SOME CHARACTERISTICS OF CONDITIONED AVERSION IN RED-WINGED BLACKBIRDS

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ABSTRACT.—Red-winged Blackbirds (*Agelaius phoeniceus*) were observed while feeding on food treated with methiocarb for each minute of 5-min exposure periods on 5 successive days. Feeding decreased during the first exposure, but examination of the data for exposures 2–5 indicated that at least two exposures are necessary for formation of a conditioned aversion. Tests on the individuals of six groups of birds each tested at a different interval (1 day; 1, 2, 4, 8, 16 weeks) after learning an aversion to a treated food indicated little extinction of the aversion. The experiment indicated that much of the extinction is due to the effects of testing conditions and not methiocarb. Another experiment demonstrated that red-wings can recognize the absence of methiocarb from their familiar food as well as recognize it in different food. *Received 8 November 1976, accepted 2 July 1977.*

CONDITIONED taste aversions have received extensive study by psychologists (Rozin and Kalat 1971), principally because learning can take place after a considerable interval (several h) between sampling the food and becoming ill and because the aversion develops after only one or several pairings of the food and illness. The more recent extensions of some of the principles of taste-aversion learning to birds (Capretta and Moore 1970, Wilcoxon et al. 1971, Shettleworth 1972, Brett et al. 1976) have led to experiments suggesting that this phenomenon may be useful in developing repellents for use against depredating birds (Rogers 1974). Recent research (Schafer and Brunton 1971, Guarino 1972) has shown that methiocarb [3,5-dimethyl-4-(methylthio) phenol methyl carbamate (Mesurol®)] (Chemagro Division, Baychem Corp.) is a promising bird repellent that acts by creating a conditioned aversion in those birds that consume it (Rogers 1974).

The present experiments were designed to examine several characteristics of conditioned aversions in an economically-important avian species, the Red-winged Blackbird (*Agelaius phoeniceus*) (Dyer 1967, Dolbeer 1975). The specific questions asked were: (1) what is the time course of development of a conditioned aversion, both within the first exposure and across several exposures; (2) what is the duration of an aversion once it has been learned; and (3) does this species form an aversion that is specific to the aversive agent-food combination or to one or the other of these elements?

GENERAL METHODS

Male Red-winged Blackbirds of various ages were trapped at the Patuxent Wildlife Research Center, Laurel, Maryland, and kept in captivity for at least 2 weeks prior to use in experiments. They were individually housed in cages 36 × 61 × 41 cm high, in a room with a temperature of approximately 23°C and a light cycle of 6 h light, 18 h dark. The shortened light period was employed to maximize the birds' feeding rate without reducing the total quantity of food consumed. Earlier preliminary experiments demonstrated that a 6-h period was the shortest time during which the birds could readily obtain enough food to maintain initial body weights (Rogers 1974). All testing was carried out during a 5-min (Experiment 1) or a 1-min (Experiments 2 and 3) period during the first hour of light. This testing period

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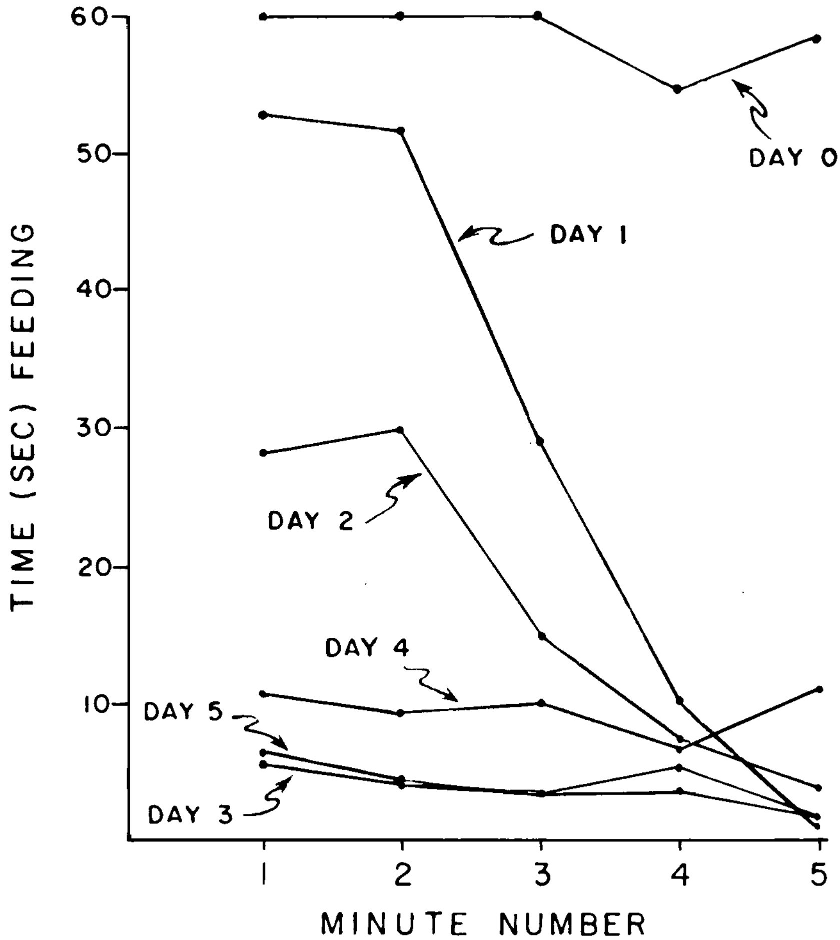

Fig. 1. Feeding responses of eight male Red-winged Blackbirds in each minute of 5-min testing periods on successive days. Day 0—feeding on untreated food. All other Days—feeding on food treated with 0.07% methiocarb.

represented the first exposure to food on the test days. Food was always available *ad libitum* for the last 5 h of the light period from a food cup located at the front of the cage. Water was always available from a graduated drinking tube at the back of the cage. To reduce spillage, each food cup (diameter 7.5 cm) was placed within a larger cup (diameter 11.3 cm). This larger cup caught the spillage from the smaller one during normal feeding activity.

The birds were maintained on a diet of Purina Game Bird Flight Conditioner (GBFC) from Ralston Purina Company. [Use of commercial products does not imply endorsement by the U.S. Government.] The test diet was prepared by thoroughly mixing in the food (usually GBFC) 0.07%, by weight, methiocarb. All birds used were experimentally naive at the beginning of each experiment.

Data were obtained by observing the individual birds via remote television monitor, and recording for each minute of the test period (1 or 5 min) the amount of time spent feeding, the number of visits to the foodcup (whether or not feeding occurred), and the number of drinking bouts. The food was weighed both before and after the test period.

Experiment 1

This experiment was designed to examine the time course of the response to methiocarb upon first exposure, as well as to examine the effect of the repellent on the

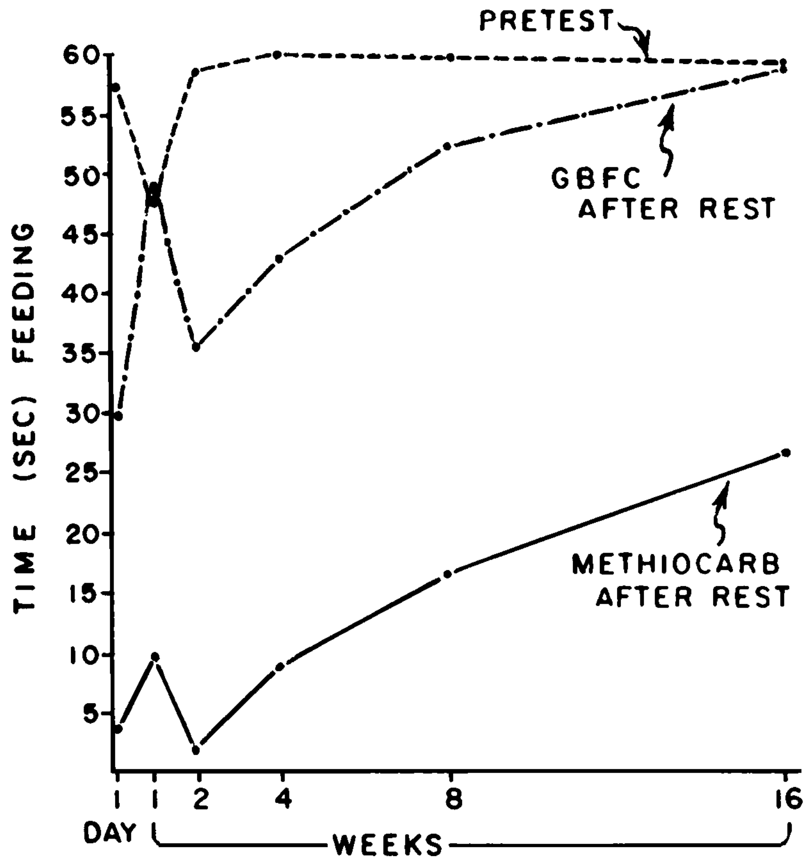

Fig. 2. Feeding responses of 6 groups of 9 male Red-winged Blackbirds at various intervals after formation of a conditioned aversion to 0.07% methiocarb. Top curve represents feeding on untreated food before training. Middle curve represents feeding on untreated food after the rest interval, the day preceding retesting with methiocarb. Bottom curve represents feeding on treated food after the rest interval.

feeding behavior of the birds during successive daily 5-min exposures to the treated food. After habituation to the test situation for several days eight birds were individually observed for each minute of a 5-min feeding period with untreated GBFC (Day 0). On Days 1 through 5, they were observed for each minute of a 5-min exposure to 0.07% methiocarb in GBFC.

The feeding responses of this group of red-wings on succeeding daily exposures to methiocarb-treated food are shown in Fig. 1. A two-way (day × min) analysis of variance with repeated measures indicated that successive exposures to the repellent significantly altered the daily pattern of feeding during the test period ($F = 102.38$, 5/35 df, $P < 0.001$) as well as an effect of minutes within days ($F = 19.69$, 4/28 df, $P < 0.001$). The interaction was also significant ($F = 9.61$, 20/140 df, $P < 0.001$) indicating a different pattern of response on successive days. The curve for Day 1 indicates that, on initial contact and for approximately 2 min, the feeding rate is near normal (Day 0 curve); by the third minute, however, a great decrease in feeding rate occurs and the birds are feeding at a rate less than one-half of normal. They have essentially stopped feeding by the fifth minute of the first exposure. This decrease in feeding on the treated food during the first exposure may be due to one or a combination of factors. It may be due solely to the intoxicating effect of methiocarb—they are simply too sick to eat. It also may be due to the birds becoming ill and associating the illness with some sensory aspects of the treated food (forming a conditioned aversion). Examination of the curves for Days 2 through 5 shed some light on these not-completely-independent hypotheses. If learning was not taking place on or as a result of the first-day experience, the patterns of the succeeding exposures would all be the same. They are not. The feeding rate for Day 2 (min 1) begins at a point about one-half of that on Day 1. Thus, the descending curves for Days 1 and 2, when compared with the rather flat curves for Days 3, 4, and 5, indicate that, under these conditions, at least two successive daily 5-min exposures are necessary before Red-winged Blackbirds learn a conditioned aversion to methiocarb. An alternative explanation might be that the birds became sicker and sicker each day as a result of the cumulative effects of the methiocarb. This probably is not the case because the birds behaved in an otherwise normal fashion and ate the untreated food immediately when it was offered.

Experiment 2

The first experiment indicated that red-wings cease feeding on methiocarb-treated food very soon after encountering it, and that relatively few exposures are necessary to create a conditioned aversion to a food so treated. For practical development and use of conditioned aversion as a repellent response, it is important to know the duration of the conditioned aversion once a bird learns it.

The individuals of 6 groups of 9 birds each were pretested for a 1-min period with untreated GBFC and then trained to avoid the methiocarb-GBFC by allowing them 1-h exposures to it on 4 consecutive days. On the fifth day, all were tested by observing them for the first 1-min period of the day while feeding on treated food to verify that they had formed an aversion to methiocarb. Each group was then allowed a prescribed length of time (1 day; 1, 2, 4, 8, or 16 weeks) before the individuals were retested to examine the time span of retention of the aversion. During this time, they were left undisturbed and had *ad libitum* access to the untreated GBFC and water during the light (6 h) portion of the day. At least 4 days before retesting, each group was returned to the testing room and observed for a 1-min period of feeding on untreated GBFC as an estimate of possible alteration in feeding behavior during the interim or as a measure of retention of learning about the testing conditions. On the next day, all were tested by observing them for a 1-min period while they had access to the methiocarb-treated food.

The bottom curve in Fig. 2 indicates the ability of the blackbirds to retain a conditioned aversion. There was a significant difference between the individuals as a function of time since training ($F = 5.5$, 5/47 df, $P < 0.001$). Up to 4 weeks post-training, there was no significant loss of the conditioned aversion (Duncan's New Multiple Range Test, $P = 0.01$). After 4 weeks between training and retesting the aversion was somewhat diminished. A comparison of the feeding rate on untreated food prior to any exposure to methiocarb (top curve, Fig. 2) with that on treated food after training and the waiting period (bottom curve, Fig. 2), indicates that even after 16 weeks the earlier aversive experience caused the birds to feed at less than one-half of their normal rate on the untreated food.

An interesting phenomenon is apparent from the middle curve in Fig. 2. This curve represents time spent feeding on untreated GBFC for the 5-min test period on

TABLE 1. Feeding response in a 1-min exposure of eight male Red-winged Blackbirds to untreated foods and foods treated with 0.07% methiocarb. The treatments are arranged in order of presentation from top to bottom[a]

Treatment	Time spent feeding (s ± SEM)
Pretest untreated GBFC	57.9 ± 2.1*+
First exposure methiocarb in GBFC	59.5 ± 0.5*
Methiocarb in GBFC after training	5.1 ± 3.4
Untreated GBFC	45.5 ± 7.0+
Untreated rice	48.5 ± 7.0*+
First exposure methiocarb in rice	17.4 ± 3.9

[a] All means not marked with the same symbol are significantly different from each other (Duncan's New Multiple Range test) (P = 0.05)

the day immediately before retesting with the methiocarb-treated food. Since this measure was taken after training with the repellent and after the prescribed rest period it probably represents the effect of learning about the testing conditions alone. It suggests that most of the increased feeding on the treated food after the longer time periods (8 and 16 weeks) may be due to extinction of learning about the testing conditions rather than extinction of the conditioned aversion.

EXPERIMENT 3

The results of the first two experiments demonstrated that red-wings are capable of learning an aversion to methiocarb when it is presented in their familiar food, and that they can recognize methiocarb in their familiar food when it is presented at a subsequent time. The experiments did not answer the question of what cue(s) the subsequent aversion was based on.

Eight birds were trained to avoid methiocarb as in Experiment 2, and the aversion was verified in a 1-min test on Day 1. On Day 2, they were retested with untreated GBFC to test whether they would recognize the absence of methiocarb. During Days 3 through 6, the group was allowed *ad libitum* access to finely-ground, unhulled dry rice. On Day 7, their consumption of this material was verified in a 1-min test. Finally, on Day 8, the birds were individually tested for 1 min with methiocarb-treated rice.

The results of this series of tests are shown in Table 1. An analysis of variance with repeated measures indicated an overall difference in feeding behavior when the birds were confronted with the various foods (F = 28.7, 5/35 df, $P < 0.001$). Duncan's New Multiple Range Test ($P = 0.05$) was used to identify the individual differences between treatment means (Table 1).

The foregoing data indicate several characteristics of the response of red-wings to methiocarb. Their reaction in the first minute of their very first exposure to methiocarb in their familiar food, as demonstrated in Experiment 1, and repeated in this experiment, is to feed normally. The birds do not respond immediately to the sensory characteristics of methiocarb alone. They then learn to associate one or more of the sensory aspects of the methiocarb, and not the food, with the aversive experience. This has been demonstrated because they recognize the absence of methiocarb and feed at a rate not statistically different from that prior to training. The data from this experiment indicate that red-wings are capable of responding to the presence of methiocarb on the basis of its chemosensory characteristics, probably taste, alone. It is possible that the birds can differentiate between treated and untreated GBFC on the basis of color because the color of GBFC mash lightens when methiocarb is added to it. Ground rice, however, is white and pure methiocarb is white; thus, there is no visual difference between treated and untreated rice. The subjects *did* discriminate between the treated and untreated rice. Since red-wings, as well as most other passerines, do not regulate their behavior on the basis of odors (Kare and Rogers 1976) they were probably not responding to the odor of methiocarb in the treated diets. The behavior of the birds when confronted with methiocarb-treated rice also suggests that they were responding to its taste. All birds initially showed almost no latency to approach the food cup and begin feeding, but after a few pecks or probes at the food, they ceased feeding activity altogether.

Discussion

Under the conditions of these experiments, approximately two successive daily 5-min exposures to methiocarb-treated food are necessary before Red-winged Blackbirds learn an aversion. Once the aversion is formed, it persists relatively unchanged for periods up to 4 weeks after training and is not completely extinguished at 16 weeks. Further work will be necessary to differentiate fully between the importance of situational cues (testing conditions) and those cues provided by the aversive agent-food combination. Additionally, red-wings apparently can react to the taste of an aversive agent when it is presented in a food other than that in which it was initially presented.

Some interesting comparisons can be made between the results of these experiments and experiments that examine conditioned taste aversions in other species. Under the conditions of my experiments, red-wings apparently require longer to learn an aversion than the traditional one-trial learning exhibited by laboratory rats and Bobwhite Quail (*Colinus virginianus*) (Wilcoxon et al. 1971). This may be the result of a combination of two factors that have not yet been resolved. First, with few exceptions, all experiments in taste-aversion learning are concerned with poisoning an animal after the ingestion of a *novel* stimulus. In my experiments, methiocarb was presented as an additive in the *familiar* food. Second, Wilcoxon et al. (1971) have demonstrated that birds more readily learn aversions to visual cues than they do to taste cues alone. Although visual cues were not controlled in my experiments, the addition of methiocarb to the familiar GBFC makes only a minor (to me) change in the color of the food. The difference in the results reported here most likely arises from a combination of the familiarity of the food and the relative non-salience of the cues involved.

Another major difference in my results from those usually reported for rats is that rats commonly refuse to eat food that has been associated with toxic consequences in the past. This frequently occurs even after the poison has been removed from the food (Galef and Clark 1971). The results of Experiment 3 indicate that red-wings can not only recognize when the illness-producing agent has been removed from the food but also do not refuse to consume this food once the agent has been removed. This may be a result of the difference between the reactions of rats and red-wings once they have been poisoned from a diet. Rats frequently fail to approach the poisoned diet (Galef and Clark 1971) whereas the birds in my experiments usually approached the food and were commonly observed probing and manipulating the treated food while not actually eating it. Consequently, they probably have the opportunity to recognize the absence of the toxic material. The difference may also be due to the nature of the test. In my experiments, testing was performed with the intoxicant presented in a familiar food (GBFC). The test period was always followed by 5 h of *ad libidum* access to untreated GBFC. Though the two (treated and untreated GBFC) were not present simultaneously, untreated GBFC was offered to the birds soon after each test with the treated GBFC. Thus, the birds had many opportunities to learn the difference between treated and untreated food. In most other experiments, the animals only experience the novel stimulus when it is paired with the aversive consequences.

Wild birds might not be expected to show such an impressive ability to retain an aversive response. The birds in this experiment were trained and then taken to another room to wait for retesting. Under these conditions, there was probably a minimum of interfering stimuli. When the birds were brought back to the testing room, they probably were associating many of the cues produced by the testing situation in addition to the sensory aspects of the food with the previous aversive experience. Wild birds would probably not have as many different cues available to associate with the aversive situation. These experiments demonstrate that, given the right cues, red-wings can retain the memory of an aversive experience for a considerable time.

The results of my experiments suggest several implications on the use of the conditioned aversion as a response to be exploited in the development and use of repellents for depredating bird species. First, it is reasonable to predict at least a low level of damage to treated crops, since I have shown that several exposures to the treated food are necessary for the development of an aversion to methiocarb when it is used on a food familiar to the birds (a condition that would obtain in most crop-depredation situations). Second, the indication that red-wings can recognize the absence of the repellent material and do not refuse to eat a previously treated food would seem to indicate that the repellent would need to be present in effective concentration during the susceptible period of a crop. This also might lead to increased damage to other crops or those of the same type that were, for one reason or another, untreated.

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The **North American Conference on Common Loon Research and Management**, sponsored by the National Audubon Society and hosted by Syracuse University, was held 12–14 August 1977 at the Minnowbrook Conference Center, Blue Mountain Lake, N.Y. Priorities determined by the participants included: (1) establishment of an informal working group to serve as a clearing-house for information on research and management efforts; (2) collection of historical loon nesting records for assessment of recent range contraction or expansion by this species; (3) coordination and standardization of breeding surveys and an effort to document the current breeding status of the loon, particularly in the northeastern U.S.; and (4) expanded research, including increased banding efforts and initiation of a winter banding program.

The working group, consisting of Judith W. McIntyre of Syracuse University, Richard L. Plunkett of the National Audubon Society, and Rawson L. Wood of the Loon Preservation Committee of the Audubon Society of New Hampshire, plans another meeting next year. Requests for conference summaries and other inquiries may be directed to the coordinator, **Judith W. McIntyre, Biology Department, Syracuse University, Syracuse, N.Y. 13210.**

The Linnaean Society of New York, as part of its centennial celebration, will host the Second Annual Meeting of the **Colonial Waterbird Group** at the American Museum of Natural History in New York City on **20–23 October 1978**. The Linnaean Society will sponsor a symposium of invited papers on factors affecting productivity in colonial species on 21 October and the morning of 22 October. Submitted papers will be given on the afternoon of 22 October and on 23 October. For information on contributing a paper, write to Dr. P. A. Buckley, **North Atlantic Regional Office, National Park Service, 15 State Street, Boston, Mass.** For registration information write to Miss Helen Hays, Department of Ornithology, American Museum of Natural History, Central Park West at 79 Street, New York, N.Y. 10024.
