BIRD - BANDING

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A STUDY OF THE CHICKADEE AND WHITE-BREASTED NUTHATCH BY MEANS OF MARKED INDIVIDUALS[1]

PART I: *Methods of Marking Birds*

By WILBUR K. BUTTS, PH.D.

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INTRODUCTION

ORNITHOLOGISTS have long recognized the need of being able to distinguish individual birds in solving ornithological problems. Bird-banding was devised as a method of filling this need. With the usual bird-banding methods, however, the bird must be taken in the hand in order to identify the individual. Could we not learn much more about birds if we marked individuals so that they could be recognized wherever seen without recapturing them? The present research was undertaken with the view of investigating the possibilities of this method of study by applying it to two common birds, the Chickadee and the white-breasted Nuthatch. The birds were marked in two ways—by staining the feathers and by means of colored bands.

Aluminum bands as a means of tagging birds have been extensively used in the United States and Canada during the past eleven years since the Biological Survey took over this work, and to a less extent for ten years before by members of the American Bird-Banding Association. Chickadees and Nuthatches have long been favorites with bird-banders in

[1] The author is indebted to Dr. A. A. Allen, of the Department of Ornithology, Cornell University, for helpful suggestions, assistance in field work, and critical reading of the manuscript; to Frederick Garrett, Edwin Webster, R. E. Crouch, and A. E. Brower for assistance in field work and in banding birds. The author wishes to express his appreciation also to the correspondents who have supplied information.

many sections because of the ease with which they may be trapped in the winter. Consequently many have been banded.[1] The amount of definite information gathered, however, has not been large. If one reads the list of "problems that can be solved by bird-banding operations" mentioned in the circular "Instructions for Banding Birds" (Lincoln, 1924), it can readily be seen that in case of most small land birds, the results achieved have fallen far short of the objectives. Of course bird-banding is still in its infancy, but can we not increase the amount of significant data obtained without any increase in the extent of bird-banding operations?

If birds are marked so that individuals can be recognized at sight, there are a number of advantages over ordinary bird-banding methods. In the first place, when a bird has once been marked, its movements can often be traced even when it does not visit a trapping station again. Very often a bird will visit a trapping station but once, when it is perhaps somewhat outside its usual feeding-range. Therefore with the usual banding methods we cannot be sure whether an individual which does not repeat has left the vicinity or not. If the bird can be recognized wherever seen, however, a search may still reveal its presence. Marked birds which return after a migration to the same region but not sufficiently near the banding station to be recaptured can likewise be detected.

Some species of birds, such as Grackles, become trap-shy, and are not easily caught after once being banded. Other birds can scarcely be captured at all as adults, although the young can easily be tagged. Banding birds which are never retaken is valueless if the birds cannot be recognized at sight, except in the comparatively rare instances when the bird is found dead. Marking birds so that sight identification is possible, however, makes tagging of trap-shy birds as profitable as banding those which are easily caught. Marking nestlings in this way should help to solve the perplexing problem of what becomes of the young birds after leaving the nest.

In making life-history studies it is often important to be able to recognize an individual at some particular moment. For example, suppose one is studying the activities of a pair of Chickadees, a species in which the male and female are alike. Another bird trespasses on the territory of the pair under observation. One of the pair drives the intruder away.

[1] 5887 Chickadees and 1537 White-breasted Nuthatches were banded prior to July 1, 1929

Was it the male or the female which did the fighting? Again it may be desirable to know whether both sexes incubate, whether the female ever sings, and which sex feeds the young the more frequently. Of course, even with the usual banding methods the male may be banded on the right tarsus and female on the left, but the possibilities along this line are limited to distinguishing only two birds. It is much more satisfactory to mark the birds with colors.

The amount of data which can be collected by marking individuals may be increased through the activities of other observers. In any neighborhood there are usually some people interested in birds who are glad to watch for and make reports on marked birds, although they may not have sufficient time and knowledge to become bird-banders themselves. The use of colored bands or stains also saves the time of the bird-bander. What bird-bander has not had the experience of trapping birds for several hours or even days and getting nothing but repeats? Of course, the recording of repeats is important, but there is little point in catching the same bird day after day or several times in the same day. It is much easier to note the presence of a bird distinguished by colored bands, than it is to retrap the bird to learn its identity: one can concentrate on trapping new birds, let the old ones go in and out of the traps as they please and yet at the same time record their presence. When all the birds coming to the station have been banded with colored bands, the operator can cease banding until new birds begin coming to the traps. For some species it would thus only be necessary to trap a few times a year and yet keep an accurate record of the birds visiting the station. The rest of the operator's time can be spent in the field, making observations and following the birds' movements. The behavior of birds which are not continually trapped is also much more natural.

The ability of the operator to let banded birds go in and out of the trap, and only spring it on unbanded birds is especially important in case of Chickadees. These birds usually visit the feeding station in small flocks of ten or a dozen individuals. After trapping a few times the operator finds he has most of the birds banded, but some never seem to get caught. Others already banded, perhaps bolder birds, usually go into the trap first. Then, before all the birds are caught the flock leaves, frightened away by the trapping. It is much easier to catch all the birds in a flock if only unbanded birds are trapped. Of course, even if uncolored bands are used, one can usually see with a pair of field-glasses whether a bird is

banded or not and allow the banded ones to pass in and out, but the individuals visiting the station could not then be determined, and important records might be lost. Chickadees also tend to become trap-shy after being caught a few times, so that it soon becomes difficult with ordinary bands to determine what individuals are present. They may cease to visit a trapping station if some one else nearby is simply running a feeding station. On the other hand, if trapped but once and marked with colored bands, the birds become tame, some individuals readily learning to eat out of the hand.

The marking of individuals also facilitates experiments in avian psychology, a field which has scarcely been touched.

It is readily apparent that this kind of banding vastly increases the amount of data which can be collected in a given time as well as considerably extending the field of bird-banding. In order that birds may be identified if captured by other workers in another part of the country, the Biological Survey bands should be applied along with the colored ones. If the feathers are stained, the bird should also be banded.

As an example of an extensive investigation carried on by means of marked individuals, we may cite the work of J. P. Burkitt (1924) on the English Robin. Burkitt did not mark the birds with colors, but used "rings" made of aluminum and "some dark tinny material." He says: "As to rings, I have up to now used variations of numbers up to three on a leg or up to four between both legs. To form the latter variations one of the rings had to be black and somewhat longer and narrower than the aluminum ones in order to be more easily detected. . . . I gave up my first idea of coloured rings as quite too difficult of detection. I may warn others that it often takes much patience to get a clear steady view or proper background for identifying the rings." Burkitt carried on his studies over a period of several years, and was able to get important information regarding matings, territories, local movements, and length of life of the Robin. My own experience bears out Burkitt's statement that it requires much patience to identify the bands, but I have come to the conclusion that colored bands are quite practical; indeed, light or medium-colored bands are much more easily detected than are dark ones.

STAINING THE FEATHERS

Staining the feathers as a means of marking birds has often been attempted. In general the results have not been satisfactory, because the colors tend to fade in a short time. Dr. J. B. Watson, however, successfully used this method in

marking the Noddy and the Sooty Tern in his studies of homing and nesting activities of these birds on the Florida Keys. (Watson and Lashley, 1915.) In a former paper (Butts, 1927) was included a preliminary report of the experimental work on the use of stains which had been carried on at Cornell University.

There are two types of substances, dyes and paints, which can be used to color feathers. In the former the color is in solution and actually penetrates the object stained. In paints the coloring agent or pigment is suspended or dissolved in some adhesive substance which makes it adhere to the object painted. Pigments are in general more permanent than dyes. In order to test the permanence of the various coloring agents, they were applied with a brush to feathers of the domestic fowl. The feathers were then exposed to sunlight, wind, and rain for several weeks. The more permanent colors were also tried on living birds.

Dyes. In the earlier experiments at Cornell the following dyes or stains were tested: iodine, picric acid, indigo, carmine, congo red, methyl blue, methyl green, Hoffman's green, orange G, saffranin, gentian violet, indanthrene blue B, anthraflavone G C, thio indigo red B, indanthrene golden orange G, pontamine yellow, pontamine red, acid fuchsin, and basic fuchsin. Alcohol was used as a solvent for all dyes which would dissolve in it. If insoluble in alcohol, water was used, and the feathers were first washed with ether, alcohol, or carbon tetrachloride.

Some of these dyes are quite light-fast. The more permanent ones, however, will not penetrate the feathers. Such are insoluble in alcohol and impracticable because they must be used in aqueous solutions in which the object to be dyed must be boiled, and since the feathers are somewhat oily, aqueous solutions will not penetrate. The color merely adheres to the outside and soon wears or washes off. Previous washing of the feathers in ether or alcohol does no good. Some of the alcohol-soluble dyes do penetrate the feather so that the colors will not wash out. These dyes, however, are not light-fast. Fuchsin seemed to be the dye which penetrated best, and it was tried on living birds. The color did not last for more than three weeks, and often it had become quite faint in one week.

The following dyes also proved unsatisfactory: Fast Light Yellow 3 G, Chrysodine Y Extra Conc., Magenta Extra Conc., Methylene Blue Extra Conc., Victoria Green Conc., National Alphazurine, National Acid Green L Extra, National Croceine

Orange Y Conc., National Fast Red S Conc., National Wool Yellow Extra Conc.

Dr. Rudolph Drost experimented with dyes for coloring birds in Germany, and claims to have found a method of staining which produces colors that will last for several months. He kindly sent me this information, but he requested that complete directions should not be published for fear that inexperienced persons might use the stains and cause injury to the birds. Certain solvents which take up the oil in the feather and allow the dye to penetrate are added to the dyes. These solvents have a cooling and anesthetic effect and would injure the bird if used too freely. The dyes he used are Fuchsin, Diamangirün, and Victoria Blau. Strange to say, Fuchsin is also the dye which I had found most satisfactory to produce a red stain, although the color never lasted more than two or three weeks. The solvents used by Dr. Drost I added to the Fuchsin. The stain, however, when tried both on test feathers and on living birds, proved but little more permanent than before, the color fading within two weeks. When used with some dyes the solvent appeared to increase the permanence slightly, while with others it had no effect. It cannot be used with dyes which are insoluble in alcohol. To test the Fuchsin I was using, I sent for some to the same manufacturer in Germany who had supplied Dr. Drost. Samples of Diamantgiün and Victoria Blau were also obtained. Results with these German dyes were no better than with similar ones made in this country.

Paints. The pigments used in a good grade of paint or enamel are more permanent than dyes, and they will not fade when exposed to sunlight. However, when a paint is used on feathers, the adhesive substance will cause them to mat together, thus bringing about possible injury to the bird. Of course, the paint can be thinned with some substance like gasoline or carbon tetrachloride which does not become sticky on drying, but if thinned sufficiently to prevent the feathers matting together, there will not be sufficient adhesive material to make the pigment adhere. Even if not thinned the pigment wears off after a time.

Among the substances of this class which I have tried are waterproof drawing ink in several colors, several kinds of enamel, and artists' oil paint. Waterproof drawing ink loses its color in a few days. The fading is due to wear and to the action of sunlight. The same is true of the enamel used to color electric-light bulbs.

"Duco," "Valentines Brushing Lacquer," and similar

enamels are more permanent. When applied to test feathers and exposed to sunlight and rain for several months they did not fade greatly. Cheaper grades of enamel, however, lost their color. Even the best kinds when applied to the breast or wings of Chickadees, Nuthatches, and Song Sparrows wore off within a short time, usually within two weeks. They were tried thinned with alcohol, mixed with anilene dyes, and without thinning. When used unthinned on the Chickadee, a bird whose plumage is light and fluffy, the enamel matted the feathers together considerably. Consequently it was applied sparingly on a limited area. On Sparrows, birds with more compact and firm plumage, the enamel did not greatly disarrange the feathers. About a dozen House Sparrows were thoroughly painted with unthinned lacquer, and kept overnight to determine what effect the painting would have. They seemed to be not at all injured. The birds were then released. Unfortunately the permanence of the color was not determined, since none of them were seen again. They were supplied with colored bands to make identification possible in case the enamel wore off.

When artists' oil paints were used the results were similar to those when enamel was used. They were unsatisfactory on Chickadees and Sparrows. When applied to the back of the Downy Woodpecker, however, the color was quite permanent. A Downy Woodpecker painted red on the back on March 5th still had the color bright on April 25th. On May 18th, about ten weeks after being painted, the color was still distinguishable, although rather faint. Artists' oil paint was the material found most satisfactory by Dr. J. B. Watson[1] for marking Terns in his studies of these birds on the Florida Keys. The paint was smeared on the plumage with the grain of the feathers. After six weeks the colors were still bright. A variety of colors and types of marking, such as stripes and bars, were used, so that many birds could be marked differently.

Effect of the Colors on Behavior of the Birds. After being painted or dyed the birds naturally try to remove the material by preening the feathers. As far as my experience goes, after the plumage becomes dry they do not pay any more attention to it, nor do other birds appear to notice the color. According to Watson, however, (1908) when a Noddy or a Sooty Tern was painted, the bird was at first not recognized by its mate.

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[1] *Ex litteris.*

It would be driven away from the nest as if it were a strange bird. Other birds often joined in the affray. It would usually persist in returning to the nest, however, until finally it was accepted, and allowed to go about its household duties as usual. On one occasion I watched a pair of Nuthatches after the male had been painted. The male was preening his feathers. The female approached and appeared to examine him closely. Then she flew some distance away. Presently the male flew off in the direction his mate had taken. I followed him for about three hundred yards without seeing anything of the female. The next day the pair were together again. There is no evidence of any birds having been permanently injured by either paints or dyes.

Usefulness of Marking Birds by Staining the Feathers. There is one great advantage in this method of marking the birds. The marked individuals are very conspicuous. It gives one a distinct shock to see a "blue-breasted" Chickadee, or a Downy Woodpecker with a red stripe down its back instead of a white one. People seeing such strangely colored birds, and thinking that they are new species or freaks of some sort, are likely to report them. Thus a considerable amount of data on the movements of birds can be collected. On a number of occasions during the experiments at Cornell, people called the Ornithology Department on the telephone to report a "new kind of bird" that they had seen in the neighborhood.

It has been suggested that paints or dyes could be used as an aid in the study of migration. If the birds were trapped and colored in large numbers at some point in their migration route like Louisiana, no doubt many of the marked individuals would be reported from various points to the northward. Thus much data regarding the rate of migration and the routes traversed could be obtained. In studies of this sort it would be necessary, of course, that each species of bird be painted at only one locality, unless the different operators coöperated and used different colors or a different type of marking.

Unfortunately, while artists' oil colors are satisfactory for some birds, the experiments indicate that the application of paints or dyes to small land birds in general cannot be recommended at present. Professor W. D. Bancroft of the Department of Chemistry, Cornell, believes that a stain suitable for coloring birds can be found, although the problem is a difficult one. Attempts to develop a new dye would have a better chance of success than trying to find a satisfactory one among the innumerable already known substances. The problem,

however, is one for the chemist rather than the ornithologist. The ideal substance would probably be a dye rather than a paint since the latter class of substances tends to mat the feathers together and to wear off.

In the present investigation of the Chickadee and Nuthatch, main dependence was placed on colored bands. The birds were stained principally for the purpose of testing the permanence of the colors.

ENAMELLED BANDS

Colored bands of two kinds, enamelled aluminum bands and celluloid bands, were used in the present investigation.

Mr. C. L. Whittle, of the Northeastern Bird-Banding Association, (1925) seems to be the first to have used colored aluminum bands. Using the numbered bands furnished by the Biological Survey, he at first colored them experimentally with diamond dyes and then applied a coat of varnish. The color, however, wore off within a month. Using Pyraline enamel, a product manufactured by the Dupont Company, Whittle has had much better success. He was able to identify Catbirds at sight after they had worn the bands for two years.[1]

In the July 1927 issue of the *Bulletin of the Northeastern Bird-Banding Association*, an advertisement appeared stating that Mr. A. W. Higgins would supply enamel for coloring bands or would color bands sent to him.

In the fall of 1927 Mr. Whittle kindly colored a dozen bands for me, and I used them on Chickadees and Nuthatches. Two Chickadees and two Nuthatches were retaken a year later. By this time the enamel had partly worn off, but it was still possible to identify the birds, although not with any degree of certainty, since when the worn part of the band was turned toward the observer no color was visible. Mrs. H. C. Dunham, of Wellesley, Massachusetts, used colored bands enamelled with Duco but found that the color was not permanent, although sometimes visible the second season.[2]

In order to make a more thorough test of enamelled bands, I attempted to obtain some Pyraline from the manufacturer, who advised the use of Duco as better than Pyraline. The company also recommended that the bands be cleaned in a warm solution of zinc sulphate in order to remove the greasy residue on the aluminum before applying the enamel. This

[1] *Ex litteris.* See also Whittle, 1926a b, c; 1927a.

[2] *Ex litteris.*

seems to make the color adhere better, but I have no records to show how permanent the colors are. The application of the enamel does not interfere with the reading of the numbers, providing it is not put on too thickly.

Whittle sometimes uses two colors on the same band, painting the upper half one color, the lower half another, thus greatly increasing the number of birds which can be marked differently. (Whittle, 1926b.) The size of the area colored is then quite small when small sizes of bands are used, but he writes that the colors can be readily distinguished if a close approach to the bird is possible, as is the case at a feeding station. Dr. Francis Harper has shown that it is even possible under certain conditions to read the number on an aluminum band on a bird without capturing it. (Whittle, 1928.) This was done at a window-shelf feeding station.

Undoubtedly colored enamelled bands, if properly prepared, are of great value for marking birds which come to a feeding station. If the color wears off after a season, a new band can be applied. Enamelled bands are easier to prepare than celluloid ones, but even at their best they are not as conspicuous as the celluloid. Accordingly, for an extensive study, when it is desired to identify the individual birds wherever seen, celluloid bands are much more satisfactory.

CELLULOID BANDS

Celluloid has long been used as a material for the manufacture of poultry bands. The first record of its use on wild birds is that of Mr. L. Gain (1912), who marked a number of Penguins in the Antarctic with celluloid rings in February, 1907. In October and November, on return of the birds, a score of the banded individuals were seen. It was later reported that some whalers recovered a number as late as 1910. This indicates that celluloid bands are not injured by salt water.

A number of other people have applied celluloid bands to wild birds, though apparently not extensively. In 1914 Mr. W. C. Lyon[1] placed about 25 "baby-chick" red celluloid bands on Bronzed Grackles. The next year a Grackle wearing a red band was reported by a neighbor.

Mr. S. Prentiss Baldwin[2] used celluloid bands for marking House Wrens so that the sexes could be distinguished. The

[1] *Ex litteris.*
[2] *Ibid.*

practice was discontinued when it was found that the sex could be distinguished at sight without the use of bands.

A Barn Swallow wearing a red celluloid band with the number 16 was found dead near Victoria, British Columbia, in 1927. The bander is unknown. (Lloyd, 1927.)

Celluloid poultry bands are made in two styles—"spiralets" made of celluloid wire wound into the form of a spiral, and "bandettes" made of sheet celluloid. The latter are superior from the standpoint of greater visibility and because numbers can be painted on them. They can be obtained from dealers in poultry bands (see advertisements in any poultry magazine) in sizes from one-fourth inch inside diameter up to one inch. The smallest-size bands are known as "baby chick" bands and are the same size as number 4 U. S. Biological Survey aluminum bands which are suitable for birds the size of the Grackle and the Blue Jay. They are made in fourteen different colors.

Some dealers also supply celluloid "canary bands," which can be used on smaller birds. These are about 3 mm. inside diameter and 3 mm. wide. The ends of these bands do not overlap, but turn outward, so that it would seem that they would rather easily come off the bird's tarsus. I tried them on Sparrows, Downy Woodpeckers, Nuthatches, and Chickadees, and found them satisfactory except in case of the Chickadee. This bird always begins a valiant struggle to remove the bands immediately after being released, the struggle sometimes lasting for fifteen or twenty minutes. In a number of cases the bird succeeded in removing the canary bands. Because of the uncertainty of the canary bands staying on for any length of time, it seems better to make one's own bands for use on small birds. The bands can be made much wider than are the canary bands, so that they will be more conspicuous.

Sources of the Celluloid. Celluloid may be procured from the Celluloid Corporation, 290 Ferry St., Newark, N. J.; or from the DuPont Viscalloid Co., 10 W. 33rd St., New York City. The cost is about $1.20 for a sheet 20 in. by 50 in. The thickness of the material for small size bands (Nos. 1 and 1A) should be 10/1000 of an inch. If too thick, there is difficulty in making and in applying to the bird's tarsus. If too thin, the band is apt to come off. Celluloid of the proper thickness can also be obtained from baby-rattles and other toys purchased at ten-cent stores. One can also make small bands by using the material in the larger poultry bands.

Method of Making. The celluloid should first be cut into

appropriate pieces. To make bands for birds the size of a sparrow or smaller, the pieces should be 5 mm. by 13 mm. These will make bands about 2½ mm. inside diameter and 5 mm. wide with the ends overlapping between 3 and 4 mm. The celluloid which is used in baby-rattles usually shrinks on being heated. Accordingly allowance for shrinkage must be made, the pieces being cut 6 by 14½ mm. The celluloid purchased in sheets does not shrink. If only one band is applied to a tarsus, the bands may be made more than 5 mm. wide. A width of 8 or 10 mm. is desirable since wide bands are more conspicuous. Bands for larger birds may of course be made still wider. An overlapping of the ends of 3 to 4 mm. is about right when celluloid of the correct thickness is used, but if the celluloid is rather thick, the overlap should be less, or else there will be difficulty in making the bands and in applying them to the birds' legs. If the celluloid is quite thin the ends should overlap more, so that the band will not come off. Bands of larger size should also overlap more.

The piece of celluloid cut to the proper size is then held by the ends between the tips of a pair of forceps, dipped in boiling water, and bent into a U shape. After removal from the water the celluloid will retain the shape into which it has been bent. It may then be wrapped with the fingers around a nail. The diameter of the nail should be the same as the inside diameter of the band which it is desired to make—*i.e.*, 2½ mm. for No. 1 bands. The band is then held in place on the nail by means of a metal band sufficiently large to slip over the celluloid one. Standard aluminum bird-bands may be used for this purpose, using the next larger size than the bands you are making, but it is necessary to open them slightly to slip them over the celluloid, and then pinch them together again to hold the celluloid in place. This opening and closing destroys them after a few bands have been made, so that it is better to make a special metal band for this purpose out of tin or aluminum. After the celluloid is thus held in the desired shape on the nail it is dipped in boiling water again. Prolonged immersion does not injure it, and it should be left in the water for several seconds. Celluloid which shrinks, however, should be left in the boiling water only a second or two. However, it should be left in as long as possible, because bands which are insufficiently heated have a tendency to expand after a time, so that they become loose on the bird's tarsus and may even come off. For this reason also the water must be actually boiling.

On removal from the boiling water the nail, with the band

still on, is dipped in cold water. The band may then be removed and is ready for use. After a little practice, between thirty and forty bands can be made in an hour. No doubt, after a little experimentation one could devise a more efficient method of making them.

Applying the Bands. Since it is difficult to open the band and put it on the bird's tarsus with one hand, while one is holding the bird with the other hand, some kind of an instrument for holding the band open is desirable. A short stick with a square end, 3 mm. wide, may be used. Before taking the bird in the hand, the band is opened and placed on the end of the stick, in such a way that the end of the stick holds the band open. The bird is then taken up and the band slipped off the stick onto the bird's leg.

A much better tool can be made from a small pair of scissors and two needles. The needles are soldered to the ends of the scissors, extending about half an inch beyond the tips, with the needle-points toward the base. To use this instrument, merely thrust the needles inside the band. Opening the scissors then opens the band. In order to prevent the band slipping off the end of the needles, their tips should be bent outward slightly The ends of the needles must be heated red hot to destroy the temper, before they can be bent.

After being put in position on the bird's tarsus, the band should spring shut of itself, but it may be necessary to adjust it by pinching it together slightly.

Colors. Very light or dark colors should not be used, as they are difficult to distinguish at a distance. Pink, scarlet, or medium red, medium blue, green, and yellow are the most satisfactory. White should not be used, as it is not easily distinguished from aluminum. The same is true to a lesser extent of light blue, though if the band is made wide enough it is satisfactory. Violet can be used, but it is not easily seen at a distance. Orange would probably be a good color, but it is difficult to procure. The colors are apt to fade somewhat after a time. Accordingly, close shades of the same colors should not be used. Pale shades become almost white after fading. However, no difficulty was experienced in this respect when good strong colors were used, even after the bands had been on the birds for over a year.

White celluloid may be painted various colors by using a quick-drying enamel or lacquer such as "Duco," but the color wears off in time, so that the use of painted bands might cause confusion if observations are carried on for more than one

season. The celluloid must be thoroughly cleaned before being painted.

Number of Individuals Which Can Be Marked. A numbered aluminum band should preferably be placed on each bird in addition to the celluloid one. Then, using only one color, six birds can each be marked differently and are identifiable, thus: (1) aluminum on left tarsus, celluloid on the right; (2) aluminum on the right leg, celluloid on the left; (3) aluminum and celluloid both on the right, the aluminum above the celluloid; (4) same as the last but with the aluminum below the celluloid; (5) aluminum and celluloid both on the left, the aluminum above; (6) same as the last but with the aluminum below. If one aluminum and two celluloid bands of the same color are placed on one bird, but with not more than two bands on the same tarsus, six additional birds can be marked. If two colors are used, either singly or in combination, a total of thirty-six birds can be banded, each one differently. With five colors (pink, red, blue, green, and yellow) the number is one hundred and eighty.

If necessary, in order to increase the number of birds which can be marked differently, striped bands may be used. By using several colors of enamel and several colors of celluloid, a great many combinations are possible. If the bands are coated with clear lacquer after being painted, the stripes will be rendered more permanent. Both horizontal and spiral stripes can be used, although there is some difficulty in distinguishing one from the other in the field, particularly if the stripes become partly worn off. Accordingly it is not recommended to use both kinds of stripes unless the large number of birds to be marked renders it necessary. Vertical stripes would probably not be satisfactory because if the stripes were made wide the band might appear as one solid color from one angle and as another color from another angle, while if the stripes were narrow they would blend together at a distance. The stripes on horizontally or spirally striped bands should be 2 mm. or more in width to prevent blending. Another way to increase the number of birds which can be marked is to use bands of two widths. Bands 5 mm. wide can readily be distinguished from those 10 mm. wide.

Burkitt while studying the English Robin used as many as three bands on one tarsus, and four bands on one bird. While the use of four bands might be practicable in case of moderate-sized birds, it would probably not be wise to use more than three on small birds like the Chickadee. Chickadees seem to be able to carry three bands easily enough, but four might

overload them. Even if they were not injured by a load of four bands, the difficulties in observation would be greatly increased.

The more intricate the marking scheme, the more difficult it is to identify the birds. When only one colored band is used, recognition under favorable conditions is quite easy from a distance of fifty or sixty feet. When two are used on one individual, observation is more difficult, and one has to await a favorable opportunity when both bands are visible in order to make the identification. If three were to be used, the difficulty in observing and remembering the positions of the different bands would in most instances be so great that the scheme would likely be impracticable. One should keep the marking plan as simple as possible, using more than one colored band, striped bands, and bands of different widths only when necessary.

Method of Keeping Records. Needless to say, the marking of a large number of birds necessitates the keeping of careful and extensive records. In order that no two birds might be banded alike, I first made a list of all the possible ways in which the birds could be banded, using one aluminum and one or two colored bands on each bird. The different colors were listed on separate pages. This list was then carried with me into the field, and whenever a bird was to be banded, the list was referred to, in order to determine what bands to apply and their position on the bird's tarsi. After banding, the number of the aluminum band used was then entered in the list opposite the particular combination used. This list then served two purposes: it showed what combinations had already been used, and, when a bird wearing colored bands was seen in the field, it indicated the aluminum band number of that bird. In addition to this list a card index was kept of all the birds banded. On the cards were written a record of the band number, the band combination, the date and place of banding, and the date and place of each occasion that the bird was seen.

It is much easier to ascertain what colors a particular banded bird is wearing than it is to determine the exact position of the bands. For example, one may catch a glimpse of a bird and notice that it wears a red band but be unable to determine whether the band is on the left or the right tarsus. Therefore I used one color or combination of colors at one station and a different color or combination of colors at another station. Thus, at the station on the north side of Fuertes Bird Sanctuary pink and yellow bands were used; on the east side, pink and red; and on the south, pink and green. Then if a bird with a

green band was seen on the north side, I knew that it had come from the south side even though I could not determine exactly which individual it was. If a bird with a blue band was seen at the Sanctuary, it must have come from some station outside of this area. In this way a considerable quantity of data was collected without actually identifying individual birds

Limitations and Difficulties in Use of Colored Bands. Obviously, colored bands cannot be used successfully on all species of birds. Some species keep to the tree-tops so that the bands cannot readily be seen. With others, like the Swallows, the legs are seldom visible. Still others are so shy that they do not permit a close approach. Of the birds studied I found that identification was most easily effected in case of the Chickadee and the Song Sparrow. Nuthatches and Woodpeckers were not especially difficult, although it was not so easy to see the bands, and they often stayed in the tops of the trees for some time. On several occasions it was necessary to watch a Nuthatch for fifteen or twenty minutes before an opportunity was afforded to see the bands clearly. It should not be supposed that one can identify every banded bird that is seen. Very often the bird flies away before the color and position of the bands can be ascertained. A great deal of care and patience are necessary, and a favorable opportunity for observation must be awaited. The bird should not be between the observer and the sun nor high in a tree with the sky as a background. I found that with experience, greater proficiency in determining the color-combinations was gained. At first it was somewhat difficult to decide quickly whether a band was on the right or the left leg, but after a few weeks' experience there was but little difficulty in this respect. In order to avoid mistakes, an effort was made to make two determinations of the color-combination on each bird seen. Identifications based on a single observation were usually recorded as doubtful. Because of the difficulty in making accurate determinations, observations by people who were inexperienced or who were not familiar with the colors used were also considered as doubtful.

With a good pair of field-glasses under favorable conditions identification is possible at a distance of sixty feet or more. For satisfactory work, however, the observer should be within thirty feet of the birds. There is no advantage in getting closer than fifteen feet except when the observer is not provided with a pair of field-glasses. These distances refer to identifying individual Chickadees. Larger birds with larger bands can be identified at greater distances.

Some difficulty was experienced because a few of the bands expanded after being worn by the birds for some time. If there are two bands on the same leg, and one of them expands, it will slip over the other one. In some cases also the bands came off. The stretching of the bands was probably caused by insufficient heating in manufacture, and perhaps also by being opened too widely while being applied to the tarsus. If desired, the bands can be sealed with celluloid cement. DuPont's Household Cement is satisfactory for this purpose.

Retrapping the birds is sometimes necessary whenever it is suspected that a band has come off, or when an error in banding has been made. Retrapping of birds the second season is also advisable. If a number of persons are using colored bands on the same species, frequent retrapping to be certain that the birds seen were not banded by another operator, would be necessary. If more than one operator in a locality marks the same species of bird with either stains or colored bands, only confusion can result unless the operators coöperate and use different colors. Any one contemplating such a study should communicate his intention to the United States Bureau of Biological Survey.

It would probably be best to restrict the use of celluloid bands to operators who are making earnest studies of particular species of birds. Indiscriminate use of celluloid bands by operators who have no definite object in view would serve no good purpose.

The marking of birds by colored bands is of most use in making local studies. The likelihood of the colored bands being seen on birds during migration is small.

SUMMARY OF TRAPPING OPERATIONS

The study of the Chickadee and the Nuthatch was first begun in the fall of 1924 and continued until June, 1925. A considerable amount of data was collected at that time regarding the local movements of Nuthatches, but practically nothing was learned regarding the Chickadee. Seven Nuthatches and fourteen Chickadees were banded. An account of this preliminary work was published in the *Auk* (Butts, 1927).

Work was commenced again in the fall of 1927, and continued, except for two months during the summer of 1928, until July, 1929. During the season 1927-28, 61 Chickadees and 19 Nuthatches were banded. None of the birds banded in 1924-25 were recaptured, although a Chickadee banded in

April, 1926, and two Nuthatches banded in 1926 and 1927 by other operators were taken.

The most important part of the work was done in 1928 and 1929. During this season 184 Chickadees and 37 Nuthatches were captured. Some of these were banded by other operators, but all were taken in the vicinity of the area where the birds were studied. Of these 15 Chickadees and 9 Nuthatches were returns from previous years. The increase in number of birds banded was due to improved trapping methods, maintenance of a larger number of feeding stations, and assistance from other workers. Trapping was carried on at twenty different substations.

At least fifteen persons living within the area where the birds were studied maintained feeding stations. Some of these served as points to watch for the birds in order to determine their movements. In general, however, these extra feeding stations were a hindrance rather than a help, since they attracted the birds away from the regular trapping stations. Much time was lost in waiting at one place, while the birds were feeding at another.

Food, consisting of suet, sunflower seed, and occasionally peanuts, was provided at all times. Peanuts were easily the favorite food with both Chickadees and Nuthatches. The birds would visit stations where peanuts were provided, and neglect other nearby stations. Sunflower seeds were preferred to suet.

At the principal stations food was put out in the latter part of September, and replenished at intervals until the latter part of April. After nearly all the birds had been banded at these stations, others were started. Owing to the abundance of natural food during the fall, the feeding stations were but little visited until late in November. Accordingly, but few birds were trapped before December 1st. At this season the birds paid little attention to suet, and it was very difficult to keep out a supply of sunflower seed. No matter how much was put out one day, it would all be gone the next, having been carried away by mice during the night. An attempt was made to trap the mice, but after catching twelve at one place without overcoming the difficulty, this was given up. Finally, at some of the stations the food was placed on a board nailed to the top of a pole driven in the ground. The underside of the board was covered with tin, so that mice could not reach the top. This device, when erected far enough from trees and shrubs, also prevented squirrels and chipmunks from carrying away the food.

The traps used were small wire cages about 12 inches long, 8 inches high, and 8 inches wide. These traps are set off automatically when a bird steps on a platform inside the trap. They could easily be transported, and set up anywhere in a moment by placing them on a stump or hanging them by a nail to the side of a tree.

After trapping once or twice at a station, the traps were operated manually by pulling a string attached to a stick holding the door open, so that birds already banded could go in and out of the traps, and efforts might be directed toward capturing the unbanded birds.

Some difficulty was experienced because traps in the Fuertes Bird Sanctuary were frequently stolen. To obviate this a number of "dummy traps" were constructed. These were similar to the regular traps, but had no door or trapping mechanism. Accordingly they were easier to make and less apt to be stolen. Food was put out in these so that the birds became accustomed to going in and out of them. When it was desired to catch the birds, real traps were substituted for the dummy ones.

By the middle of January nearly all the Chickadees and Nuthatches within the area studied were banded. During the remainder of the winter the various stations were visited as often as possible, in order to detect changes in the population, and movements from one station to another. By taking a position about twenty or twenty-five feet from the food and watching through a pair of field-glasses each bird as it came down to get a sunflower seed, it was not difficult to see the colored bands and determine what individuals were present. It was not always possible to identify a bird as it alighted near the food, but by watching for fifteen or twenty minutes nearly every individual in the flock would finally be seen and identified, some of them half a dozen times or more. One could get much closer to the birds than twenty feet if desired. Indeed, some of the birds learned to take seeds from the brim of my hat. However, a close approach was not deemed advisable, since some of the more timid birds might not then come to the food.

A considerable amount of time was also spent in following the birds after they left the feeding stations, in order to determine the extent of their range. Following a flock of Chickadees or a pair of Nuthatches was not at all difficult. Single birds, however, were more difficult to keep in view.

Because of the large number of trapping stations, it was not possible to keep an accurate record of the birds visiting

all of them. Efforts were concentrated on the stations in the Louis Agassiz Fuertes Bird Sanctuary. The Chickadee and Nuthatch populations and the movements of the birds within this area were accurately determined. The other stations were used as a check on observations in the Sanctuary, and to determine whether the birds ever travelled longer distances.

The Fuertes Sanctuary is a typical bottom-land wood, with an area of about eighty acres. The trees composing it are mostly elm, red maple, sycamore, and willow, with a thick undergrowth largely of spice bush and black elder.[1] The remainder of the area where the birds were studied is largely a semi-wooded suburban residential section.

LITERATURE CITED

BURKITT, J. P.
A Study of the Robin by Means of Marked Birds. *British Birds*, 17:295. 1924.

BUTTS, W. K.
The Feeding Range of Certain Birds. *The Auk*, 44:329-350. 1927.

DROST, R.
Das Färben lebender Vögel als Hilfsmittel in der Vogelzugsforschung. *Ornithologische Monatsberichte*, 33, Mar., 1925.

GAIN, L.
Penguins of the Antarctic Regions. Rep't. Smithsonian Inst., 1912:478.

LINCOLN, F. C.
Instructions for Banding Birds. U. S. D. A. Misc. Circ., 18:27. 1924.

LLOYD, HOYES.
Another Mystery Band. *Can. Field Nat.*, 41:139. 1927.

WATSON, J. B.
Behavior of the Noddy and Sooty Terns. *Papers of Tortugas Laboratory of the Carnegie Institution of Washington*, 103. 1908.

WATSON, J. B. and LASHLEY, K. S.
An Historical and Experimental Study of Homing. *Papers from Dep't. of Marine Biology*, Carnegie Inst. Wash., 7:1-60. 1915.

WHITTLE, C. L.
Notes on Colored Bands. *The Auk*, 42:136. 1925.
Sight Return of Junco. *Bul. N. E. B. B. Ass.*, 2:16-17. 1926a.
Sight Repeats. *Bul. N. E. B. B. Ass.*, 2:37-38. 1926b.
Catbirds and Colored Bands. *Bul. N. E. B. B. Ass.*, 2:56-57. 1926c.
A Recommendation to Bird-Banders. *Bul. N. E. B. B. Ass.*, 3:17, 44-45. 1927.
An Unusual Sight Recovery Record of a Purple Finch. *Bul. N. E. B. B. Ass.*, 4:108. 1928.

(TO BE CONTINUED)

[1] For a more detailed account of the ecological characteristics of Fuertes Sanctuary see Allen, "The Redwinged Blackbird; A Study in the Ecology of a Cat-tail Marsh." Abs. Proc. Linnæan Soc. N. Y., Nos. 24-25, pp. 48-74, 1911-13.