BEHAVIORAL EFFECTS OF ENVIRONMENTALLY DEGRADED 4-AMINOPYRIDINE ON COWBIRDS (*Molothrus ater*)

by

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ABSTRACT

The effects of exposure to rain and sunlight on the efficacy of 4-Aminopyridine (4-AP) as a frightening agent for blackbirds (Icteridae) was measured in terms of the ability of the exposed bait to induce abnormal behaviors in cowbirds (Molothrus ater). Two-way analyses of variance (types of exposure x amount of bait eaten) and Duncan's multiple range tests were used to examine differences in manifestation, duration, and total times involved in the reactions of the birds to 4 bait treatments: 1.27 cm rain, 8.89 cm rain, 2 weeks sunlight, and control. Chi-squared tests were used to compare treatments with regard to the frequency of occurance and the average length of occurance of 6 behaviors: hovering flight, muscular incoordination, trembling, convulsions, vocalizations, and regurgitation.

There were statistically significant differences between the duration and total times of the birds fed 8.89 cm-rained bait and the control, and in the total time involved between the 1.27 cm-rained bait and the control ($P<0.05$), but the actual values were relatively small. Qualitative differences in behavior between treatments are of more importance than the quantitative differences: the treated baits produced reactions which were more frequent, but of shorter duration, than the reactions observed in the control group. Also, these reactions were quieter and less visible than the reactions of birds fed fresh bait, implying a possible reduction in the effectiveness of the 4-AP as a frightening agent.

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Goodhue and Baumgartner (1965) first described the repellent effects of 4-Aminopyridine (4-AP; trade name Avitrol FC Corn Chops-99) wherein birds consuming treated grain exhibit distress symptoms before dying that prompt other flock members to leave the area. In a small-area test in Ohio, using treated and control fields, Stickley et al. (1972) showed the efficacy of 4-AP in protecting individual cornfields from blackbirds. In large-area tests, personnel of the Denver Wildlife Research Center demonstrated the effectiveness of 4-AP in reducing blackbird damage to field corn in South Dakota, first as a solution applied to husked ears on the stalk (DeGrazio et al. 1971) and then with treated cracked corn bait spread on the ground by hand in a dilution ratio of 1:29 (DeGrazio et al. 1972). Estimates of damage reduction were based on comparisons with the amounts of damage to those areas in previous years. Stickley et al. (1976) conducted a large-scale test of the efficacy of 4-AP in Ohio, using an aerially applied 1:99 ratio and studying closely-situated treated and untreated fields simultaneously for bird damage. In all these tests, there was significant reduction ($P<0.05$) in blackbird damage. Thus the efficacy of 4-AP as a frightening agent has been established.

West (1968) noted that, where bird pressure was low, bait would remain in the field up to 2 weeks, but he did not indicate whether this bait was still potentially effective in reducing bird damage. West also stated that 0.46 cm (0.18 in) of rain would dissolve the pellets of bait

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1 This article is written in the style of The Journal of Wildlife Management

used at that time. In other studies, 4-AP was re-applied after rains of 0.5 cm (0.195 in) or more (Stickley et al. 1972, Stickley 1974, Dolbeer et al. 1976, Knittle et al. 1976, Stickley et al. 1976, Stickley et al. 1977, Besser 1978).

These 2 factors, length of exposure in the field, and precipitation, have not been studied in detail. This study was conducted in an attempt to answer the following questions: How long will 4-AP remain effective when exposed to sunlight in the field? How much rain can 4-AP receive and still remain effective without requiring rebaiting (excluding possible changes in palatability of the bait and the possibility of the bait being washed away by the rain)?

This work was conducted at Texas A&M University with the cooperation of the Department of Wildlife and Fisheries Sciences. Credit is due to Drs. K.A. Arnold, J.S. Folse, and R.D. Slack; also to R. Williams, B. Bivins, S. Kerr, F. Mechoulam, and S. Smith for assistance in the technical aspects of this project. I am grateful to K. Green from the Avitrol Corporation for supplying the 4-Aminopyridine for this project. Special thanks go to G. Green for his timely aid in completing this study, and to Dr. N.J. Silvy for reviewing the manuscript.

METHODS

The efficacy of the bait, exposed to varying amounts of rain and sunlight, was measured in terms of its effects on the behavior of cowbirds (Molothrus ater) ingesting the bait. There were 4 treatments of environmentally exposed 4-AP under study: (1) "fresh" bait (control group); (2) bait treated with 1.27 cm (0.5 in) rain; (3) bait treated

with 8.89 cm (3.5 in) rain; and (4) bait exposed to sunlight for 2 weeks. "Fresh" bait is chopped corn impregnated with 1% (by weight) 4-AP. Bait was treated with "rain" in the following manner: the amount of water to be used was measured and then poured through a rainulator onto the bait which was spread over a 0.5 mm (0.02 in) mesh sieve (to imitate porous soil). The rainulator was made in accordance with the guidelines given by McQueen (1963); distilled water (pH 7.0) was used. For exposure to sunlight, bait was placed under fluorescent and incandescent lights simultaneously in the lab; these lights were controlled by a timer set for 12 hours of light each day. These applications of rain and light were done in this fashion to ensure consistency of treatment, and to remove dependence on the external environment for completion of the study.

Once the bait was treated it was immediately placed before cowbirds which had been preconditioned to captivity for 2-4 weeks and then isolated in a 1.8m x 1.2m x 1.8m (6' x 4' x 6') cage for study. Individual birds were observed from the time the bait was placed before them until their death or until 2 hrs had elapsed and all signs indicated a recovery from the effects of 4-AP. Sequence of behaviors and their duration (in seconds for each behavior) were recorded; behaviors were classified into 1 of 17 categories (Table 1). Six birds were tested with fresh bait and 6 with the lightly-rained (1.27 cm) bait; 5 birds were given bait with 8.89 cm rain (heavily-rained); 3 birds were fed the bait exposed to light for 2 weeks. Other data collected for each individual bird included: date of experimentation, length of time for the test, sex, weight, length of captivity, approximate age, amount of bait ingested, and amount of water drunk.

DATA ANALYSIS

Length of time from ingestion of the bait until the onset of abnormal behavior ("manifestation time"), and the length of time from the onset of abnormal behavior until death occurred or until 2 hrs had elapsed ("duration") were calculated for each bird, as was the total time involved (manifestation + duration). Calculations concerning birds which survived longer than 24 hrs used data only from the first 2 hrs of abnormal behavior, although they were observed for longer. Two-way analyses of variance (bait treatment x amount eaten) were used to examine differences in the manifestation, duration, and total times between treatments. Specific treatment differences were analyzed using Duncan's multiple range tests.

The frequency of occurance of 6 of the most characteristic abnormal behaviors (DeGrazio et al. 1971, Stickley et al. 1972, Dolbeer et al. 1976, Knittle et al. 1976, Stickley et al. 1976), and the average duration of those behaviors, were calculated for each treatment and then compared using χ^2 tests. Frequencies were calculated for the following behaviors: hovering flight, muscular incoordination, trembling, convulsions, vocalizations, and regurgitation; average duration was calculated for the first 5 behaviors involved.

RESULTS

Two-way analysis of variance of the manifestation times indicated no significant treatment effects ($P>0.05$); however, results of Duncan's multiple range test indicated a significant difference between the control treatment and the heavily-rained treatment ($P<0.05$; Figure 1).

Manifestation times ranged from an average of 5:19 minutes (s=1:51) in the control group to an average of 15:21 minutes (s=9:52) in the heavily-rained group.

Two-way analysis of variance indicated significant treatment effects for the duration times ($P<0.05$; Figure 2). Duncan's multiple range test again showed specific differences between the control group and the heavily-rained group ($P<0.05$), but the other 2 treatments were not significantly different from the control ($P>0.05$). The times for the duration of the abnormal behavior (from initiation until either death occurred or 2 hrs had elapsed) ranged from an average of 11:47 (s=2:00) for the control group to 37:48 (s=16:17) for the heavily-rained treatment. Three of the 5 birds tested in that latter category survived for at least 24 hrs, as did 1 of the 3 birds in the group fed bait exposed to light.

Two-way analysis of variance showed a significant difference between total treatment effects ($P<0.05$; Figure 3). Duncan's multiple range test showed significant differences between the control group and the heavily-rained group ($P<0.05$), and between the control group and the lightly-rained treatment ($P<0.05$); the difference between the control group and the bait exposed to light was not significant ($P>0.05$). The values ranged from 17:06 (s=3:39) in the control to 49:19 (s=17:38) in the heavily-rained group.

Frequency of occurance of hovering flight showed significant differences between treatments ($P<0.05$) based on χ^2 analysis. The frequencies ranged from 2 to 21 individual occurances; the average length of time spent in hovering flight ranged from 0:06 to 1:35 minutes (Table 2).

Hovering flight occurred less frequently, but for longer periods of time, in the control group than in the other bait treatments. Thus, the birds in the control group will be displaying aerially for longer and will be seen by more of the flock. For muscular incoordination, frequencies ranged from 26 to 94 among the treatments (significantly different at $P<0.05$); the average amount of time involved, ranging from 0:21 to 1:53 minutes, was also significantly different ($P < 0.05$). Again the behavior was less frequent but longer-lasting in the control group. The frequency by treatment of the occurance of trembling in birds, which ranged from 11 to 43, was significantly different ($P<0.05$); but the average amounts of time involved, ranging from 0:42 to 0:59, were not significantly different ($P>0.05$). Significant differences between treatments were also seen in the frequency of occurance of convulsions, ranging from 3 to 24 occurances, and in the average lengths of time of the convulsions, ranging from 0:40 to 1:16 minutes ($P<0.05$). Frequency of vocalizations ranged from 13 to 44 instances, with the average amount of time involved ranging from 0:38 to 2:37 minutes; both sets of data showed significant differences between treatments ($P<0.05$). Regurgitation was observed only once, in the heavily-rained treatment.

DISCUSSION

There was a statistically significant difference between the manifestation times involved for the control and for the heavily-rained 4-AP, but the actual figures (5:19 and 15:21) were only 10:02 minutes apart. Likewise the differences in duration time and in total time for the same 2 treatments, while they were statistically significant, were

also relatively small: 26:01 minutes difference and 32:13 minutes difference, respectively. In a cornfield, where the birds usually forage for several hours at a time (DeGrazio et al. 1971), these differences may be of only minor importance. We can assume that the birds taking the bait will still be at the field when they begin to react, whether it takes 5 minutes or 15 for the reaction to begin. Thus, despite the differences in the amounts of time involved, 4-AP exposed to up to 2 weeks of sunlight or as much as 8.89 cm of rain should theoretically still be able to serve the alarmant function. However, looking closer at the data, we see that there are certain quantitative and qualitative differences in the treatments which may adversely affect the ability of 4-AP to fulfill its function as an alarmant.

Quantitatively there were significant differences between treatments in the frequencies of occurance of hovering flight, muscular incoordination, vocalizations, and convulsions (but not for regurgitation or trembling). Except for convulsions and regurgitation, all of these behaviors were observed for a longer period of time, although with less frequency, in the control group as compared with the other bait treatments. Convulsions were most frequent in the heavily-rained treatment, and regurgitation was only observed once (in the heavily-rained treatment).

Qualitatively, the control birds displayed aerially and made frequent vocalizations, while the birds baited with the other treatments tended to display on the ground more often than in the air, and with fewer vocalizations. This means that these birds will not be seen as easily as the birds of the control group. Since part of the function of 4-AP as an alarmant dictates that the flock be able to see the reacting birds, it

would seem that the bait treatments other than the control do not serve the function of 4-AP well.

Also note that 3 of the birds fed heavily-rained bait, and 1 of the birds fed bait exposed to 2 weeks of sunlight, survived at least 24 hours. One of the birds treated with heavily-rained bait did not display abnormal behavior at all after ingesting the bait.

These results indicate that, while in most instances the various treatments of 4-AP (despite minor time-lags) remained potent enough to kill the bird ingesting the bait, the ultimate alarmant result of the 4-AP may have been impaired. That is, individual birds still reacted to the environmentally treated baits, but their reactions were qualitatively different (with less noise, and less display that would be visible above the vegetation) from the reactions of birds baited with fresh 4-AP, implying that the treated baits may have a reduced effectiveness in alarming the flock. Keeping in mind the fact that 4-AP is designed to function as an alarmant, and that it achieves this through the aerial displays and loud vocalizations of reacting birds, the significance of the altered behaviors (due to the bait treatments) becomes apparent.

Also, there are points about the individual treatments of the bait which should be taken into consideration. Rain, besides increasing the amount of time involved for the 4-AP to take its effect, and besides affecting the quality of the behavior displayed, can interfere with the commercial application schedule of 4-AP to cornfields by washing bait away, covering it up, or hastening its decomposition (Stickley et al. 1977). It may also affect the palatability of the remaining bait, although I did not encounter this problem in my work.

The bait exposed to sunlight for 2 weeks, like the bait exposed to rain, also showed an increase in the time required for displays to begin, and showed qualitateively less-dramatic aerial displays. However, this fact may be of little importance: under high bird pressure the bait is usually consumed within 5-9 days, so it is rarely out in the field for 2 weeks; and if the bait was out for 2 weeks, this would indicate a low bird pressure (DeGrazio et al. 1972). Dolbeer et al. (1976) and Woronecki et al. (1979) indicated that when bird pressure is low, there is less chance of success of 4-AP as an alarmant, due to the lower incidence of reacting birds. Thus, if any bait remains in the field for up to 2 weeks, its effectiveness as an alarmant is greatly reduced, either due to the environmental weakening of the chemical, or due to low bird pressure.

In summary, there were some statistically significant quantitative differences in the times involved for the reaction of the alarmant, but in actual values the differences were very small. More important are the qualitative differences in the behaviors themselves: as the 4-AP was exposed to light and rain, birds taking the bait displayed abnormal behavior in ways that would be less visible or less audible to the flock (i.e., closer to the ground where they would be hidden by vegetation, and quieter), thus reducing the alarmant effect. Besides this, rain may physically interfere with the efficacy of the chemical by washing bait away, covering it up, hastening its decomposition, or affecting its palatability. Lengthy exposure to light, besides reducing the effectiveness of 4-AP, indicates a reduced bird pressure which in turn implies a lower success for the chemical as an alarmant simply because the fewer number of birds means fewer birds will be displaying and alarming

the flock. Thus, the application frequencies of the bait on cornfields may need to be modified to allow for the effects of the rain or of over-exposure to the sun.

LITERATURE CITED

Besser, J.F. 1978. Improvements in the use of 4-aminpyridine for protecting agricultural crops from birds. Proc. 8th Verte. Pest Control Conference (University of California, Davis). pp.51-53.

DeGrazio, J.W., J.F. Besser, T.J. DeCino, J.L. Guarino, and R.I. Starr. 1971. Use of 4-aminopyridine to protect ripening corn from blackbirds. J. Wildl. Manage. 35:565-569.

DeGrazio, J.W., J.F. Besser, T.J. DeCino, J.L. Guarino, and E.W. Schafer, Jr. 1972. Protecting ripening corn from blackbirds by broadcasting 4-aminpyridine baits. J. Wildl. Manage. 36:1316-1320.

Dolbeer, R.A., C.R. Ingram, J.L. Seubert, A.R. Stickley, Jr., and R.T. Mitchell. 1976. 4-Aminopyridine effectiveness in sweet corn related to blackbird population density. J. Wildl. Manage. 40:564-570.

Goodhue, L.D., and F.M. Baumgartner. 1965. Application of new bird control chemicals. J. Wildl. Manage. 29:830-837.

Knittle, C.E., J.L. Guarino, O.E. Bray, J.L. Cummings, and M.R. Ouellette. 1977. Protecting ripening sweet corn from blackbirds in Wisconsin with 4-aminopyridine. Proc. Bird Control Seminar, Bowling Green, Ohio 7:188-194.

McQueen, I.S. 1963. Development of a hand portable rainfall-simulator infiltrometer. USDI Geological Survey Circular 482. 16pp.

Stickley, A.R., Jr. 1974. Avitrol. Proc. Bird Control Seminar, Bowling Green, Ohio 6:273-274.

Stickley, A.R., Jr., S.B. Williams, and K.M. Simpson. 1977. Survey of effectiveness of Avitrol FC Corn Chops-99 in field corn in northern Ohio. Proc. Bird Control Seminar, Bowling Green, Ohio 7:182-187.

Stickley, A.R., Jr., R.T. Mitchell, R.G. Heath, C.R. Ingram, and E.L. Bradley, Jr. 1972. A method for appraising the bird repellency of 4-aminopyridine. J. Wildl, Manage. 36:1313-1316.

Stickley, A.R., Jr., R.T. Mitchell, J.L. Seubert, C.R. Ingram, and M.I. Dyer. 1976. Large-scale evaluation of blackbird frightening agent 4-aminopyridine in corn. J. Wildl. Manage. 40:126-131.

West, R.R. 1968. Reduction of a winter starling population by baiting its preroosting areas. J. Wildl. Manage. 32:637-640.

Woronecki, P.P., R.A. Dolbeer, C.R. Ingram, and A.R. Stickley, Jr. 1979. 4-Aminopyridine effectiveness reevaluated for reducing blackbird damage to corn. J. Wildl. Manage. 43:184-191.

Table 1: Types of behavior exhibited by cowbirds baited with 4-Aminopyridine.

Comfort behavior
Convulsions
Defecation
Drinking
Eating
Escape behavior[1]
Grasping with the claws
Hovering flight
Motionlessness
Muscular incoordination
Normal flight
Pecking
Regurgitation
Salivation
Trembling
Vocalizations
Walking

1 Attempting to get out of the cage

Table 2: Frequencies and average lengths of time involved for the 6 characteristic behaviors in each of the 4 bait treatments.

BEHAVIOR		TREATMENT			
		CONTROL	LIGHT	LIGHT RAIN	HEAVY RAIN
Hovering flight	FREQUENCY	2	21	12	18
	A.L.T.*	1:35	0:06	0:09	0:09
Muscular incoordination	FREQUENCY	26	94	91	74
	A.L.T.	1:53	0:21	0:44	0:38
Trembling	FREQUENCY	11	41	41	43
	A.L.T.+	0:59	0:44	0:42	0:57
Convulsions	FREQUENCY	3	24	10	10
	A.L.T.	0:59	0:44	1:16	0:40
Vocalizations	FREQUENCY	13	14	30	44
	A.L.T.	2:37	0:38	0:46	1:06
Regurgitation	FREQUENCY*+	0	0	0	1
	A.L.T.				

* Average length of time for performance of the behavior

\+ This is the only instance where there were not significant differences between the treatments for the times involved ($P>0.05$)

*+ This is the only instance where the frequencies of occurance were not significantly different between treatments ($P>0.05$)

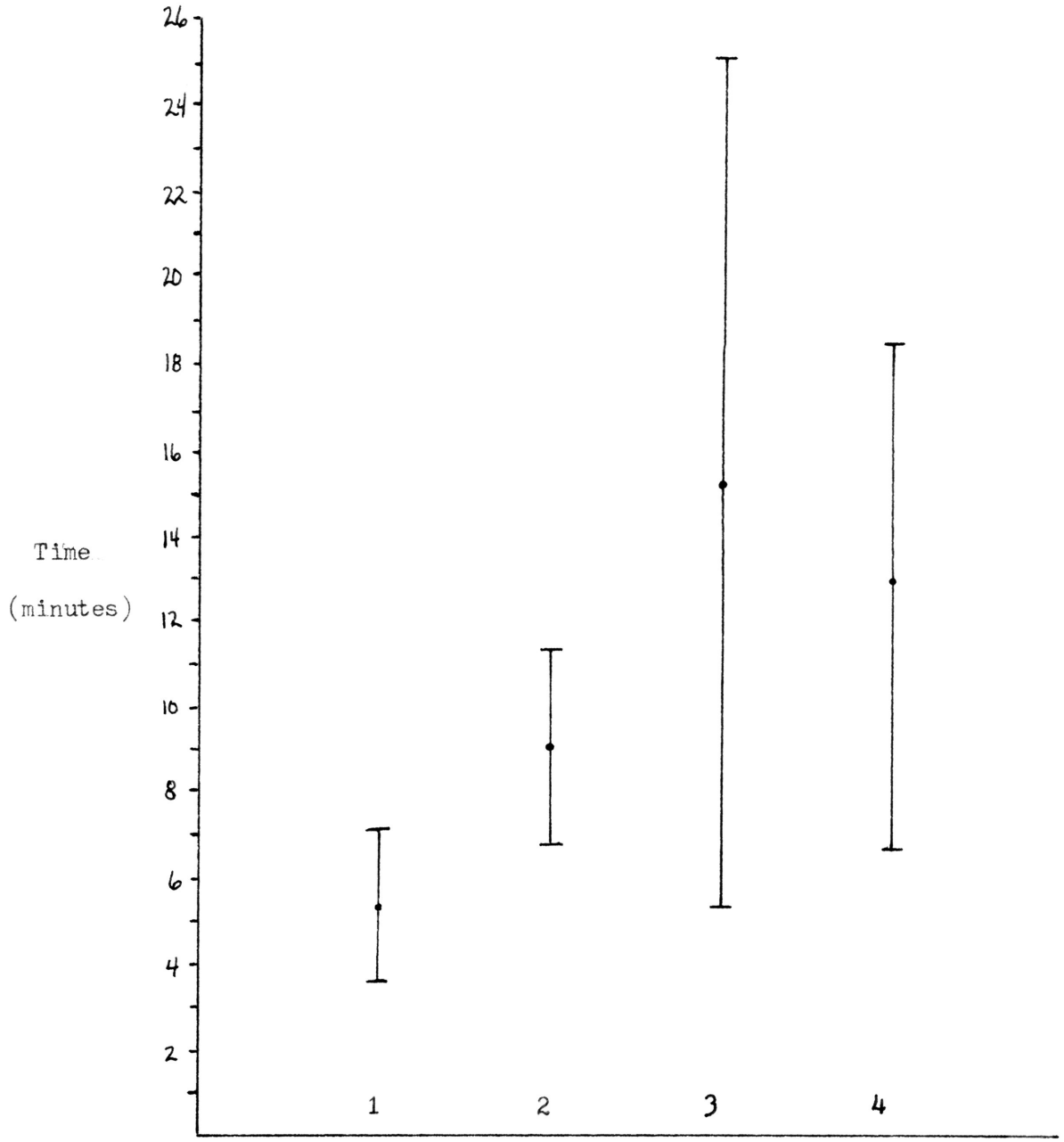

Figure 1: Means and standard deviations for the manifestation times in all 4 bait treatments: (1) control (n=6); (2) light rain (n=6); (3) heavy rain (n=5); and (4) 2-week exposure (n=3).

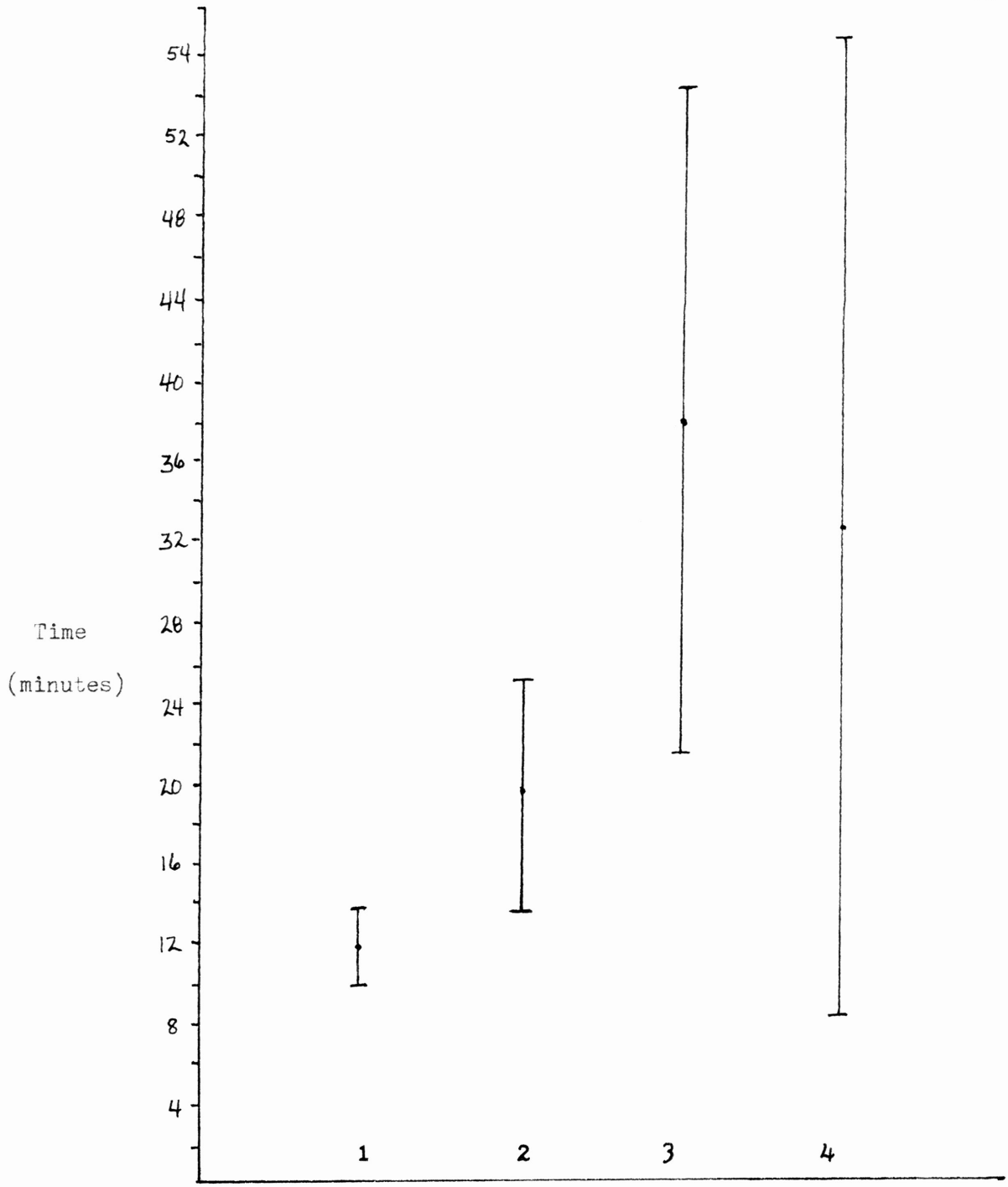

Figure 2: Means and standard deviations for the duration times in all 4 bait treatments: (1) control (n=6); (2) light rain (n=6); (3) heavy rain (n=5); and (4) 2-week exposure (n=3).

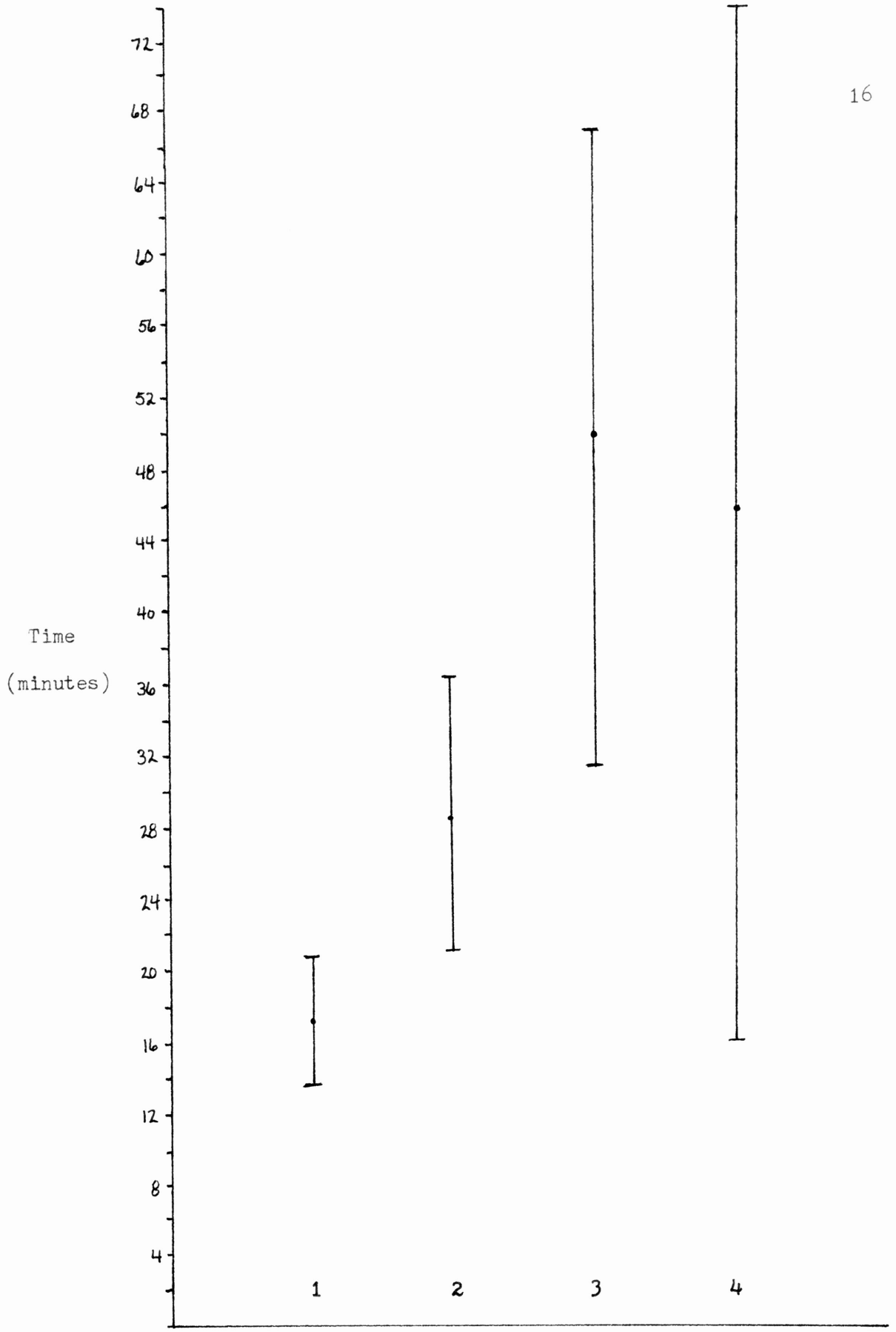

Figure 3: Means and standard deviations for the total times in all 4 bait treatments: (1) control (n=6); (2) light rain (n=6); (3) heavy rain (n=5); and (4) 2-week exposure (n=3).