Control of Cowbird Parasitism on Kirtland's

Warbler Through Use of Natural Behavior Patterns

(EPP75-08905)

Adrian College

May 18 - July 26, 1975

James N. Bull

Eileen S. Chaffee

Mary E. Gaasch

* Kenneth C. Goist, Jr.

Susan Lumpkin

James W. McDaniel, Ph. D. (Faculty Advisor)

ABSTRACT

In 1973 Steven Fretwell of The Bird Population Institute suggested that Robins lay blue eggs in order to recognize foreign eggs in their nests. This is an evolutionary development that has given Robins an advantage in preventing social parasitism by species such as the Brown-headed Cowbird. It has been demonstrated that Robins will remove Cowbird eggs and other eggs that have been placed in their nests. Robins' removing Cowbird eggs increases the probability of survival of Robins; it follows that the probability of Cowbird survival can be increased by their avoiding Robins' nests. Just as the distinctive blue of Robin eggs allows Robins to detect foreign eggs, so should egg color allow Cowbirds to discriminate among nests and preferentially deposit their eggs in nests where they will not be removed by the host bird.

This study was designed to test the hypothesis that Cowbirds can discriminate on the basis of color, and that Cowbirds possess preferential response tendencies on the basis of color. The research consisted of two related approaches to the problem. There were a number of experiments carri out in a laboratory to investigate discrimination and preferences under rigidly controlled conditions. There were also several experiments designed for field research to test the hypotheses under more natural conditions. The two approaches augmented each other by making data available for verification in the field or the laboratory.

The primary concern for the findings from this research was that they might be applied toward controlling parasitism of an endangered species the Kirtland's Warbler. At the start of the 1975 breeding season it was thought that there were no more than 500 Kirtland's Warblers in the World. Since this bird nests only in the Jack Pine forests of Michigan, there is concern about the continuation of the species. Scientists and Government Wildlife Agencies have felt that Cowbird Parasitism on Kirtland's Warbler has been a major factor in that bird's decline. Extensive trapping program have been carried out to remove Cowbirds from the Kirtland's Warbler nesting range. Successful findings from the present research would offer an additio control of parasitism by using Cowbirds' natural preferences and aversions to redirect their choice of nests away from Kirtland's Warblers'.

Low incidence of Cowbird parasitism and extensive nesting failures precluded definitive field support for the hypotheses. There were significant results obtained from the field research for related areas. Bird nests are notoriously difficult to locate, but a successful method was developed that will facilitate future field research using active nests.

This method consisted of identifying individual territories of birds on the basis of singing male birds and pair interactions such as courtship, display copulation, and ritual feeding. Within territories, individual nests were located by listening for secondary songs of adults on the nest and by flushi adults from nests.

It was further demonstrated that artificial eggs could be introduced into nests without disrupting normal development of the young. In some cases attempts were made to color the natural eggs in a nest rather than introduce artificial ones. A method for permanently coloring eggs without damaging the embryos was developed. This consisted of removing the egg's waxy coating and dyeing with food coloring.

Nesting failures and losses of artificial eggs from dummy nests were attributed to predation by Blue Jays. An experiment was designed to verify this, and it was found that Blue Jays will remove artificial eggs from nests. Recent findings from Kirtland's Warbler research have indicated that predation by mammals and other birds may be the next most serious problem affecting Kirtland's Warbler. Our findings support the feasibility of this suggestion.

The laboratory research used female Brown-headed Cowbirds that had been trapped by the Fish and Wildlife Service on the Kirtland's Warbler nesting grounds in Michigan. These birds were used in a variety of experiments to demonstrate their ability to discriminate and to show differential responding on the basis of color. Standard operant conditioning paradigms in specially modified operant chambers showed that Cowbirds could discriminate between colors. Food reinforcement was contingent upon a peck at a particular color, and the number of responses to other colors decreased rapidly with experience. The Cowbirds also demonstrated improvement over successive reversals of the correct color. These data support the hypothesis that Cowbirds possess the ability to discriminate on the basis of color.

After it had been shown that Cowbirds could discriminate, an attempt was made to show that they would respond differentially to colors. It was argued that if extraneous variables affecting response differentiation were controlled, then any observed differences in responding must be due to a preference for a particular color. Apparatus was designed to allow Cowbirds the opportunity to approach or avoid any of several bird nests containing various colored eggs. The apparatus allowed one to measure the amount of time a subject spent in the immediate vicinity of each stimulus. It was assumed that the greater this time, the stronger was the preference for a particular stimulus. Data supporting the preference were obtained, but these were found to be low in reliability due to large individual differences among birds.

Color preferences were also measured using operant conditioning paradigms where subjects received food reinforcement according to a Fixed Interval schedule for responding to a series of colored stimuli. Reinforcement was independent of response rate under this experimental design, so differential response rates for the different colors was the measure of color preference. The findings gave support to the hypothesis that Cowbirds have color preferences. Reliably high response rates were found for red stimuli, and low rates were found for blue and green stimuli. These findings are in accord with Fretwell's original suggestions and corollary hypotheses regarding Cowbirds.

Control of Cowbird Parasitism on Kirtland's Warbler Through Use of Natural Behavior Patterns

Kirtland's Warbler (Dendroica kirtlandii) is one of the fifty or so species of wood warbler that live in North America. While each species o warbler has its own ecological niche, the Kirtland's nests only in the second growth Jack Pine forests of Michigan; its winter grounds, thought to be in the Bahamas, are unknown to date. Since its discovery in the nineteenth century, its numbers have always been low, but with the spread of an agrarian economy into Michigan it has been exposed to pressures which have threatened its very existance. Destruction of its nesting grounds has been halted, and controlled burning of mature Jack Pine fores has been carried out for over 15 years to provide the younger trees necessary for successful breeding. In the past three years, conservation have been alarmed by a second, and perhaps more dangerous threat to the Kirtland's Warbler: social parasitism by the Brown-headed Cowbird (Molothrus ater). Although Cowbirds parasitize many bird species, it can be especially devastating to an endangered species. Attempts have been made to reduce Cowbird pressures by trapping and killing Cowbirds in the Kirtland's Warbler nesting areas. This was first done under the auspices of local agencies, and is currently supervised by the U. S. Fish and Wildlife Service. Initial results appeared to be effective, showing a slight rise (8%) in Kirtland's Warblers following the first two years of trapping. The census of the summer of 1974 showed a startling drop (23%) in the number of nesting birds, and authorities are at a loss to explain it. This research was aimed at discovering additional methods for controlling Cowbird parasitism of the Kirtland's Warbler.

Ornithologists have reported that certain species of birds, e.g. Robins and Catbirds, which lay blue eggs, show little evidence of Cowbird parasitism, and when a Cowbird does lay an egg in the nest of one of these birds, the host bird ejects it from the nest. Stephen Fretwell (1973) has suggested that the distinctive blue color of the Robin's eggs allowed them to be easily discriminated from the Cowbirds' which could then be removed from the nest. Such a behavior would increase the productivity of the Robins and thus become a genetically salient feature of the species.

Conversely, it was hypothesized, Cowbirds have paralleled this evolutionary development of Robins and other species which lay blue eggs by developing an aversion to nests containing blue eggs. To test this hypothesis it must be shown that Cowbirds are able to discriminate on the basis of color, and behavioral evidence of aversive or preferential tendencies toward certain colored stimuli must be demonstrated.

Traditionally, psychologists have argued that laboratory research is adequate to discover lawful relationships in behavior. Operant conditioning and psychophysical methods have proven suitable for determining both discrimination abilities and preferential tendencies. However, biologists have frequently pointed to the artificiality of the laboratory setting and have stressed field research with its greater richness of behavior. In this study, both of these approaches were used. By selecting the best aspects of each, they were combined in a mutual feedback relationship to obtain as much data as possible on the critical variable affecting Cowbird parasitism.

In the field, active nests of commonly parasitized species were found and experimentally manipulated. Sparrow-size artificial eggs of six different colors were introduced into the nests and checked regularly for evidence of Cowbird parasitism. Further, "dummy" nests containing artificial eggs were set out in an attempt to induce parasitism. A differential rate of Cowbird parasitism as a function of egg color would provide evidence for Cowbird preferences or aversions for certain colors.

Limitations posed by using a wild species in the laboratory necessitated refinement of standard operant conditioning techniques. Thus, initial concern was focussed on care and maintenance, magazine training, and schedules of reinforcement. Prior to preference testing, the Cowbirds color discrimination ability was tested using two different operant techniques. Using both operant and non-operant methods, color preferences were tested and response rates to various colored stimuli were compared.

Introduction: Field Investigations

Straka (1966), Goforth and Baskett (1971), Taylor, Sluckin and Hewitt (1969), Salzen, Lily and McKeown (1971), Gray (1961) and others have shown avian color preferences in the laboratory; no similar research has been done in a field situation. Rothstein (1974), however, working with nesting Catbirds, has shown that a definite learning process is involved in avian egg recognition, thus providing a basis for preference research in the field. He also suggested that hosts which were able to learn their own egg type could more easily evolve anti-parasite adaptations. In another paper Rothstein (1975) demonstrated that egg recognition ability, when present, was based on true recognition rather than discordancy. In both studies he looked at egg rejection by host species. Since Catbirds preferred their own blue eggs to white Cowbird eggs which are very similar in size, there is a strong probability that the discrimination is based on color. McClure (1945) did color manipulation of Mourning Dove eggs in their nests but found no color preference or aversion; all the eggs were accepted.

The Brown-headed Cowbird, as a social parasite, presents a unique problem in this type of work. Since the Cowbird does not nest, egg rejection from the nest cannot be used as a measure of preference. Thus, in this study, two other methods were used to examine Cowbird color preferences. The first of these involved manipulation of host species nests with colored eggs; the second used "dummy" nests containing colored eggs. The incidence of Cowbird parasitism was used as a measure of preference or aversion in both methods.

In addition to the approaches outlined above, two peripheral experiments were designed to solve problems which arose from the preference work. One of these tested the efficiency of various egg dyeing methods; the other examined the problem of Blue Jay (Cyanocitta cristata) predation on nests and eggs.

Study Area

Field investigations were made in a three square mile area at the intersection of U. S. Forest Service Roads 4101 and 4348 in the Huron National Forest, Iosco County, Michigan. Much of the three square miles was covered by mature Red Pine (Pinus resinosa) plantations. Within this section three areas of smaller, 3 - 20 m tall Red Pine and second growth Jack Pine (Pinus banksiana) were used in this study. These stands of Red Pine and Jack Pine provided suitable habitat for the Cowbird host species. Also present in the area were Red and White Oaks (Quercus alba and Quercus rubra). Numerous standing dead trees, fallen trees, and brush piles provided perches, roosts and cover for birds in the area. Ground cover consisted primarily of Sweet Fern (Myrica asplenifolia), several Ericacia such as Blueberry (Vaccinium agustifolium), Bog Laurel (Kalmia polifolia), Sand Cherry (Prunus pumila), and various grasses (Graminae), and lichens.

Two of the areas bordered on Buck Creek, part of the Au Sable River system. All areas bordered on mature Red Pine plantations providing a prime ecotone for avian activity. The areas by survey location, with notation of special characteristics were as follows:

1. T 23 N, R 7 E, Section 3, East portion: This area was more level than the others, trees were less dense, and there was much more open space. Many dead trees were found standing here.
2. T 24 N, R 7 E, Section 2, Southwest corner: This area was fairly open, with dead trees and oaks more numerous than standing pines. Situated on the crest of a hill, it was the only area which did not border directly on Buck Creek.
3. T 23 N, R 7 E, Section 10, West portion: This was the largest of the areas. It included both hill and lowland with varying degrees of tree density and height.

A fourth area used in the study was significantly different from the others; it did not consist of Red or Jack Pine and the associated ground cover described above.

4. T 23 N, R 7 E, Section 3, Pond area: This area was a marsh which consisted of grass clumps, dead tree stumps, and ground cover

of moss (Sphagnum sp.), Sundew (Drosera rotundifolia), and Sedges (Carex sp.). This marsh, on the periphery of a small pond created by a dam on Buck Creek provided the best Song Sparrow and Catbird habitat, as well as considerable Cowbird activity.

The temperature in the region ranged from a minimum of 1°C to a maximum of 33°C with an average midday temperature of 21° - 24° C. The rainfall for the duration of the field studies was 18.08 cm with six days of rain in May, nine in June, and three in July. However, there were seven days with morning rain which affects avian activity: May had one morning rain, June had five, and July only one. Climatic data for the last three years (1972-1974) showed no significant temperature difference for 1975. Rainfall, however, for the same period was higher this year. In 1972, the only other year with complete data for all months, 6.83 cm of rain fell in the same time period and was distributed over 15 days as compared with 18 days for 1975. There was less rain in the crucial morning hours of 1975 compared to 1972. It is unlikely that climatic factors, which were typical for the region adversely affected the avian behavior investigated in this study.

Experiment I

In this experiment, nests of species which are common Cowbird hosts were located and manipulated with colored clay eggs. A significant difference in the incidence of Cowbird parasitism between nests with a particular experimental color egg and a control group was defined as evidence of color preference.

Holcomb (1973) and Rothstein (1975) report that rejection of colored eggs by hosts was not a methodological problem. Holcomb (1971) showed that artificial eggs were accepted in Red-winged Blackbird nests; and Rothstein (1975) showed that the Chipping Sparrow (Spizella passerina), a highly parasitized species, is also an acceptor species. According to Rothstein acceptor species, which include all highly parasitized hosts who are not rejectors, do not recognize their own eggs and thus cannot perform the necessary discrimination between their own and an introduced egg. Only one rejector species, the American Robin (Turdus migratorious) was used in this experiment in an attempt to support Fretwell's hypothesis.

Methods

Twenty-nine nests of eight different species were found and used in this study (See Table 1). The species were selected for use on the basis of reportedly high parasitism (Friedman, 1929, and Bent, 1963, 1964, 1968) and their abundance in the study area. Territories were located by the presence of singing males or the observation of pair activity and by following secondary songs to the nest itself. In most cases, the nest was found when an incubating female was flushed from it.

Both territories and nests were marked with numbered strips of colored survey flags attached to nearby vegetation. Nests were sequentially designated experimental or control so that at least one nest of each species (where more than one was available) was in the control group. There were eleven nests in the control group and eighteen experimental nests.

The experimental nests were manipulated by introducing colored clay eggs, or by coloring the host eggs. Six colors were used: red, green, blue, yellow, orange, and white. A color was randomly assigned to a nest and two same-colored eggs were introduced.

The clay eggs were hand rolled to approximate the size and shape of small passerine eggs, fired in a kiln, and painted with enamel spray paint. Larger glazed ceramic eggs used in Robin and Brown Thrasher nests were donated by B & W Ceramics of Adrian, Michigan. El Marko permanent and water color markers were used to color host eggs in a few instances.

Both control and experimental nests were checked for the presence of Cowbird eggs at least three times a week. Changes in the number of eggs and nest disturbances were also noted.

Results

No significant results on Cowbird color preferences were obtained. Only six Cowbird eggs were found: four of these were in nests designated control, three of which were Chipping Sparrow nests and one a Field Sparrow nest, the other in a Vesper Sparrow nest. However, in both of these cases the clay eggs were missing at the time parasitism was recorded.

Discussion

Two confounding variables can account for the lack of significant results. One such variable was the method used to locate active nests which required flushing incubating females. According to Mayfield (1961) once incubation has begun the period of greatest susceptibility to Cowbird parasitism has passed. Other common methods used to locate nests, such as a thorough search of all vegetation over several hundred miles (Mergenrader, 1962) or following birds carrying nesting material (Epple, 1972) were not feasible in a study which required a large number of nests be found in a limited amount of time.

The second confounding variable was nest desertions and missing eggs. Jacob (1938) and Nickell (1951) have commented on the fact that numerous nests are deserted for no apparent reason and with no obvious interference. It is possible that repeated disturbances caused by experimenters in checking nests forced the birds to renest. The same interference may have made the nests more visible to predators which would explain the damage to some of the nests. Evidence given later in this report on the frequency of Blue Jay predation supports the latter hypothesis.

Experiment II

The objective of this experiment was to find a non-toxic, long lasting method for dyeing passerine eggs. McClure (1945) reported water colors as an adequate method for dyeing bird eggs. However, the waxy coating of passerine eggs prohibited a long lasting effect using food coloring and vinegar dyes. Thus two other materials were tested: 1) the use of alcohol to remove the waxy coating prior to the application of food coloring, and 2) a permanent marker dye. Hatching success was used as a measure of the effects of these two techniques on the developing embryo.

Methods

Four nests were used in this experiment. One out of three eggs from both a Brown Thrasher and a Vesper Sparrow nest was selected and colored with El Marko permanent blue markers. Two eggs from the remaining two Vesper Sparrow nests were dyed with a solution of blue food coloring and vinegar. The waxy coating was removed by rubbing the surface of the egg with a cotton swab soaked in 70% Isopropyl alcohol. The nests were checked to determine whether the dyed eggs hatched and to note the permanence of both methods.

Results

All dyed eggs retained their color for the six-day duration of the experiment. All eggs hatched except those two dyed with the permanent marker.

Discussion

While the limited size of the experiment does not permit conclusive statements, the data obtained indicate that toxins in the permanent marker may have been responsible for the eggs not hatching. Alcohol and food coloring seem not to have an adverse affect on the developing embryo since these eggs hatched successfully. However the effect of this dyeing method on further chick development has yet to be determined.

Experiment III

Several studies have demonstrated artificial, or "dummy" nests, to be a viable method for investigating Cowbird parasitism. Selander and Yang (1966) and Robinson and Warner (1964) used such nests while studying Cowbird behavior in the laboratory. Johnson (1957) cites an instance of dummy nests used successfully in field research with Cowbirds. Dummy nests are also commonly used as baits in bird traps. This experiment employed dummy nests containing colored clay eggs in an attempt to test Cowbird color preferences. The number of Cowbird eggs found in these nests was used as a dependent measure of parasitism as a function of color. The colors tested were red, green, blue, yellow, orange, and white.

Forty-eight Goldfinch nests obtained from the Cranbrook Institute of Science, and three Field Sparrow and nine Chipping Sparrow nests collected in the area were used. The 60 nests were divided into three experimental conditions. Twenty-four nests were spray-painted so that there were four nests of each experimental color. Each of these contained two white clay eggs similar to those used in Experiment I. Each of twelve unsprayed nest contained three eggs, two of one of the experimental colors and one white egg. Since white was also considered to be an experimental color, two of these nests contained three white eggs. The remaining ten were equally distributed over the five remaining experimental colors. The other 24 nests contained two same-colored eggs, providing four nests for each color.

The dummy nests were placed throughout the four research areas (C. F. study area description). The greatest number were put in Areas 2 and 3 (24 and 18 respectively) since these were the largest areas and contained the fewest number of active nests. Of the remainder, 12 went to Area 4, and six to Area 1. A randomized block statistical design was used to distribute the nests and conditions over the four areas. Except in Area 4 where the vegetation made it necessary to use deciduous shrubs, dead stumps, and the ground as nest sites, all nests were attached to pine trees of various sizes and species. Locations were chosen for visibility and ease of re-finding. Nests were attached to the vegetation with string, twigs, and grass so that they were visible from above and from at least three sides. All the nests in pine trees were from one to two meters from the ground. Within each area, nests were placed from 10-100 m apart, with the majority being from 50-60 m from each other. Each nest site was marked with a numbered survey flag strip tied to nearby vegetation.

Forty-three of the 60 nests were distributed on the morning and afternoon of June 10, 1975. Following a check of the nests on June 12, which revealed a 96.7% egg loss, it was decided to postpone further nest placement until egg losses were controlled.

On June 13, all of the eggs in Areas 2 and 3 were replaced and glued into the nests with DUCO cement. These nests were checked daily and missing eggs replaced for eight consecutive days. Eggs in Areas 1 and 4 were not replaced and the remaining 17 dummy nests were not put out because of the continued high rate of egg loss.

Results

Of the 92 clay eggs placed in 43 nests, 89 (96.7%) were missing on the initial check. Sixty nine of the 81 additional eggs (85.0%) were lost. The total egg losses from dummy nests was 91.5%. No Cowbird eggs were found in any of the nests.

Discussion

The problem of egg loss described above prevented the determination of Cowbird color preferences by this method. It is impossible to tell whether Cowbirds laid in any of the nests because their eggs may have been stolen also.

The nature of the egg losses, the torn condition of some of the dummy nests, and the recovery of one chipped and cracked clay egg suggested predation by Corvids, particularly Blue Jays which were abundant in the area. The following study was done to test this hypothesis.

Experiment IV

It is a widely held notion that Blue Jays (Cyanocitta cristata) are common nest predators, frequently stealing eggs, preying upon nestlings, and destroying nests of other birds. This assumption has rarely been challenged, but Bent (1946, p. 39-40) cites one conflicting report in which an analysis of the stomach contents of 292 Blue Jays revealed only three with evidence of egg shells and two with bird remains. Barrows (1912, p. 414) after lengthy observation, concluded that predation by Blue Jays was infrequent and limited to a few prey species. A review of the literature reveals no systematic investigation of nest predation by Blue Jays, or other Corvids, although several instances of Corvids preying upon nestlings of other species has been reported (e.g. Prescott, 1963, 1965, 1967).

As a result of the problems encountered in Experiment III, an investigation of Blue Jay predation was designed to determine whether such predation was responsible for the loss of eggs from dummy nests, and further to provide evidence for the frequency of Blue Jay predation on nests and eggs.

Methods

Six dummy nests were distributed on June 27, in an area where all nests could be observed from a centrally located blind. Each nest contained two eggs of one of the six colors used in Experiment III. Between June 28, and July 11, 45 hours of observation were accumulated, spanning all daylight hours. Eggs were placed in the nests at the start of each observation period and removed at its end. The remainder of the day the nests were left in place, but without eggs. The color of the eggs in each nest was determined randomly prior to the observation, subject only to the criterion that all six colors be used in each observation period.

Three instances of egg stealing by a Blue Jay were observed: on July 3, between 0745 and 0915 one orange egg was taken from a nest; on July 7, between 0930 and 1030 two yellow eggs were taken from one nest and two white eggs were taken from another. In each of these cases a Blue Jay was seen to land in the tree containing the nest, to approach the nest and remove an egg, and to fly off, carrying the egg in its bill. Each episode took place in less than one minute. During all observation hours Blue Jays were frequently seen while no other known predators were noted at any time in the area under observation.

Discussion

The findings reported here provide experimental evidence for the occurrence of egg stealing by Blue Jays. They also furnish a good rationale for the continued trapping and removal of Blue Jays from the Kirtland's Warbler (Dendroica kirtlandii) breeding area. Orr (1975) names predation as partially responsible for egg and nestling losses in the Kirtland's Warbler, and one observed instance of Blue Jay predation on Kirtland's Warbler has been reported (Orr, 1975, p. 65). In light of Orr's report and our findings, the problem of Blue Jay predation requires continued attention.

Laboratory Investigations

A large number of techniques have been used in the laboratory to test avian preferences for a variety of stimuli. Some methods have been used more successfully than others depending on the behavioral repetoire of the species being tested. In these investigations of Cowbird color preferences, several preference methodologies were used in an attempt to find one appropriate for that species. Two types of operant techniques which had been successfully used with birds were employed as well as one non-operant method which was revised several times to increase its efficacy.

Prior to the actual preference work, however, it was necessary to develop methods for the proper care of birds, which included determining appropriate deprivation schedules for birds used in operant work and testing Cowbird's need for grit as a supplement to their diet. Further, it had to be demonstrated that Cowbirds were able to discriminate between colors. This was done using two different operant discrimination learning paradigms.

Methods

All birds were Brown-headed Cowbirds of indeterminant age. They were trapped in northern Michigan by the U. S. Fish and Wildlife Service, Office of Planning and Assistance.

Subjects were housed in 30 x 30 x 22 cm cages in an isolated animal room. A 6 x 7 cm recessed receptacle provided ad-lib access to grain except during periods of deprivation. Water was provided on the opposite side of the cage as was a 6 x 6 cm box of grit. A Michigan light/dark cycle, 14 hours of light and 10 hours of dark, was simulated by using high intensity lamps operated by electrical timers.

In the experiments using operant techniques, a standard operant chamber was modified for use with Cowbirds. The 6.1 x 7.3 cm grain magazine (Ralph Gebrands) was in the center of one wall, 1.8 cm above the floor. On the same wall two response keys were equally spaced on either side of the magazine. The keys (BRS/LVE) were rear-illuminated by in-line read out IDD cells, manufactured by Industrial Electronics Engineers, Inc., with Kodak Wratten filters:

Color	λ (nm)	% Transmission
38 blue	494.3	39+
30 magenta	505.5	37.8
61 green	533.8	13.7
32 magenta	546.8	16.9
56 green	555.5	38.2
4 yellow	580.0	35.8
22 orange	598.8	48.2
23A red	605.5	36.3
29 red	632.7	11.0
38A blue		

The chamber was illuminated by a small lamp located near the ceiling opposite the magazine. A small fan mounted on an outside wall, circulated air and subdued the sounds from the surrounding laboratory. The contingencies were electro-mechanically controlled by an adjacent relay rack.

Preparing birds for operant work initially entails magazine training. By systematically operating the feeder, the birds soon approach and eat from the magazine. When they reliably approached and ate from the magazine at each presentation, key shaping began. The birds were trained to peck a disk lighted with a neutral density filter for a food reinforcement by the method of successive approximations. To compensate for position preference, the lighted key was alternated randomly. Before the birds were placed in operant discrimination or preference, they had to have rea a criterion of stable performance on a fixed ratio (FR) 10 schedule of reinforcement.

Experiment I

There is some evidence that avian weight is at its lowest in the morning and peaks in the late afternoon (Partin, 1933, Kontagiannis, 1967 and Lindale and Summer, 1934). Although the above cited studies are concerned with weights and not feeding patterns, the two are closely related. The concern of this experiment was to determine, by finding a daily feeding pattern, a schedule of deprivation that would be conducive to high response rates in operant work, but not produce debilitating weight loss in subjects.

Methods

Six naive Cowbirds, three male and three female, were used. The experimental chamber which was 23 x 21 x 22 cm, was constructed of 1.2 cm hardware cloth. A recessed feeder, 5 x 7 cm, which contained a photo cell at the threshold, was on the back wall. Water was available at the opposite wall. The chamber was isolated from any extraneous stimuli and the electo-magnetic controls were in a separate room.

The subjects were placed in the chamber individually and feeding responses were recorded on a cumulative record. Food and water supplies were checked each day. Four subjects each spent two 24-hour periods and two spent one 24-hour period apiece in the chamber.

Results

A total of 10 24-hour periods were recorded for the six subjects. Mean cycles calculated from the cumulative record for each hour were used to determine a general feeding pattern. Feeding activity peaked between 8 and 10 am and again between 1 and 2 pm (see figure 1), and subjects did not eat during the dark periods.

Discussion

From the distinct feeding pattern obtained in this experiment an effective deprivation schedule was devised. Gossetts et al. (1966), working with several wild avian species, confined feeding to a single period after each days' experimental session. Following this precedent, subjects were given ad-lib access to food for a 4.5 hour period following each daily session in the operant box. Water and grit were available at all times. Thus, subjects were deprived during the last three light hours, through the 10 dark hours and for the first four light hours. This schedule, which included the overnight weight loss and the peak morning feeding hours, proved to be adequate to produce responding in the operant chamber without injury to the bird.

Experiment II

There is little data on the amount of grit needed to maintain a bird's weight. Bartonek (1969) found that the average volume of grit in the esophagi of 305 Canvasbacks (*Aythya valisineria*), Redheads (*Aythya americana*), and Lesser Scaup (*Aythya affinis*) was only .007 to .004 ml. The present study was designed to measure the effects of the availability of grit on Cowbird body weight, so that debilitating weight losses in the captive population could be avoided.

Four female Cowbirds were used in this experiment. The subjects were kept in their home cages with ad-lib access to food and water. Half of the subjects had access to grit placed in their cages, the other half were deprived of grit. After 23 days, these conditions were reversed for the remaining 10 days. Subjects remained in their home cages at all times except for daily weighing midway through the light/dark cycle.

Results

The mean weights of the subjects were calculated for each condition, grit and no grit (See Table 2). A two-tailed t-test yielded no significant results ($t = 1.25$).

Discussion

The lack of significant results is due, in part, to the small sample size and the limited time each subject spent in either condition. A study with a larger number of subjects tested over an extended period of time is necessary before any conclusions can be drawn. Since there were no apparent deleterious effects on those birds deprived of grit, the other birds used in this project were not provided with grit.

Experiment III

Before testing color preferences and aversions it must first be demonstrated that Cowbirds can distinguish between various colors. This experiment investigated discrimination learning in Cowbirds.

Discrimination (Smith, 1951, Fellows, 1968) is a process in which selective responses are made to differences between stimuli. One stimulus is reinforced and becomes a discriminative stimulus (SD) for responding. The stimulus not reinforced is the S^{Δ}. Learning a discrimination problem involves making a series of correct responses to the SD while decreasing the number of responses to the S^{Δ} (Maier and Maier, 1970, Fellows, 1968, Reid, 1958).

Some discrimination problems involve two stimuli presented either successively or simultaneously. In others there are many stimuli that are identical except one. These are oddity problems. The most common discrimination problems are spatial or visual. Although many types of responses are used to test discrimination, this study employed pecking responses to lighted discs as Beale (1970) did with his visual discrimination problems. Powell (1972) has used the key pecking response to test discrimination with a wild avian species.

This experiment employed two different discrimination methodologies. The first was a standard serial reversal discrimination problem. In this series of discrimination tasks the stimuli remained the same, but their reinforcement value changed from trial to trial. In the second method, one stimulus (S^{Δ}) was different in each presentation and the second stimulus (SD) remained the same, always with the positive reinforcement value. In both methods the percentage of total error (responses to S^{Δ}) was the standard measure of discrimination learning.

Phase 1

Methods

One female Cowbird was put in a modified operant box for two and one half hour daily sessions. The subject weighed approximately 90% of its ad-lib feeding weight (see experiment I for procedure).

A steady rate of responding on FR 10 was obtained on a light off/ light on discrimination paradigm. During the next session the pecking discs were illuminated with two colors, 61 green and 30 magenta. One of the colors was designated correct, i.e., reinforcement was contingent on a response to this key. The colors appeared randomly on the left key and the right key following each reinforced response. The reinforcement values of the colors were reversed after approximately one and a quarter hours, i.e., midway through each two and one half hour daily session. The number of responses to each color was tabulated separately for each trial. After five sessions, two new experimental colors, 38 blue and 29 red, were tested in the same manner for three sessions.

Results

Both experimental conditions of this two-color reversal learning discrimination paradigm showed decreased percentages of error over sessior The percentage of error decreased for both colors in condition one with some fluctuations in the first sessions (see table 3.1).

Table 3.2 shows the change in percentage of error over the three sessions in condition two. Although the percentage of error was not initially as high as in condition one, the last figures are much lower.

These lower percentages may indicate some formation of a learning set in discrimination tasks (Harlow, 1949).

Phase 2

Methods

Three naive female Cowbirds were used daily for two and one half hour The subjects weighed approximately 90% of their ad-lib feeding weight.

The modified operant chamber as previously described was used in this experiment. The response keys were rear illuminated with Kodak Wratten filters: 61 green, 56 green, 4 yellow, 22 orange, 23A red, 29 red, 30 magenta, 32 magenta, 38 blue, 38A blue, and .40 neutral density.

After at least one session with a steady response rate of FR 10 to a lighted key, subjects were placed in the discrimination paradigm. Both keys were illuminated with colored lights, one of which was designated correct, i.e., was reinforced. The correct color was always presented randomly, on the left or right key. On the other key appeared one of the ten incorrect colors. The chance these colors changed after reinforcement was controlled by a probability gate set at 50%. The responses on each incorrect color were counted separately, and the responses on the correct color were counted with reference to the incorrect color that was on the opposite key at that time.

Results

The ability of the subjects to discriminate between the correct color and the others was shown by the decrease in the percentage of error over sessions (see table 3.3).

Bird numbered 035 (see table 3.3) died the day after session five was completed. The cause of the abrupt increases in errors in session five for this subject is unknown, it is impossible to predict whether errors would have decreased again.

Table 3.3B clearly shows a decrease in percentage of error. Only two sessions are shown because bird 057 was presented with a different correct color during session three. This subject made no responses during that session, nor in the following sessions when the original correct color was reinstated.

Bird 052 provided greatest amount of data, as shown in Table 3.3. The overall decrease in percentage of error was 20.05%. The high percentage of error in session four may be due to the very low response rate, .13 response per minute, and the fact that all seventeen of the incorrect responses made in this session were perseverative errors, i.e., responses to the original incorrect color.

Discussion

Selective responses to the differences between stimuli demonstrates discrimination in Cowbirds. The improvement over trials is a result of the extinction of responses to the S^{Δ} and the increase in the number of responses made to the SD.

Experiment IV

A number of non-operant methods have been used in avian preference testing. Gallup (1970) operationally defined a preference for mirror-image stimulation in Finches and Parakeets as the amount of time spent on a perch directly in front of a mirror. In this experiment a method similar to Gallup's was used to examine egg color preferences in Cowbirds.

This experiment consisted of three phases: the octagonal chamber experiment, the square chamber experiment I, and the square chamber experiment II. In each phase, an attempt was made to correct mechanical and methodological problems discovered in the previous phase or phases.

Phase 1

Methods

Seven naive female Cowbirds served as subjects in this experiment. Each side of a plywood octagonal experimental chamber was 14 cm wide and 30.5 cm high with a 9 cm x 10 cm rectangular opening and a perch constructed of wooden dowels. All of the perches rested 9.5 cm from the floor of the chamber and were connected electromechanically to separate clock counters so that a bird's weight closed a circuit and gave an estimate of the amount of time spent on each perch. The top of the chamber was covered with a piece of 0.6 cm hardware cloth, and a table covered with newspaper provided the floor. A plywood obstruction, 13.5 cm wide and 30.5 cm high, was placed in the middle of the chamber to help prevent a bird from lighting on one perch while gaining visual access to other stimuli.

Six 4 x 5 transparencies of a Redwinged Blackbird's nest containing two ceramic eggs of the same color against a homogeneous brown background were attached to the outside of the chamber so that they could be clearly seen through the rectangular openings. Six experimental egg colors were used: red, green, yellow, white, orange, and blue. Although the position of the food and water remained constant in the chamber, the position of the transparencies were changed systematically to counterbalance any position effects.

Each subject was tested during 19 daily, five hour sessions. They were allowed free access to all perches during each experimental session.

Results

The total number of seconds spent on each perch by each subject was tabulated, and a Freidman two-way analysis of variance by ranks yielded no significant differences between the six transparencies ($\chi_r^2 = 3.26$: $p > .50$)

Methods

Five female Cowbirds were used in this experiment. Each side of the plywood square experimental chamber was 45.5 cm wide and 30 cm high with a perch 7.5 cm from the floor. The perches were 28 cm wide, separated by 1.5 cm from one another, and were constructed from wooden dowels and 0.6 cm hardware cloth. They were connected electromechanically to separa clock counters so that a subjects weight closed a circuit and gave an estimate of the amount of time, in seconds, the subject spent on each perch.

A plexi-glass cube 27.5 cm wide and 30 cm high on each side, divided by two diagonal pieces of plywood was placed inside of the square chamber This formed four triangles, each with one transparent side for displaying stimuli directly in front of each perch. The top of the chamber was covered with 0.6 cm hardware cloth and a table covered with newspaper provided the floor. No food or water was available to the subjects in the experimental chamber.

A Chipping Sparrow (*Spizella passerina*) nest was placed inside each of the triangular stimulus booths. The stimulus eggs were divided into two separate sets. Set 1 consisted of two red, two blue, two green, and two yellow clay eggs. Set 2 contained two Robin, two Chipping Sparrow, two orange, and two white eggs. On alternating days, one of the two sets of colored eggs was placed in the nests. The positions of the eggs were systematically changed to counterbalance possible position effects.

Each subject was tested in the chamber for three hours daily for six consecutive days. They were allowed free access to all perches during each experimental session.

A Freidman two-way analysis of variance by ranks between sessions on Set 2 showed a preference for Chipping Sparrow eggs, with the least time spent in front of the white eggs ($\chi_r^2 = 8.34$: $p < .05$). The same analysis between sessions on Set 1 revealed no significant differences ($\chi_r^2 = 1.44$: $p >.$ However, when the perch times between subjects were analyzed, a preference for green eggs in Set 1 was detected ($\chi_r^2 = 7.08$: $p <.10$). An analysis between subjects in Set 2 yielded the same results as between sessions ($\chi_r^2 = 8.28$: $p <.05$).

Phase 3

Methods

Five female Cowbirds served as subjects in this experiment. The same square chamber described above was used in this phase with the addition of one major innovation: a timer stopped each session after exactly three hours.

Two 4 x 4 factorial designs were developed for the two sets of eggs to test for egg color preferences, position preferences, and interactions between the two variables. Set 1 consisted of two blue, two green, two yellow, and two orange clay eggs. Set 2 contained two Robin, two Chipping Sparrow, two Field Sparrow, and two white clay eggs. Each subject was tested in the chamber for three hours daily for eight consecutive days.

Results

No significant differences were found between colors or between positions, nor was a significant interaction found between the two variables in either set of eggs. The greatest variances were between positions ($F = 2.03$, $df = 3$, $p >.10$; two-tailed) in Set 1 and between colors ($F = 1.53$, $df = 3, 48$, $p <.25$; two-tailed) in Set 2. A one-way analysis of variance performed on the between-subjects over both sets of eggs ($F = 126.14$, $df = 4, 34$, $p < .001$; two-tailed).

Discussion

Throughout this investigation of egg color preferences using a non-operant technique, mechanical errors and physical limitations of the equipment were discovered, and the changes made were aimed at eliminating these problems.

The possible confounding variables of the octagonal preference chamber were the opportunity to see more than one transparency at a time, the subjects perching on the floor rather than on the perches, and the use of the transparencies. These sources of error were eliminated in the second phase by the use of the square chamber and the replacement of the transparencies by real nests. Following these changes a significant Cowbird preference for Chipping Sparrow eggs was demonstrated when the stimuli consisted of clay and natural eggs. However no color preferences were found comparing clay eggs only, and there was a large between-subjects variance in both sets of eggs which remained unaccounted for.

The timer was added to the square chamber experimental design to allow the legitimate use of a more powerful statistical analysis in an effort to isolate the sources of variance. The results of this final phase of the study revealed that the greatest source of error was the between-subjects variance. Despite this large variance there was an indication of an egg color preference in Set 1 as well as an indication of a position effect in Set 2.

Several factors may explain the large between-subject variance. First there were occasional perch timing failures that occurred in all three phases and among all subjects. Secondly, the subjects were not exposed to the eggs of each set in each of the four positions more than once. A greater number of sessions may have resulted in a more consistent distribution of perching times among the subjects, thus reducing the variance.

Experiment V

Animals frequently enter the experimental situation with tendencies to respond more frequently to certain stimuli than others (Blough, 1966). Karr and Carter (1970) successfully defined these tendencies as preferences in a study of color preferences in pigeons by examining the total number of responses to various wavelengths during extinction after reaching a stable state on a 3-minute VI schedule of reinforcement. This experiment utilized the successful Karr and Carter (1970) methodology to detect color preferenc in Cowbirds.

Methods

Two female Cowbirds served as subjects in this experiment. Subjects were deprived of food (See experiment 1) prior to each two and one half hour session, so that they weighed approximately 90% of their ad-lib feeding weight. The subjects were first trained to peck at two white colored keys of neutral density on a 2.5 - minute VI reinforcement schedule After several sessions, the subjects were tested during extinction. During extinction all ten colors were paired with each other, and key position was interchanged such that every 45 seconds there was a 50 per cent chance that either color, or position, or both would change. The total number of responses on both keys for every color was recorded. One subject was tested for one session, while the other subject was tested for two sessions.

Results

A total of 260 responses by both subjects over all three sessions were recorded. The subjects' response rates decreased too rapidly to make any conclusions about color preferences.

Discussion

Previous research by Ferster and Skinner (1957) and Karr and Carter (1970) strongly suggest that many more hours on the 2.5 minute VI reinforcement schedule were needed in order to obtain adequate extinction curves. However, due to time limitations of the project and the problems of subject care and maintenance, the experimenters were forced to initiate extinction before a true stable state was reached. This procedure may have been useful in discovering color preferences had more time been available and deserves further attention.

Experiment VI

Straka (1966) has shown that when given a choice, pigeons will drink more blue-colored water than red or green-colored water. Goforth and Baskett (1971) found that Mourning Doves consistently consumed more grain presented against a blue background than against backgrounds of other colors. In neonate chicks, Kovach (1971) observed that neonate chick made significantly fewer approaches to green stimuli than to red or yellow stimuli.

In this experiment a fixed-interval schedule of reinforcement was use to test color preferences in Cowbirds. All colors tested were equally reinforced. Thus, differences in the number of responses to any particula color would be the result of something other than reinforcement, and it was assumed that differential responding would reflect preferences.

Methods

Six female Cowbirds were used in this experiment, each weighing approximately 90% of their ad-lib feeding weight. The subjects' experimental histories consisted of several hours of magazine training and manua shaping. Response rate criteria were established as prerequisites for preference testing. Several different schedules of reinforcement were employed: a fixed ratio (FR) schedule, a variable interval (VI) schedule, in which the intervals between reinforcements vary in a random or nearly random order--in the present experiment, intervals varied about a mean of two minutes; and a variable ratio (VR) schedule, in which the reinforcemen occurs after a given number of responses, the number varying unpredictably from reinforcement to reinforcement. Bird number 028 had been previously trained on a VI two minutes; bird 015 on a VI two minutes, then on a FR schedule; bird number 057 on a FR schedule; bird number 051 on a VR schedu bird number 050 on a FR schedule; and bird number 019 on a FR then a VI two minute schedule.

The operant chamber used in this experiment was identical to that used in Experiment V.

Due to criterion levels of response rates required before preference testing, deaths of birds, lack of response, and mechanical difficulties, th birds were used for differing numbers of sessions. Each 2.5 hour daily sessions was identical and occurred at the same time in each subjects ligh dark cycle. When the subject was placed in the chamber, both keys were li with the first color of the cycle. During the sessions both keys were illuminated by the same color which changed only after the second reinforc ment period. This period followed the appropriate response--a key peck following a fixed time interval. The color changes always followed the same order, comprising a cycle of 10 color pairs. The time intervals involved on the FI schedule were gradually increased from 10 seconds to two minutes but were changed only at the end of a cycle so that each color would be tested under identical conditions. All responses were recorded on automatic counters, one counter for each color. Not all birds reached FI two minutes.

Results

Total responses for each bird on each color are shown in table 4, and the preferences for each bird are shown in table 5. Pooled data from all six birds were analyzed by a Freedman two-way analysis of variance on the ranked colors for each bird, and showed significant differences between number of responses to each color ($\chi_r^2 = 210.72$, df = 9, $p<0.001$).

Discussion

The significant finding of this study is that Cowbirds have definite preferences for certain colors. The between-subjects preferences however are not consistent, a finding that concurs with Gray's (1961) discovery that there are extreme differences in preferences among chicks of the same age and hatch group.

The overall ranking of color preferences indicate preferences for r and magenta, which conflicts with those of Straka (1966) and Goforth and Baskett (1971). Green, the least preferred color in Kovach's 1971 study was also least preferred by the Cowbirds in this experiment. Since blue is next to green in the color spectrum, it follows that blue would also a less preferred color, which was borne out in the overall preference ranking.

Further studies with a larger number of subjects would be appropria and a better understanding of specific morphological factors that mediat behavior patterns in relation to colors is needed.

Project Summary

The data obtained in this study did not provide adequate evidence for the efficacy of a control method for Cowbird parasitism on the Kirtland's Warbler based on natural color preferences and aversions. Laboratory investigations revealed that Cowbirds discriminate between, and do prefer, certain colors to others. However, due to methodological problems in the field research, it was not demonstrated that these preferences act in determing suitable hosts. Further research in this area is needed. Replications of the preference studies using a greater number of subjects might reduce the between-subjects variance and more clearly define the order of Cowbird color preferences, as well as provide a basis for continued preference work in the field. It is felt that limiting the host species used in active nest manipulations to one common species (e.g. Chipping Sparrows) and allowing more time and personnel to find nests earlier in the breeding season would solve most of the problems encountered in the field.

In addition to demonstrating discrimination learning and preferences in the Cowbird, information was obtained on maintaining Cowbirds as laboratory subjects. Appropriate deprivation and reinforcement schedules were ascertained which will facilitate further experimentation with this species which has only rarely been used in the laboratory.

The field experiments, while not demonstrating Cowbird color preferences, shed light on another problem plaguing the Kirtland's Warbler: Corvid predation. The extremely high rate of eggs lost from dummy nests, and observations of Blue Jays stealing eggs, indicate this may be a more serious problem than previously suspected, and certainly one that deserves more attention. Careful observations of Blue Jays, and other Corvids, in the field is necessary to determine the frequency of predation on active nests, particularly those of the Kirtland's Warbler, and research aimed at control methods begun.

The preliminary research presented here indicates the complexity of the parasitic habit of Cowbirds, and has raised many questions which meri examination. Further research on the nature of the stimuli that Cowbirds attend to when selecting a host, and on the role that prior experience plays in making that choice is needed. With continued study, a natural control for Cowbird parasitism may be found, and a great deal of information on the phenomena of social parasitism in avian species obtained, which is an interesting problem in itself.

Active Nests Used In Various Experiments

Species	No. of Nes
Eastern Kingbird (Tyrannus tyrannus)	1
Brown Thrasher (Toxostoma rufum)	5
American Robin (Turdus migratorius)	3
Nashville Warbler (Vermivora ruficapilla)	1
Rose-breasted Grosbeak (Pheuticus ludovicianus)	4
Vesper Sparrow (Pooecetes gramineus)	5
Chipping Sparrow (Spizella passerina)	12
Field Sparrow (Spizella pusilla)	7
Song Sparrow (Melospiza melodia)	2

Table 2

Mean Daily Weight of Cowbirds

With And Without Access to Grit

Subject No.	Grit	No Grit
033	37.07 gm	35.75 gm
034	41.78 gm	42.22 gm
038	28.88 gm	32.38 gm
044	34.98 gm	38.02 gm

Table 3

Performance of Cowbirds on Discrimination Tasks

Table 3.1

Percent Error for One Cowbird on 5 Successive Reversals

Subject No. 027	Percent Error for Each Color	
	Color	
Session No.	61 Green	30 Magenta
1	34.78	14.25
2	16.27	45.42
3	7.40	49.37
4	5.44	12.95
5	8.30	9.12

Table 3.2

Percent Error for One Cowbird on 3 Successive Reversals

Subject No. 027	Percent Error for Each Color	
	Color	
Session No.	38 Blue	29 Red
1	7.65	24.10
2	13.09	11.33
3	4.68	1.23

Table 3.3

Percent of Error and Total Number of Responses for 3 Cowbi

On a Simple Discrimination Task

Subject No.	Correct Color	Session	Percent Error	Total Respons
035	30 Magenta	1	14.16	1829
		2	11.02	1325
		3	8.30	879
		4	2.24	624
		5	11.08	3382
057	38 Blue	1	60.04	423
		2	6.60	60
052	38 Blue	1	20.39	1961
		2	10.67	356
		3	---	0
		4	80.9	21
		5	1.67	1198
		6	1.66	1801
		7	0.34	4656

Table 4

Total Number of Responses by 6 Cowbirds To Various Colors in a Preference Task

Color	Subject No. 028	015	057	051	050	019	Total Respons To Color
61 Green	833	1684	341	839	1551	266	5514
22 Orange	701	1981	280	1061	1532	324	5879
32 Magenta	716	2902	393	831	1439	387	6668
23A Red	1042	2318	418	1077	1732	523	7110
4 Yellow	937	1917	461	1088	1497	351	6251
30 Magenta	968	1774	414	1150	1600	420	6326
38 Blue	1013	1559	361	950	1440	366	5689
56 Green	1126	1515	326	913	1581	399	5860
38A Blue	660	2429	425	678	1260	257	5709
29 Red	736	1838	409	853	1371	376	5583
Total By Bird	8732	19917	3828	9440	15003	3669	(60589)

Table 5

Color Preferences of 6 Cowbirds by Rank

Determined by Number of Responses to Each Color

ubject No.	Three Most Preferred Colors (By Rank)	Three Least Preferred Colo (By Rank)
028	1. 56 Green	8. 32 Magenta
	2. 23A Red	9. 22 Orange
	3. 38 Blue	10. 38A Blue
015	1. 32 Magenta	8. 61 Green
	2. 38A Blue	9. 38 Blue
	3. 23A Red	10. 56 Green
057	1. 4 Yellow	8. 61 Green
	2. 38A Blue	9. 56 Green
	3. 23A Red	10. 22 Orange
051	1. 30 Magenta	8. 61 Green
	2. 4 Yellow	9. 32 Magenta
	3. 23A Red	10. 38A Blue
050	1. 23A Red	8. 32 Magenta
	2. 30 Magenta	9. 29 Red
	3. 56 Green	10. 38A Blue
019	1. 23A Red	8. 22 Orange
	2. 30 Magenta	9. 61 Green
	3. 56 Green	10. 38A Blue

Ranking of Pooled Data From All 6 Birds

1. 23A Red	6. 56 Green
2. 32 Magenta	7. 38A Blue
3. 30 Magenta	8. 38 Blue
4. 4 Yellow	9. 29 Red
5. 22 Orange	10. 61 Green

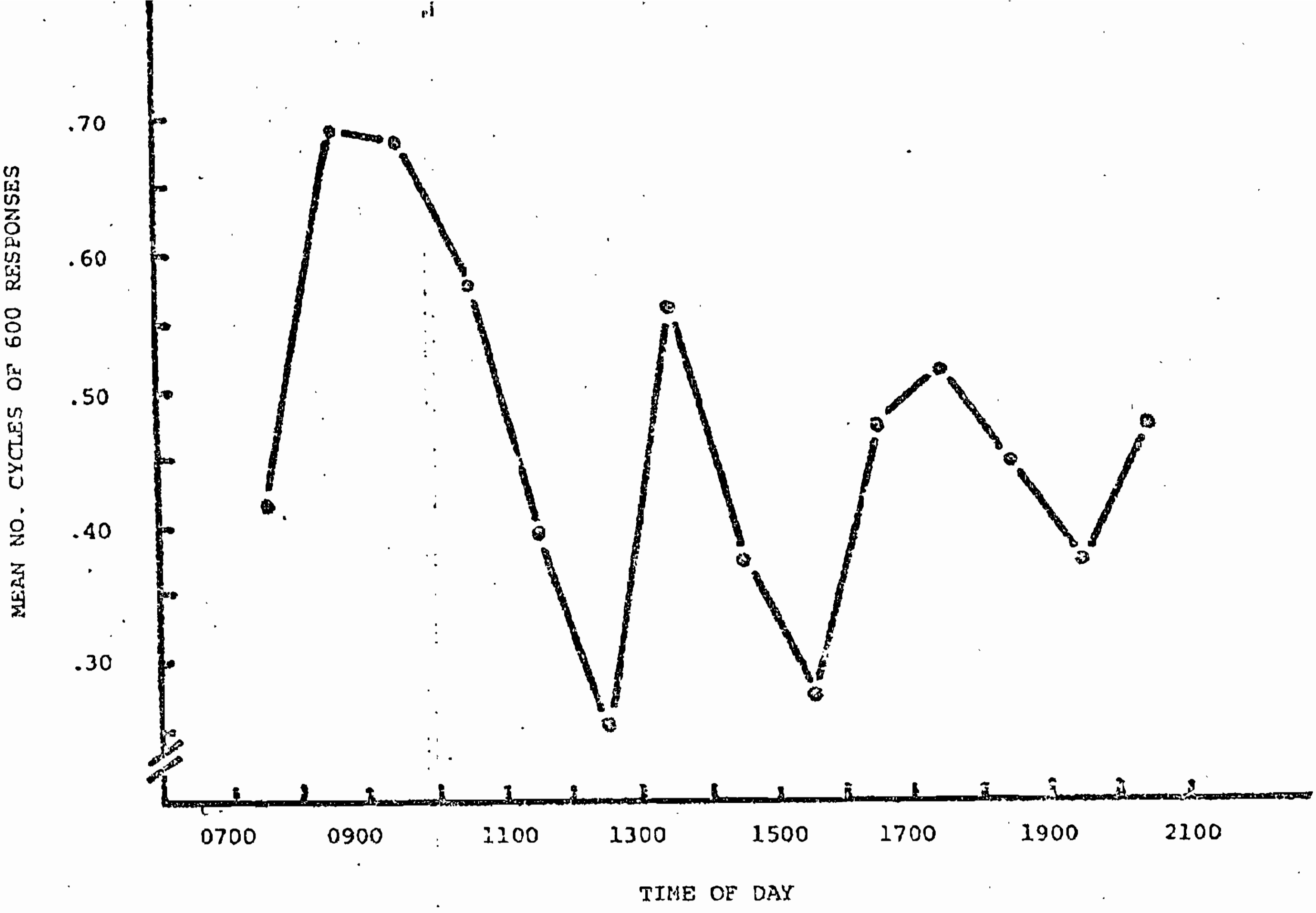

Figure 1. Pattern of daily feeding activity for 4 Cowbirds as measured by number of feeding responses. Data are presented as fractions of 600-response cycles.

Barrow, W. B., 1912 _Michigan Bird Life_. Michigan Agricultural College, Lansi
Michigan. p. 414.

Bartonek, James C., 1969 The amount of grit needed by birds. _The Wilson Bulletin_, _81_, 96 - 97.

Beale, I. L., 1970. The effects of amount of training per reversal on successive reversals of a color discrimination. _Journal of the Experime Analysis of Behavior_, _14_, 345 - 352.

Bent, Arthur C., 1946. _Life Histories of North American Jays, Crows, and Titmice_. Part I. Dover Publications, Inc., New York.

1964. _Life Histories of North American Wood Warblers_. Dover Publicatio Inc., New York.

1964. _Life Histories of Thrushes, Kinglets and Allies_., Dover Publications, Inc., New York.

1964. _Life Histories of Nuthatches, Wrens, and Thrashers_. Dover Publications, Inc., New York.

1965. _Life Histories of Blackbirds, Orioles, Tanagers, and Allies_. Dover Publications, Inc., New York.

1968. _Life Histories of Cardinals, Grosbeaks, Buntings, Towhees, Finches, and Allies_. Dover Publications, Inc., New York.

Blough, D. S., 1966. The study of animal sensory processes by operant methods. W. K. Honig (Ed.), _Operant Behavior: Areas of Research and Application_. Appleton - Century - Crofts, New York.

Duncan, I. J. H., Horne, A. R., Hughes, B. O., & Wood-Gush, D. G. M., 1970. The pattern of food intake in female Brown Leghorn fowls as recorded in a Skinner box. _Animal Behavior_, _18_, 245 - 255.

Epple, Arol., 1972. Tips for locating nesting birds. Passenger Pigeon, Fall, p. 34.

Fellows, B. J., 1968. The Discrimination Process and Development. Pergamen Press, Oxford, 1 - 11.

Ferster, C. B., & Skinner, B. F., 1957. Schedules of Reinforcement. Appleton-Century - Crofts, New York.

Freidman, Herbert, 1929. The Cowbirds: A Study In the Biology of Social Parasitism. Charles C. Thomas, Springfield, Ill.

Gallup, G. G., & Capper, S. A., 1970. Preferences for mirror-image stimulation in Finches (Passer domesticus domesticus) and Parakeets (Melopsittacus Undulatus). Animal Behavior, 18, 621 - 624.

Goforth, Reid W., & Baskett, Thomas S., 1971. Effects of colored backgrounds in food selection by Penned Mourning Doves (Zenaidura macroura). The Auk, 88(2), 256 - 263.

Gossetts, Robert L., Gossetts, Madeleine, F., & Riddell, William, 1966. Comparisons of successive discrimination reversal performances among closely and remotely related avian species. Animal Behavior, 14, 560 - 56

Gray, P. H., 1961. The releasers of imprinting: differential reactions to color as a function of maturation. Journal of Comparative and Physiologic Psychology, 54, 597 - 601.

Harlow, Harry F., 1949. The formation of learning sets. Psychological Review, 56, 51 - 65.

Holcomb, Larry C., 1971. Nest building and egg laying by Red-winged Blackbirds in response to artificial manipulations. The Auk, 88(1), 30 - 34.

Jacobs, J. Warren, 1938. Eastern Cowbird *vs.* Kentucky Warbler. *The Auk*, *55*(*2*), 260 - 262.

Johnston, Bette J., 1951. A technique for trapping Cowbirds. *Wilson Bulletin*, *69*(*3*), p. 275.

Karr, A. E., & Carter, D. E., 1970. Color preference in the pigeon. Measurement during extinction and during variable interval reinforcement. *Proceedings of the 78th Annual Convention of the American Psychological Association*.

Kontogiannis, J. E., 1967. Day and night changes in body weight of the White-Throated Sparrow, *Zontrichia Albicollis*, *The Auk*, *84*, 390 - 395.

Kovach, Joseph R., 1971. Effectiveness of different colors in the elicitation and development of approach behavior in chicks. *Behavior*, *38*:1-2, 154 - 168.

Linsdale, J. M., & Summers, E. L., Sr., 1934. Winter weights of Golden-Crowned and Fox Sparrows. *Condor*, *36*, 107 - 112.

Maier, R. A., & Maier, B. M., 1970. *Comparative Animal Behavior*. Brooks/Cole Publishing Co., Belmont, California, 13 - 15, 301 - 306.

Mayfield, Harold, 1961. Vestiges of a proprietary interest in nest by the Brown-headed Cowbird parasitizing. The Kirtland's Warbler. *The Auk*, *78*(*2*), 162 - 166.

McClure, H. Elliot, 1945. Reaction of a Mourning Dove to colored eggs., *The Auk*, *62*, 270 - 272.

Mergenrader, Gary L., 1962. The incidence of nest parasitism by the Brown-headed Cowbird (*Molothrus ater*) in roadside nesting birds in Nebraska. *The Auk*, 85 - 88.

Nickell, Walter P., 1951. Studies of habitats, territory and nests of the Eastern Goldfinch. The Auk. 68, 447 - 470.

Orr, C. D., 1975. 1974 Breeding success of the Kirtland's Warbler. Jack-Pi[ne] Warbler, 53, 59 - 66.

Partin, J. L., 1933. A year's study of House Finch weights. Condor, 35 60 - 63.

Peterson, R. T., 1963. Field Guide to the Birds of Texas. Houghton Mifflen Company, Boston, p. xxi.

Powell, Robert W., 1972. Operant conditioning of the common Crow (Corvus brachyrhynchos). The Auk, 89, 738 - 742.

Prescott, R. W., 1963. Blue Jay attacks Cowbird nestling, Wilson Bulletin, 75, p. 459.

1965. Attempted Robin predation by Crow. Wilson Bulletin, 77, p. 86.

1967. Unusual activities of a House Sparrow and a Blue Jay at a Tufted Titmouse nest. Wilson Bulletin, 79, p. 346.

Reid, R. L., 1958. Discrimination - reversal learning in pigeons. Journal of Comparative and Physiological Psychology, 51, 716 - 720.

Robinson, Gerald G., & Warner, Dwain W., 1964. The Auk, 81(3), 315 - 325.

Rothstein, Stephen I., 1974. Mechanisms of avian egg recognition: Possible learned and innate factors. The Auk, 91(4), 796 - 807.

1975. Mechanisms of avian egg recognition: Do birds know their own eggs. Animal Behavior, 23, 268 - 278.

Salzen, E. A., Lily, R. E., & McKeown, J. R., 1971. Color preference and imprinting in domestic chicks. Animal Behavior, 19, 542 - 547.

Selander, R. K., & Yang, S. Y., 1966. Behavioral responses of Brown-headed Cowbirds to nests and eggs., The Auk, 83(2), 207 - 232.

Smith, K. U., 1951. Comparative Psychology. Prentice-Hall, Inc., New York 316 - 362.

Straka, Joseph A., 1966. Note: Color preference in the pigeon, utilizing drinking as the response measure. The Psychological Record, 203 - 20

Taylor, Ann, Stuckin, W., & Hewitt, Rosemary, 1969. Changing color prefer of chicks. Animal Behavior, 17, 3 - 8.