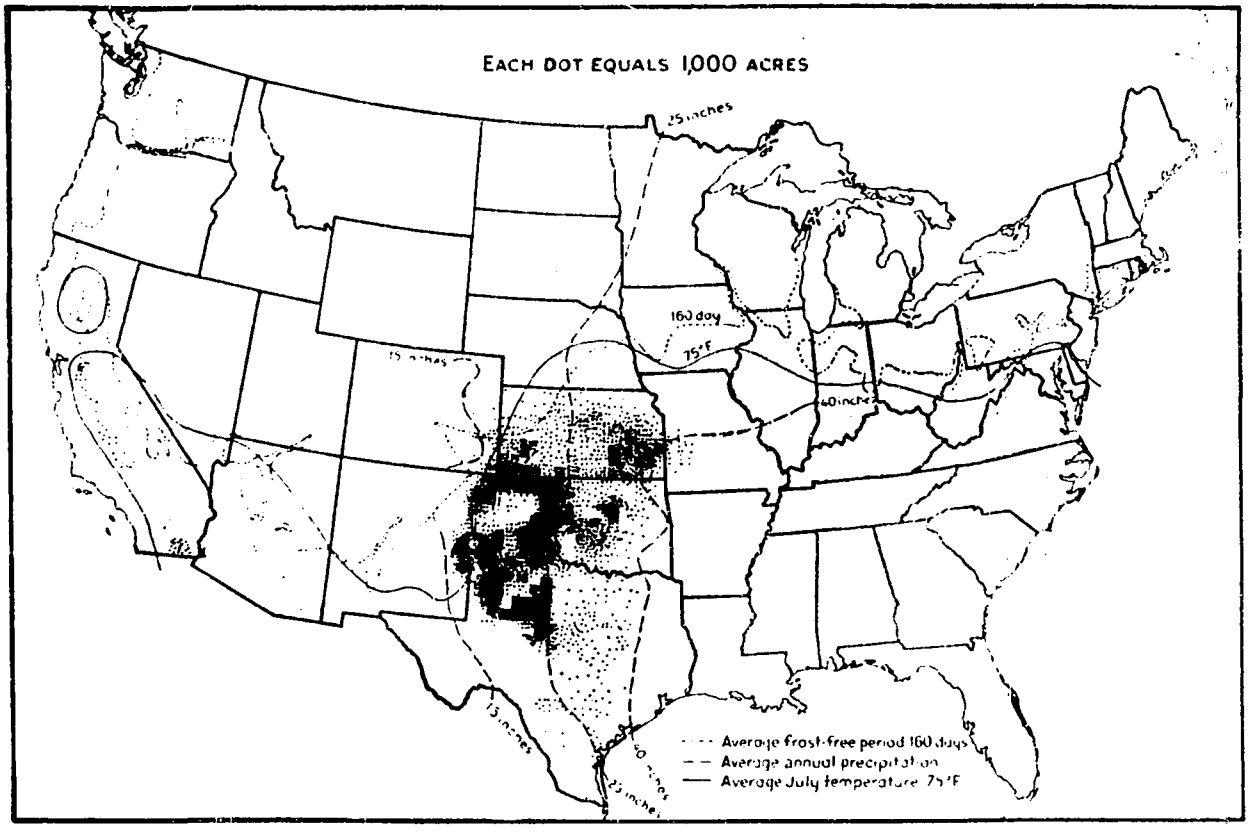
The crow population is apparently stabilized over much of its range and may even be declining in some portions. Answers to the questionnaire already mentioned indicate that this is probably true, at least locally. No general country-wide trends are evident. Within recent times it has increased in the plains area and to the north where more land has been brought under cultivation. Aldous (1944) points out that this is due to more extensive agriculture, both in the breeding grounds to the north (see Figure 4) and in the wintering grounds in the southern plains area (Figure 5).



Wheat acreages and regions of the United States and Canada.

FIGURE 4

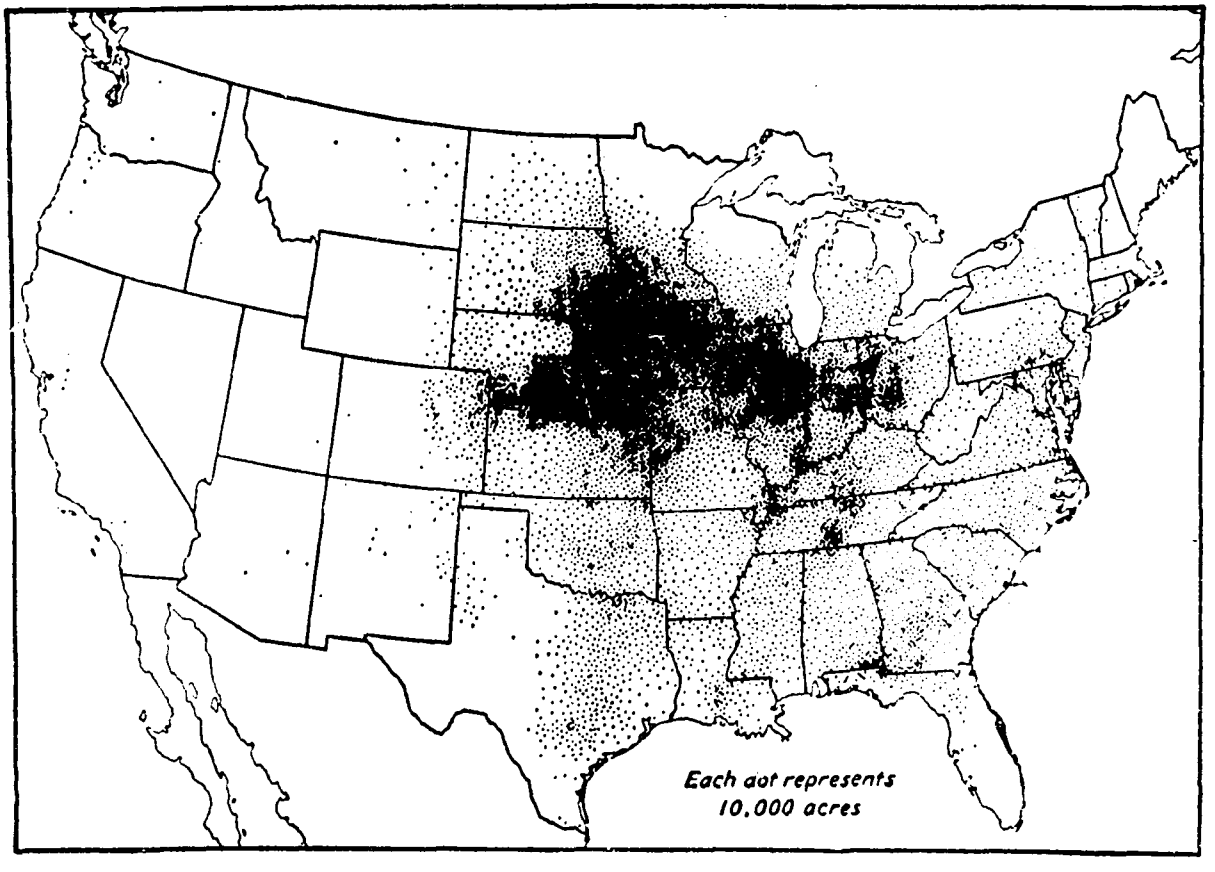
From the Yearbook of Agriculture 1941



Distribution of grain sorghums in the United States, 1929.

FIGURE 5

From the Yearbook of Agriculture 1941



Distribution of corn acreage in the United States. (Prepared by the Bureau of Agricultural Economics from 1929 census figures.)

FIGURE 6

From the Yearbook of Agriculture 1941

GENERAL CHARACTERISTICS OF THE CROW

Behavior

In spite of the common beliefs about the crow's evil nature, it has acquired a reputation for sagacity and resourcefulness shared by few other birds. Henry Ward Beecher is reputed to have said that if men wore feathers few would be clever enough to be crows, and there are many who would support his opinion. What degree of "intelligence" may be claimed for the crow depends upon the interpretation given to that term and also upon that given to certain aspects of crow behavior. If the crow shooter derived more sport from the hunt by considering it a "battle of wits" the concept is justified. At any rate the crow is a wary and adaptable animal.

Many examples may be cited to illustrate this adaptability. Twice during this investigation crows with greatly deformed beaks were collected. Figure 7 illustrates the condition of one of these. The other was similar. Eating would appear to be virtually impossible for birds in such condition, yet both birds were in good flesh, had food in their crops, and both were more than two years old. Eifrig (1905) reports a crow with only one leg which was in good condition when collected. The stub of the missing leg was healed and well-worn, indicating that the injury was not recent. The writer observed a crow during the winter of 1951-52 whose left leg extended out to the side and was completely useless for walking. This crow fed with a flock and appeared to get about on one foot without difficulty.

Crows normally pick up and carry articles in their beaks but

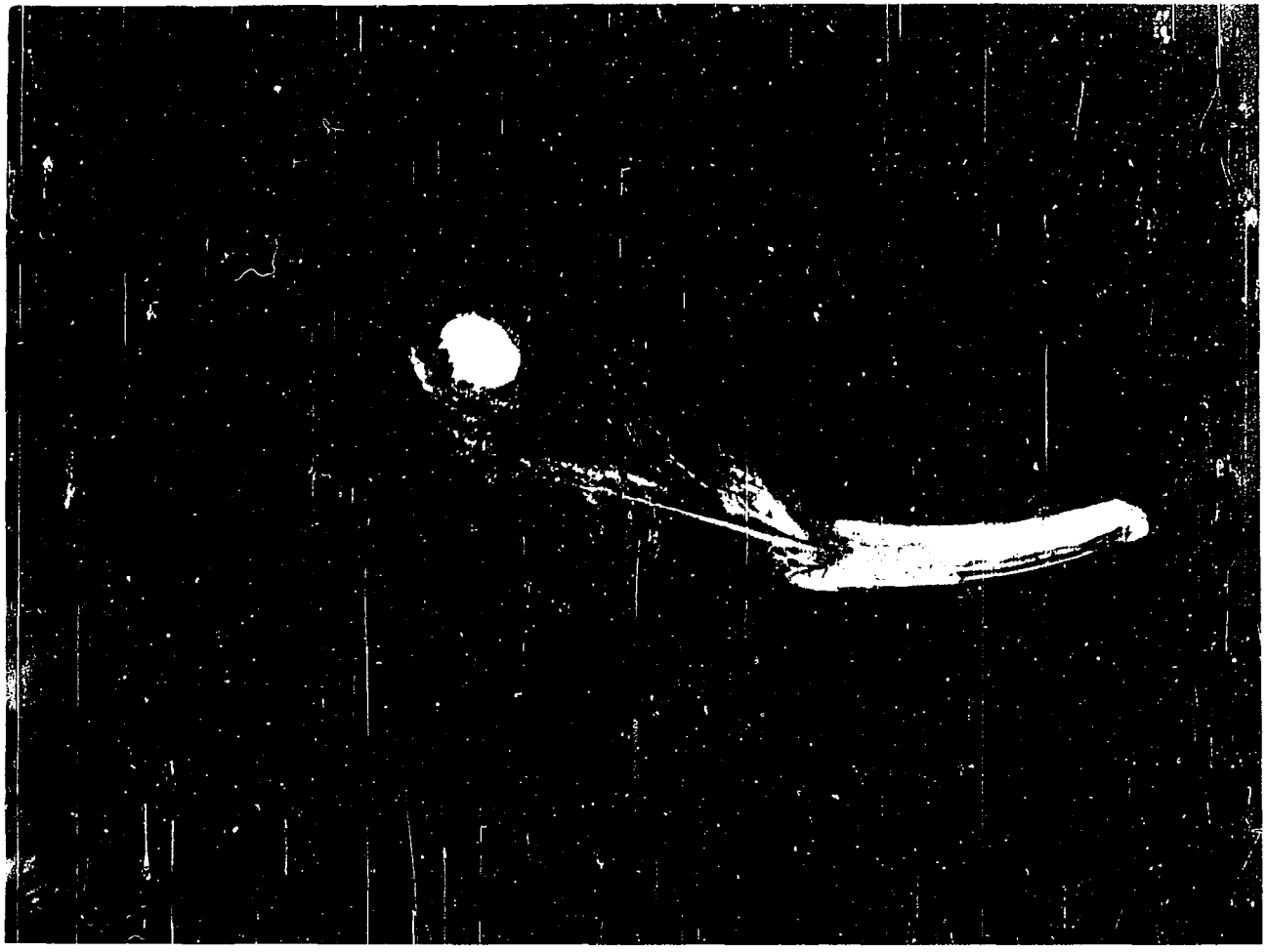


FIGURE 7

Crow With a Malformed Beak

may occasionally use their feet to transport certain objects. Pierce (1922), Fewkes (1884), and Kneeland (1883 a) record cases of crows carrying objects in this manner. This most often happens when for some reason opportunity is not afforded to pick up the object in the normal way. A crow startled at its meal may take flight and carry its food in its feet. Crows have sometimes used their feet to capture fish while in flight (Chamberlain 1884), or to carry objects in "play". The feet of the crow are not especially well suited for carrying and the writer does not recall ever having seen objects transported more than a few feet in that manner. Such actions are apparently uncommon.

Crows sometimes appear to carry on activities in a pure spirit of play. Such behavior has been described in the case of the raven, (Bent 1946, pp.195 and 210). In March, 1951, a family group of crows consisting of a pair and two yearlings were observed feeding some distance off the road in an open field. The light was excel lent and the birds were watched closely through 7x35 binoculars. One of the young crows discovered a piece of white paper several inches square. It seized this and repeatedly leaped into the air several feet carrying the paper in its claws. At the peak of each leap the paper was dropped and the crow would pounce upon it again. After a minute or more of these antics the bird rolled over onto its back on the ground and held the paper aloft in its claws. Using its beak and first one foot and then the other to tussle with the scrap, it "played" thus for another minute or more before abandoning

its "toy" and following the adults across the field.

Another evidence of "play" is the activity of flocks of crows on windy days. The flocks observed appeared to be composed of young unmated birds, but it is probable that all crows react to wind in much the same way. Under such circumstances the crows fly up and beat their way laboriously to the windward. In such strong breezes little headway is made, and after laboring for a half-minute or so the birds suddenly flip over, catch the wind beneath their wings, and are flung back across the countryside in what appears to be a wild abandoned swoop, only to right themselves and alight perhaps one-half mile away. This behavior was observed many times.

Young crows taken early from the nest and reared in captivity by the writer were always tame. Even though confined in the same cage with wild crows for months at a time, they always came to the closest part of the cage when approached, and sometimes attempted to beg food, even though nearly a year old. This behavior was constant, although other birds in the cage showed great fear and flew wildly about. Both tame and captive wild crows appeared to be conscious of the protection afforded by the wire covering of their cage. If a person entered the cage the birds were noticeably more nervous and the tame ones were reluctant to approach within reach, unless offered food or other attractive objects. The captive crows always resisted being caught and handled. This accounted for their wariness, for they quickly learned to associate a person's entering with capture and handling.

When provided with more food than they could consume, crows reared in captivity hoarded part of it about their cage. They put portions of the food under leaves, in crevices, and under the edges of objects in their cages.

That crows are attracted by bright objects is well known, and has been the basis for many accounts of the finding of lost articles in crow's nests. The captive crows which I had showed this trait and tame birds would always accept and sometimes steal keys, pencils, and other shiny or brightly colored objects. Warne (1926) describes such activities of a crow which he kept. Occasionally these articles may be concealed in the manner previously described for extra food.

An interesting observation was reported by Kneeland (1883 b) who tells of crows carrying stones into the air and dropping them upon intruders. I know of no other case of such behavior, and it is an excellent example of "intelligent" behavior in this bird.

In common with many other kinds of birds, crows have been observed "anting" by occupying ant hills and permitting the ants to crawl over their feathers. McAtee (1938) has summarized the information on this subject. He quotes Frazer (1881) as saying that a tame crow "deliberately takes his stand upon an ant-mound and permits the ants to crawl over him and carry away the troublesome vermin." The ants were seen to seize the parasites and bear them away. Some birds have been seen to capture ants and place them among their feathers. I know of no records of wild American crows being observed in such activities, but European species of the same genus have been seen to do so.

Longevity and Mortality

Most crows do not attain a great age. Although they are said to live as long as 25 years in captivity it is apparent that only rarely does a crow live more than half that long in the wild. Table 2 shows the mortality by months and years in a sample of 476 crows which were banded as nestlings. Black (1941) calculated that on the average for each 100 eggs laid, 71 nestlings hatched, 53 of these young reached banding age, 23 lived to be one year old, 15 reached breeding age, 12 lived three years, 8 lived four years, 4 lived five years, 2 lived to be six years old and 1 lived eight years. Table 3 is a record of the causes of mortality in a sample of 886 returns from crows banded with Fish and Wildlife Service bands. These figures are probably not very significant, for only crows killed by man or where they could readily be found by men would be likely to be included. The table is given because it shows a remarkable similarity in the susceptibility of adults and juvenile birds to the various mortality factors. Apparently adults are about as likely to be shot or trapped as are younger birds.

The nest mortality is very high in this species. Emlen (1942) found a high nestling mortality in California. His sample included 88 young birds from 31 nests. Only 20 of these in 13 nests survived to the thirtieth day. This represented a mortality of 77 per cent. In Ohio in the areas where this study was conducted, nest mortality has also been quite high. In 1949 in central Ohio only 5 nests were successful in a sample of 26 whose fate was known. Fourteen newly

TABLE 2. LONGEVITY OF 476 CROWS BANDED AS NESTLINGS *

Age of birds in years	Reported Deaths by Calendar Month												Total Mortality	% Mortality by years.
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.		
0					21	43	47	17	18	34	32	23	235	49.37
1	19	14	15	20	16	8	4	3	5	5	7	8	124	26.05
2	6	10	11	4	6	4	1	2	2	2	3	0	51	10.71
3	2	2	5	7	5	0	1	0	1	1	1	0	25	5.25
4	1	2	2	1	1	1	2	0	0	0	2	2	14	2.94
5	0	1	3	3	0	2	2	0	2	0	1	0	14	2.94
6	0	0	1	1	1	2	1	0	0	0	0	0	6	1.26
7	1	0	1	0	0	0	0	1	0	1	0	0	4	.84
8	0	0	1	0	0	1	0	0	0	0	0	0	2	.42
9	0	0	0	1	0	0	0	0	0	0	0	0	1	.21

* Data from the files of U.S. Department of the Interior Fish and Wildlife Service.

TABLE 3

CAUSES OF MORTALITY IN BANDED CROWS *

	Juvenile	Adult
Shot	349	313
Found dead	41	17
Unknown	24	16
Caught in trap	19	22
Miscellaneous causes	9	9
Found injured	8	6
Caught by hand	6	5
Sick bird when captured	6	0
Died in nest	5	0
Poisoned	3	0
Trapped and released	3	11
Killed by weather	2	1
Collected as scientific specimens	2	0
Drowned	1	1
Killed by birds	1	0
Killed by train	1	0
Killed by hawks and owls	1	1
Starvation	0	3
Total	481	405

* Data from the Bird Banding files of the U.S. Fish and Wildlife Serv.

constructed crow nests in northwestern Ohio were examined on May 9, 1950. Only two of these appeared to be in use at the time, the others had apparently been deserted. In Ottawa County, Ohio in 1951, young were fledged from two of nine nests observed. This represents a loss of over 80 per cent of the nests but does not take into account possible renesting. It was not possible to determine the extent to which renesting might have compensated for the mortality recorded, but second attempts probably followed many of the nestings broken up early in the season. Neither does this figure include nestlings lost from nests where some birds were fledged. If the mortality rate is as high as it appears to be, it is difficult to understand how the crow population can maintain itself.

Another interesting fact has been noted and it would appear to indicate a heavy mortality in young crows. The American Crow Hunters Association holds its annual crow shooting contest in the late spring each year, and data on age ratios of the birds killed have been secured for two years. Of 201 birds killed on June 18, 1949, in Wood County, Ohio, 135 were breeding adults two years old or older, 24 were birds of the year, and 42 were yearlings. Of 189 crows killed in 1951 at Vandalia, Illinois, 132 were adult birds. At Delta, Manitoba, in early June of 1950 a small sample included 12 adults and 7 yearlings. The great preponderance of birds over 2 years old is not to be expected in a thriving population. At the season when the crow shooting contest is held it is not to be expected that young of the year will respond well to calling, but yearling birds appear to

come to the call as readily as adults. More investigation is needed before this problem can be solved.

Color Aberrations

Albinism is not uncommon in the crow. A completely white specimen collected in Crawford County, Ohio, in May 1945 is in the collection of the Zoology Department of Ohio State University, and several other such specimens have been seen. I have seen partially albino birds and a number of others have been reported. Stoner (1935) reports such a bird. The writer repeatedly observed a partial albino in a flock of crows in northwestern Ohio in 1947 and in that instance it seemed to be persecuted by others in the flock. Warne (1926) reports a captive crow that developed white patches in its wings after being colored normally for several years.

Erythristic specimens apparently are rare, but there is one in the collection of the Ohio Cooperative Wildlife Research Unit at Ohio State University, collected in Gallia County, Ohio, in 1939. Some of the feathers on this specimen have been damaged by dermestid beetles and the colors are thus changed. The throat, belly, and undertail coverts are relatively unharmed and are a warm brown tone. The breast, top of the head, and back are light brown or buff, there being some variation among feathers. The retrices and remiges apparently were originally this same color, but due to damage are creamy white. The shafts are ivory. The eyes, beak, and feet of this bird were dark brown when it was collected.

Voice

Crows are capable of uttering a great variety of sounds. The writer has been able to recognize ten different types of notes which are described here. Many of these are given with a variety of inflections. In addition crows are good mimics and captive specimens have frequently been taught to utter simple words. Warne (1926) had a pet crow which he taught to say "good boy"! One of the birds which I had in captivity imitated the human voice and uttered the word "hello" which had often been repeated in its presence.

According to Brand (1938) the frequency range of the voice of the crow is from 1450 to 1650 vibrations per second. It is apparent in listening to an undisturbed flock of crows at their feeding that nearly the full range must be used normally.

The most common call is a leisurely Ca-a-a-a descending in pitch and repeated a variable number of times. It is commonly given in groups of 2 to 6 at a rate of about one per second. This call appears to be conversational but often produces no apparent response in other crows in the vicinity. The pitch varies as does the rapidity of delivery. In general it seems that the calls rise slightly in pitch and increase in rapidity with excitement, but in no way resemble the alarm or "warning" notes. This one basic call deserves the term "conversational" because it is used in a number of variations by undisturbed crows, and appears to give expression to the reactions of the individual to its surroundings. These reactions must be communicated to other crows regardless of their frequent apparent indifference.

Several other calls are common in early spring. One of these is a Ca-a repeated softly and with exaggerated bowing. The wings are slightly lifted, the head is lowered, and the soft note emerges as if with considerable effort. The crow sounds and appears as though it were partially choked. Since this note is given commonly during the mating season it is presumed to be a part of the mating display. I have observed such a performance in the middle of an open field with no other crows in sight, but the note is often given in the company of other crows. Townsend (1923) describes such a bowing performance, but describes the "song" as a rattle. This "rattle" song has been variously described as a "gurgling" note and a "grating" sound. It is not at all certain that all of these descriptions apply to the same type of vocal effort. At any rate these notes comprise one of the earliest spring songs in the Mid-west, sometimes being heard in the woods as early as late January. The "song" is difficult to describe but is intermediate between a "rattle" and a "gurgle" having a somewhat liquid quality.

Another note apparently associated with the mating instinct and certainly more deserving to be called a song has been recorded. Townsend (1927) (1928) described the cooing notes of the crow. I have heard this only once. On July 6, 1949, I was observing crows from a blind at a garbage dump west of Columbus, Ohio. The flock was made up principally of non-breeding yearling crows, with a few family groups of adults and fledglings. Several crows were in the trees immediately surrounding the blind. One of those immediately above me

gave the rattle "song" repeatedly and then began a soft cooing, repeating over and over. Another in a tree a few yards away did likewise and the cooing continued for several minutes. The notes were soft and melodious and markedly dove-like in quality. They were given in series of varying length, the longest being less than 10 seconds. I watched the bird above my blind and noted that through the performance it continually manipulated a small dead leaf. Townsend (1927) describes in detail the circumstances under which this song was given and describes its being produced on the wing.

Here then are three "songs" apparently associated with mating: the soft bowing Ca-a, the rattle, and the coo. The first two at least are frequently given in the absence of other crows.

There are at least two kinds of warning notes characteristic of crows, the most common of which is a sharp oft-repeated Ca-a Ca-a Ca-a given with a staccatto quality and no change in pitch. The notes are short and sharp and serve as notice of danger to other crows. The immediate and active response of the other crows in the vicinity is indication of this. As in the case of the "conversational" notes, these "warning" cries are subject to great variation in speed, pitch, and intensity. These characteristics vary with the degree of stimulation afforded by the disturbing factor. If one approaches a flock across an open field where visibility is good for half a mile or more he will be detected while still far from the flock. One of the crows will fly up to a fencepost or tree, and will announce one's approach with a definite but unhurried series of warning notes.

Several other crows may quietly assume vantage points and join in the intermittent outcries. Many of the flock continue to feed but they appear watchful, and when approached too closely one or more birds take flight with more insistent vocalizing, at which time the whole flock will rise and fly to the nearest trees.

If the flock were approached in a different manner quite another result would be apparent. A flock feeding in a field near the edge of a woodlot, if approached unseen through the cover of the trees and brush, may be tested for their reaction to sudden danger. Crawling cautiously to a point nearest the flock, very carefully and slowly the observer brings himself into full view of the birds. The first to detect his presence springs into the air with a startled, staccato warning and instantly the whole group bursts into flight with rapid wing beats, and once in the air all may join in the chorus. This type of warning then is the one most familiar and commonly heard whenever one is in the field in the vicinity of crows.

The other "warning" note lacks the social implications of the one just described. It might better be called a "threat," for it is not loud enough to effectively "warn" many other crows. This note may be described as a guttural rattle similar in general nature to the rattle mating "song,", but lower pitched, dry, and guttural. It is apparently used only in the presence of another individual crow or an enemy not greatly feared or offering little immediate danger. I have never heard this note given except to another crow or to an avian predator. Dr. Milton B. Trautman tells me that he has heard

this note given in the presence of dogs and perhaps men. I have frequently heard it at garbage dumps where crows quarrelled over especially tempting scraps and it is frequently given by crows as they dive at passing hawks. It would appear to fill the same gap in the crow's "vocabulary" as does the growl in the case of the dog.

Another common note is the familiar "rally" call. In response to this outcry crows come from as far as they can hear, perhaps even farther, as they hear nearer crows take up the cry and fly toward the center of disturbance. This rally note is not so short or staccatto as the alarm note and the response of other crows is entirely different. This note is given upon the discovery of an owl or occasionally at the sighting of a mammalian predator. It is also given when another crow is found to be in difficulty, or when a crow call is skillfully used.

The begging note of the young is a familiar sound in the woods in May and apparently adults do not lose the capacity for uttering it. Females have been reported as giving this note in the presence of the males during the mating period. Townsend (1927) describes such an incident. Once in Manitoba in early June before any young were out of the nest an adult crow appeared to follow the writer for some distance along a timbered ridge, continually giving this begging note. Young crows in captivity seem to persist in begging until much older than do those which grow up normally in the wild. This may be explained by the greater success of captive birds in securing food by begging, and by the severely restricted opportunity to gather food in

the normal fashion. Adults have been observed to persistently ignore begging young when family groups were feeding together in fields.

Captured crows often give vent to loud squalls. This sound brings prompt and vigorous response from other crows within hearing. They immediately give the rally call and all in the vicinity converg e upon the scene and continue their noisy clamoring as long as the squalling continues. This squalling note is one of the easiest to imitate on a crow call and even the rankest novice can be assured of some success if this note is used.

Another note commonly given by crows during the nesting season might be called a scolding note. It is given when the nest or fledglings are threatened. In some respects it resembles the rally call but produces none of the effects of that note. No other crows come to the aid of scolding parents unless the previous year's brood is associated with the adults, in which case these unmated birds join in harassing the enemy. This scolding note is not so drawn out as the rally call and may be described as being between that and the alarm note in nature.

The voice of the crow is wonderfully expressive. This is evident upon even the most casual observation, but the crow apparently is neither rare nor exotic enough to excite interest in most people. Bicknell (1885) in writing of the singing of birds dismisses the crow with the statement "The cawing of crows belongs to all seasons."

R. P. Lister, in his poem "The Speechless Crow" writes:

"In their bare winter elms the crows
Cry all day long with raucous voices,
So much alike that no one knows
Which crow complains and which rejoices."

This need not be so, for no bird speaks his reactions in language more easily interpreted by men.

FLOCKING BEHAVIOR

Formation of Winter Flocks

One of the most spectacular and important aspects of crow behavior is their congregation into huge flocks in autumn and winter. These flocks roost together at night and disperse over a relatively large area of countryside to feed durigg the day. The greatest damage to agricultural crops occurs during the period of flocking when many birds feed together.

Flocking is not entirely confined to the late summer, fall, and winter seasons. Scattered small flocks occur at all times of the year and roosts of several hundred birds may be found throughout the spring and summer. These appear to consist of yearling, unmated birds.

The gathering together of these great winter flocks of crows is no sudden or spectacular phenomenon, but is rather the formation of many small flocks which combine as the season progresses, until the roosts become few in number but largest in size by late winter. Weather appears to exert some influence upon the date of flock combination, which is seldom completed before late December. Figures 8 and 9 show the locations of known roosts in Ohio late in the winters of 1948-49 and 1950-51.

Where small flocks of non-breeding yearling crows have been under observation, they have served as nuclei around which the larger autumn flocks accumulated. This accumulation begins in late summer and is quite evident during the latter part of July and early August.

FIGURE 8

Distribution of Crow Roosts in Ohio

During the Winter of 1948-49

FIGURE 9

Distribution of Crow Roosts in Ohio

During the Winter of 1950-51

Breeding adults care for the fledged young until they are able to care for themselves and then remain with them maintaining a family group which forages about the countryside for several weeks. When the young are capable of sustained flight the family groups begin to join the roving yearling flocks in their evening flights to the roosts. At this time the small roosts show a rapid increase in size and shortly thereafter many of them break up, presumably to combine with others to form the larger autumn gatherings.

Robert Higgins, studying the behavior of crows at a summer roost in central Ohio, heard the first young birds in the flock on July 4. This flock increased from about 150 birds in June to 338 by the first of August. After this date it decreased rather rapidly until by mid-August, when the study was terminated, less than the original number of birds were present. This decrease probably represented the first flock combining of the season.

Composition of Flocks

As these flocks shift to more favorable locations with the coming of severe weather there appears to be some segregation on the basis of age. This is certainly true of those flocks studied in Ohio. Collections made at roosts in central Ohio in late winter show a great preponderance of adult birds. Table 4 shows the age ratios of birds collected at roosts in Ohio and Kentucky in 1950 and 1951. The figures for Tennessee in 1938 are from Wing (1941). He postulates that the high ratio of juvenile to adult birds on the wintering grounds may be due to differential migration. This would seem to be

TABLE 4

AGE RATIOS IN BIRDS COLLECTED AT ROOSTS

IN LATE WINTER AND EARLY SPRING

Locality	Date	Number of Adults	Number of Juveniles
Fayette Co., Ohio	Feb. 3, 1950	13	3
Licking Co., Ohio	Feb.16, 1950	69	1
Fayette Co., Ohio	Feb.27, 1951	6	1
Licking Co., Ohio	March 5,1950	13	1
Licking Co., Ohio	March 8,1950	34	14
Ft. Thomas, Ky.	Feb. 11,1950	20	8
Warsaw, Ky.	Feb. 19,1951	2	19
Warsaw, Ky.	Feb. 21,1951	0	30
Warsaw, Ky.	Feb. 25,1951	0	2
Warsaw, Ky.	Mar. 26,1950	1	12
Blount Co., Tenn.	Jan. 10,1938	4	27
Blount Co., Tenn.	Jan. 17,1938	1	5

These crows were collected by various people and submitted to the writer for examination. Some of the Kentucky crows were examined by the collectors who had been instructed in proper aging techniques. The Tennessee data are from Wing (1941).

indicated by the data. In Ohio and even in northern Kentucky adult crows far outnumber young of the previous year as late as early February. By mid-February, however, there seems to be an influx of juvenile birds into the area along the Ohio River and sometime in March these young appear in the roosts in central Ohio. It would appear that young crows from Ohio and regions north of there move farther south than the Ohio River in their first migration, and the data collected by Wing (1941) would indicate that some may winter in Tennessee. Black (1941) found adults to be twice as numerous as young of the year in the winter crow population in Illinois. Scott (1938), however, reported 23 adults and 54 young in a sample collected in winter in Wisconsin. These figures were secured by an "estimate" of the age of the birds. There is a paucity of age ratio data in the literature and much more work should be done along this line.

Wing also found an unbalanced sex ratio. In the sample which he examined he found about 40 males per 60 females. He mentions that differential migration of the sexes is known for some species and may occur to some extent in the crow. His sample of adult crows was very small (5 birds) and of these 2 were males and 3 were females. If one considers only adults, no significance can be attached to this difference. It is possible that such a differential migration might include young birds. Black (1941) found that in Illinois the proportion of males was highest in the north and progressively declined southward. This would indicate the possibility of such a differential

migration. In Illinois, however, he found that for the state as a whole the sexes were equal. This could indicate that the difference in migration is not so pronounced in that area. Still farther west in the roosts in Oklahoma, Imler and McMurry (1939) found 52.6 per cent males to 47.4 per cent females in a sample of 1000 birds. It would be interesting to have sex ratio data from the more southerly roosts in Texas. In contrast to the apparent tendency to find more females in southern roosts, Hicks and Dambach (1935) found 60 per cent females in a roost in east-central Ohio on February 19, 1935. This is the same ratio Wing found in Tennessee. This date is rather late and the authors state that the roost had grown throughout the winter and had increased by an estimated 5000 birds from January to February. Where these birds may have come from is not stated, but it is possible that some may have been migrants moving northward by that date.

Behavior of Crows at Roosts

The behavior of birds at individual roosts is a fascinating social study and presents many problems as yet unsolved. The roost forms the nucleus from which the birds move out at daybreak and feed in the surrounding countryside. The feeding area may vary in size according to the size of the roost and the abundance of the food supply. Evening flights of from 25 to 30 miles have been traced, and evening flights have been observed in a direction where the nearest known roost was nearly 50 miles away.

The flight lanes may radiate from the roost in all directions or may be confined to a few covering a sector of 180 degrees or even less. Near the roost the crows may appear to approach at random, but the lanes are quite distinct away from the immediate vicinity of the woodlot or grove where they spend the night. In two cases where roosts in central Ohio were located only a few miles apart, no evidence was seen of birds on flight lanes from different roosts meeting and passing each other. The two feeding areas appeared to be distinct.

These evening flights are started by the birds foraging farthest from the roost and follow relatively fixed and well-defined flight lines. By mid-afternoon the crows located farthest from the roost begin to drift slowly back toward the roosting site, moving from field to field and feeding as they progress. They are joined by other crows and the flight gains size and momentum. Crow flocks are exceedingly loose groups. There seems to be no compulsion to stay compactly together in flight or to all take flight together. An evening flock then becomes scattered along the flyway and crows come into the roost site in streams rather than flocks. Aldous (1944) found by trapping, marking, releasing, and retrapping, that individual crows used the same flight line and feeding areas day after day. At one group of traps where 476 crows were banded and released, 188 recaptures were recorded. My own observations, although not so conclusive as his, also indicate this to be true. Naturally marked individuals have been observed repeatedly traveling the same flight

lanes in evenings and these observations were many miles from the roost.

Crows appear to alter their pattern of flight according to the wind when approaching the evening gathering place. Flight lines coming in against the wind generally fly low over the ground, rising to clear obstructions and then dropping down again, the type of flight generally known as "hedge-hopping". Those coming in with the wind have been observed to fly high. When crows come in high with the wind or high in calm weather, they often come down to join the earlier arrivals by a sort of tumbling or diving descent. This behavior is characteristic of a number of birds that roost in flocks and is particularly spectacular in such species as the purple martin and the chimney swift. The descent of the crow is not so stereotyped as it is in those species, and may vary from a slow spiral to a whirling dive so fast that it seems certain to end in disaster, but from which the bird recovers in the last instant and sweeps off across the treetops in a glorious arrow-swift glide. Two or more birds often chase each other in this activity. They approach the roost site in a high sedate flight. As they arrive above it one may make a sudden pass at another and both come tumbling from the sky with seemingly slight control. As the birds gather in the trees and on the ground there is generally a good bit of chasing and other activities which have the appearance of being pure "horse-play."

In much of the midwest where crow roosts are heavily shot, the birds do not gather directly at the roost site. They may congregate

in a few places several miles from the roost and remain there until an hour or so before dark. At that time small groups begin to leave and go to some area adjacent to the roosting cover. This exodus from the first congregating area continues at an increasing rate until all of the birds have gone. I have never observed them to fly to the roost in a body; it has always been a constant stream of small flocks making up a typical flight line. It is usual for the birds to congregate in the fields about the roost, feeding and sitting about until it is quite dark. Then in a quite different manner they all rise at once, settle like a great black cloud into the trees or other cover for the night.

Once in the roost a continuous low undertone of "crow talk" continues for as much as an hour or more before the birds finally become quiet for the night. The crows appear to crowd together in the roost and settle compactly in the trees; not infrequently branches are broken by their weight.

Shortly after entering the roost the indigestable material in the stomach is regurgitated and discharged as a pellet. According to Aldous(1944) most of the pellets are disgorged within two hours after entering the roost. The stomachs of most of the specimens collected at roosts during the course of this study were completely empty, indicating that the material had already been disgorged.

When the crows in a roost were disturbed by shooting to collect specimens, they arose with great clamoring, which died down after a few minutes. On nights with bright moonlight they could be seen

circling silently above for some time before they settled into cover again. Waiting in darkness for several minutes after firing into roosting birds one may suddenly hear a great rustling of wings as the birds settle in the trees almost overhead.

Winter roosts vary greatly in size, being larger in those areas which received an autumn influx of birds from the north. These areas include the Oklahoma and north Texas region, the Illinois-Indiana-Ohio region, and the Atlantic coast of the United States north of the Carolinas. South of the western wintering grounds crows are absent and in the southeastern United States resident crows are presumably the only ones present, and although flocking occurs the population is not great enough to produce the huge congregations observed elsewhere. Roosting groups range in size from a few hundred birds (even a few dozen in summer) to several hundred thousand, and the process of flock combination in the fall and early winter and flock splitting in late winter and spring is almost continuous. In central Ohio flocks combine until the last of December, when maximum size is reached. By late January these large flocks may begin to split up and smaller flocks reappear where they had been evident earlier in the season. Figure 10 shows the date and rate of dispersal of one such roost in central Ohio. These observations were made by R.C. Higgins as part of a special problem in Zoology at Ohio State University.

Dr. Mildred Miskimen (1952) in watching flocks of crows near Columbus, Ohio, during the autumn migration period, noticed that

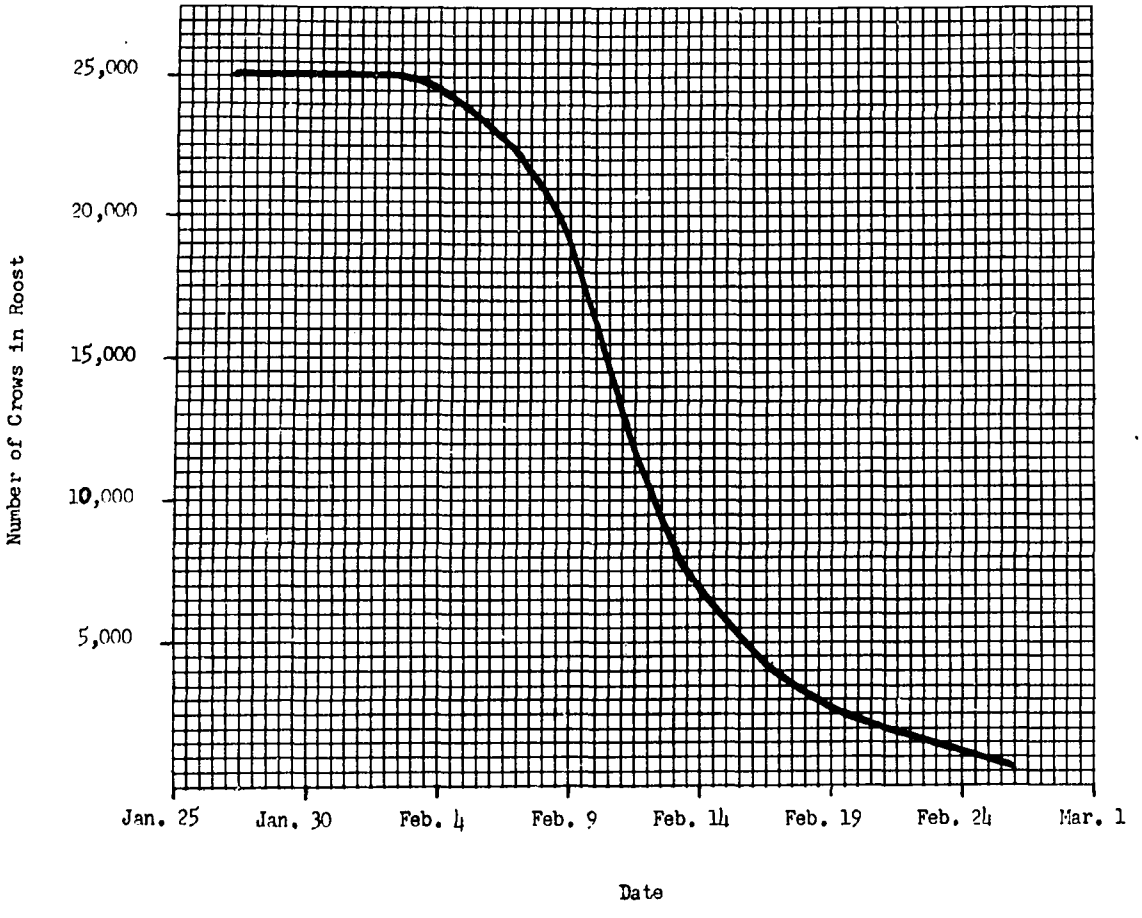


FIGURE 10

Rate of Dispersal of a Crow Roost in Central Ohio

roosts were made up of separate flocks. These approached the roosting site from the same direction and in the same general manner each evening. Sudden increases or decreases in the size of these groups was interpreted as the arrival or departure of migrating flocks of crows. Apparently such flocks maintained their individuality and came in or moved out as units. Temperature did not noticeably affect the activities of the birds, but wind and light intensity did. The numbers of birds present also seemed to affect the flocking behavior, larger groups maintaining a closer formation than smaller ones.

The social behavior of wintering crows is as yet imperfectly understood, and offers promise of reward for diligent study.

MIGRATION

The crow is often considered to be a resident bird remaining in the same locality throughout the year. In the southeastern parts of its range this appears to be true, but in the Great Plains region north-south movements take place in spring and fall which leave no doubt of the migratory status of most of the crows in that part of the country. Figure 11 has been compiled from data in the bird-banding files of the U.S. Fish and Wildlife Service and shows the distances and directions traveled by crows banded during the breeding season and recovered on the wintering grounds, or vice versa. The number of returns from birds which nest in Saskatchewan and Alberta and winter in Oklahoma and Texas is sufficient to establish the migration pattern there. Many of the returns from the Canadian breeding grounds are over 1000 miles from the point of banding and several are more than 1400 miles. Some must migrate much farther than this, for breeding pairs are scattered over the undeveloped country far to the north of any of the points where banded birds have been recovered and relatively few crows winter in the Great Plains area north of Oklahoma. There would be slight chance of recovering any of these birds on the breeding grounds regardless of the number banded. Aldous (1944) reports that he and Dr. Harry C. Oberholser examined 301 crows taken in Oklahoma in February and found 72 per cent to be Corvus brachyrhynchos hesperis, the western subspecies. It is possible that there might be a

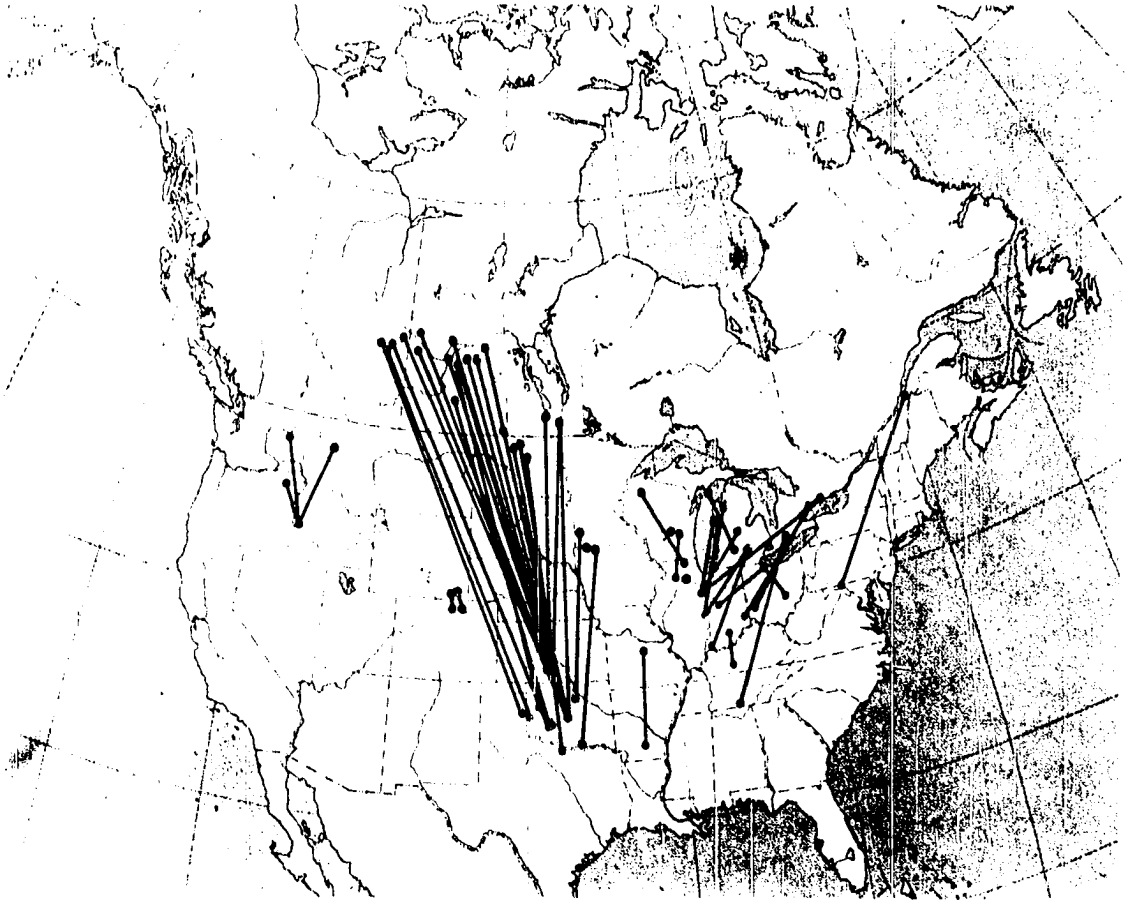


FIGURE 11

Seasonal Movements of Crows as Indicated by Banding Returns

genetic difference in the subspecies which would account for the greater migration in the west, but it is more likely that the lack of suitable wintering areas between the breeding grounds and the southern part of the United States enforces such seasonal movements. Aldous points out that the winter concentrations in Oklahoma result from a combination of favorable factors, including roosting sites, abundant food, relatively mild winters and many watering places. The first three of these could probably be stated as general requirements.

Emlen (1938), in discussing the winter crow population in New York, states that the distribution of the birds coincided more closely with the original distribution of the southern hardwood forest than with existing vegetational cover. Discussing the winter distribution of crows in California (1940) he says that soils seem to be more important than the cover there.

In the east it will be noted that none of the migrations recorded are more than a few hundred miles in extent. An examination of the records of crows banded in the eastern part of the United States during the breeding season and recovered in winter, or vice versa, reveals that many were resident in the same area throughout the year. What migratory movement there is is largely in a northeast-southwest direction. Just why this should be is not clear. The western crows are forced into a southeast-northwest route by the Rocky Mountains and by the availability of good wintering territory in the south, but Michigan crows could presumably find

as good feeding and roosting sites in southwestern Ohio as in southwestern Indiana where most of them seem to go. The short migrations, if extended straight south, would not carry the birds into mountainous or unproductive country.

Dr. M.B. Trautman has suggested that the winter concentration of crows on the north shore of Lake Erie may result from a hesitancy on the part of these birds to fly across the open water of the lake. This could result in the "piling up" of birds in the area immediately to the north of the lake. The lake does not freeze over until January and by that time crows have probably lost the physiological stimulation to move south and are nearly ready to begin their northward movement again. Dr. Trautman has noticed that before the lake is frozen, those crows that do fly across do so only at great altitude. After the winter freeze-up takes place crows crossing the lake may fly low over the ice.

If the lake is actually a barrier to migrating crows this might explain some of the westerly movement of eastern crows in the autumn. Lake Erie and Lake Huron may form a natural funnel to force crows from eastern Ontario to come around the west end of Lake Erie before progressing south. Since it appears that many Michigan crows also move considerably west of south, such an explanation leaves much to be desired.

As previously mentioned there is considerable evidence that there may be some segregation by age and possibly also by sex during the winter.

Crows in the southern states apparently do not migrate, but do gather into flocks in the winter. These do not approach the northern concentrations in size for their ranks are not swelled by such an influx of northern birds.

The crows along the Atlantic coast do not migrate for long distances although there is some exodus from the New England states. The crow winters as far north as Newfoundland (Peters and Burleigh 1951), and is common to abundant along the coast as far south as the Carolinas. Low (1934) reports three categories of crows in the Cape Cod region. From banding returns there it appeared that a portion of the population was composed of permanent residents. Another segment was never taken in winter and was assumed to have wintered farther south. Another set of records included birds banded in the autumn and recaptured but once shortly thereafter. Since these were banded as adults, it is postulated that they were autumn transients from the north. There is no certainty that they were not locally reared, in which case they would fall into the second group. Scattered records over the northeastern and north-central states indicate that these three classes of crows are to be found generally over that region. There is an increase in the numbers of coastal crows as some inland birds move down to the coast and some from the north move south to form concentrations of birds from New York to Virginia.

South of the Great Lakes the largest concentrations of birds are in the corn belt. This can readily be seen by comparing the

winter distribution, Figure 3 with Figure 6, which is the distribution of corn acreage in the United States. To include all of the winter crow concentrations in the central United States the grain sorghum area of Oklahoma and Texas (Figure 5) must be added. This area in conjunction with the corn belt winters most of the North American crow population.

The crow migrates entirely by day, spending the hours of darkness in a roost. It is not a rapid flyer, progressing normally with deliberate wingbeats. Blake (1947) in a series of observations found the rate of wing flapping in this species to be about 2.0 $\pm$ 0.31 times per second. Broun and Goodman (1943) in observations made at Hawk Mountain in Pennsylvania found the crow's speed of flight to range from 17 to 35 miles per hour, and to average 26 miles per hour. The whole migration is unhurried, with the birds progressing by easy stages, gleaning food in fields and woods as they go.

The fall migration in the east is not a conspicuous phenomenon, and may extend from September until January. There the birds may occupy roosts for many weeks, then abandon them and move south when the food supply wanes or the weather becomes severe. In the plains area most of the crows are on the wintering grounds by November.

Spring migration may also be somewhat prolonged. Roosts abandoned in December may be reoccupied in January and used until the flocks disperse, perhaps as late as March. It seems that the arrival of crow flocks in spring is much more noticeable than their unobtrusive disappearance in the autumn. In Manitoba at least three people mentioned to me that crows arrived in the spring about the 27th of

March. This information was volunteered without prompting and came from farmers and a biologist. It illustrates the regularity and significance of the arrival of these birds on the breeding grounds.

REPRODUCTIVE BEHAVIOR

Pairing

The gonads of the crow begin to increase in size by late January and reach their maximum late in March. In the specimens which I have checked the testes are less than 2 mm. in length in December, and in April may measure 20 mm., with a volume of 2 cubic centimeters. The testes of first year birds increase somewhat in size, but at most do not exceed more than 20 per cent of the volume of those of an adult male during the reproductive period.

The exact time of pairing is uncertain. Crows exhibit little of the conspicuous courtship activity so characteristic of many other birds. Crows in late February and early March exhibit some behavior which is probably related to mating activities. This behavior consists primarily of repeated soft "caws" given with exaggerated bowing and slight lifting of the wings. Such display frequently takes place when no other crows are evident in the vicinity and I have never observed this behavior to culminate in copulation or other evidence of pairing. Similar behavior in other Corvidae has been well established as courtship. It is most pronounced in the early spring and is well correlated with the increase in gonad size, hence it is probably related to the sexual cycle. Copulation has been observed in central Ohio in late February.

The paucity of courtship display among crows has led to the speculation that perhaps crows mate for life, as is believed to be the case with the raven (Harlow 1922) and the rook(Tucker, in Bent 1946 pp. 285). A lack of display is notable in paired birds of many

other species which mate for life. Additional evidence to indicate mating for life was found in the banding records in the files of the U.S. Fish and Wildlife Service. Table 5 indicates the extent of scattering of birds banded during one nesting season and recovered during subsequent ones. Only about six per cent were recovered farther from the point of banding than adjacent counties. If mating was an annual event much more scattering would result. About half of these birds were banded as adults, the remainder as juveniles. Many of the juveniles were not retaken until they were past breeding age and presumably mated. Irrespective of status about 94 per cent of these birds were retaken at or near the locality of hatching or previous nesting.

Young crows apparently do not mate until the second spring after hatching. Black (1941) discovered this to be the case, and I have found no exceptions in my work. Banding returns indicate that these young return the year after hatching and spend that spring and summer in the locality where they were hatched. If adults (presumably the parents) are nesting in the vicinity, the young maintain a close association with them all through the nesting season. These yearling crows have not been positively observed to assist in any of the tasks of nest building or caring for the young, but they are permitted to visit the nest after the young are hatched. The presence of unmated crows about the nest may have given rise to the reports of polygamy and polyandry in this species. Polygamy may sometimes occur, but young birds at the nest have probably been responsible for a

TABLE 5

RECOVERY LOCALITIES

FOR

CROWS BANDED AND RECOVERED IN DIFFERENT BREEDING SEASONS

	Same County	Adjacent County	Farther
Adults	40	8	3
Yearlings	24	8	1
Age Unknown	12	1	2
Total	76	17	6

About ninety-four per cent returned to same county or adjacent county.

majority of these reports.

Nesting

Crows sometimes reappear at old nesting sites as much as two or three weeks before nest building begins and observations indicate that these are the birds that subsequently nest. Their behavior is different from that of wintering crows. The tendency to flock is greatly diminished and these birds perch alone on exposed dead snags and in the tops of tall trees in the woodlots. One may drive through the countryside in February and see such birds in nearly every grove and woods. This behavior continues until nest building begins.

(a) Nest Site

The location of the nesting site is influenced by several factors. These include (1) the presence of satisfactory feeding areas nearby, (2) the presence of a tree with a suitable branch arrangement to hold a nest, and (3) relative remoteness from human activity. These are believed to be listed in order of relative importance, although there is considerable individual variation in crows regarding the qualifications of a suitable site.

The crow is an extremely versatile bird, but my observations in the mid-west and in southern Canada indicate that the feeding habits of nesting crows are rather uniform, at least in those areas. The area where food is collected for the young is normally an open field or other area with vegetation low enough to permit the crow to alight and walk about without difficulty. This may be recently prepared seed beds, small grain plantings, pastures, or meadows early in

spring or after mowing. Natural areas which approach the conditions mentioned are equally acceptable. Under some conditions beaches, some kinds of marshes, and the shores of streams or lakes are utilized.

The presence of a suitable tree is apparently not essential. Over most of the crows' range trees are readily available, but upon occasion crows utilize what appear to be very inferior sites and are apparently strongly influenced by the other factors mentioned. The literature contains a number of references pertaining to unusual nesting sites of crows. Aldous (1937), Ferry (1910), Hochbaum (1944), Mitchell (1915) and Wolfe (1931) report crows nesting on the ground. Aldous (1937), Bradshaw (1930), Mitchell (1915) and Potter (1932) report other unusual nesting sites. Such odd nesting sites are sometimes utilized when trees are available near at hand.

The western crow, Corvus b. hesperis, is reported to sometimes nest in colonies, a habit never reported for the eastern subspecies. Emlen (1942) made a detailed study of one such colony in California where about 60 pairs of crows were nesting in a walnut orchard. His activities in the orchard disrupted a number of nests and the subsequent renesting of many of these crows enabled him to make observations on a total of 111 nests in the 108 acre tract. The nests were generally well spaced, averaging 250 feet apart, the closest being 80 feet. The number of nests in excess of the 60 pairs of birds resulted from the activities of the observer in robbing the nests of eggs, causing the renesting of the pairs. A small community roost was maintained in the orchard through the breeding season. This

roost consisted of about 300 birds in late May and June.

Crow nests have been observed in many species of trees. The primary requirement is an arrangement of branches which furnishes an adequate platform for nest construction. Some degree of inaccessibility from the ground seems to also be a factor. Unusually low nests are generally located in dense or thorny shrubs or trees. Bent (1946) states that in New England and the Maritime Provinces the majority of crows nest in coniferous trees. Crows in the midwest utilize coniferous stands where available, but no particular preference for such has been noticed. No quantitative study has been made however. The observations of T.E. McMullen made in Pennsylvania, Delaware and New Jersey are recorded by Bent (1946). He found that 112, or 49 per cent of 227 nests located, were in oak trees. This corresponds quite closely to my own observations in central and northwestern Ohio. Of 100 nests located there, 45 per cent were in oak trees. Oaks make up considerably less than 45 per cent of the timber stand in the areas examined, thus this rate of use suggests a requirement for nest tree qualities most frequently satisfied by oaks. Table 6 summarizes the utilization of various tree species in Ohio. Oaks with many heavy forks and stiff branches probably furnish more potential nest sites than most other trees do.

The nest is generally located near the main trunk of the tree or in a fork of a large branch. The exceptions which I have observed had compensating characteristics, such as are found in the osage hedge where crow nests are sometimes built near the top, the density

TABLE 6

UTILIZATION OF VARIOUS TREE SPECIES FOR NESTING BY OHIO CROWS

Tree	Percentage of Nests
Oak	45
Ash	13
Elm	11
Beech	10
Osage	2
Hickory	2
Catalpa	2
Maple	2
Cottonwood	2
Walnut	2
Apple	2
Hawthorn	1
Honey locust	1
Basswood	1
Crabapple	1
Black cherry	1
Sycamore	1
Kentucky coffee tree	1

and stiffness of the branches compensating for their small size. Emlen (1942) found that, in California, late nests built after the leaves opened tended to be "peripheral," often in small terminal branches.

Nesting sites vary greatly in the amount of isolation that they afford the nesting pair. Crows ordinarily do not build nests in the vicinity of farm buildings or homes, but so many exceptions to this have been observed that one must hesitate to make general statements. Nests within fifty yards of a house have been observed more often in suburban areas on the outskirts of cities than in rural communities. Hunting is usually restricted in these suburban areas, a good food supply is generally available close at hand, and the birds are little disturbed in spite of their close proximity to human habitations.

Crow nests may be located in any part of the small grazed woodlots so common throughout the midwest, but in larger forested blocks there is a noticeable tendency to nest near the periphery. This is logical because most of the food is secured from open farm land.

In Ohio, and presumably in similar country elsewhere, many crows nest in isolated trees in fencerows or in fields far from the nearest woodlot. These nests appear to be more conspicuous and exposed but the observed nest mortality has been no higher than in woodlot nests.

The nest of old birds is generally located in the vicinity of that of the preceding year and it is not uncommon to find two or even three years' nests in the same tree. Reimann (1942) points out that

this habit aids in locating new nests by reference to the old. Rather uncommonly a nest of the preceding year may be repaired or used as the base for extensive remodelling. Emlen (1942) found this to be true in the case of 13 or possibly 17 of 111 nests in a colony in California. In Ohio only one such nest was found and it had been in use for three seasons.

Very rarely an old nest of some other species may be used as a base for nest building. Ralph Andrews found such an example in a marsh along the south shore of Lake Erie in 1952 where a crow was using the previous year's nest of a black-crowned night heron. The location was especially interesting because another nest occupied by a black-crowned night heron was situated just 18 inches above the one in use by the crow.

Frequently one or more false starts may be made and the nests abandoned at an early stage in construction. I have observed nests in one woodlot in Ottawa County, Ohio, where a pair, whose work could be identified because of the liberal use of long strands of dead grass, made at least four starts before a nest was finally completed.

(b) Nesting Dates

The range of the crow is very large and there is a considerable difference in the dates of the beginning of nesting. Bent (1946) lists the earliest egg date for Florida as January 21, the earliest for Alaska as May 10.

In central Ohio many nests are begun by mid-March, and almost all crows are nesting by the first of April. Nest mortality is quite high, and renesting attempts may appear for many weeks. During this study no nests with eggs were observed later than the last week of May. Trees are leafless for some time after nesting begins and the bulky nests are frequently quite conspicuous; such nests can often be spotted from a distance of one-half mile or more.

(c) Nest Construction

Both sexes assist in the construction of the nest. The time consumed in the building process varies greatly and no explanation for such variation is apparent. Pairs of crows have been observed where both sexes worked diligently making trip after trip with nesting material as fast as it could be gathered. Under these circumstances the nest would be completed in a few days. At other times nest building appeared to be an incidental activity. Such an observation was made on March 22, 1950. A group of four birds, presumably a pair and two yearlings, were feeding together in a pasture several hundred yards from my car. They were observed through binoculars for nearly 45 minutes. During this period one of the crows carried some grass or a bit of weed a quarter of a mile across the fields to a nest under construction in a woodlot. None of the other crows went to the nest, and the one which carried the material did not repeat the act. There appeared to be no activity about this nest when it was visited 12 days later, although construction was well along when

first observed. Other nests have been located where several weeks were spent in construction. Mr. Homer Price of Payne, Ohio, watched one pair which took nearly a month to complete the building. Emlen (1942) found that in the case of first nestings in California the period averaged about 13 days.

The nest itself is a sturdy and well-built structure. This is contrary to the opinion of most casual observers who have not examined a nest at close range. From the ground the nest appears to be a loose assemblage of small sticks and twigs, but this is only a base upon which is built a compact and smoothly lined structure.

The bulky base is constructed of dead twigs seldom over 3/8 inch in diameter and usually less than two feet in length. Most of these are gathered from trees, as is attested by their freshly broken and unweathered ends. This character is useful in identifying nests of the year, for many are so well constructed that from the ground they may appear quite usable for a year or more after being completed. Reimann (1942) points out that this characteristic is useful in separating crow nests from those of the Cooper's hawk, which they resemble. He states that the Cooper's hawk constructs the base of its nest with the broken ends of the twigs pointed in toward the center of the nest and the slender tips exposed, the reverse of the method used by the crow.

The depth and bulk of this twig foundation depends almost entirely upon the nature of the branches supporting the nest. The twig base may be built up in narrow forks for more than a foot. The

top of the nest commonly measures 12 to 14 inches across, with a nest cavity about 7 inches across and 4 inches deep. Soil is carried in sufficient quantity to make an earthen floor and the cavity is then generally lined heavily and smoothly with grass, moss, shreds of bark commonly from grape vines, and any of a wide variety of other materials. Tufts of hair gathered from carcasses of livestock or wild animals, binder twine, and occasionally feathers are often used, The completed structure is well able to withstand the rigors of the weather and the strain of use by a brood of young. Figure 12 illustrates a typical nest of the crow.

(d) Other Inhabitants of Crow Nests

The nests are so substantial that they persist and are often used as homes in subsequent years by other birds and mammals. Squirrel nests are frequently constructed upon old crow nests. White-footed mice also use them, and raccoons have been observed using such nests for sunning platforms. Cooper's hawks, broad-winged hawks, long-eared owls, great horned owls, and mallards have been known to utilize old crow nests during their own reproductive period. Ralph Andrews has told me of such a nest in the Lake Erie marshes which was utilized by mallards in 1952, but occupation by ducks must be most uncommon.

A number of invertebrates have been found living in the nests of crows; some of these are parasitic upon the birds, but others presumably subsist upon organic material in the nest. Larvae and puparia of the parasitic flies belonging to the genus Protocalliphora

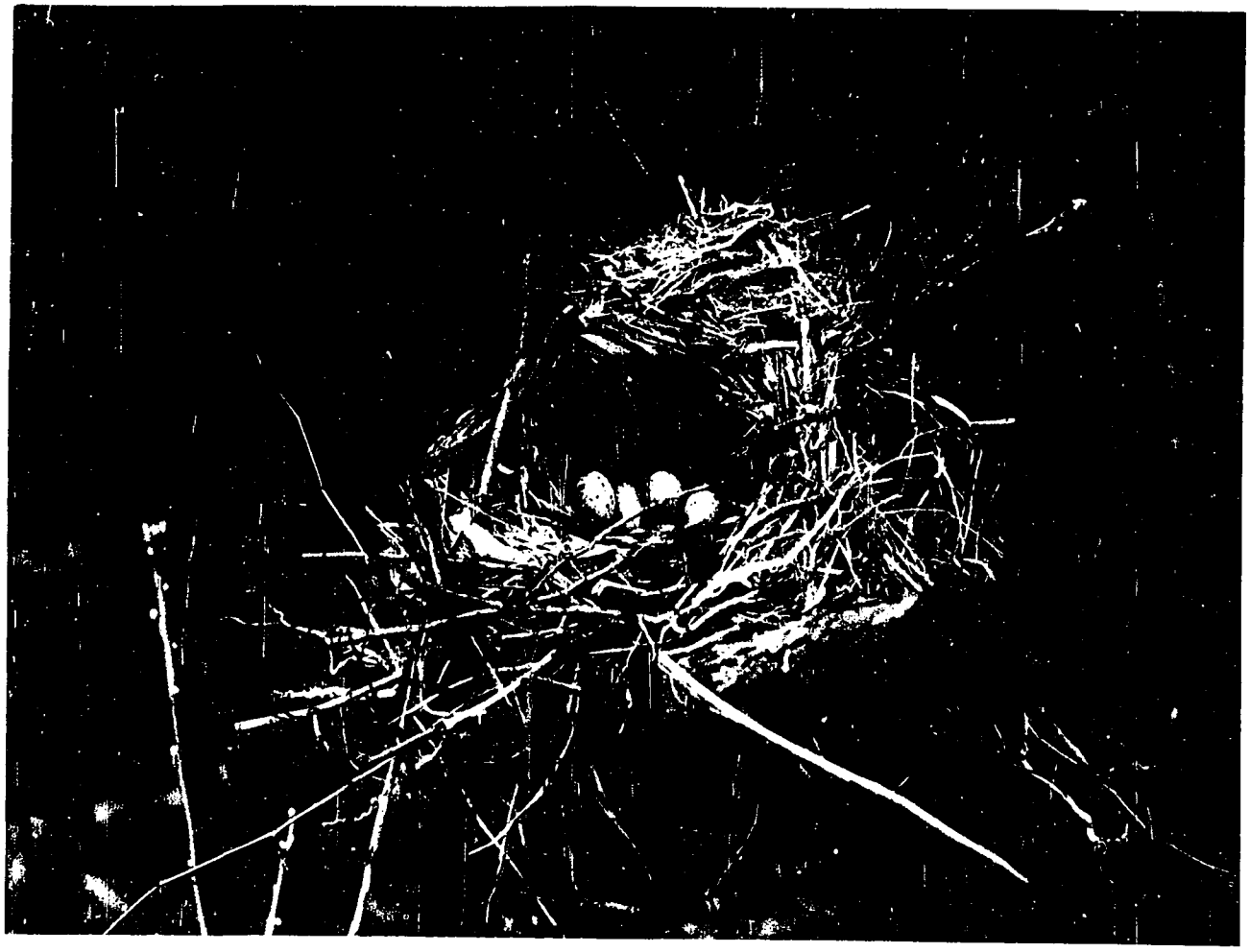


FIGURE 12

A Typical Nest of the Crow

have been found by a number of investigators. Jellison and Philip (1933) found these and the following in nests which they examined in Montana: blood-gorged adults of the mosquito, Culicoides biguttatus Coquillett, adult dermestid beetles, Dermestes signatus Leconte, and two species of Mallophaga, Docophorus communis Nitzsch and Myrsidea subaequalis Lyonet. Dr. Edward S. Thomas has found some interesting invertebrates associated with crow nests in Ohio. In one nest collected in Licking County, Ohio, on May 23, 1945, the following were found: 1 earthworm (the season had been moist), larvae and puparia of a parasitic fly Protocalliphora, very many unidentified mites, 5 or 6 adults and a number of larvae of the beetle, Trox affinis Robinson, a small immature cockroach, and about 10 Crematogaster ants. The Trox beetles and the Protocalliphora larvae and puparia have been found in other nests. Every nest examined by the writer has contained the beetles.

Eggs and Egg Laying

Egg laying begins as soon as the nest is completed. The usual clutch size is 4 or 5 eggs. In 61 sets in the Price collection there are 7 sets of three eggs, 19 sets of four, 28 sets of five, 6 sets of six, and 1 set of seven eggs. Emlen (1942) in his study of western crows found the clutch size to average 4.4 eggs. He found second clutches to be slightly larger than first sets. This is the reverse of what is known of many other birds.

The eggs are usually laid at the rate of one per day. Emlen (1942) found this to be true in 43 nests, and in 14 others an extra

day intervened. In 10 cases this extra day was just preceding the laying of the last egg. He found that most of the eggs were laid in the latter part of the morning.

The eggs of the crow vary greatly in size, shape, color, and pattern of the markings. Two hundred seventy-three eggs comprising sixty sets in the collection of Homer Price of Payne, Ohio, averaged 29 mm. in greatest diameter and 41 mm. in length. The diameter varied from 26 to 32 mm. and the length from 35 to 49 mm. The longest and shortest eggs were the same diameter, being 28 x 49 mm. and 28 x 35 mm respectively, thus illustrating the wide variation in shape to be found. Occasionally runt eggs are found in sets, but those observed have been infertile. In a set of four eggs collected in April, 1949, near Columbus, Ohio, three appeared quite normal and the smallest measured 30 x 42 mm.; the fourth, which proved to be infertile, measured 22 x 31 mm.

The color variations are at least as great as those of size and shape. A series of sets in the Ohio State Museum were compared with the standard plates in Ridgway (1912). The ground color was found to vary from creamy white (Jacobs 1935) through pale dull glaucous blue, pale niagara green and dark bluish glaucous. Eggs are occasionally so heavily marked as to have the ground color obscured. The blotching is deep olive, dark olive-buff, fuscous, olive, light Quaker drab or pale green-blue gray. The blotches may be bold or fine and in varying degrees of density. When eggs are boldly marked, the heaviest markings are at the large end of the egg. The pigment on some

finely marked specimens is so uniformly distributed that the egg appears almost uniformly olive green with little or none of the ground color showing through. Rarely erythristic egg sets are found. Jacobs (1935) reports such a set in which the ground color was whitish or buff and the blotching was rusty red or reddish brown.

There is great variation among crow eggs in general, but those in a single set are usually rather uniform in shape and color. Since the crow has but one functional oviduct all of the eggs must be formed in the same manner and should be similar in shape. Many sets, however, contain one or more eggs which differ radically from the remainder of the set in color, shape, or both. Variations in the degree of pigmentation might readily be explained, but variations in the shape of eggs in a single clutch are more difficult to account for. A possible explanation might be that the nest has been used for egg laying by more than one female crow. Evidence supporting this possibility is not substantial, but a few observations tend to strengthen it. Three crow hunters have told me that they have shot several crows from the same nest over a period of a few days. The question naturally arises as to the source of these birds which in at least two cases numbered a half-dozen or more. In the notes of Homer Price, whose egg collection I was privileged to examine, instances were found where the odd eggs in a set had been incubated to a noticeably different stage from the others at the time of collection. While not conclusive in themselves, these observations point to problems of much interest.

Incubation

Incubation generally begins with the laying of the last egg. Reimann (1942), however, states that when large clutches are laid, the female commences to incubate before the set is complete. His observation is likely correct for not uncommonly a bird may be hatched one or even two days later than others in the brood. In a nest near Columbus, Ohio, in 1950, one bird was hatched two days later than the others. It did not thrive, and subcumbed at 22 days of age. The incubation period is variously recorded. Emlen (1942) states that in the western crows which he studied the period from the laying of the last egg until hatching was 16 days in 3 nests, 17 days in 8 nests, and 18 days in 1 nest. Bent (1946) and Bergtold (1917) record the incubation period as 18 days, Black (1941) as 19 days, and Reimann (1942) states that it is approximately 21 days.

The female does virtually all of the incubating. In many hours of nest watching by students and myself, only once was a male crow observed to occupy the nest and then only briefly. The male generally spends the day in the vicinity of the nest, perched in a tree or on a post or feeding in nearby fields. At irregular intervals he feeds the female on the nest and periodically she may vacate the nest and join him briefly to feed nearby. At much times the nest may be unoccupied for periods varying from only a minute or so to over forty minutes. If the nesting pair are old crows who have successfully reared a brood during the preceding summer these young birds may return and remain with the adults during the nesting

season. They may participate in nesting activities, but to what extent has not been clearly determined. Due to the difficulty of aging and sexing crows in the field it has been impossible to determine the status of "extra" birds in the vicinity of the nest except in a few instances.

One nest at Columbus, Ohio in 1950 was under careful observation from the beginning of incubation. Three yearling crows were present in the area and frequently visited the nest where the adult was incubating. They were observed many times to fly to the nest and lower their heads momentarily in the same manner as did the male. Assisting students and I are at a loss to explain this behavior. Could it be that they are feeding the incubating female as the male does?

Very peculiar behavior was observed on the day that hatching took place in this nest. The incubating female seemed restless on the nest, as is normal at hatching. She moved frequently and did not sit as low in the nest as during incubation. The male came to the nest and fed the female, who stood up at his approach. Six minutes later he returned, and this time the female got out and perched beside him on the edge of the nest and both appeared to peer intently into the nest. The male then flew off and the female resumed her incubating. Twelve minutes later four crows, presumably the male and the three yearlings, approached the nest. All four perched on the edge of the nest and the female got off the nest again. All peered into the nest and then all but the incubating female flew off making

a great racket with their excited "cawing." They kept this up for more than forty-five minutes.

At another nest which contained young three crows were observed to remain in the vicinity, and once all three birds were seen feeding the young. Again at this same nest the "extra" crow occupied the nest brooding the young in the evening, and the other two which had both been feeding, left the area together. These isolated instances indicate a relatinnship imperfectly understood but likely fruitful for study by students of animal behavior.

After hatching the egg shells must be removed by the adults. They are never found in the vicinity of the nest. Unhatched eggs may remain in the nest for several weeks, but generally disappear before the young are fully grown.

Reaction to Nest Disturbance

The reaction of the brooding female to disturbance near the nest site varies somewhat, but it is usual for the bird to sit low in the nest and remain motionless until the intruder approaches quite close. How closely one can approach varies with the nature of the nesting tree, the surrounding woodlot, the stage of incubation, and quite possibly with variations in the wariness of individual birds. The bird usually does not leave the nest until the intruder has started up the tree or a ladder is placed against the trunk. If incubation is advanced or small young are in the nest the bird frequently remains on the nest until approached within a few feet. Several times adults have nearly been captured by

cautiously climbing up under the nest. When flushed from eggs the bird generally flies off silently across the woodlot.

This behavior changes radically after the young are hatched. Adults cannot then be flushed without the intruder suffering a barrage of vindictive crow language which will be continued until he leaves the vicinity. Such invective is always delivered from a safe distance. I have never seen crows make any attempt to attack a human intruder, although they would probably defend their nest against a small mammal or another bird. After the young are hatched, adult crows commonly begin to scold as soon as a person is sighted approaching the nest or entering the woodlot. Such scolding may become frenzied if one starts up the nest tree. At one nest under observation the adult apparently learned to recognize my automobile. I visited this nest almost daily to weigh and photograph the young and carried an extension ladder on top of the car to aid in reaching the nest. The adult crow would fly up and begin to circle and scold as soon as the car came into view, although other cars without ladders on top incited no such response.

Non-breeding juveniles which were associated with breeding pairs joined in the scolding when the nest was disturbed and continued as long as the adults persisted. There appeared to be no tendency for neighboring pairs to cooperate in harassing an enemy at a nest, no matter how frenzied the scolding might be and even though only a few hundred yards intervened between nests.

Crows do not exhibit the strong territorial behavior common in so many other birds. Only once in the course of this study was any activity observed which might be interpreted as territorial defense. In May, 1949, the writer was watching a nest located in a clump of trees in a pasture. The female was incubating and the male was feeding in a field several hundred yards away. A third crow appeared, flew to the nest tree, and alighted on a limb adjacent to the nest. The incubating bird pecked viciously at the intruder without leaving the nest and the male quickly arose and flew to the nest tree, where he alighted but made no attempt to attack the intruding bird, which was by that time approximately two yards from the nest. All of the birds sat quietly for several seconds and then the female sprang from the nest and chased the intruder into a nearby woods pasture.

Black (1941) also reported that the crow defended no territory other than the nest itself. Since nests of the eastern crow are almost never close together, it is rather surprising to find so little territorial defense.

Development of the Young

Newly hatched crows are brooded for some time by the female. Emlen (1942) found that in the western crow this period ranged from 9 to 14 days. He also found that the birds averaged 12.3 grams in weight when hatched. The young at first are nearly naked, and are of a pale fleshy pink color. Their eyes are closed. The inside of the beak and mouth is bright red. The neck is long, the body is grotesquely rotund, and the abdomen inflated. The legs are long

and appear to be awkwardly manipulated, but the young bird is remarkably well adapted to elevating its wide mouth to the highest possible point and maintaining it there until fed.

When aroused, first by sound and later by sight or sound, the young bird rears its head and supports itself on the caudal tip of the body and its two tarsi. The feet project out at an angle on each side, further broadening the base of the tripod. The neck is stretched straight up to the ultimate height and the mouth is opened wide. In this position in the nest the tiny animal is deceptively stable, reminding one of nothing so much as a tall vase with a weighted base.

Development is very rapid. Figure 13 shows the gain in weight made by the young in one brood from the time that they were a few days old until fledging. The one young, represented by the lower lines on the chart, hatched two days later than the other three and succumbed at the age of 22 days in a state of extreme emaciation.

The period of most rapid growth was between 10 and 14 days of age when gains in excess of 20 grams per day were recorded. Growth was generally slower during the last half of the development in the nest.

The eyes begin to open at about 6 days of age, although in some young the eyes may remain closed at least a week. By the time the young are three days old pigment deposition is prominent in the skin. This pigmentation progressively darkens the skin until the whole body is quite blackish before the feathers appear.

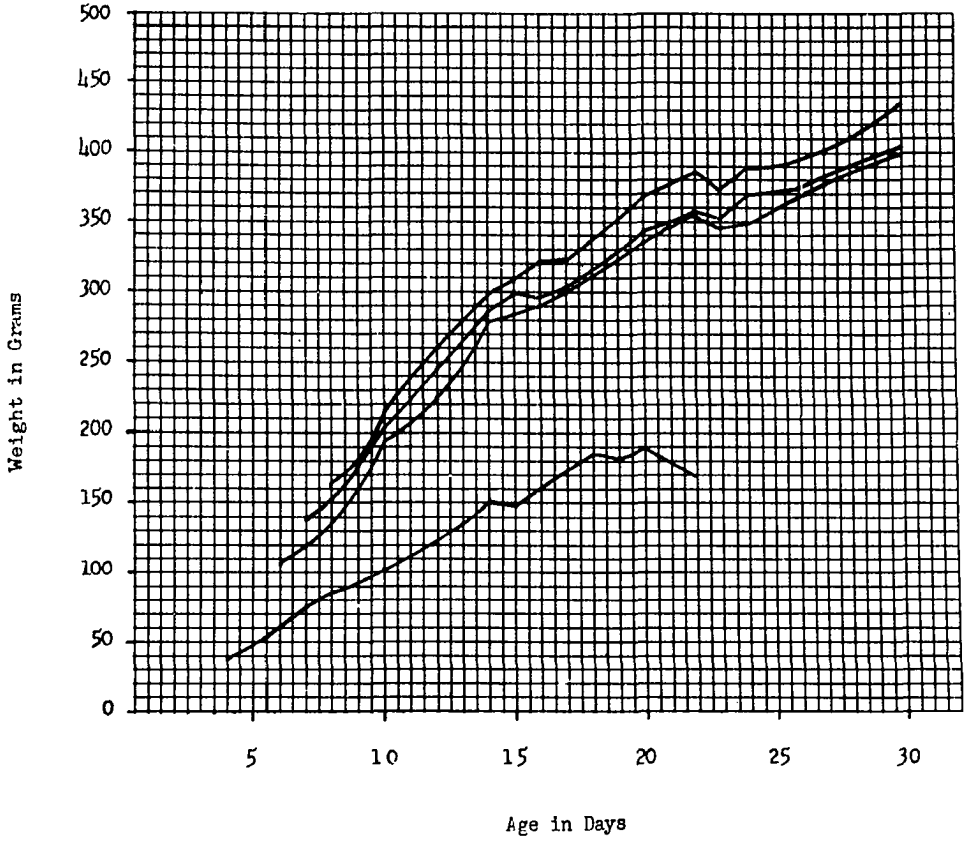


FIGURE 13

Age-weight Relationships in a Brood of Young Crows

At about 6 days of age the tips of the primaries begin to show and at one week tiny flecks of down are conspicuous on all of the feather tracts. Figures 14 to 32 inclusive, illustrate the rate of development of the young.

Both sexes assist in caring for the young. Food is collected in open grassy fields, plowed ground, along beaches, or wherever crows can alight and walk about unimpeded by dense or tall vegetation. The food given to the young contains many of the same items eaten by the adults, but in different proportions. Grain, insects, small animals of various kinds, birds' eggs, and garbage may all be fed to the young.

The feeding of the young by both adults is not a continuous dawn to dusk chore. At times one carries food while the other broods, or both may work together bringing food simultaneously and returning together to the field to collect more. The food is apparently normally carried in the crop and regurgitated for the young. From the nature of much of the food it seems unlikely that any other method of carrying could be satisfactorily employed, and my own observations suggest that the food must be regurgitated. The time between feedings varied from a few seconds when both adults were carrying food, to periods of one and one-half hours or more. The average period observed between feedings was about 15 minutes. The adults generally brought food rapidly every few minutes for several trips, followed by a lapse of 20 minutes or so before feeding would be resumed. This lapse might be extended for much longer, to 1½ hours

FIGURE 14

A Crow About Five Hours Old

FIGURE 15

A Crow Approximately 24 Hours Old

FIGURE 16

A Crow Approximately 48 Hours Old

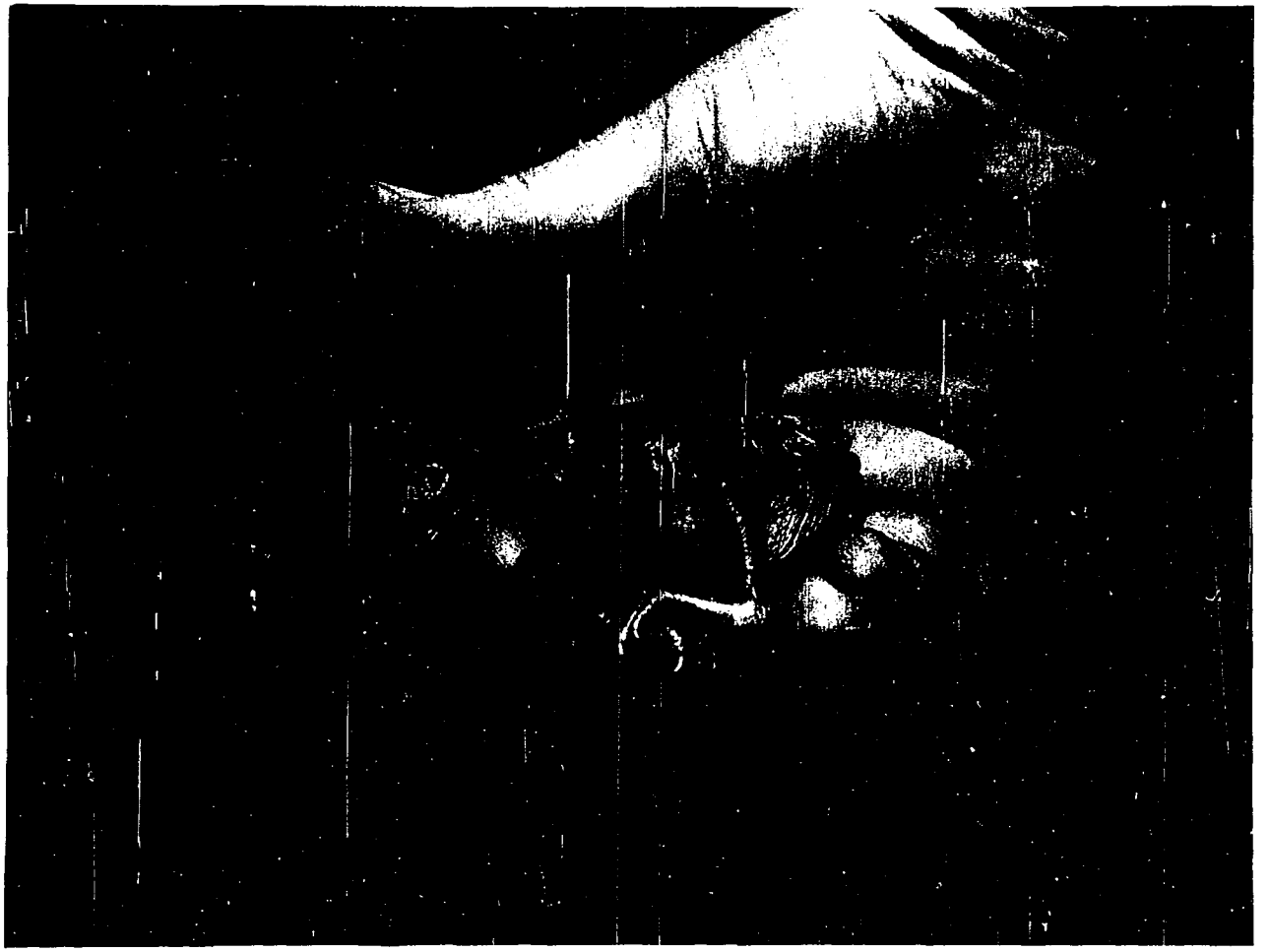


FIGURE 17

A Crow Three Days Old

FIGURE 18

A Crow Four Days Old

FIGURE 19

A Crow Five Days Old

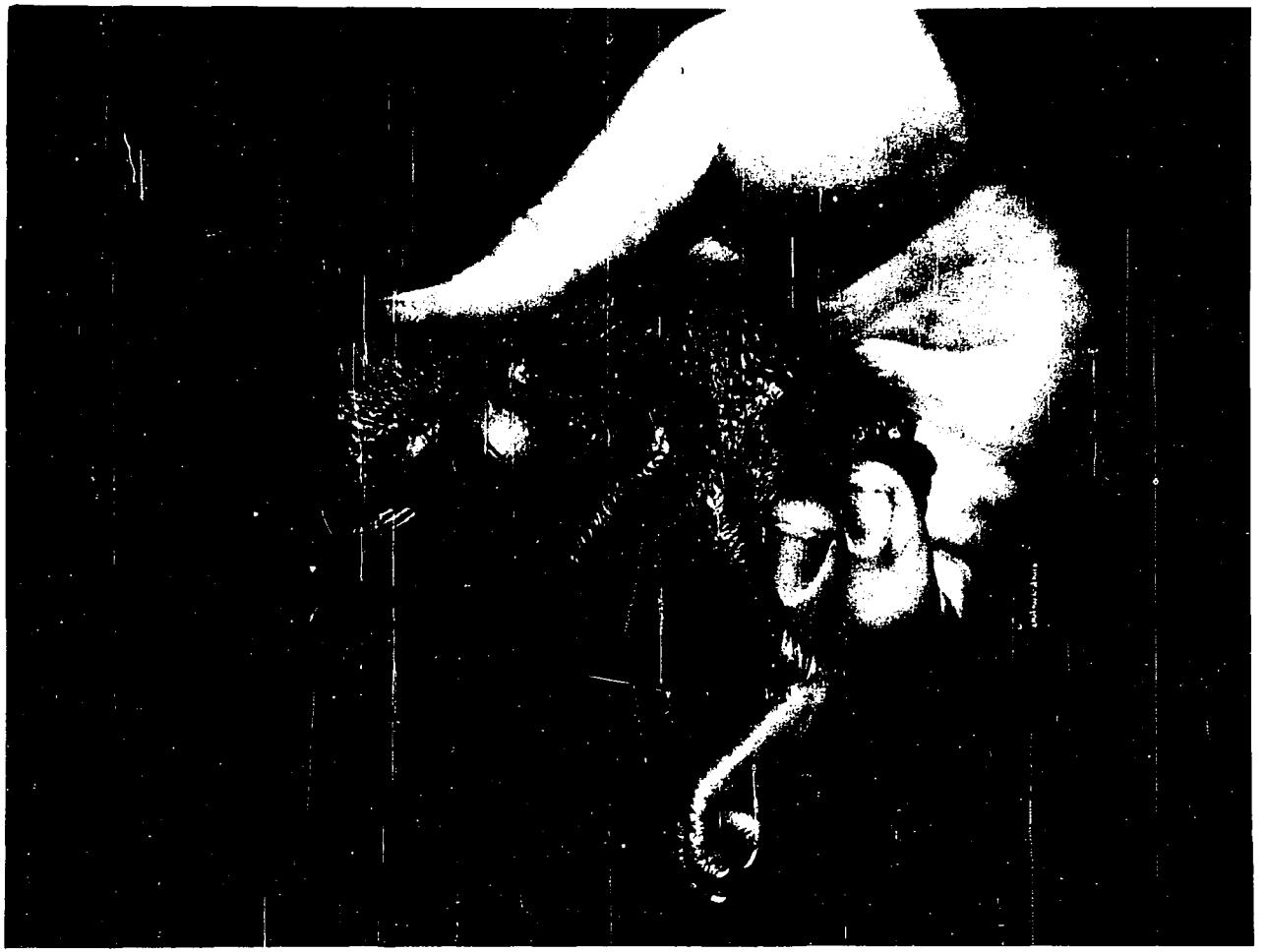


FIGURE 20

A Crow Six Days Old

FIGURE 21

A Crow Seven Days Old

FIGURE 22

A Crow Eight Days Old

FIGURE 23

A Crow Nine Days Old

FIGURE 24

A Crow Eleven Days Old

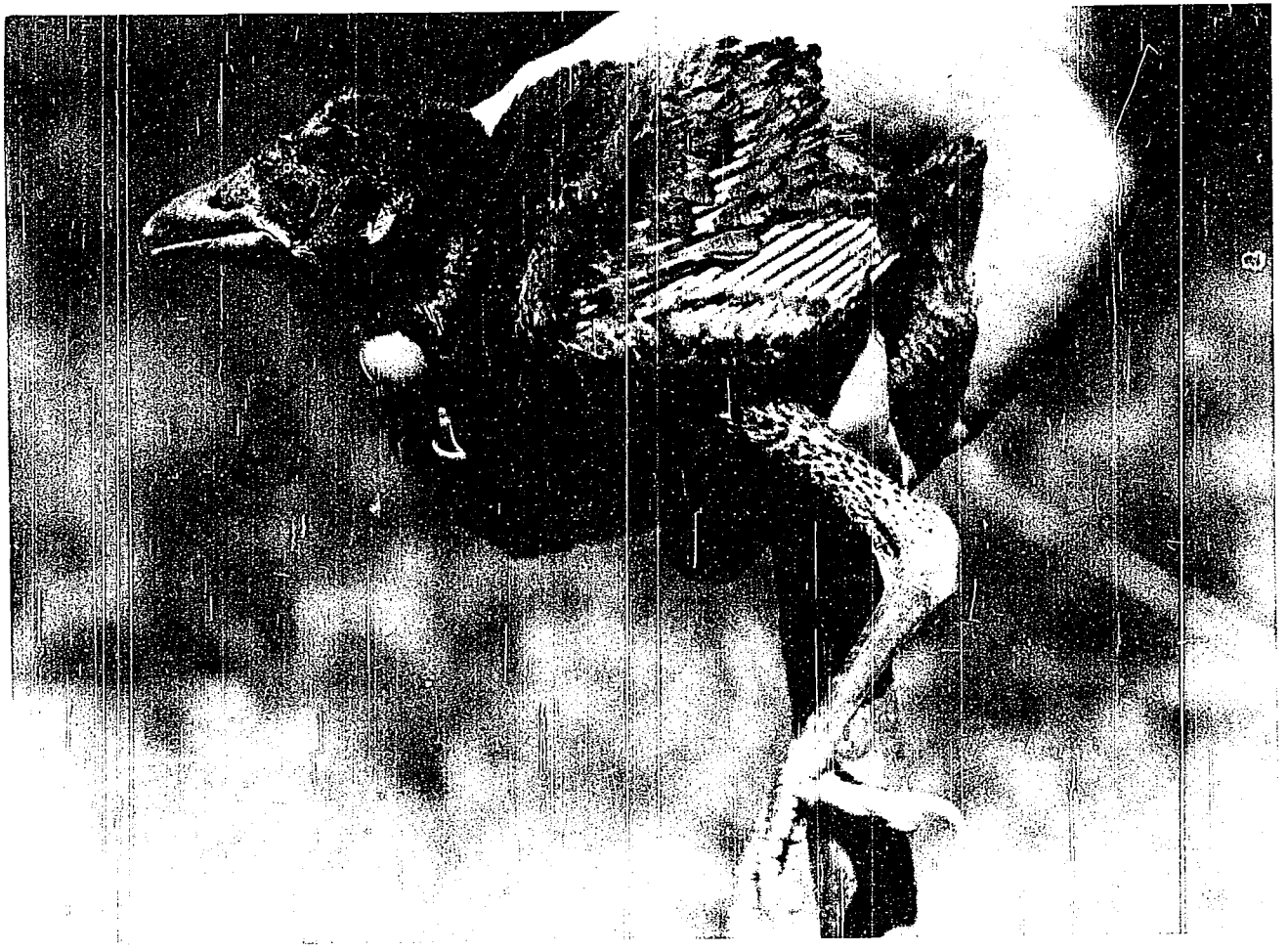


FIGURE 25

A Crow Fourteen Days Old

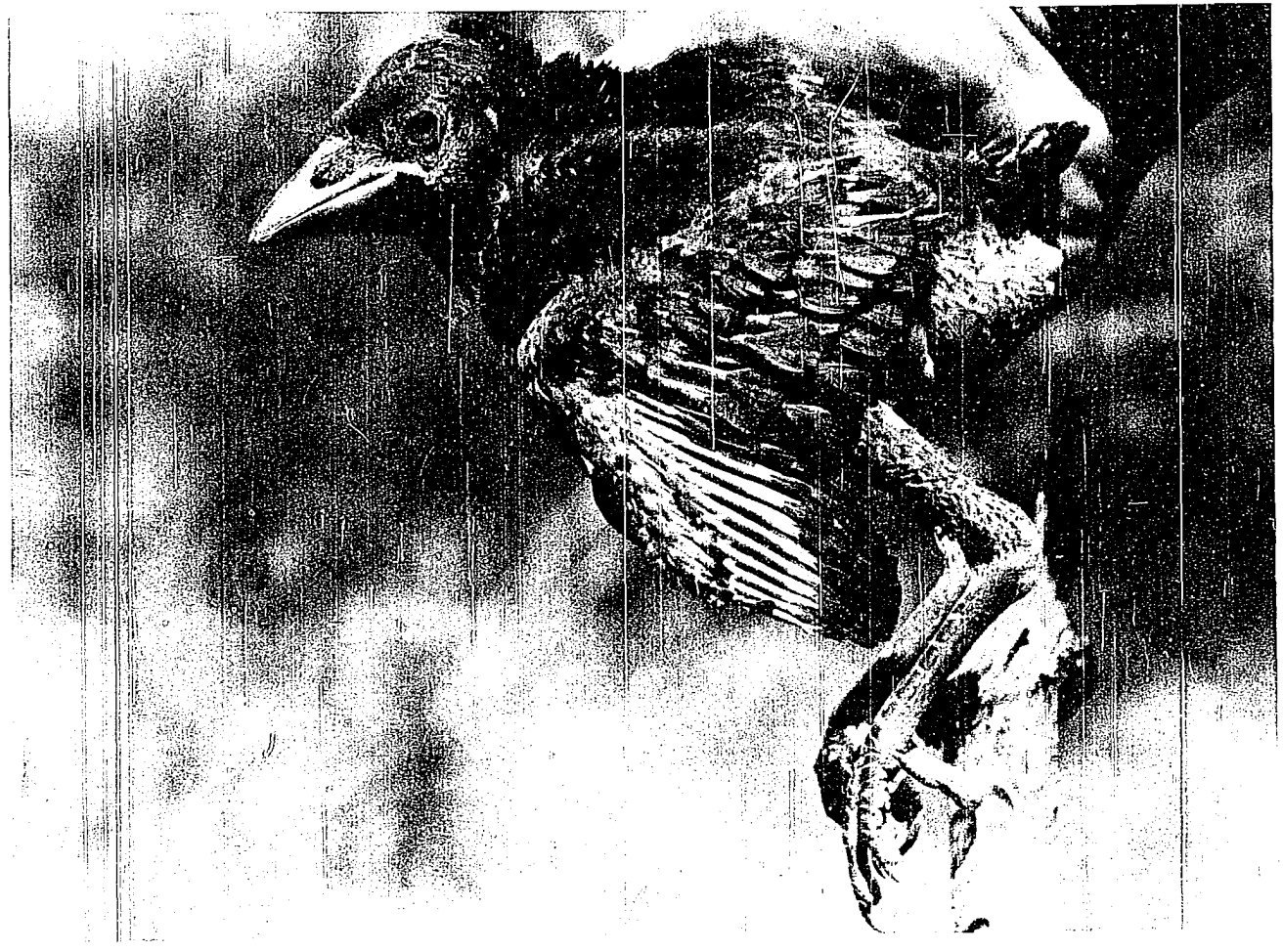


FIGURE 26

A Crow Fifteen Days Old

FIGURE 27

A Crow Sixteen Days Old

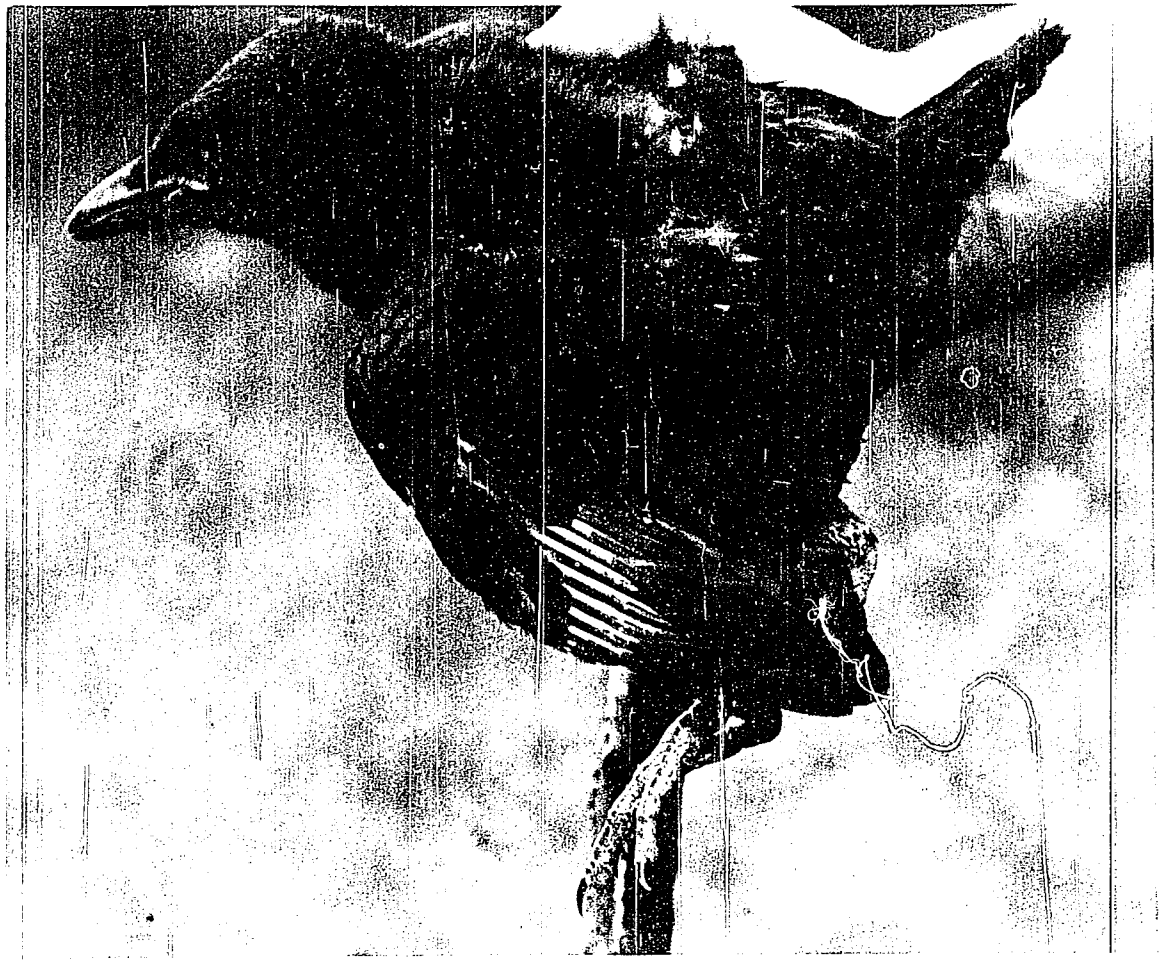


FIGURE 28

A Crow Twenty Days Old

FIGURE 29

A Crow Twenty-one Days Old

FIGURE 30

Crows Twenty-three Days Old

FIGURE 31

Crows Twenty-five Days Old

FIGURE 32

Crows Twenty-nine Days Old

or more.

From observations made at a few nests where the hatching date was known, it appeared that feeding was less frequent the first few days after hatching. The adults spent much time in brooding the young and periods of one and one-half or even two hours elapsed during which no food was brought to the young. The whole process of attending to the needs of the nestlings is very irregular. When yearling crows are associated with nesting adults, they frequently visit the nest containing young. The adults make no effort to prevent this and adults and juveniles frequently perch side by side on the edge of the nest. In a few instances already mentioned "extra" birds have been observed to feed the young, but these may not have been yearlings, although that is certainly a good possibility. On at least four occasions yearling birds have been observed to lower their heads into the nests and remain in such a position while curiously bobbing the tail and body for periods sometimes as long as ten minutes. It is impossible to see exactly what the birds are doing but, since all of the nests where this has been observed have contained young, a plausible conclusion is that the yearlings were scavenging food scattered in the nest during the process of feeding. The gravest criticism of this explanation lies in the fact that no such food particles have been observed even in nests without yearling visitants.

How nest sanitation is accomplished when the young are quite small is not known. As soon as they develop sufficiently to move

about in the nest they manage this quite well for themselves. Turning their heads to the center of the nest they back as far to the edge as they can. Lowering the head and elevating the body as high as possible, the tail is wagged rapidly and the fecal material is ejected rather forcefully over the side of the nest. This keeps the interior of the nest clean, but frequently covers the outside of the nest and the branches around it with excrement.

Young crows show no fear of man until about two and one-half weeks old, when suddenly the fear fixation occurs and instead of clamoring for food when the observer climbs to the nest, the young crouch low and recoil from hands outstretched to grasp them. This change may take place within 24 hours. For a day or two this fear can be overcome by a little handling and the young will again beg for food from humans, but a few days thereafter no amount of handling will restore their confidence or incite the begging reaction. Young taken from the nest after this period are difficult to rear in captivity and seldom become really tame. Cruickshank (1939) has reported this behavior in crows that he reared and I have found no exceptions in the crows that I have studied. Young taken before the fear fixation must be hand fed for a longer period, but eat so readily that little trouble has been experienced in keeping them.

The young develop rapidly but it is about a month before they are ready to leave the nest. This time varies; in those nests where the exact age of the young was known the young have left at ages varying from 28 to 35 days.

A few days before the young leave the nest they may be seen standing erect or even climbing up on the edge of the nest. In this position they stretch their wings and fan them against the air. The birds at first are hesitant and awkward, but facility is gained rapidly and before venturing from the nest the young are able to use their wings so well that they must hold to the nest firmly with their feet to avoid being lifted into the air by their rapid wing motion.

The first venture from the nest is generally made on foot where branch arrangement permits. The young crows walk and hop awkwardly about the tree before venturing to attempt short flights. Where the arrangement of branches about the nest does not permit perching or walking the young may be confined to the nest somewhat longer than would otherwise be the case. At least, where the young remained in the nest for the longest period there appeared to be no suitable branches adjacent upon which to perch. The young probably leave the nest of their own volition. No attempt by adults to entice or force them from the nest has been observed.

Once out of the nest the individuals of a brood quickly become separated and scattered over the woodlot. The parents continue to feed them and gradually as they become stronger on the wing they begin to fly to the adults and follow them about the woodlot begging. The young eventually accompany their parents into the open fields and begin to gather their own food, but this is generally two weeks or more after fledging.

The young of crows nesting in isolated trees may remain in the

nest tree for some time after leaving the nest. Since no other trees are near, short flights are impossible without alighting on the ground, a contingency which fledglings appear to avoid. After a week or two the young will have gained sufficient skill and confidence to follow the adults to the nearest grove or woodlot. One nest in an isolated tree was visited repeatedly from the time the young left the nest until they left the tree. They left the nest at the age of 35 days. For several days following, they sat motionless among the branches when I was present. This behavior pattern gradually changed to one of hopping or flying from limb to limb, always keeping as much distance as possible between themselves and me. A few days later, if strongly disturbed, they would fly out from the tree a few yards, then circle and come back. This pattern continued, the flights becoming longer, until one day nearly two weeks later one of these flights was extended to the nearest tree several hundred feet away.

At the time of leaving the nest the young have the blue eyes and bright red mouth lining of nestlings, but brown pigment soon begins to form in the eye and the inside of the mouth fades to a pale pink. By late summer the eye is brown and the inside of the beak near the tip and along the edges has begun to darken. This pigmentation will continue until, in the mature bird, the whole inside of the mouth and throat is black. But the process is not completed until the bird is a year and a half old or older.

By July most of the young crows are gleaning their own food in the company of the adult. They may still attempt to beg food at

times but are generally ignored. The young fly well and are not readily distinguished from adults in the field. Their voices, however, are definitely juvenile and are not often used except for begging when the adults are present. They may be decoyed at this time by the use of a crow call. They follow the adult from the woodlot and circle over the caller, but make no sound even though the adult may furiously utter the rally call.

The young undergo a partial postjuvenal molt in which the contour feathers and wing coverts are molted. The flight feathers, the remiges and retrices are retained. These feathers are not so heavily pigmented as those of the adults and this difference is further accentuated by wear. Emlen (1936) has shown how this character can be used to age crows until their second summer. By spring these feathers are quite worn, foxed and brown in contrast to the glossy blue-black feathers of the adults. In addition to color, the shape of the retrices is also characteristic. Those of the young birds are worn round or pointed on the ends, while those of the adults are abruptly truncated. The tail of the adult is also more rounded on the end, not so square as in the juvenile. The color difference is not sufficient for use in the field except under the most favorable conditions. In good light in the spring, family groups may be recognized with binoculars at easily attained distances. The difference in plumage is apparent when the birds are side by side. At close range it is sometimes possible to positively ascertain the age of solitary individuals. This aging character is lost in June of

the year following hatching, when the first complete molt takes place and the birds assume the adult plumage. Adults also molt after the nesting is over, but their molt is a little later than that of the juveniles.

Pigmentation of the inside of the mouth is ordinarily not completed by the time the molt into adult plumage occurs. Black pigmentation progresses back from the front through the mouth and throat. The time of completion of this process varied in different individuals. More information is needed on this point, but many crows show pink in the throat for some time after the June molt and this character may be useful at that time to separate breeding from non-breeding birds. Figure 33 shows the difference in mouth pigmentation in adult crows, yearlings and young of the year.

Young of the year in their first plumage are easily identified. The feathers are dull brownish black and the iridescence that is present is greenish in hue. According to Dwight (1900) this greenish hue is characteristic of the young of birds with iridescent feathers in which the adults are more blue or purple than the young. This includes the grackles and some of the swallows.

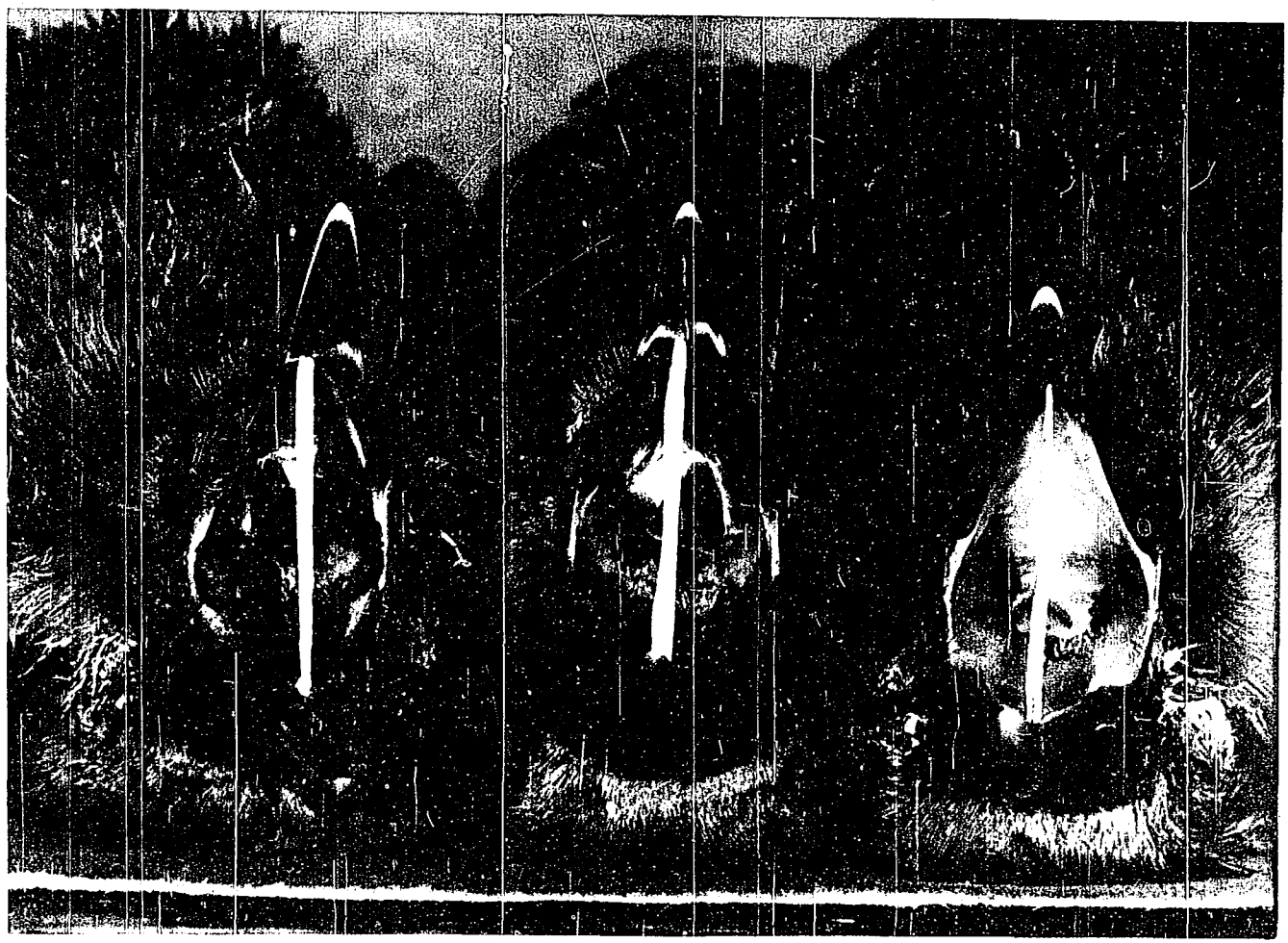


FIGURE 33. Mouth Pigmentation in Crows of Different Ages.

The crow on the left is an adult. The interior of the beak, mouth and throat are entirely black. Note the conspicuous pink (light) color in the throat of the yearling crow (center bird), and the entirely pink mouth and throat in the young of the year (bird on the right).

FOOD HABITS

Introduction

The food habits of the crow have long been the subject of controversy which has at times become quite heated. A considerable number of bulletins, articles, and reports have been published through the years purporting to indicate what crows feed upon and the economic importance of the species to farmers, sportsmen, and others. A perusal of these reports indicates that the crow is truly omnivorous. No matter what ones opinion of the crow in its relation to man, it is certain that much evidence to support that view can be found without trouble. For this reason it is unlikely that biased opinion on any side of the question can ever be changed. Common ground for opponents and proponents of the crow may better be looked for elsewhere than in relation to its food habits.

The crow received the attention of workers quite early in the history of biological investigations by the federal government. The species had increased tremendously with the clearing of eastern forest lands for agriculture and its propensity for digging out sprouting corn, eating soft corn in the autumn, young poultry and eggs, and fruit made it a real pest in agricultural areas of the young nation.

Data on Food Habits

Barrows and Schwartz in 1895 published the first government release on the crow as a bulletin of the Division of Ornithology

and Mammalogy of the Department of Agriculture. This was revised in 1910, and in 1918 Kalmbach published the U.S.D.A. bulletin "The Crow in its Relation to Man". These and the more recent of Kalmbach's bulletins on the crow in its relation to agriculture have drawn heavily upon the file of food habits data accumulated by the Fish and Wildlife Service and its predecessors in the federal government.

Kalmbach (1939) reports that his food habits data are based upon the analysis of the contents of a series of 2118 crow stomachs collected in 40 states, the District of Columbia, and several Canadian Provinces. I have examined the data in the files of the Fish and Wildlife Service and while the quantity is great and the care and accuracy with which each stomach was examined is evident, there is reason to doubt that the results adequately characterize the present food habits of crows except in the most general way. Following are some of the factors which detract from the validity of these data:

(1) A very considerable percentage of the collections were made as long ago as a half-century or more. It has been shown that the crow is relatively omnivorous. Its feeding is greatly influenced by the availability of the various foods. In view of the tremendous changes in crops, land use, and cultural practices since the beginning of the present century, it is difficult to believe that these have not in some degree affected the food habits of this bird. Such things as the greatly reduced acreage of woodlots in the midwest, and especially the remoteness from homesteads of those remaining ones, might be expected to influence the amount of damage to poultry and

fruit during the nesting season. The increased amount and availability of grain left in the fields in the fall and winter due to machine harvesting might also be expected to affect the crow's diet. These and other examples illustrate the many changes that have come about since the collection of much of the data on the food habits of crows.

(2) In spite of the numbers of stomachs analysed, attempts to piece together a picture of the diet of crows in a given area throughout the year proved futile. While there may be ample data for the Dakotas in the autumn, for Indiana in the spring, and for Washington D.C. in winter, the data for other seasons at each locality is likely to be meagre indeed. A compilation of the seasonal data from such widely separated and different areas does not truly represent the annual diet of the crow. Collections often consisted of many crows taken in the same locality within a period of a few days. In such cases examination of the records generally showed close similarity between the stomach contents of individual birds. Such large collections contributed disproportionate amounts of data from small time and area samples.

It is not the intention to discount the excellent work on food habits accomplished by the federal government. The data accumulated have served a real purpose in determining the general food habits of the crow. The personnel of the Fish and Wildlife Service fully recognize the limitations of the material available. It is not their intention or desire to represent it for more than it is. It is

desirable, however, to point out the inadvisability of using such generalized information as a basis for local decision or action. There is still a need for local food habits study if the local economic status of the crow is in question.

Although few strictly comparable data from various parts of the country were found, some examples may demonstrate this need. Kalmbach (1939) found corn to comprise 33.26 per cent of the food of the crow during May, the month when corn is planted. Hering (1934) found that New York crows ate only 1.10 per cent of corn during that same period. Corn made up 13.67 per cent of the crow's annual diet in New York, while countrywide it averaged 38.42 per cent of the annual food. Corn was largely replaced in the bird's diet by buckwheat during the early spring months and again during November and December. Imler (1939) found corn and grain sorghum in equal proportions made up about half of the crow's diet in southwest Oklahoma in winter, while Kalmbach found that corn alone made up more than half of the average diet during those months.

Crop Damage

The destructive potentialities of fall and winter crow concentrations are undeniable. Whether or not they are fulfilled depends entirely upon the availability of the various crops in the wintering area. A survey was conducted in the winter of 1937-38 by Imler and Kalmbach (1939) in Oklahoma where an estimated 3 to 3 3/4 million crows were spending the winter. In the region of greatest concentration it was estimated that 838,000 crows fed over 2592 square miles,

giving an average of 323 birds per square mile. Under those conditions estimates of the damage were secured from farmers and from field appraisal. The following table from their paper indicates damage inflicted:

TABLE 7

Crop	Appraisers' estimate of acres destroyed	Appraisers' estimate of crop destroyed	Farmers' estimate of crop destroyed
	Number	Per cent	Per cent
Grain Sorghum	1,534	3.8	6.0
Indian Corn	691	1.7	2.9

The authors state that farmers in the area felt that this damage was not as severe as that in preceding years when crops were not so good. Damage then had been more keenly felt.

In the case of concentrations as great as this, exposed crops may be completely destroyed locally, The 323 birds per square mile equals approximately one bird per two acres, but since the suitable feeding area is much less than the total, the density is for all practical purposes much greater. Even in areas where harvestable crops are not present, such a population could soon exhaust the supply of waste grain and other food, competing seriously with non-mobile local game species.

All cultivated grain crops are readily eaten by crows. Over the country as a whole, corn makes up a major portion of the diet of these birds in the winter. The "corn belt" area of Iowa, Illinois, Indiana, and western Ohio winters practically all of the midwestern

crows. Increases in the concentrations of wintering birds in southwestern Kansas, Oklahoma, and northern Texas have occurred since the widespread cultivation of grain sorghum began. This grain is a staple of crows wintering in that area.

Wheat, oats, barley, and rye are all eaten readily, and largely replace corn in the diet of birds summering in the prairie provinces of Canada. In the midwest these grains are important items in the diet only for a brief period after the seeding of fields in the spring or fall and again after harvest when the waste grain is available in stubble fields. The gleaning of after-harvest wastes represents no economic loss to the farmer, although locally it may mean competition with some game species. The devouring of small grain after planting is not serious or even important in the midwest. I cannot state with certainty about other areas. In the case of fall-sown grains, other foods are so much more readily available that there is little incentive for crows to do more than pick up those kernels left on top of the ground in the drilling operation. In the spring wheat areas somewhat similar conditions pertain. So many seeds per acre are present that the random gleaning of exposed kernels is of little significance.

Corn is a somewhat different matter. That eaten by crows in winter is largely waste grain left in the field after harvest. The gleaning of waste grain may mean competition with game species for food and occasionally, where livestock is turned into the corn fields after harvest, crows may devour grain of some value. Competition with

livestock is probably of slight economic importance. Corn left unharvested in the field through the winter may be considerably damaged.

Crows feed on corn at other times in the year and with more important consequences. After planting in spring, when the grain has sprouted, and from the time it appears until it is several inches high, crows sometimes dig out the plants and devour the softened kernels attached. With the limited number of carefully spaced seeds per acre the effect of intensive feeding by even a few crows can be most annoying and important.

The most important damage is done in early autumn. From the time the kernels fill and reach the "milk stage" until they become hard late in the fall, crows may feed on the standing corn. At this season the birds have begun to flock and hundreds, or even thousands, may descend upon a single field and destroy many bushels of grain in a short time. Not only what is eaten is destroyed, but even more is exposed to the weather, insects, and disease, and is eventually ruined. The crows seldom eat all of the kernels on an ear. They perch on the stalks, rip open the husks with their beaks and eat the grains exposed along one side of the ear. The shredded husks permit water to enter and the entire ear may rot. At best it will be mishapen and of little value. Figure 34 illustrates this type of damage inflicted on standing corn by crows. This type of damage is by far the most serious inflicted on the corn crop. Individual farmers may lose hundreds of dollars worth of the grain in

FIGURE 34

Crow Damage to Soft Corn

a few weeks.

Buckwheat is readily eaten and in areas where it is an important crop crows may feed on the seeds extensively. Hering (1934) reports that buckwheat largely replaces corn in the diet of crows in central New York where the crop is widely grown.

Cultivated fruit and nuts and a great variety of mast is eaten, by the crow. Cultivated cherries are readily eaten, but larger fruits such as apples and peaches are seldom bothered.

Almond groves have sometimes suffered severely. Emlen (1937 pp. 192-197) describes this damage in California, and Gardner (1926) describes severe damage to almonds in Washington. Emlen (op. cit.) also cites an example in southern Washington where a flock of approximately 30,000 birds were said to have stripped orchards clean. He found that captive crows could consume 30 almonds per day, and thus calculated that such a flock could consume a million nuts, or about 5000 pounds, in a single day — the productive capacity of five average acres. Other species than the crow were also involved, but the damage by crows was serious, especially since the orchards operated on a narrow margin of profit. The crows were selective and concentrated on trees bearing sweet thin-shelled nuts. There was also more damage to peripheral trees than to those located well within the orchard. Damage from crows was more severe in the lowlands.

Pecans are eaten readily. Hoffman (1924) discusses the effect of crows in pecan orchards. Lemaire (1950) found that pecans made up 21.9 per cent of the fall food of crows in the Baton Rouge region of

Louisiana. How much of this was taken from orchards was not known but he believed crow damage to be one of the important causes of loss to pecan growers. He also reported that crows hold the nuts with their feet and crack them with their beak. In eating pecans very little shell was ingested, which makes the quantity consumed even more significant.

Peanuts are sometimes attacked, as are a number of other crops grown commercially in local areas. These include watermelons, which are sometimes severely damaged. Other garden crops and cultivated berries are relished but damage to such crops is not widespread.

Wild Fruits and Seeds as Food

Wild fruits of various kinds are taken by crows whenever they are available. Kalmbach (1939) indicates that nearly 14 per cent of the annual diet of the crow is composed of items in this class. In prehistoric times such materials must have been much more important in the birds' diet than at present. Lemaire (1950) found red mulberries and blackberries to be the most important items in the spring diet of crows in Louisiana.

The fruits of poison ivy and poison sumac appear to be especially attractive to crows and nearly every study of the food habits of this bird reports one or both of these items to be important components of the diet. Many writers have commented on the possible economic importance of this habit. The hard seeds are not digested and it has been speculated that crows may be important agents in the

dissemination of these obnoxious plants but Kalmbach and others have pointed out that crows consume most of these seeds during the months when these birds are flocked and that much of the seed is probably deposited in dense stands of timber where there is little chance of germination. Crows are only one of a host of birds which feed upon these fruits and many of the others are much more likely to deposit the seeds in locations where they become a nuisance or a hazard.

Various species of dogwood, Cornus sp., are eaten by crows. Lemaire (1950) found the fruit of the rough-leafed dogwood to make up more than a third of the winter food of crows in southern Louisiana. At this same season poison ivy seed was found in 80 per cent of the crows collected and made up 28.5 per cent of the food. Beer and Tidyman (1942), in analysing data from Wing (1941), found poison ivy seeds in 34 of 36 stomachs and Cornus seeds in 27 of 36 examined. They believed the relationship between the amounts of these hard seeds and the amount of grit in the gizzard indicated a substitution of seeds for grit.

Seeds of a wide variety of other plants including black gum, hackberry, oaks, beech, various species of sumac, greenbrier, seeds of wild legumes, grasses and other herbaceous plants are found in crow stomachs. Sometimes these seeds occur in quantity depending upon the amounts available.

Insect Food

Throughout the warmer months of the year when insects are active they make up a major part of the diet of crows. According to the

figures compiled by Kalmbach (1939) more than one-third of all food consumed by crows during May, June, July, and August is insects and this food exceeds 10 per cent of the diet throughout the period beginning in April and ending in November. About one fifth of the total annual diet, or more than two-thirds of the animal material in the diet, is composed of insects. This aspect of crow habits has been intensively used by those who believe the crows' food habits to be of positive value. Insects form an even larger portion of the diet of nestling birds. Table 8 shows the difference in food habits between nestlings and adults. The diet of the young birds is generally compared with the average yearly diet of the adults. The difference is pronounced, but if the comparison is made between the diet of nestlings and that of adults during the period when nestlings are being fed the difference is minimized. It should be remembered that the adult sample included an unknown number of non-breeding birds. The writer strongly suspects that little difference would be noted if a comparison could be made between the diet of nestlings and that of the nesting adults during the period when they are feeding nestlings.

Many people lump all insects into one category and register the total on the credit side of the ledger. This cannot reasonably be done. The great majority of insects are not particularly harmful and many are among the most efficient agents available for controlling some of the harmful forms. Those recorded from crow stomachs are a miscellaneous lot, but a majority of the forms are definitely injurious

TABLE 8

COMPARISON OF DIETS OF NESTLING AND ADULT CROWS

Food	Annual Diet of Adults	Diet of Nestlings	Diet of Adults during Nestling period
May and other beetles	4.28	20.03	20.79
Ground beetles	1.56	3.90	5.54
Grasshoppers	7.34	14.60	4.29
Caterpillars	1.56	5.34	2.71
Misc. insects and similar forms	4.23	14.17	6.44
Carrion	2.58	3.95	2.13
Misc. Animal Matter	6.57	21.50	10.56
Corn	38.42	11.91	33.26
Misc. Vegetable Matter	33.46	4.58	14.28

Percentages copied or compiled from Kalmbach (1939).

to agriculture. Some of the harmful forms eaten in quantity include stages of the following: May beetles Scarabaeidae, click beetles Elateridae, weevils Curculionidae, grasshoppers and crickets Orthoptera, cicadas or harvest flies Cicadidae, caterpillars or the larvae of Lepidoptera, and many others. Table 9 shows the monthly averages as computed by Kalmbach from the data in the files of the Fish and Wildlife Service. The table indicates that the various insects are taken somewhat in proportion to their relative abundance in the area where the crows feed, May beetles being highest in May, grasshoppers highest in September.

The only group of beneficial insects taken in any quantity is the Carabidae or ground beetles. Most of these beetles are predaceous insects feeding on other and frequently harmful forms. A few feed on plant materials but seldom affect crops. The adults are active, mostly ground dwelling insects and are picked up by crows throughout the season. They comprise a siz able portion of the diet of both adults and nestlings through the spring and summer months.

Crows are voraceous feeders and have been reported as effective agents of control in cases of certain insect outbreaks. Hodson (1943) reports that crows destroyed about 20 per cent of the forest tent caterpillars during a period of heavy infestation. Neff and Wilson (1940) found the western crow to be one of the most important grasshopper predators in California. They state that crows fed on the egg bed of the grasshoppers to such an extent that an observer unversed in the habits of grasshoppers would have his attention called to the

TABLE 9

MONTHLY PERCENTAGES OF THE PRINCIPAL FOOD ITEMS OF THE ADULT CROW
from Kalmbach (1939)

Kind of food	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
May beetles, etc.	0.18	1.19	1.04	4.98	20.79	10.06	4.47	5.26	0.91	0.54	0.77	1.77	4.28
Ground beetles..	.07	.10	.26	2.30	5.54	3.24	2.13	1.76	2.31	.14	.74	.19	1.56
Grasshoppers....	.51	1.14	.56	1.84	4.29	5.83	14.04	19.14	19.24	8.68	10.73	2.07	7.34
Caterpillars....	.18	.41	1.36	1.13	2.71	6.41	1.95	.62	2.12	1.19	.30	.39	1.56
Misc. Insects...	.35	2.01	1.36	4.47	6.44	10.41	11.26	8.29	3.06	.96	1.62	.67	4.23
Carrion.....	8.95	2.45	2.66	5.24	2.13	1.48	.29	.95	2.69	.32	1.44	2.37	2.58
Other Misc. Animal Matter..	4.70	3.67	8.81	14.13	10.56	9.55	10.14	3.38	1.99	2.46	3.14	6.32	6.57
Corn.....	51.95	43.19	36.85	35.28	33.26	20.53	9.13	17.96	29.60	54.33	63.93	65.00	38.42
Other grain.....	7.00	9.74	34.22	20.90	8.43	10.20	20.22	22.80	8.33	7.08	2.67	.89	12.70
Cultivated fruit	2.55	3.42	.26	2.74	.91	14.12	9.31	5.79	1.66	2.40	.07	1.36	3.74
Wild fruit.....	19.76	19.57	10.65	5.06	3.49	7.28	14.05	13.67	25.82	20.50	12.94	14.75	13.96
Weed seeds and Rubbish.....	3.80	13.11	1.97	1.93	1.45	.89	3.01	.38	2.27	1.40	1.65	4.82	3.06

egg beds by the bands of crows feeding there. Grasshopper eggs also were found in the stomachs of about 20 per cent of the crows which the writer collected in Manitoba in June,1950.

Aquatic Animals As Food

Crows feed along the beaches and shores of lakes and oceans and along streams where these are available. The food taken varies from refuse washed up, through a great variety of living organisms, to fish which may be caught alive. Crows have often been observed to feed on dead fish washed ashore, although where gulls are plentiful opportunities for doing so are much reduced.

Shellfish are readily eaten and several references were found to the habit of carrying these animals into the air and dropping them onto rocks. The shells were thus broken and the crows were then enabled to devour the flesh. Abbott (1883, p. 576) and Mackay (1882, p. 222) cite such examples.

One sporting goods company, in pushing the sales of its crow hunting equipment, has stated that the crow cuts into the fish supply of the nation. They state, "Crows love to eat trout and will wait near a stream or river bank for hours for a trout to come into shallow water where the crow will pounce upon it with all the alacrity of a kingfisher." There are a number of published observations of crows catching and eating live fish, but no food habits study has ever disclosed a significant proportion of fish in the diet of this bird. The hunting of fish is not a general habit of the species and

it can be safely said that the crow is not a threat to the nation's fish supply. William Brewster (1883) writes that he saw crows dipping like swallows in fishing over water. They did not actually dive, but struck the surface. Chamberlain (1884) saw a crow, as it was flying close to the surface of the water, thrust its claws down into the water and catch a fish which he estimated to weigh about one-half pound. The bird transferred the fish to its beak and carried it struggling to a rock. Frazer (1881) saw crows wading in shallow water and catching minnows.

Small turtles and snakes may be killed and eaten, and locally crows may actually seek such prey.

Predatory Habits of Crows

The predatory habits of crows have been widely publicized so that most people are aware of the propensity of these birds for robbing the nests and killing the young of other birds and mammals. From the sportsman's viewpoint the destruction of duck nests appears to be one of the most important aspects of crow behavior. It has received considerable attention already and a special effort was made during the course of this study to gather information which might help in understanding some of the puzzling aspects of the problem.

(a) Predation on Waterfowl

Kalmbach (1937), in studies conducted on waterfowl breeding areas in southern Saskatchewan and Alberta, found nest destruction

by crows to be exceedingly heavy. Of 512 duck nests under observation, 156 or 31 per cent were definitely destroyed by crows. Although this is not as severe as the damage claimed by some, it probably represents heavy crow predation. It was apparently assumed that all of the crows present were breeding birds and an estimate was made of more than 50 pairs in one area. This particular study area was seven miles long and from one to two and one-half miles wide. The same assumption was made by Hammond (1940) in his study of the crow problem on federal waterfowl refuges.

Determining the breeding population of crows in an area is exceedingly difficult. No technique other than a direct count of occupied nests is known and the limitations of that method are obvious. The figures presented presumably represent the total spring population and include the yearling birds. Hammond (op. cit.) had compiled a table using the results of his own work as well as that of Kalmbach and Bennett (1938) in Iowa. The results indicated that damage to duck nests increased in nearly the same ratio as the crow population.

The high rate of nest predation mentioned is not universally true. Studies were conducted on the Lower Souris refuge in North Dakota by Kalmbach (1938), where only 1.7 per cent of 351 nests were destroyed by crows in 1936 and 3.4 per cent in 1937. This rate of predation was not considered to be a serious menace to the waterfowl population. In Iowa Bennett (1938, p. 68) found 4.8 per cent of the blue- winged teal nests destroyed by crows. Low (1945) studying the

redhead in Iowa found 2 out of 160 nests destroyed by crows.

The rate of predation is neither affected by the kind of cover nor the amount of concealment, at least in the manner that one would expect. Kalmbach rated waterfowl nests according to the degree of concealment; those with little or no cover and visible from some distance he called "poor," those wholly obscured from above and to the side he rated "excellent," and "fair" and "good" were intermediate. The greatest percentage of successful nests were in the "poor" category. Percentages destroyed by crows were as follows: "poor," 25 per cent; "fair," 30 per cent; "good," 35 per cent; and "excellent," 32 per cent. This same phenomenon was recorded by Hammond (1940. The explanation for this is not apparent, but obviously some factor or factors other than visibility must affect the susceptibility of duck nests to crow predation. Kalmbach points out the likelihood that ducks with exposed nests may guard them more zealously.

Stimulated by these interesting observations of Kalmbach, careful observations of the behavior of nesting crows were made. A portion of these observations were made in the vicinity of marshes and potholes in the waterfowl breeding areas of southern Manitoba. The data thus acquired indicate that the nest predation suffered by waterfowl may not be the work of nesting crows, but may be caused principally by unmated yearling birds.

The crows nesting near waterfowl breeding areas where observations were made were all feeding young in the nest, thus no

observations were obtained during the incubation period. The areas were all relatively undisturbed marsh and it is possible that where waterfowl nests are located along straight narrow dikes, such as described by Kalmbach (1937, pp. 2-3), nesting crows might then find it profitable to engage in nest hunting because of the increased ease with which nests could be located.

The nesting pairs under observation did all of their food collecting in a manner which enabled them to quickly gather sufficient food and return to the nest in trips spaced only a few minutes apart. Hunting flights were seldom observed and then only incidentally as the birds were enroute to regular feeding grounds. These feeding areas were similar to those described for crows nesting in upland agricultural regions. Open fields with short vegetation where the bird could alight and walk about unimpeded were most frequently utilized. This is so like the manner in which all nesting crows observed gathered food for their young that it is undoubtedly the usual method. After the young have left the nest the family groups feed in open fields in much this same manner. Kalmbach (1937, pp. 21-22), noted this in Canada and stated that the marsh no longer held the attraction for the crows that it had earlier in the season. Such hunting methods are not likely to result in the locating of many waterfowl nests.

H.A. Hochbaum and L.K. Sowles, at the waterfowl research station at Delta, Manitoba, noticed that on the basis of behavior there appeared to be two kinds of crows in that area. Small groups of birds

were roving and hunting over the marsh in a manner quite different from some of the other crows which they observed frequently. In discussing the matter with them they agreed that these roving flocks seemed to correspond to the hunting and feeding flocks of yearling crows which are so common in the midwest. Single birds and groups of two or three were subsequently observed hunting in marsh areas, and in several instances were observed closely enough to be identified as yearling birds. Groups of as many as 10 or 12 crows were observed feeding in fields and around potholes so it was well established that many unmated yearling birds were in the area. These observations were made in early June and nesting was well along with most nests containing half-grown young.

Ralph Andrews, who was conducting a duck production study in the marshes on the south shore of Lake Erie, reported that the rather severe early season crow damage suffered there appeared to be perpetrated by several small roving flocks of birds. Two groups of crows were present on the area where he was carrying on his intensive study. One small flock of 4 or 5 birds, and another of 8, regularly inhabited certain sections of the marsh and had actually been seen in the process of nest robbing.

It is not known whether such small flocks of crows are comprised of individuals associated with nesting pairs or whether they are completely unattached. Whatever the case, such birds have frequently been observed hunting over the marsh in a manner that presumably could result in the location of duck nests concealed in the vegetation.

Hunting crows can be recognized by the method of flight, rather low and with the beak pointed down. In spite of the enormous difference in shape and color the hunting flight of the crow is reminiscent of that of a tern. Marshes are normally rather breezy in spring and crows have been observed to utilize the wind in making their hunting more effective. In such cases the crows beat slowly into the wind, low across the marsh, in the typical hunting manner. As they approach the windward side they rise abruptly, catch the wind, and borne by it, sweep back across the marsh to begin another crossing into the wind again. In so doing their progress is so slow that at times they appear to hang in one spot without visible means of support. Such a method must considerably increase the efficiency of food gathering.

It should not be inferred from the above discussion that breeding crows do not rob nests, for such is not the case. Nesting crows do prey upon eggs whenever the opportunity arises. It may well be that during the season before the young hatch, adults, or at least the male, may hunt in the same manner as non-breeding birds. The female could scarcely indulge in such time-consuming occupations, for during the period of incubation she is so attentive that she is seldom absent from the nest for more than a few minutes at a time. Incubation of crow eggs is under way before ducks begin to nest, so little opportunity is afforded for robbing nests unless accidentally located. Since the male takes little or no part in incubation he could, and probably does, hunt nests where the opportunity is present and may carry such food to the incubating female. This might account in part

for the drop-off in the rate of nest predation as the season advances, for as soon as the young are hatched the male is immediately removed from the class of birds with leisure to hunt, and joins the female in the feeding activities previously described.

All crows probably feed upon eggs or young birds and nesting pairs carry such food to their young whenever the opportunity arises. I have tried to show that such opportunities do not occur as frequently for nesting crows as for others. Nevertheless the remains of eggs or nestlings are commonly found in the stomachs of nestling crows. Kalmbach (1937, p. 26-28) found the remains of birds and their eggs in 25 of 43 nestling crows collected in Canada. Of the 25, 21 contained the shells of birds' eggs, of which 7 were definitely and 5 tentatively identified as those of ducks. The remains of ducklings were found in 3 stomachs. He states that it is not known whether these were killed by the crows or picked up as carrion. No doubt exists that crows may prey on ducklings when they can. Kalmbach points out that all individuals in a brood of crows may be fed portions of the same item, thus making it possible to record the evidence of a single act of vandalism from several stomachs. Egg shell was present in the stomachs of three out of four nestlings in one brood examined in Manitoba. Since the stomachs of nestling crows generally contain little grit or other grinding material it may be that egg shells are retained longer than in the case of adults.

The finding of egg remains in the stomachs of crows does not necessarily denote nest depredation. Bennett (1938, p. 68) reports

that in Iowa pecks of crow-destroyed duck eggs could have been gathered around the marshes each year, but that practically all such eggs had been promiscuously dropped over the countryside before the nesting season began. Much of such egg dropping has probably ceased before young crows are hatched, but most of such eggs are certain to be picked up where crows are present, for they are generally little concealed.

Kalmbach noted a decided improvement in the extent of hatching of duck nests as the season advanced. One would naturally be inclined to credit this to the increasing amount of cover as new growth in the marshes and fields increased. The relationship of concealment to freedom from crow predation previously discussed (p. 129) gives reason to question this. Kalmbach was of the opinion that the seasonal decline in nest destruction indicated that egg destruction by the crow was governed as much, if not more, by the nutritional demands and seasonal changes in the habits of the crows as by the early season vulnerability of the nests. He states that such food items as eggs have their maximum attraction for crows during their own reproductive period. The evidence indicating that non-breeding birds may be largely responsible for nest predation gives ample reason to question this. The sudden preoccupation of adult male crows with parental duties might explain part of the decline, although I am unwilling to discount entirely the value of the increasing cover. Other factors aside from concealment of the nest itself are important in determining how readily it may be found. Not all nest hunting by crows is done in the manner previously described. What appears to be nest hunting has been observed where

crows fly to and investigate areas from which birds flush. If this is so, the ability of a hen to enter or leave her nest unobtrusively would greatly affect its vulnerability. The increasing growth of vegetation as the season advances would certainly affect this ability. The growth of vegetation does not explain the apparent increased vulnerability of well-concealed nests, but may partially account for the general seasonal decrease in predation.

Crow predation on ducklings has not been considered to be a serious problem except locally and under abnormal circumstances. Bennett (1938, p. 68), working with Errington, found that in Iowa exposure resulting from drought increased the predation on ducklings. The lowering of the water level in potholes leaves expanses of mud several yards wide between the dwindling water and the surrounding vegetation. This exposes the ducklings to many hazards including the depredations of crows. Any conditions which result in exposure of small ducklings may result in the loss of some to predators.

(b) Predation on Upland Game Birds.

Upland game birds are subject to crow predation, although I know of no instances where the destruction has reached the proportions found by Kalmbach in waterfowl in Saskatchewan. Ruffed grouse ordinarily suffer little damage from this source. Their nests are not located in habitat normally hunted by crows. Bump et al. (1947, p. 334) records that among grouse nests broken up by predators, losses in the various regions studied which were attributed to crows ranged from 3.3 to 8.2 per cent of the nests located, and averaged

4.5 per cent for the whole state of New York. They considered the crow among the less important predators of grouse. One case of a crow carrying away a grouse chick was recorded by Bump, but he says that this was apparently very unusual.

The nesting habits of the ring-necked pheasant make it much more susceptible to crow predation than the grouse. Baskett (1942) and Randall (1940) list the crow as the most important predator of this species. In many studies the crow has been listed among the more important predators of this bird, but many workers believe that natural predation is of minor consequence in good pheasant range, except where birds are concentrated as on refuges in winter. Under these circumstances, crows are not among the predators to be dealt with.

Nests exposed by mowing or other agricultural operations are virtually certain to be destroyed by crows, but this does not represent loss of production, because hens rarely continue to incubate nests after such disturbance. The work of Leedy, Dustman, Seubert, and others in Ohio indicated that many pheasant eggs are dropped promiscuously early in the season, and early nests are frequently "dump nests" used by several hens and are never incubated. It is probable that crows ultimately get these eggs. This represents no loss, but does the crows' reputation no good when the evidence of his feeding is found in the form of shells strewn about.

McCabe and Hawkins (1946) record the crow as a nest predator of the Hungarian partridge in Wisconsin.

The bob-white quail apparently suffers little from the depredations of crows. Stoddard (1931, p. 191) reports that only 5 cases of quail nests broken up by crows came to light during the field work for this study and that the evidence was not entirely satisfactory for two of these. Stoddard also states (p. 204) that loss of chicks to these predators is of rare occurrence in the southeast. This he attributes to the abundant cover, the ability of the chicks to hide, and the fighting ability of the parent quail. Wilson and Vaughn (1944, P. 72) state that the small crow population present in their areas in Maryland minimized the egg loss. No cases of crow predation are cited.

Mosley and Handley (1943, p. 128) cite cases of predation by by crows on the nests of wild turkeys. They found no damage to nests of native wild birds, but two nests of free ranging, captive reared, birds were destroyed. This constituted 5 per cent of the nests under study and contained 2.9 per cent of the eggs. These authors also report (p. 188) that egg destruction by crows has been serious in some of their laying pens.

(c) Predation on Other Birds.

In addition to game birds many other kinds are preyed upon by crows. Species that nest in conspicuous colonies are especially susceptible to attack by crows. Baker (1940) reports that in Waller County, Texas, every nest in a colony containing approximately 1500 nests of the little blue heron and 3000 nests of the snowy egret had

been destroyed by April 17. There is a possibility that some other predators may have destroyed a few nests, but the destruction was almost entirely the work of crows. About 750 black-crowned night herons and 1000 yellow-crowned night herons were also nesting in the 300-acre wooded area. The nests of these species were not ravaged so seriously and many were left undamaged. The greater success of these nests was attributed to their more scattered distribution. It was estimated that less than 40 crows were responsible for this damage. One crow nest was found.

In view of such reports as this it is interesting to speculate upon what effect the crow may have had on the densely concentrated nests of the passenger pigeon as it increased in numbers and enlarged its range with the coming of agriculture.

Gull and tern colonies also suffer crow predation at times, although these birds are capable of vigorously resisting such attacks. Bent (1946, p. 239) records finding a number of eggs of the herring gull which had been carried away and eaten by crows. Crows also take the nestlings. Bent reports seeing them carry away young gulls and he found where more than a dozen had been killed and partially eaten.

Walkinshaw (1949) records crow predation on the eggs and young of the sandhill crane. Buss and Hawkins (1939) in studying the upland plover in Wisconsin, found that crows destroyed 4 of the 26 nests under observation in 1938, and 4 out of a total of not more than 22 in 1939.

Chamberlain (1884) records an instance of the crow carrying away young robins, Kalmbach (1937) records the finding of the shells of

small passerine eggs in 9 out of 43 stomachs of nestling crows collected in Canada during the nesting season.

Several cases have come to my attention where crows have robbed the nests of small birds in Ohio. Two of these involved the nests of mourning doves. Crows have frequently been observed to eat the eggs, and presumably the young, from the nests of small birds after the cutting of a hay crop exposed the nests.

(d) Predation on Poultry

The crow has a bad reputation as a robber of poultry yards. Inquiry among farm folks and my own farm experience lead me to believe that much of this reputation must have been earned some time ago. I can well recall what a problem crows were when chicks were hatched under hens and placed with them in coops scattered through orchards or other areas in the vicinity of the farm homestead. Now, when most chicks are commercially hatched and started in brooder houses, little trouble is experienced with crows, at least in the mid-western states. The poultry industry has developed so that it is unlikely that the crow will ever again be a factor of any consequence.

Where game birds are being reared on game farms and open laying pens are used, crows may be a major problem. This may also be true where birds are being reared in semi-natural surroundings. Control measures may be a necessity if near-potential production is to be achieved.

(e) Predation on Mammals

Less direct evidence of crow predation is available in the case of mammals. No persistant evidence comparable to that furnished by a robbed waterfowl nest is left when the crow attacks small mammals. A fair proportion of the mammal diet of these birds also represents a beneficial relationship of the bird to game or to agriculture. Mice and other small rodents are commonly eaten. Kalmbach (1939, p. 10) states that these make up 1.6 per cent of the diet of adult crows and 8.8 per cent of that of the nestlings. He also states that young cottontail rabbits are the crows' favorite food. This might be rather hard to prove, but it is true that young rabbits are frequently taken. Smith (1950, p. 41) records one instance of a crow carrying away a nestling cottontail, and Kirkpatrick (1950) cites seven eye-witness accounts of crow destruction of rabbit nests, in five of which the crows were definitely preying on young rabbits. In three of these cases three crows were involved, which may indicate that unmated birds were the culprits. All of these attacks took place in the spring and all were in areas with sparse vegetation. Kirkpatrick points out that young rabbits in the nest are known to squeal during the day and that there is a possibility of the crows having been attracted to the nests by this sound. Other reports in the literature document the killing of young rabbits by crows. Barrows and Schwarz (1895) found rabbit remains in 38 of 909 crow stomachs examined. Haugen (1942) records an instance of taking from a crow a freshly killed nestling rabbit. In spite of the number of such reports no person studying cottontails has proposed that the crow

is a serious predator on the species.

Crows are also known to feed upon ground squirrels where these mammals are abundant, and upon shrews. The latter are largely beneficial, hence their destruction adds nothing to the economic value of the bird. Occasional attacks upon newborn pigs or lambs were reported in a survey conducted by the Farm Journal in 1925. I have never observed this or talked to anyone who had, and therefore assume that it is of rare occurrence.

Carrion

Carrion regularly makes up a part of the diet of crows. According to Kalmbach (1939) it makes up a 2.58 per cent of the annual diet and varies seasonally from a high of 8.95 per cent in January to a low of 0.29 per cent in July. The crow generally performs a service to man in feeding upon this material. The sight of these birds feeding on highway kills is very common, especially in the winter, and Crook (1936) believed that this source of food may affect the ease with which crows are able to winter or may even affect their wintering range. Slaughter houses are attractive to crows and the food supply is so abundant and constant that small numbers of crows often winter in the vicinity of such establishments north of their regular wintering range.

The suspicion or fear that crows may act as agents in the transmission of diseases of poultry or livestock is often voiced. It is true that crows are subject to some diseases of domestic poultry

and that they may fly from farm to farm feeding on the carcasses or excrement of diseased animals. The possibility of their transmitting some of these organisms from diseased to healthy flocks cannot be discounted. This same possibility also exists for other species including vultures, pigeons, English sparrows and starlings, yet, in so far as I have been able to determine, no direct evidence has been found that any of these birds has ever caused the infection of a healthy flock. Lampio (1951) points out that some kinds of organisms which may live in the dead body of a host are destroyed when the carcass is consumed by carrion feeders and thus sources of infection are removed.

ENEMIES OF THE CROW

Parasites and Diseases

The crow is subject to infestation by a wide variety of parasites and a limited number of disease organisms. The parasites are listed in Table 10. In so far as it has been possible to determine, little work has been done regarding the effect of these various organisms upon crows and knowledge of the degree to which these birds are parasitized is likewise scanty.

The presence of several disease organisms has been recorded, but they apparently seldom cause heavy mortality. Eaton (1903) records an epidemic of roup in a crow roost in New York. He estimates that at least 1000 crows died there of this disease. They were found in fields for 10 miles around, as well as at the roost. This disease is a form of coryza or sinusitis. There are two types of this disease. One is nutritional, caused by a lack of vitamin A. The other is infectious and the causative agent is not known.

Mitchell and Duthie (1929) report an epidemic of tuberculosis in crows in western Ontario. Beaudette and Hudson (1936) also report this disease in the crow. The occurrence of favus in a crow from eastern Pennsylvania has been reported by Bell and Chalgren (1943). Favus is caused by a fungus, Achorion schonleinii, and affects the skin.

Hawks and Owls

Crows have been recorded as prey for many kinds of bird and mammal predators, but they ordinarily suffer little from those normally

TABLE 10

PARASITES OF THE CROW

Parasite	References
Biting Lice:	
Philopterus corvi (Linnaeus)	Morgan-Waller (1940), Peters (1936)
Degeeriella secondaria (Osborn)	Morgan-Waller (1940)
Degeeriella rotundata (Osborn)	Peters (1936), Morgan-Waller (1940)
Myrsidea interuptata (Osborn)	Morgan-Waller (1940)
Myrsidea americana (Kellogg)	Peters (1936)
Mites:	
Acarina	Morgan-Waller (1940)
Liponyssus sylviarum (Canestrini & Fanzago)	Peters (1936)
Trouessartia corvina (Koch)	Peters (1936)
Ticks:	
Amblyomma americanum (Linnaeus)	Peters (1936)
Haemaphysalis leporis-palustris Packard	Peters (1936)
Louse Flies:	
Lynchia americana (Leach)	MacArthur (1948)
Ornithoica confuenta Say	Johnson (1925)
Blow Flies:	
Protocalliphora avium (Shannon & Dobroscky)	Jellison-Philip (1933)
Protocalliphora azurea (Fallen)	Coutant (1915)
Tape-worms:	
Hymenolepis corvi (Mayhew)	Morgan-Waller (1940)
Hymenolepis variabile (Mayhew)	Morgan-Waller (1940)

Table 10 continued

Parasite	References
Flukes:	
Collyriclum faba (Kossack)	Morgan-Waller (1940)
Round Worms:	
Acuaria anthuris (Rudolphi)	Morgan-Waller (1940)
Acuaria cordata (Mueller)	Cram (1927)
Microtetrameres helix (Cram)	Morgan-Waller (1940), Cram (1927)
Diplotrianena tricuspis (Fedtschenko)	Morgan-Waller (1940)
Syngamus gracilis Chapin	Cram (1927)
Capillaria contorta (Creplin)	Morgan-Waller (1940)
Porrocaecum ensicaudatum (Zedder)	Canavan (1931)
Protozoa:	
Haemoproteus danilewskii Kruse	Morgan-Waller (1940)
Plasmodium relictum (Huff)	Morgan-Waller (1940)
Leucocytozoon sakharoffi Sambon	Morgan-Waller (1940)
Leucocytozoon berestneffi	Coatney-Jellison (1940)
Trypanosome:	
Trypanosoma avium Danilewsky	Coatney-West (1938), Morgan-Waller (1940)
Coccidia:	
Isospora sp.	Morgan-Waller (1940), Boughton (1938)

encountered. The great horned and snowy owls have been seen to capture and kill crows, Bent (1946, p. 249). Errington, Hamerstrom and Hamerstrom (1940) found the remains of 23 crows in 4815 great horned owl pellets which they examined. The congested roosts at night would certainly offer a ready food supply to these nocturnal hunters. The snowy owl is a rare bird in most parts of the crows' range, and would of necessity be one of the least important. White (1893) has reported the sharp-shinned hawk killing a crow. Sutton (1929) found the remains of a crow in the crop of a Cooper's hawk; Mailliard (1908) also reports this species attacking crows. Wood (1938) and Shelley (1928) report the crow as an item in the diet of the goshawk. Criddle (1917) records the red-tailed hawk as preying on the crow. McAtee (1935) lists the crow in 8 of 754 red-tailed hawk stomachs and in 1 of 391 red-shouldered hawk stomachs examined. All of these predatory birds together probably have an insignificant effect upon the crow population.

Crows in turn harass the larger hawks, and especially the larger owls such as the barred owl and the great horned owl. Attempts on the part of crows to molest the smaller hawks have seldom been observed. On July 6, 1949, while watching crows from a blind, I saw a Cooper's hawk suddenly alight in a tree where a number of the crows were perched. The hawk was not more than 3 feet from two or three of the crows, but their only reaction was a short utterance of the "growl" warning note. The Cooper's hawk remained in the tree for nearly a minute. As it took flight it made a half-hearted pass at one of the nearer crows.

That bird dodged but did not appear to be frightened and none of the other crows showed any sign of alarm.

When the larger Buteos such as the red-tailed and red-shouldered hawks soar about over a wood lot, crows frequently rise to do battle. One or two birds generally make the attack. The "growl" note is given and under the diving attacks of the crows the hawk generally beats a hasty retreat. Sometimes the rally call is given and a number of crows join in the attack, but this is not the usual reaction to hawks. When flocks of crows were busy feeding I have observed red-tailed hawks flying about unmolested overhead. The great compulsion to do battle incited by the appearance of an owl seems to be lacking in the case of hawks. In April, 1952, at Columbus, Ohio, Jeff Swinebroad saw a red-shouldered hawk join in with a flock of crows in harassing a great horned owl. There was no show of animosity between the crows and the hawk, but occasionally the crows perched near the owl would flinch or take flight when the hawk swooped in over them in making a pass at the owl.

The sight of an owl invariably results in an outcry (the "rally" call) and crows seem to appear from nowhere to join in the battle. The encounter can scarcely be called a battle for the owl commonly remains in his roosting spot, snapping his beak and glaring balefully at his tormentors. The crows perch about it as closely as they dare, and a part of the flock dives at the harassed owl from various angles. All of this is accompanied by great vocalizing from the crows. The sound is familiar to everyone who has tramped the woods in crow

country in the fall, winter, or early spring.

When the owl takes flight, as he must sooner or later, the crows stream across the woods in pursuit, redoubling their clamoring. This continues until the owl succeeds in eluding his tormentors. The crows' intolerance of owls can be used against them, as described in the section on sport shooting.

Mammals

Among the mammals, man is so outstandingly successful as a predator of crows that he can scarcely be compared with the others. The inroads of man upon the crow population are discussed in the following sections and no further mention is necessary here.

Errington (1935, p. 195) lists the crow among the foods found at red fox dens in Iowa. He states that these birds were "probably killed by crow shooters." The crow has also been found in the diet of several other mammalian predators, but it is unlikely that many healthy adult crows are captured by mammals except under unusual circumstances.

Mammals are often important nest predators of the crow. There is evidence to indicate that in its present numbers in Ohio the raccoon is the most important of these predators. Laurel Van Camp of the Ohio Division of Wildlife pointed this out convincingly in Ottawa County, Ohio. Raccoons were so abundant in that area that their tracks could be observed almost anywhere that the ground surface would show them. Small pools of water in the center of open crop fields were surrounded by a maze of raccoon tracks. Fourteen

new nests of the crow were examined there on May 9, 1950. Only two of these were active. All of the others were abandoned and claw marks on the bark indicated that the trees had been climbed by raccoon. In one case a raccoon was flushed from a new crow nest where it had been curled up in the sun. Raccoons were so abundant in that particular area and woodlots so small and isolated that nearly every tree must have been climbed by one of the mammals sometime during the season. Van Camp said that where a few years previously he had been able to band 100 young crows without difficulty he was now unable to locate more than one-fourth that many of banding age. It is quite possible that the raccoon was largely responsible for this decline.

The red squirrel has been recorded as an egg predator and may prey upon crow eggs. The opossum is another mammal which might be expected to occasionally rob a crow's nest. Certain snakes probably do likewise. Wilson (1923) records an instance of a snake attacking a crow. In the spring of 1949 in Van Wert, Ohio, M.M. Good saw four crows alight in a newly-worked field and remain persistently in the same location for some time. Upon investigation he discovered that they were stationed just out of reach of a large snake (blue racer.) They made no attempt to attack it but remained about it until flushed.

Small Birds

In addition to the vertebrates discussed above which may actually destroy the crow, its eggs, or its young, there are a number of smaller birds which, while not dangerous to the crows, harass them

greatly. In much of the midwest the worst of these is the red-wing. Within the past thirty years this bird has become a common summer resident nesting in meadow fields in this region. Crows flying over these areas at heights normally used in feeding activities are constantly subject to attack. Crows have often been watched as they flew from woodlots across open fields for one-half mile or more. In that distance as many as ten or twelve red-wings have risen to attack them. Each bird followed the crow, sometimes for several hundred yards, so that the crow was harassed almost constantly, and frequently by several birds at a time. Crows hunting over marsh areas are subjected to the same treatment. It seems doubtful that under such circumstances hunting could be very efficient. The yellow-headed blackbirds also vigorously defend their nesting areas whenever crows approach. It would be interesting to know the effect of a good population of blackbirds upon the rate of waterfowl nest predation in a marsh.

Some of the larger flycatchers, including the eastern kingbird, the Arkansas kingbird, and the scissor-tailed flycatcher, are exceedingly intolerant of the crow. On farms some years ago when chicks were put out with hens in individual coops, many farmers in the midwest highly prized a pair of kingbirds in their orchard, for no crows were permitted to come near.

The purple martin reacts toward crows in the same manner as the other species just mentioned. Bent (1946, p. 500) says that the Indians and later the negroes induced the martin to nest near their

dwellings because of its readiness to drive away any winged intruder that might attack poultry. These small birds probably do not affect the crow population, but undoubtedly exert some influence upon where they nest and feed.

THE CONTROL OF CROW DAMAGE

The reduction of the numbers of crows where they are causing economic loss, or for the prevention of damage to farm crops or to game, has been attempted in a number of ways, none of which have proven to be entirely satisfactory.

Scarecrows

Human effigies have been used as "scarecrows" all through historic times and it might logically be assumed that some degree of success attended these efforts or the practice would have died out. Under some circumstances the "scarecrow" may be at least partially effective. A number of persons consulted reported benefits from using such devices, but since detailed observations were not made the amount of credit due the practice cannot be positively determined. Many observations, my own and those of others, indicate that crows frequently pay no attention to such "frightening" devices. After a period of a few days the birds may actually perch upon them during feeding forays to the area. Just what brings about such different reactions, if such differences really occur, is not known.

Many variations of the "scarecrow" principle have been tried. The hanging of bright metal or glass objects about the device is common. Suspending these on strings or otherwise arranging them to move in the breeze is thought by some to increase their effectiveness. It is doubtful whether any such device is effective over a long period but may be so for a few days until the birds become accustomed to its presence. Under some circumstances protection even for such a brief

period may effectively curtail serious losses.

Shooting a few crows and hanging their bodies in conspicuous places about the area to be protected appears to give at least temporary relief from their depredations. Crows are greatly excited by the sight of dead of their own kind and the use of this sort of protective measure is widespread.

Noise Makers

Noise makers have generally been found to be more effective than moving objects. The "carbide exploder" or "automatic acetylene exploder" is one such device which has been successfully used. This outfit operates when water dripping on carbide produces sufficient gas to create an explosion. The frequency of explosions can be controlled by regulating the drip of water and flashes can be given as often as four times per minute or as infrequently as once each ten minutes. The report is about like that of a 12-gauge shotgun. Cardinell (1937) records an instance in Michigan where large numbers of crows were roosting in a woodlot near a cherry orchard. When exploders were started in the orchard to drive away other birds, the crows left and did not return while they were in use, not even passing over the property. Had the crows been feeding on the cherries or strongly attracted to other crops there is a possibility that the results might have been different. The exploder is somewhat of a nuisance in the vicinity of dwellings, but it may possibly be an effective device to keep crows away from an area to be protected.

Such devices are likely to be most effective where crows are subjected to shooting throughout the season.

Shooting

The shooting of crows has generally been considered ineffective in controlling damage to crops or poultry, but a systematic campaign of shooting and nest destruction should provide protection during the nesting season, especially if carried on over a period of several years. Since it appears that crows return to the same locality year after year, such local control should progressively reduce the nesting population and the flocks of unmated yearling birds. Depredations on young poultry and on sprouting grain or on the nests of waterfowl or other birds might be reduced in this manner. The greatest losses which occur when the crows are flocked in late summer, fall and winter are not likely to be greatly affected by this means, for such flocks are comprised of crows assembled from a wide area and local control during the summer cannot greatly affect their size.

Roost shooting in the autumn or winter generally has little effect in noticeably reducing the numbers of birds in an area. Night shooting generally results in the crows moving to a new location but the distance is seldom more than a few miles, and since the daytime feeding range of the birds is much greater than this, little benefit can be expected. Occasionally it may be true that a flock so disturbed may change their feeding area so that the problem is solved in one locality, but problems are often created in the new feeding areas.

The Bombing of Roosts

The bombing of large roosts is an effective way of killing great numbers of crows, but for roosts of moderate or small size it is frequently not possible to predict with sufficient accuracy where the birds will be concentrated enough to produce a heavy kill. Since the explosives must be arranged at the roost during the day while the crows are absent it is essential to know where most of the birds will settle for the night. Where the concentrations are so great that all available roosting space is occupied or where such space is so limited that it is all utilized, bombing may be an efficient way of removing large numbers of birds. There are legitimate criticisms of this system which appear to be impossible to overcome. It is inevitable that an exploding bomb in a crow roost will maim and cripple many birds in addition to those that are killed. Many of these birds may live for sometime before they succumb to predators, starvation or infection and disease. Although this does not diminish the value of the crow control achieved; it is disturbing to many people and to be avoided wherever possible.

Bombing has been used in a number of places, most notably in Oklahoma and Illinois. In Oklahoma Imler and Kalmbach (1939) found concentrations where small trees in the roosting area with crowns 8 to 10 feet in diameter frequently harbored 45 to 110 birds. These authors calculated densities of one bird to two square feet of ground surface covered by the tree. At one spot near the center of a roost bombing operations were carried out and dead crows, probably including

all of the birds occupying the spot, averaged 1.46 per square foot of ground surface. Hanson (1946) estimated that three and three-quarter million crows were killed at roosts in Oklahoma from 1934 to 1945. This equals the maximum total winter population in 1937-38 as estimated by Imler and Kalmbach (1939). Imler and McMurry (1939) report that at one bombed roost in Oklahoma where they collected specimens, an estimated 18,000 birds were killed in one night.

While bombing on such a scale as this undoubtedly produces a considerable reduction in the numbers of birds present at the time, it cannot be counted upon to relieve damage at other seasons. Its chief value is as immediate protection for late-maturing crops. Kalmbach (1937) called attention to its limitations as a remedial measure for heavy predation on waterfowl. He pointed out the dilution which occurs when the birds disperse and that only a part of the crows return to areas where eggs are available. His opinion was that unless the winter control resulted in decided reduction in the aggregate number of crows throughout the country, it was doubtful that a noticeable improvement in the continental supply of waterfowl would result.

Banding returns from Oklahoma showed that the birds occupying winter roosts were not summer residents of the area, and therefore winter control could not affect the breeding population.

Trapping

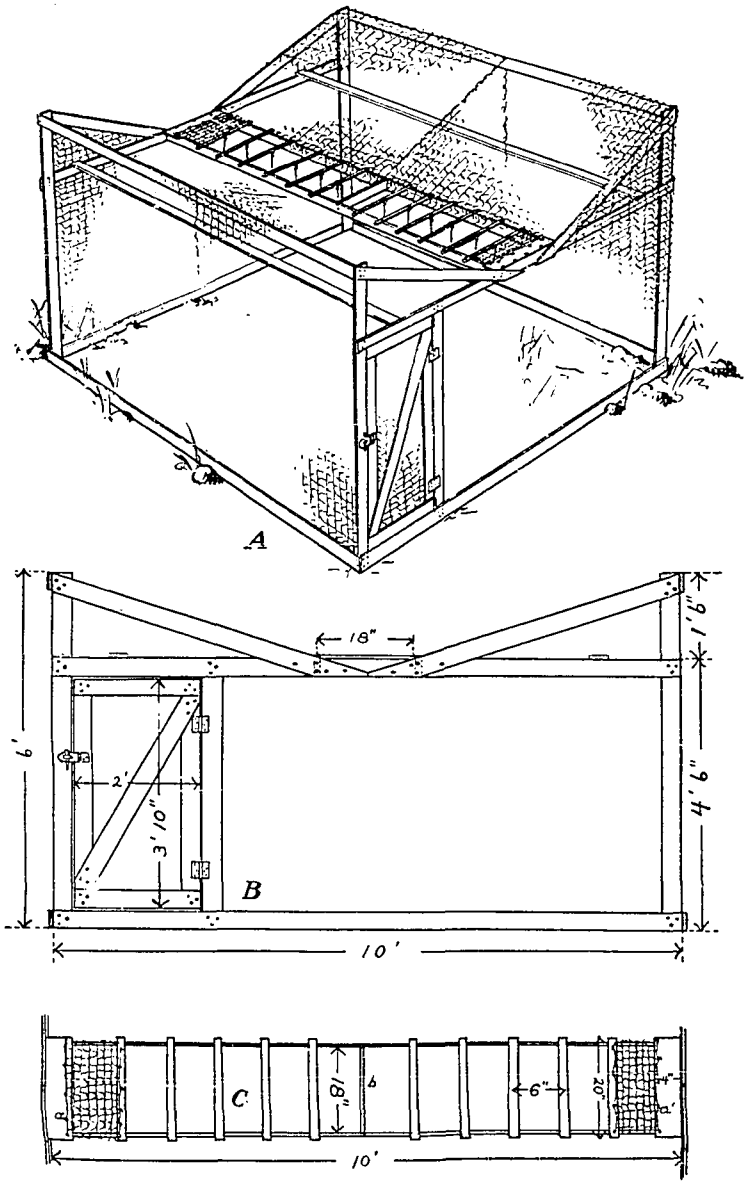
Trapping has been successfully used to capture numbers of crows.

The most common trap used is the "Australian" crow trap. It is a wire pen varying in dimensions but usually about 8 x 10 or 10 x 12 feet and about 6 feet high. Figure 35 illustrates such a trap. The crows enter by dropping between the slats of the ladder-like portion across the top. These slats are spaced 6 inches apart, a distance which permits the crow to drop through between them, but prevents its escape, which can only be attempted with spread wings. Short wires hanging from the slats also discourage attempts to fly through. The entrance being lower than the sides of the cage, most birds ignore it in attempts to get to the highest place possible. This tendency is encouraged by placing poles for perching near the top of the cage along each side. The trap is baited with grain, offal, eggs, or other material attractive to crows. Several crows left in the trap as decoys are said to make its use more effective.

Such devices are not effective during the spring and summer months. It is while the crows are flocked and especially when food supplies are low that the birds may be taken in this way.

Repellents

The use of repellents to prevent damage by crows and other birds to newly planted seeds has been advocated. A number of commercial repellents are available and although there are apparently many satisfied users these repellents possess some characteristics which are not entirely desir able. Dambach (1944) and later Dambach and Leedy (1948) found in tests in Ohio that the repellents were unsatisfactory in preventing damage. Most commercial repellents had a



—Cage trap of Australian type, for capturing crows, and details of construction: *A*, View of completed trap; *B*, plan of "ladder" opening; *C*, end elevation.

FIGURE 35

The Australian Crow Trap

slight retarding effect upon the germination of the seed. Experiments in several other states also indicated deleterious effects upon seed germination from the use of repellents. Dambach and Leedy (op. cit.) found that a band of shelled corn scattered around the periphery of the field a day or more before the planted corn emerged gave fairly satisfactory protection. Sprouting corn is susceptible to damage for only a brief period from the time it emerges until it is several inches high. The scattered grain is apparently taken in preference to the planted seed, especially if it has been soaked before scattering. Einarsen (1943) does not recommend this method in Oregon, however, for he finds that it attracts greater numbers of the pests and rarely achieves the desired result.

The use of dyes to color seeds has been tried. Dambach and Leedy (1948) found that corn dyed a bright green was not taken readily by crows or pheasants and that in some cases considerably less damage resulted where such seed was used. The results were variable, however.

Several investigators have found coal tar to be as efficient as any repellent. Dambach (1944) gives the following directions for applying this material. The seed is prepared by mixing a tablespoon of coal tar with one-half bushel of warm grain. The grain is first heated with warm water. The excess water is drained off and the coal tar is stirred in while the corn is still warm and moist. The grain must then be spread out and dried before use. Corn thus treated is fairly repellent to crows.

Poisons

Although poisons, when properly selected and used, are among the most efficient agents for controlling damage by some forms of wildlife, their use is best left to trained workers. Safe and effective use requires an intimate knowledge of the effects of the material used as well as the habits and ecology of all forms of animal life in the area. Even trained biologists do not always succeed in securing control without severe damage to other species which at times may more than offset the good accomplished.

Poisons for the control of crow damage have not been widely used and the results of their use have not been outstanding. Strychnine has been used but heavy kills cannot be expected with this or other quick-acting poisons. The first birds to eat the poisoned bait react immediately and on the scene. The remainder of the flock, apparently associating the reaction with the feeding, are frightened away. One of the best accounts of efforts of this kind is given by Gardner (1926). In the Goodnoe Hills region of Washington crows had destroyed valuable almond crops for years. All previous control methods, including shooting, scare-crows, belling, and stringing of trees, had not proven successful. Experiments were conducted attempting to poison a flock of about 30,000 birds which was attacking almond orchards and watermelons in the vicinity. Meat baits failed and choice almonds and watermelons poisoned with strychine were used as bait. Less than one per cent of the crows were killed, but the results were highly satisfactory for the crows all left the vicinity. Some

unprotected orchards in another area were attacked, but the treated ones and the watermelons were afforded complete immunity. A single treatment of this kind is said to be effective for a week or ten days.

Kalmbach (1939) states that no difficulty is experienced in killing crows with slow-acting toxins, but their use is so hazardous as to make them impractical for general use. He says (p. 17) that since quick-acting poisons are ineffective for large-scale operations and the slow-acting ones too dangerous, "the utility of poison baits in crow control is limited largely to local situations where the deterrent action produced by killing a few birds will result in a measure of crop protection."

The use of strychnine involves some danger to domestic animals and beneficial forms of wildlife and the greatest care should be exercised in preparing and distributing baits containing it. There may be local restrictions on the spreading of poison bait and at any rate other methods of control are preferable if they can be used.

Bounties

The payment of bounties for the killing of crows is practiced in a number of places and is strongly advocated by some groups of crow shooters and other sportsmen. The bounty system has been subjected to close scrutiny a number of times, most recently by Latham (1951). The general conclusion of those who have studied the matter thoroughly is that as a method of control the system is impractical. Economically it is expensive because all of the animals which would have been killed without the incentive of a bounty must be paid for before benefits

begin to accrue. It is virtually impossible to avoid fraudulent practices under such a system, and its effectiveness in securing the desired results has never been demonstrated in spite of the expenditure of huge sums of money by several states. If an effective method for curtailing crop damage or loss is truly sought there is certainly no justification for settling for a bounty.

Biological Control

Biological control of crows has not been attempted as far as is known. Birds which roost in such large compact flocks might be susceptible to infection with certain disease organisms. Disease takes a heavy toll in crow flocks at times, as has already been mentioned. Unfortunately, most of the known diseases of crows may also infect poultry flocks and deliberate use of these would be extremely risky and ill-advised.

One possibility, the inducing of small harassing species of birds to nest in local areas, appears to hold promise for control in such areas during the spring and summer. This is not entirely untried, as previously pointed out, but could be applied on a much wider scale. Little is known about management measures for red-wings and yellow-headed blackbirds, or of their effectiveness in preventing crows from hunting over an area. Most of the flycatchers cannot be relied upon to nest in an area with certainty. The purple martin, however, offers real promise. This bird occurs everywhere that crows might be troublesome and can reasonably be expected to respond to efforts to attract it.

Once established, it will likely be present all through the spring and summer season, when crows may be a problem. Its effectiveness in driving these larger birds from the vicinity has already been described.

Miscellaneous Measures

A number of miscellaneous preventatives for crow damage have been suggested. One such measure is the threading of corn on horse-hair, Another consisted of coating the inside of paper cones with birdlime, placing a few grains of corn in the bottom of each, and scattering them about the crows' feeding area. It seems unlikely that these and other equally ingenious methods will ever come into widespread use.

SPORT SHOOTING OF CROWS

Crow shooting is highly esteemed as a sport by many hunters. The American Crow Hunters Association with a membership of about 300 is a national organization of the most ardent of these sportsmen. The American Crow Hunting Championship Shoot is a regularly scheduled event of that organizatinn. It is held each year, generally in June, and the winner is declared the National Crow Shooting Champion. The ranks of the followers of this sport would undoubtedly be greatly increased if the crow could be elevated from his present lowly position as a thoroughly repugnant bird. Advocates of the sport all testify that crows offer top quality wing shooting and, as will presently be indicated, the usefulness of the bird need not be ended once it has served as a target for a skilful shooter.

Crow shooting is practiced in various ways. In its best developed form it involves the skilful use of crow call and shotgun and a considerable knowledge of the behavior pattern of crows. Many crows are killed in their roosts at night by hunters. There is considerable stimulation to be experienced in hiking through fields and woods at night and slipping quietly beneath a flock of roosting crows. The excitement of shooting into the massed birds and the ensuing bedlam is undeniable. It can scarcely be argued, however, that such shooting compares favorably as sport with daytime hunting when the targets are visible. The principal reason presented as justification for roost shooting has been the belief of participants that the killing of crows

constitutes a direct and considerable benefit to sportsmen, farmers and others.

Flyway shooting has been well described by Popowski (1946). The crows' habit of approaching the roost along well-defined flight lines makes possible the establishment of blinds with an excellent chance of good shooting. The steady flight of birds from shortly after mid-afternoon until dark, permits several hours of sport.

Another method of crow shooting requires the use of a decoy. This is generally a great-horned owl, or a reasonable facsimile, but any of a wide variety of enemies of the crow will do, even dead crows or artificial ones. There seem to be several schools of thought about how such decoys should be used. Some place them high in a conspicuous place, while others believe it better to arrange them near the ground. The position is probably dictated more by the shooting habits of the hunter than the behavior pattern of the crow. After the decoys are positioned properly the shooters retire to a blind near by, or to some concealing vegetation. By using a crow call to imitate the rally call of these birds they may soon have a flock of crows diving viciously at the decoy, and calling others to the battle. Under these circumstances a skilful caller and shooter can bag a number of crows before the flock leaves the scene. Popowski (1946) discusses this and gives detailed instructions.

Since few other birds offer so much in the way of wing shooting, it would appear that crow shooting might be promoted as a sport to provide shooting during parts of the year when game seasons are ordinarily

closed. The bird has much to recommend it to the shooting public. It is widely distributed and its abundance is more or less directly proportional to the occupation of the land by man. Where shooting pressure is greatest, crows are likely to be plentiful. No game bird even approaches the ideal distribution of the crow. It is able to withstand considerable gun pressure. Local populations have been subjected to considerable shooting for years without serious depletion. It is true that most such shooting is done by a few individuals and that pressure might be much increased, but there are certain practices which at present exact a heavy toll of crows that might be discontinued or modified if necessary. Roost shooting and roost bombing at best provide inferior sport, and might well be eliminated except in instances where crow damage is clearly such as to require control. The mortality from such practices is unknown, but it is certain that a very large percentage of all crows killed are killed in roosts at night. There would undoubtedly be great objection and criticism of any attempt to diminish or halt the killing of crows at roosts.

One enormous obstacle to efforts to popularize sport shooting of crows is the present attitude of crow shooters. Although readily admitting the great sport they enjoy, they generally speak of it in terms of "vermin" control. Such an attitude is fostered by the fear that a status for the crow other than that of "vermin" might result in the curtailment of their sport or at least the imposing of restrictions not presently suffered. This may be denied by many and is certainly not the whole reason for the "vermin" attitude, but it is a feeling

shared by many.

The ordinary concept of "game" involves the eating of at least portions of the animals taken. The flesh of crows is regarded with repugnance by most people, the stigma being so strong that the expression "to eat crow" is commonly used to express the unpleasantness associated with defeat or mistakes which cause embarassment. The cause for such discrimination against crow as food is somewhat obscured by the testimony of the many persons who have eaten the flesh of this bird and pronounce it quite good. Aldous (1944) reports that in Oklahoma crows killed in the process of roost bombing were served in hotels and restaurants and eaten by many local people. He reports that he found them to be as appetizing as quail or duck. To test this personally, crow was served to the family of the writer, which includes three children not especially omnivorous. The meat was served as crow (chicken fried) and eaten with gusto by every member of the family, a distinction not even shared by chicken. The experience was convincing. The crow does have sufficient attributes to qualify it as an excellent game bird.

If the crow were to become a part of the game resource it would be desirable to carefully check the effect of increased hunting pressure on the species. This may seem a premature concern, but considering the apparent low nesting success one may reasonably question the ability of the bird to withstand greatly increased gun pressure. To determine the effect of increased hunting would necessitate the development of adequate census methods. It is not too early to tackle this problem

now for it promises to be a difficult one, and one upon which little or no information is available at present.

SUMMARY

The study of the life history of the crow was undertaken because of the reputed, although controversial, economic importance of the species and because of obvious gaps in the knowledge available in the literature. Systematic work on the problem was begun in the autumn of 1948 and continued through 1951. This work consisted of field observations, examination of museum material and of specimens collected, study of the food habits and banding records in the files of the U.S. Fish and Wildlife Service, a survey of the literature, and the compilation of data from questionnaires mailed to employees of state conservation departments and professional and amateur ornithologists.

The results of this study indicate that the crow must be judged beneficial or harmful to mans interests on a purely local basis. No overall verdict is justifiable. Ways are suggested in which the relationship between men and crows might be improved.

The American crow, Corvus brachyrhynchos Brehm, is widely distributed over North America. Its range extends from the Atlantic to the Pacific Ocean, and from the Gulf of Mexico north practically to the tree line. Four subspecies are recognized: the eastern crow is the form found east of the great plains and north of the gulf states, the southern crow occurs east of the great plains and north to Maryland, Tennessee and southern Illinois, the Florida crow occupies peninsular Florida and southeastern Georgia, and the western crow is the form occurring west of the great plains. The bird is not uniformly abundant

over its range. The activities of man have in general been favorable to the crow and the species is most abundant in agricultural sections of the country.

In spite of the low repute in which it is held, the crow has gained a reputation for cunning and sagacity and in truth the crow is an adaptable bird. Specimens with severe handicaps such as malformed beaks and missing or deformed legs have been found in good flesh. The feet are sometimes used to transport objects and crows have even been seen to catch fish in their claws.

Although crows are said to sometimes live for more than a score of years in captivity, wild birds seldom live half that long. Crows do not mate until the second spring after hatching and from information secured from banding returns it appears that less than 22 per cent of the young which reach banding age ever live to produce progeny.

The crow belongs to the Oscines or singing birds and although its voice is not generally musical it is capable of uttering a wide variety of sounds. Crows have been taught to utter simple words and at least ten different types of notes and their variations can be recognized and interpreted.

Crows nesting north of central United States are somewhat migratory. East of the plains area the north-south movement is not as pronounced as farther west, where crows nesting in the prairie provinces of Canada and northward, migrate to Oklahoma and Texas in the fall. Crows banded in these regions are known to have migrated over 1400 miles and some must travel much greater distances.

The northward movement begins in January and crows of southern Canada are on the breeding grounds by late March. The autumn migration in the east is not well defined. Crows begin to flock in late July and August, and the largest concentrations are frequently not formed until after mid-December. The crows in the great plains area are on the wintering grounds by November. There is some evidence that in the east and midwest, young crows migrate farther south in winter than adults do. There is also a little evidence to indicate a differential migration of the sexes.

Crows return to the same locality to nest year after year. Of the birds banded on the breeding grounds and recaptured during subsequent breeding seasons, 94 per cent were retaken in the same county or in the county adjacent to the one where they were banded. The unmated yearling birds also return to the vicinity where they were hatched, and are included in the calculation. These yearlings are frequently associated with the paired adults and appear to participate in nesting activities to a limited extent.

Pairing is not a conspicuous activity and there is a possibility that crows may mate for life. In view of the small amount of scattering indicated by records of banded birds, pairing probably takes place on the breeding grounds.

Nests are built in woodlots and sometimes in isolated trees in crop fields. Both sexes participate in nest construction which in Ohio is generally completed by the first week in April. Average sized clutches contain 4 or 5 eggs and incubation is almost entirely by the

female. There is disagreement concerning the length of the incubation period but it is probably about 18 days. Renesting may occur if first attempts are disrupted early in the season.

After hatching the young are cared for by both parents. Development is rapid, with daily gains in weight as high as 25 grams. The rate of gain is less rapid during the last half of the nestling period. Crows remain in the nest for a period ranging in length from 28 to 35 days and leave the nest without any coercion by the adults. There is only one brood per year.

After leaving the nest the young crows are fed by the adults for two weeks or more, and remain with them throughout the summer. By August these family groups join with unmated crows and other family groups in flying to communal roosts each evening. More and more crows join these roosts as the season progresses. The roosts grow, break up and combine until in mid-winter the largest concentrations occur. Very large roosts may contain several hundred thousand birds. Roosts appear to be made up of individual flocks which range out in the same direction along fixed flight lines during the day and return along definite flight lines in the evening. Crows were observed to fly low when coming into roosts against the wind and to fly at high altitude with the wind. A tumbling or diving descent to the roosting site was noted, somewhat less stereotyped but similar to that of swifts and martins. Winter roosts occur wherever roosting cover is available in the vicinity of a good winter food supply. This kind of range is most common in the "corn belt" and in the grain sorghum area of Oklahoma and

Texas.

The crow is omnivorous, feeding upon a great variety of wild seeds, cultivated crops, insects, small mammals, and the eggs and young of birds. The food habits vary with the season and the availability of the food materials and are likely to be quite different in the various parts of the country. The habits of the crow in feeding upon cultivated crops sometimes cause considerable economic loss to farmers in areas where crows are abundant. Heavy losses have been suffered by growers of corn, sorghum, pecans, almonds, melons, peanuts and other crops.

The insect food of crows includes a number of species of considerable economic importance. Notable among these are beetles of the family Scarabaeidae, grasshoppers, and caterpillars. Many insects of little or no economic importance are eaten, as well as a few predatory or parasitic forms of positive value.

Fish, turtles, snakes and other forms of animal life are eaten when available. Mussels and clams are sometimes carried aloft and dropped, the crows then alighting and devouring the flesh.

The predatory habits of the crow have given it a bad reputation among sportsmen. Crow predation on waterfowl is especially serious at times. There is reason to believe that a major portion of such predation may be the work of yearling non-breeding crows rather than that of nesting pairs. Observations of the habits of crows with nestlings indicate that they do not feed in a manner conducive to the locating of many duck nests.

Crow predation on upland game is of much less magnitude than that on waterfowl, but may be serious on game farms or where the birds are reared in numbers under semi-wild conditions. Modern methods of poultry raising have eliminated much of the opportunity for crows to carry away young chicks. This was a problem at one time, but only in rare circumstances is it likely to be so again.

Diseases and parasites are usually not important factors in limiting crow populations but there are some records of disease having killed large numbers of birds in winter concentrations. The known parasites of the crow are listed.

Some vertebrates are natural enemies of the crow but probably have little effect on the crow population. An exception may be the raccoon which is presently abundant over much of the crows' range and may be considerably affecting the numbers of this bird. Other species of less importance include the great horned owl, the goshawk and perhaps the Cooper's hawk. A number of small birds harass crows. Some of the most important of these are the redwing, the yellow-headed blackbird, the kingbird, and the purple martin. These small birds probably do not affect the numbers of crows but do influence them in where they nest and feed.

The control of crow damage has been attempted in many ways. It must always be a local endeavor, since crows return year after year to the same locality. Being migratory, at least to a degree, little effect upon summer crow populations can be expected from control measures applied in winter, and vice versa.

Shooting may be effective locally, especially if applied to nesting birds. The bombing of roosts is an efficient method of reducing the numbers of wintering birds in areas where crops are being damaged. The crippling of large numbers of birds is unavoidable with this method.

Poisoning is not recommended in most cases because of the ineffectiveness of quick-acting poisons and the hazards involved in the use of slow-acting ones. Repellents are moderately effective, but some have a deleterious effect upon seed germination.

The "Australian" crow trap has been used in capturing numbers of these birds in winter, but such operations are generally ineffective in reducing winter concentrations sufficiently to make a noticeable difference in crop damage. Bounties are ineffectual and economically unsound.

Biological control using disease organisms to infect winter roosts may be possible but is highly impractical and dangerous. To induce the nesting of harassing species of birds like the purple martin may give protection from crows and deserves more widespread trial.

The crow offers excellent wing shooting and is favorably distributed in relation to hunting pressure. Although there may be some question about how much shooting the crow population can stand there is at present no reason other than prejudice to prevent more widespread sport shooting and utilization of the crow as a game species.

In spite of the popular impression to the contrary, the flesh of the crow is palatable and has been eaten with pleasure by many people. Crow hunting as a sport could well replace the promiscuous roost shooting and roost bombing now widely practiced.

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