PREFERENCES IN JAPANESE QUAIL FOR SUCROSE
AT FIVE MOLARITIES OF CONCENTRATION

By

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J.S.M.

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CHAPTER I

INTRODUCTION

Although man has traditionally separated his taste sensations into four response categories of sweet, sour, bitter and salty, behavioral studies on the gustatory phenomena in animals are limited to the observation of two general responses (Kare, 1966). A foodstuff can evoke a response of preference or the substance can evoke a response of rejection. In the event of a specific food preference, several causal factors are commonly proposed as the determinants of the organism's choice (Jacobs and Scott, 1957; Young, 1959). Possibly, the organism may make a selection based upon an "inherent wisdom" which enables it to maintain a "nutritional homeostasis" (Richter, 1941). In this event, organic need may be viewed as regulating food choices in the organism's attempts to incorporate a minimal quantity of requisite nutrients. Another factor upon which the organism's food choice may be based is that of palatability. The term palatability refers to the hedonic worth of a foodstuff which is contingent upon the organism finding that the substance "tastes good" regardless of its nutritional properties (Young, 1959). A third possible determining factor in appetitive preference involves the acquisition of feeding habits. In this latter case, the organism builds up a habit of food acceptance because ingestion of the food had produced reinforcement previously. Thus, in order to evaluate the possible influences of nutritional appetite, palatability and learning in food selection, it would seem necessary to identify and control the prevailing organic state of the organism, the physical properties of the foodstuff and the type of feeding experiences that the organism has encountered.

Although several causal factors are commonly proposed as determinants of the organism's appetitive preference, comparative behavioral experiments studying taste responses in various animals have indicated the existence of possible species differences (Carpenter, 1956; Kare, 1961; Kare and Ficken, 1963). However, the comparative data on taste responses and on the underlying determinants of taste preference and rejection remain inclusive. Nevertheless, Kare and Ficken (1963) point out that apparent contradictions in the findings of behavioral studies does not necessarily deny the existence of an overall theory which can explain the species differences. The behavioral studies on taste responses have also revealed large variation among individuals within a species (Kare and Ficken, 1963). The source of the variation found in taste preference behavior should be carefully considered before any conclusions are drawn. First, it is apparent that the behavioral studies vary in experimental procedure and in the method of analyzing the data. Also, until recently, taste response studies have not adequately controlled for the effects due to the organic state of the organism and for the effects due to the past feeding experience of the organism. Consequently, some of the behavioral work is of limited use in drawing valid conclusions.

Review of the Literature

The literature on the avian sense of taste for "sweetness" reveals contradictory findings. Some of the studies indicate that birds will prefer one or more of the true sugar solutions (Engelmann, 1937, 1957; Hamrum, 1953; Jacobs and Scott, 1957; Kare, Black and Allison, 1956; Duncan, 1960; Warren and Vince, 1963; Vince and Warren, 1963; Brindley, 1966). In contrast, other studies indicate that birds are indifferent to sugar in their food (Jukes, 1938) and are indifferent to all true sugar solutions (Kare and Medway, 1959; Kare and Ficken, 1963). However, despite the fact that the literature on the preference for sweetness in birds is ambiguous, behavioral studies have demonstated that the general sense of taste in birds is a relatively acute faculty (Hamrum, 1953; Kare, Black and Allison, 1956).

Engelmann (1937) conducted one of the first "free choice" experiments studying the preference for "sweetness" in birds. In this experiment, chickens were offered a choice between various sweet test solutions and water. Sucrose, fructose, maltose and saccharine were used to make the test solutions. Engelmann reported that the chickens clearly preferred test solutions of sucrose, fructose and maltose over water. The saccharine solution was found to be the least preferred test solution.

Engelmann (1957) conducted another taste preference study offering chickens various sweet solutions. In this study the chickens showed a preference for sucrose, but they did not demonstrate a clear preference for the less sweet sugars (Moncrieff, 1951), maltose and lactose. As reported previously (Engelmann, 1937), the birds exhibited practically no preference for the artificial sweetness of saccharine. Engelmann suggests that the taste sensations evoked by maltose and lactose test solutions serve as warnings. He concludes that the sense of taste plays a secondary role in food selection and that the optical and tactile stimuli plays a more important part in food choice.

Jukes (1938) performed another one of the early "free choice" experiments in the study of the preference for sweetness in birds. Twenty-four Single Comb White Leghorn chicks were given twenty-nine days of preliminary taste experience with a basal diet containing 8 percent powdered sucrose. After the preliminary period, the birds were presented with a free choice of four diets containing various concentrations of sucrose, which ranged from 0 percent to 20 percent. The purpose was to determine which sucrose concentration would be most preferred by the birds. Four free-choice diets, each with a different concentration of sucrose, were available in each cage. The diets were put in separate feeding troughs which were placed at each side of the square cages. The food containers were rotated each day to control for position habits.

Although the results indicate an increasing amount of preference for the 10 percent and the 20 percent sucrose diets, Jukes reports that the differences among the food intakes for each of the diets were not statistically significant. Jukes also observed that one group of chicks consumed three times as much diet from a preferred trough position as the group did from the second most preferred trough position. This indicated that trough position was more important to the birds than was the sweetness of the diet. The finding that sweetness plays a secondary role in feed selection is supported by the later work of Engelmann (1957) who reported that, in food selection, the taste sensation of the substance plays a secondary role with optical and tactile stimuli being more important.

Hamrum (1953) conducted a taste preference study in which sixteen Bob-White Quail (<u>Colinus virginianus virginianus</u>) were given two-bottle drinking preference tests in which various compounds, among which was sucrose, were paired with water. The molarity of the sucrose test solutions ranged from 0.005 M to 0.30 M. The sugar concentrations were presented to the quail in an ascending order from the lowest to the highest concentration. Under these conditions, Hamrum found that the Bob-Whites readily accepted (approximately 50% preference) sucrose at the stronger concentrations (.1 M, .2 M, and .3 M) and that the birds exhibited a preference (60% and above) for sucrose at the lower concentrations (.05 M and below). Hamrum points out that his results demonstrate that the Bob-White quail is more sensitive (i.e., indicated a lower threshhold) to sucrose than rats and humans (Richter and Campbell, 1940).

Jacobs and Scott (1956) conducted a taste preference experiment in which sixty male Red Rock crossbred chicks were presented with choices of various combinations of 12 percent sucrose solution, 0.13 percent saccharine solution, and water. The treatments were as follows: water-water choice, sucrose-water choice, saccharine-water choice, sucrose-saccharine choice, and sucrose-saccharine-water choice. The chicks demonstated a statistically significant preference for the sucrose solution whether paired with water or saccharine, or presented with both water and saccharine. As in the studies by Engelmann (1937, 1957), the birds consistently avoided the saccharine solution. Although the birds with the sucrose solution available for choice showed the greatest total liquid consumption, the rate of weight gain and the amount of food intake by the chicks did not show any change from the weight gains and food intakes prior to the experiment.

After the initial preferences were established, a test was conducted to provide a reliability check on the preference for sucrose and the avoidance of saccharine. This check was accomplished by reversing the treatments of the previous preference experiment. The sucrose was substituted for the saccharine in the saccharine-water choice, and the saccharine was substituted for sucrose in the sucrose-water choice. Under these new conditions, Jacobs and Scott report that the birds still demonstrated a significant preference for the sucrose.

Since a preference for sucrose had been exhibited by the chicks, Jacobs and Scott conducted a third experiment to determine the possible operation of homeostatic factors in governing the preference for sucrose. It was assumed that if the sucrose preference was a function of some "hidden" caloric hunger, then it should be possible to suppress the preference by satisfying that hunger. Thus, the chicks could be force fed a highly concentrated sugar solution to provide sufficient caloric energy to suppress the sucrose preference.

Subsequently, four 24-hour and two 5-hour tests were run on the birds in the sugar-water choice treatment and in the sucrose-saccharine-water choice treatment. One group of each treatment was given a 4.0 M dextrose solution, and the other received a saline solution in an equal amount. The solutions were administered intraperiteneally in the sucrose-water treatment group and by crop injection in the sucrose-saccharine-water treatment group. Injections were made at two-hour intervals. The quantity of the dextrose (in grams) administered to each chick was equivalent to the bird's largest daily intake of sucrose in the initial preference experiment. Thus, on the bird's test days, it received approximately the same number of calories through force-feeding as it had previously received through self-feeding.

At the end of the test periods, there had been a significant decrease in the preference for sucrose in only one out of the three force-feeding groups. Therefore, even though the data were not conclusive, Jacobs and Scott state that the sucrose preference in the chicks had not been demonstrated to be contingent upon the caloric value of the sugar.

Duncan (1960) carried out a number of taste preference tests on mature feral pigeons (Columba Livia var. Gmelin) using the method of single stimuli. Separate groups of eight randomly selected pigeons were each presented with one of the test solutions. Glucose and sucrose were used to make the "sweet" test solutions. One concentration of a test solution was offered for three successive days, and, then, after a day during which water was presented, another concentration of the same substance was offered for three successive days.

Even though the results indicated a significant preference for the 3 percent concentration of glucose, Duncan reports that, in general, the pigeons were indifferent to the glucose solutions but exhibited a preference for the sucrose solutions. Except for a drop in preference at the 3 percent level, the data indicated an increasing preference for the sucrose solution up to the 14 percent level. Then, above the 14 percent level, there was a steady decline in preference with a strong rejection at the 28 percent level.

Kare, Black and Allison (1956) conducted a study of the sense of taste in fowl in which over four thousand newly hatched Rhode Island Red-Barred Plymouth Rock crossbreds and White Leghorns were presented with approximately four dozen different test solutions. Included among these test substances were sucrose and saccharine solutions. The various test substances were mixed with tap water because the authors assumed that the addition of water would allow a maximum amount of taste discrimination. This assumption was based on the observation that the fowl retains feed in its mouth for only a brief period of time and that it secretes much less saliva than does man (Dukes, 1955). The authors report moderate preference for the sucrose solutions and moderate rejection for the saccharine solutions. These results support previous findings (Engelmann, 1937, 1957; Jacobs and Scott, 1956) that chicks will prefer sucrose and reject saccharine solutions. However, the authors conclude that, in the case of the sucrose preference, careful consideration should be given to the effect of the nutritive value, consistency and osmatic pressure of the solution.

Kare and Medway (1959) conducted a study on the ability of newly hatched Rhode Island Red-Barred Plymouth crossbred cockerels to discriminate among carbohydrates in solution. The choice of sugars allowed the introduction of a number of variables that might be involved in the response of a bird to a carbohydrate solution--e.g., concentration, sweetness, osmatic pressure, viscosity, nutritive value, toxicity, optical characteristics, among others. Kare and Medway report that the birds were indifferent (showed no apparent preference for either the sugar solutions or the water) to lactose, galactose, raffinose and fructose. A possible, though slight, preference for maltose was exhibited by the chicks, but xylose, which was accepted at very low concentrations, was increasingly rejected at concentrations above 5 percent. In general, the birds were indifferent to sucrose and dextrose; however, when a sucrose concentration of 25 percent was paired with water, the birds showed a moderate rejection of the sucrose solution. Although the results which indicate that the chicks will reject sucrose solutions at higher concentrations are in agreement with the previous findings of Jacobs and Scott (1957), the general response of indifference to the sucrose at the lower concentrations exhibited in the present study is contradictory to the earlier findings of Jacob and Scott (1957) who report a significant preference for sucrose at the lower concentrations. Kare and Medway's investigation of the various characteristics of the different sugars failed to suggest any physical or chemical basis for explaining the bird's preference behavior.

Kare and Ficken (1963), report an experiment which studied the effect of caloric need on the preference for sugar in chickens. Initially, the birds were found to be indifferent to sucrose when given a choice between a 10 percent sucrose solution and distilled water. After this preliminary preference test, a group of birds was given a diet limited to seventy-five percent of the quantity consumed by a control group. Under these conditions, the birds exhibited a preference for the sucrose solution. The authors concluded that caloric deficiency in birds can lead to a preference for sucrose, which is an additional source of calories. It was also noted that the birds which were on the restricted diet continued to demonstrate a sucrose preference for a period after an adequate diet had been restored. This continued sucrose preference led to the conclusion that it is possible for a sugar preference to be related to the prior adequacy of the bird's diet.

In addition, Kare and Ficken suggest that dietary deficiency and subsequent nutritional need might be used to explain conflicting findings in the preference behavior studies. Therefore, the discrepancy between Jacobs and Scott's (1957) findings, which indicated that chicks preferred sucrose solutions and Kare and Medway's (1959) findings, which showed that fowl are indifferent to sucrose solutions, might be explained on the basis of nutritional need. That is, the preference exhibited by the birds in the Jacobs and Scott study might have been based on a caloric deficiency engendered prior to the start of the study.

Warren and Vince (1963) presented great tits (Parus major) with free choice between glucose solutions and water in two-bottle drinking preference tests and found that the birds preferred glucose concentrations over water. The percentage of preference was much the same at both test concentrations -7 and 14 percent glucose.

In a second study, Vince and Warren (1963) considered the effects of age and prior feeding experience on the taste preference in the great tit. They found that both wild adult birds and young hand reared birds of this species demonstrated a significant preference for glucose. The hand reared group of adult birds appeared to prefer the glucose solution, but the mean preference was not statistically significant. It was noted that the wild birds showed a greater preference for the sweet solution than did the hand reared birds.

Recently, Brindley (1966) conducted an experiment designed to study the taste preferences of bob-white (Colinus virginianus) and Japanese Quail (Coturnix coturnix japonica). The birds were presented with a test solution and water for a two-day free choice period. Four test solutions, including a 10 percent glucose solution, were used.

Brindley reported that the majority of the quail significantly preferred the glucose solution to water. The statistical analysis also tested for effects due to the color of the drinkers and for effects due to the brooder-lamps. The analysis of variance for the bob-white quail at 10 days of age indicated that the effects other than those associated with the test solutions were negligible. However, the analysis of variance for the Japanese quail at 10 days of age indicated significant effects for the test solutions, for the color of the drinkers and for position of the brooder-lamps. The position of the brooder-lamps had a significant effect at the .05 level and the color of the waterers had a significant effect at the .01 level. The birds appeared to have a strong preference for the color red. The authors suggest that the effect of color on preference can be used to explain some of the anomalous responses of individual birds.

Although the review of literature reveals divergent and conflicting findings on the sense of taste for "sweetness" in birds, the data do not necessarily indicate that different species have basically different taste experiences. There appears to be many factors involved in the determination of preference behavior. As Vince and Warren (1963) have pointed out, individual variation in preference behavior can be affected by the age and by the previous experience of the bird. Further, Kare and Ficken (1963) have demonstrated how nutritional deficiency can affect the preference behavior of the birds.

In addition, some of the taste preference experiments may be of limited use in drawing valid generalizations because they used a small number of subjects (Duncan, 1960; Warren and Vince, 1963). Also, there are wide variations in experimental method and in procedure. Even when the basic designs are similar, factors such as length of preference period and time between rotation of drinkers may vary. This latter factor may be of special importance when the rotation periods are so brief that the birds do not have time to break old feeding habits and to establish new ones. Another problem in comparing preference test results is caused by the lack of adequate statistical analysis, which might result in the assumption of differences when there are none. Much of the data are merely presented graphically, and, in the process of describing the data, there is no standard procedure in determining at what point indifference will become rejection or preference. The use of adequate statistical analysis becomes even more important when one considers the large individual variation that is possible within a species.

Statement of the Problem

The review of literature has demonstrated that the behavioral data on the avian preference for "sweetness" are contradictory. Even the few studies on the response of quail to sweet stimuli are conflicting in their conclusions. Frings (1951) has reported that quail will readily accept sucrose solutions when hungry. Brindley (1966) reports that both bob-white and Japanese quail show a significant preference for a 10 percent glucose solution when maintained on an adequate diet. Kare (1965), however, has stated that both bob-white and Japanese quail are indifferent to sucrose solutions. In one study, Kare and Ficken suggest that dietary deficiency and subsequent nutritional need might explain many of the discrepancies in the findings of behavioral studies on the sense of taste.

This study, therefore, was performed to investigate the taste preference behavior of Japanese quail (Coturnix coturnix japonica) when given a free choice between sucrose at five molar concentrations (0.10, 0.20, 0.30, 0.40, and 0.50 M) and distilled water, as well as, to investigate the possibility that caloric need may serve as the basis for sugar preference. In addition, the investigation was concerned with any differential preference for the various concentrations of sucrose that might be exhibited by the quail.

CHAPTER II

METHOD

Subjects

Twenty-four male and female Japanese quail (Coturnix coturnix japonica) from the Oklahoma State University Poultry Science Department were used as subjects. Twelve of the birds were experimentally naive, and twelve of the birds had been used in a previous experiment. However, the quail that had been used in a previous study were naive in respect to taste preference work. At the start of the study all the birds were approximately 240 days old. All of the birds appeared to be in fairly good condition. At the beginning of the study, the quail ranged in weight from 101.5 grams to 142.5 grams with a mean weight of 118.85 grams and a standard deviation of 10.31 grams.

Apparatus

Each quail was housed in a separate cage. Two sizes of individual cages (11 x $8\frac{1}{2}$ x 12 and 15 x 18 x 9) were used. A pair of 250 ml drinking tubes were mounted on the front of each cage. These waterers were composed of a stoppered graduated cylinder with a bent glass tube fastened to the bottom. The glass tube at the bottom was the only part of the waterer that extended into the cage. The tube protruded about two inches into the cage and was approximately one-half inch from the bottom of the cage. Thus, the opening in the waterer was about one and one-half inches from the cage floor. One waterer was positioned immediately to the left of center, and the other waterer was positioned to the immediate right of center at the front of the cage. During the testing, the waterers were rotated at the end of each 24-hour preference period.

Individual metal food cups were provided in each cage. The food containers measured 3 inches in diameter by 1 3/4 inches in depth and had a 1 1/4 inches circular hole cut in the lid. The feeders were placed in the back sections of the cages. Purina Game Bird Breeder Layena, a complete ration, served as the basic diet. Throughout the experiment, the birds were maintained on an ad libitum dry food schedule. The sucrose which was used to make the test solutions was laboratory Baker Analyzed Regent crystal sucrose (C_{12} H_{22} O_{11}) obtained from the J. T. Baker Company.

During the study, the quail were subjected to an artificial twelve hour day and twelve hour night (8:30 A.M. - 8:30 P.M.). The experimental room environment was thermostatically controlled. The temperature varied between 71 and 80 degrees F., and the relative humidity varied between 63 and 74 percent.

Preliminary Procedure

The twenty-four quail were randomly divided into an experimental group and a control group of equal size. The birds were then randomly assigned to individual cages. All of the birds were given an initial ten-day habitation period during which the two graduated drinking tubes attached to each cage were filled with distilled water. Individual liquid intakes were measured in ml daily at 8:00 P.M. The distilled water in the drinking tubes was changed every 48 hours, and the drinking tubes were cleaned regularly.

On the final five days of the fifteen-day habituation period (days 11-15), each quail was allowed access to the two drinking tubes which were filled with distilled water for 20 hours each day. During the remaining four-hour period, only one drinking tube with distilled water was presented to each bird. This four-hour period occurred between 9:30 A.M. and 1:30 P.M. each day. Individual readings were taken at the beginning and at the end of each four-hour period as well as at the end of each 24-hour period at 8:00 P.M. The double readings on both waterers at the beginning and at the end of the four periods served to correct for possible liquid loss due to spillage.

During the next five-day period (days 16-20), the quail were again presented with a 20-hour free choice between two drinkers filled with distilled water. However, during the remaining four-hour periods, the experimental group was presented a single drinking tube containing a 0.25 M concentration of sucrose, and the control group was presented a single tube containing distilled water. Again, this four-hour period occurred between 9:30 A.M. and 1:30 P.M. each day. Fluid intakes were measured for each bird in both groups at the beginning and at the end of each four-hour period as well as at the end of each 24-hour period at 8:00 P.M. Fresh mixtures of the 0.25 M sucrose solution were prepared every 48 hours.

Preference Test Procedure

During each of the five preference test periods (beginning on day 21), all of the quail were offered a free choice between one concentrations of sucrose (0.10, 0.20, 0.30, 0.40, and 0.50 M) were used as test solutions. The five sucrose concentrations were presented to the quail in a random order, and each concentration was presented only once. Individual readings were taken at the end of each 24-hour taste preference period. Fresh concentrations of all sucrose solutions were prepared for each preference test period.

Each 24-hour preference test period was followed by a 24-hour period during which both the experimental and the control groups were presented a 20-hour free choice between two waterers each containing distilled water. During the remaining four hours, the experimental group was presented a single waterer containing a .25 M sucrose solution, and the control group was presented a single waterer containing distilled water. This four-hour period occurred between 9:30 A.M. and 1:30 P.M. Readings were taken at the beginning and end of each four-hour period. All of the birds were weighted at the beginning of the habituation period, at the beginning of the preference test, and at the end of the preference test period.

CHAPTER III

RESULTS

Weights

At the beginning of the study, the mean weight of the experimental group was 116.5 SD 9.72 grams (range, 101.5 - 136.1) and that of the control group was 121.2 SD 10.80 grams (range, 108.2 - 142.5). The mean weight of the quail at the start of the preference tests was as follows: Experimental group, 123.3 SD 14.07 grams (range, 91.6 - 156.7); and Control group, 126.7 SD 13.37 grams (range, 104.5 - 148.0). The mean weight of the birds at the end of the preference test were as follows: Experimental group 121.2 SD 11.77 grams (range, 93.4 - 141.0); and Control group 130.0 SD 14.86 grams (range, 106.0 - 157.5).

Sucrose Intake

The intakes of the test solutions by the experimental and control groups during the preference test periods are plotted as the mean ml intakes per 100 grams of body weight for the five sucrose concentrations in Figure 1. Figure 1 indicates that for the first four molar concentrations the mean sucrose intakes per 100 grams of body weight of the experimental group exceeds the mean intakes of the control. Figure 1 further indicates that the control group had a greater mean intake only at the 0.50 M concentration.

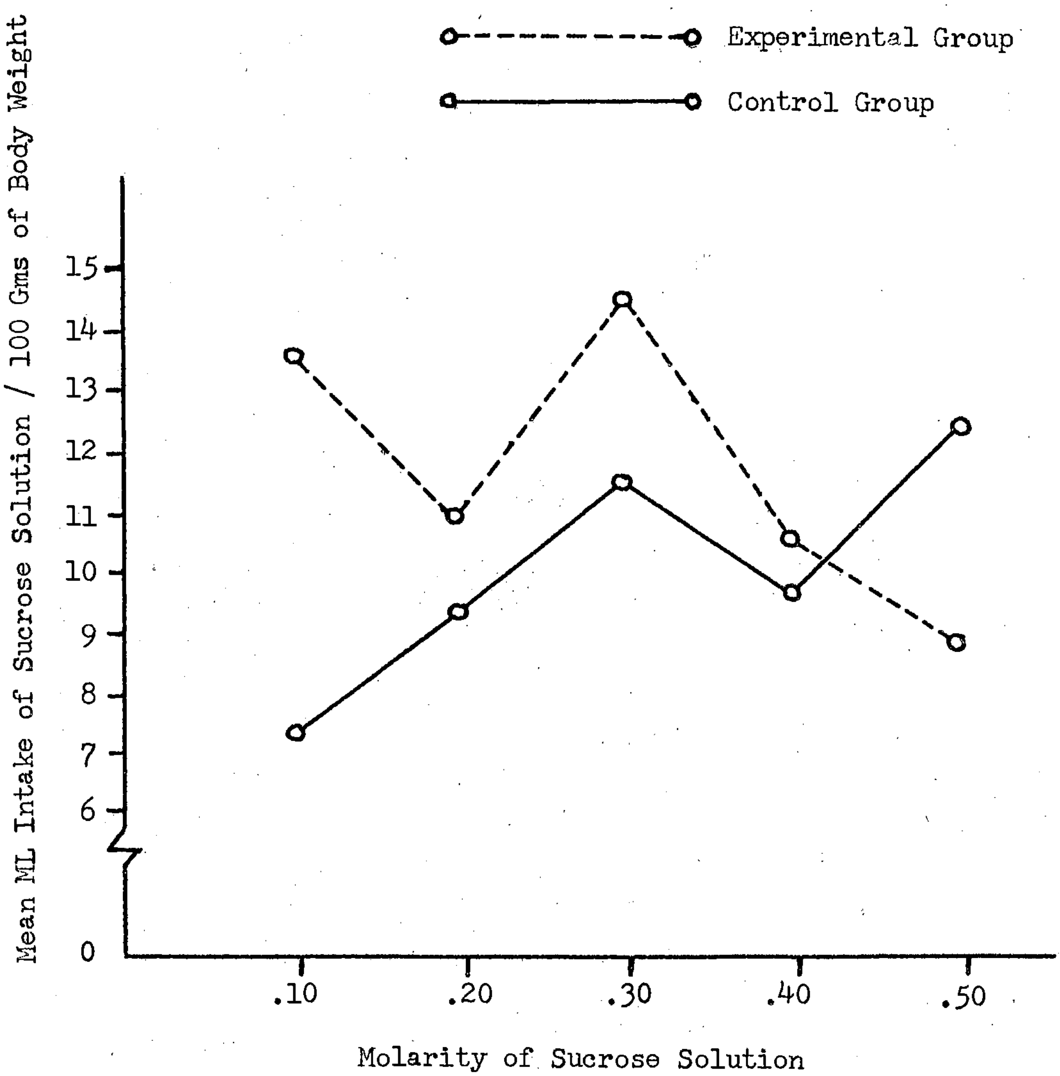

Figure 1. Mean Fluid Intake by Japanese Quail Offered Five Molarities of Sucrose in Two-Bottle Drinking Preference Tests

The statistical procedure used to evaluate the sucrose intake data was a two-factor analysis of variance with repeated measures on one factor (Winer, 1962). Data from the analysis, as presented in Table I, show that the first factor, groups, had two levels (experimental and control). The second factor, molar concentrations, had five levels (0.10, 0.20, 0.30, 0.40 and 0.50 M). The test for repeated measures was made on the second factor.

Although the F values for groups and for concentrations were not significant at the .05 level, the F value in Table I for the groups X concentrations interaction was significant at the .01 level. In an attempt to better understand the source of the groups X concentrations interaction, the simple interaction effects were analyzed. Table II indicates that the simple effects between groups within 0.10 M concentration were significant at the .05 level. All other simple effects between groups within concentrations (Table II) and between concentrations within groups (Table III) were found to be insignificant ($P > .05$).

Even though the F value presented in Table I for concentrations was not significant ($P > .20$), individual comparisons appeared appropriate because of the increase in mean intake at the 0.30 M level shown in Figure 2. By means of Duncan's Multiple Range test, which uses a protection level of α for the collection of tests, the quail's mean intake per 100 grams of body weight at 0.30 M concentration was found to be significantly greater ($P < .05$) than the mean intake at 0.20 M and at 0.40 M concentrations (Table IV).

TABLE I

SUMMARY OF THE ANALYSIS OF VARIANCE FOR SUCROSE INTAKE DURING THE PREFERENCE TESTING

Source	df	SS	MS	F
Total	119	4,101.4937		
Between Subjects	23	1,669.0543		
Groups	1	85.6995	85.6998	1.1907
Subjects within Groups	22	1,583.3545	71.9706	
Within Subjects	96	2,432.4394		
Concentrations	4	159.4456	39.8614	1.8076
Groups X Concentrations	4	332.4603	83.1150	3.7691*
Concentrations X Subjects within Groups	88	1,940.5335	22.0515	

*Significant at the .01 level

TABLE II

AOV: SIMPLE EFFECTS OF GROUPS BY CONCENTRATIONS INTERACTION

Source	df	MS	F	P
Between A within B_1	1	245.25	7.66	.05
Between A within B_2	1	18.62	.58	
Between A within B_3	1	58.66	1.83	.25
Between A within B_4	1	7.37	.23	
Between A within B_5	1	91.26	2.85	.25

TABLE III

AOV: SIMPLE EFFECTS OF CONCENTRATIONS BY GROUPS INTERACTION

Source	df	SS	MS	F	P
Between B_1 and B_2, A_1	4	41.63	10.41	.47	
Between B_1 and B_3, A_1	4	5.86	1.46	.07	
Between B_1 and B_4, A_1	4	62.28	15.57	.71	
Between B_1 and B_5, A_1	4	153.17	38.29	1.74	.25
Between B_2 and B_3, A_1	4	78.75	19.69	.89	
Between B_2 and B_4, A_1	4	2.07	.52	.02	
Between B_2 and B_5, A_1	4	35.09	8.77	.40	
Between B_3 and B_4, A_1	4	106.34	26.58	1.21	
Between B_3 and B_5, A_1	4	218.95	54.72	2.48	.25
Between B_4 and B_5, A_1	4	20.11	5.03	.23	
Between B_1 and B_2, A_2	4	21.76	5.44	.25	
Between B_1 and B_3, A_2	4	106.65	26.66	1.21	
Between B_1 and B_4, A_2	4	24.58	6.14	.28	
Between B_1 and B_5, A_2	4	162.34	40.58	1.84	.25
Between B_2 and B_3, A_2	4	30.58	7.64	.35	
Between B_2 and B_4, A_2	4	.03	.01	.00	
Between B_2 and B_5, A_2	4	63.12	15.78	.72	
Between B_3 and B_4, A_2	4	28.82	7.20	.33	
Between B_3 and B_5, A_2	4	5.83	1.45	.07	
Between B_4 and B_5, A_2	4	60.58	15.14	.69	

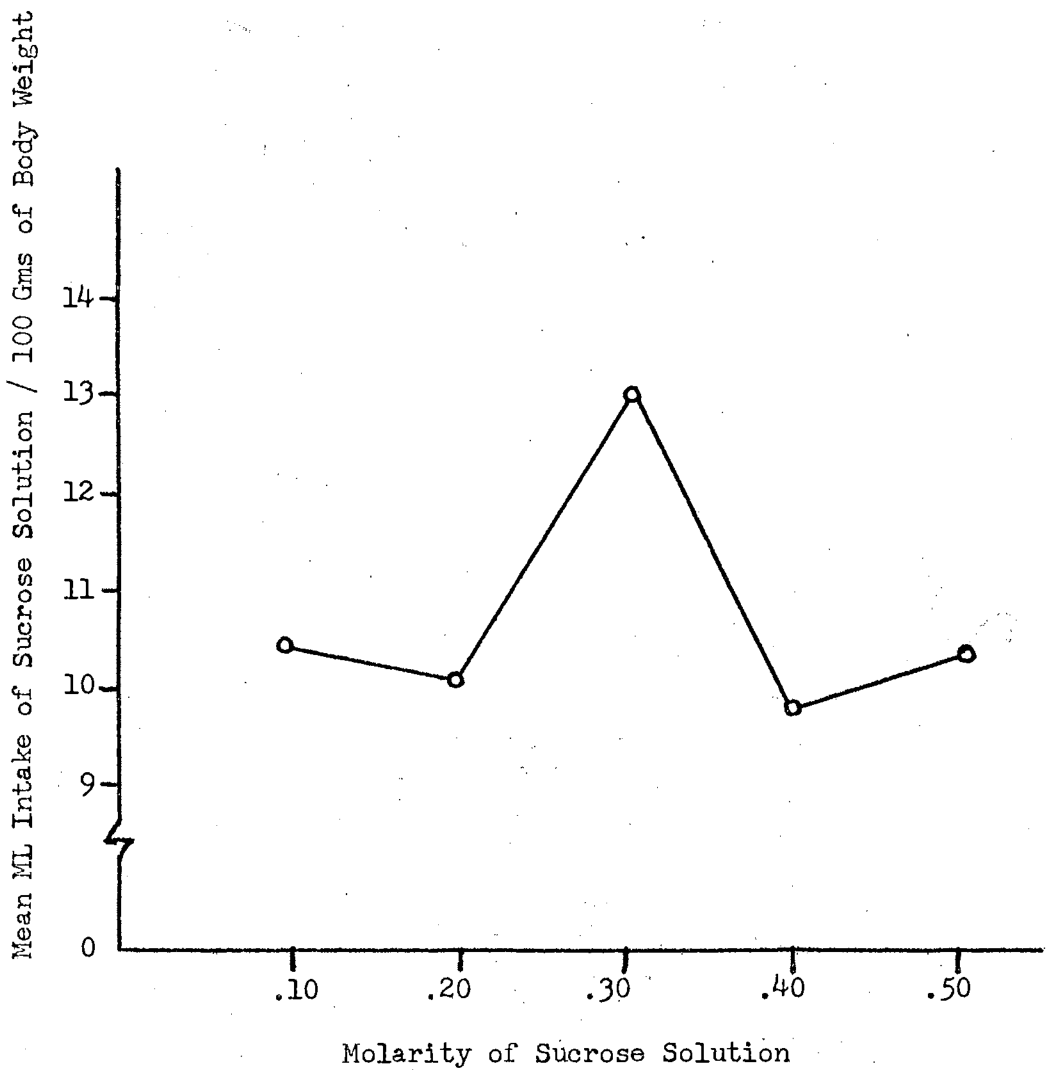

Figure 2. Mean Fluid Intake by All Japanese Quail Offered Five Molarities of Sucrose in Two-Bottle Drinking Preference Tests

TABLE IV

DUNCAN'S MULTIPLE RANGE TEST ON THE MEAN INTAKES AT THE FIVE MOLARITIES OF SUCROSE DURING PREFERENCE TESTING

Sucrose Concentrations	0.20	0.40	0.50	0.10	0.30
Means	9.7730	10.0358	10.3737	10.4483	12.9758
9.7750		.2608	.5987	.6733	3.2008*
10.0358			.3379	.4125	2.9400*
10.3737				.0746	2.6021
10.4483					2.5275

$S_{\bar{B}}$ = .9584	p =	2	3	4	5
SSR .95 (p, 88)		2.809	2.959	3.059	3.126
LSR		2.6921	2.8359	2.9317	2.9960

*Significant difference at the .05 level

Liquid Intake

In the computation of the means for the daily liquid intakes, the data for four female quail which were laying eggs during the habituation period were omitted. It had been observed that the female quail's liquid intake during its egg laying period was often several times higher than its normal liquid intake. The mean daily liquid intakes for the two groups of quail during five day periods are plotted in Figure 3. Mean 4-hour liquid intakes for three separate five day periods are plotted in Figure 4.

Preference

To determine the percentage of preference (or aversion) in the 24-hour free choice drinking test, the total daily intake (distilled water and test solution) was divided into the daily test solution intake to give a ratio which was multiplied by 100 (test solution intake/total daily intake X 100 = % of preference). A percentage of 50 percent suggested indifference. And, as Kare et al. (1957) has suggested, a value above 50 percent may be taken as indicating preference, and a value below 50 percent may be taken as indicating aversion.

The preference test data for the experimental and for the control groups are plotted in Figure 5. Each point on the graph represents the mean percentage preference for twelve birds. Table V summarizes the analysis of the preference test data which was analyzed by a two factor analysis of variance with repeated measures on one factor (Winer, 1962). Groups, had two levels (experimental and control). Molar concentrations, had five levels (0.10, 0.20, 0.30, 0.40 and 0.50 M). The repeated measures were on molar concentrations.

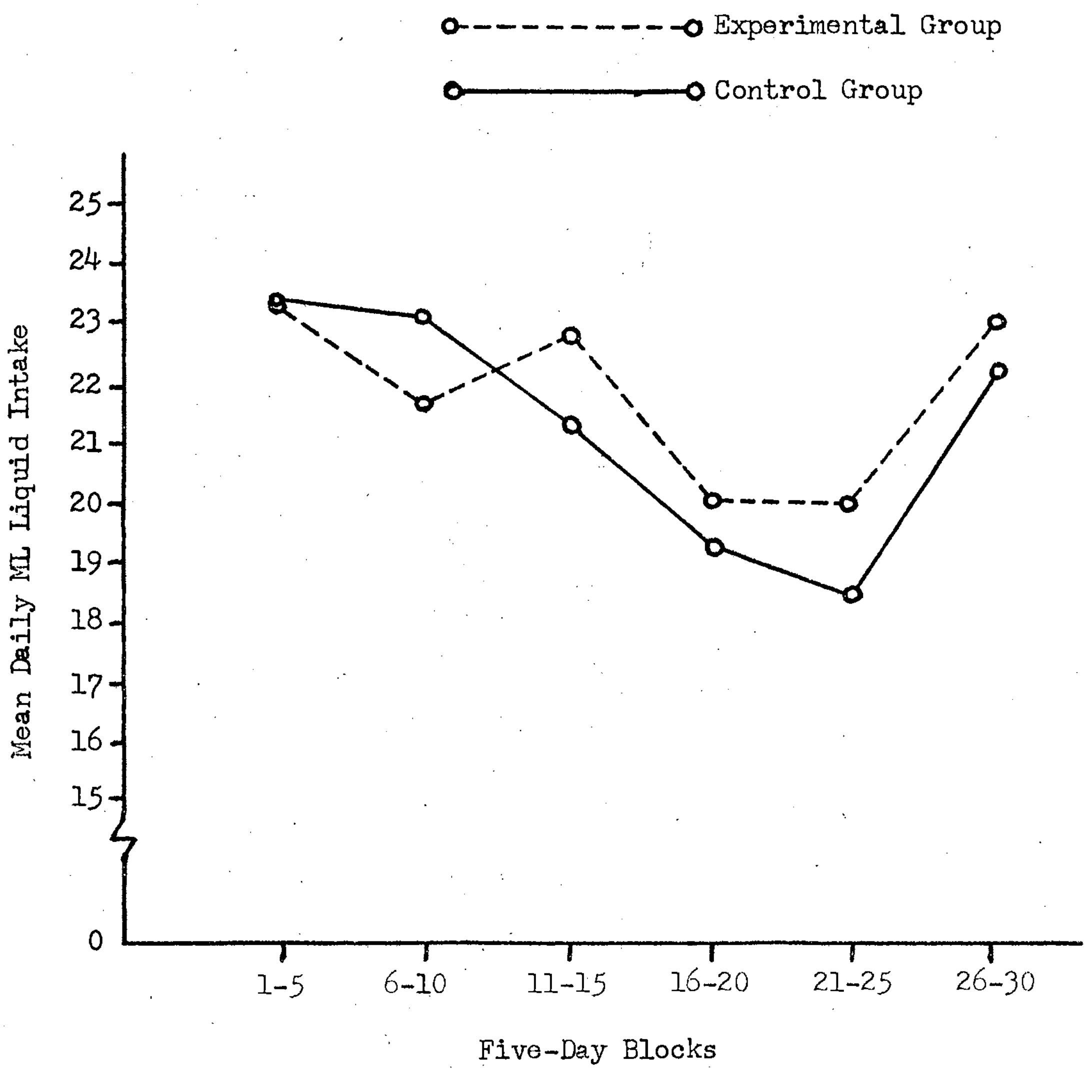

Figure 3. Mean Fluid Intakes by Japanese Quail For Five-Day Blocks During the 30-Day Experimental Period

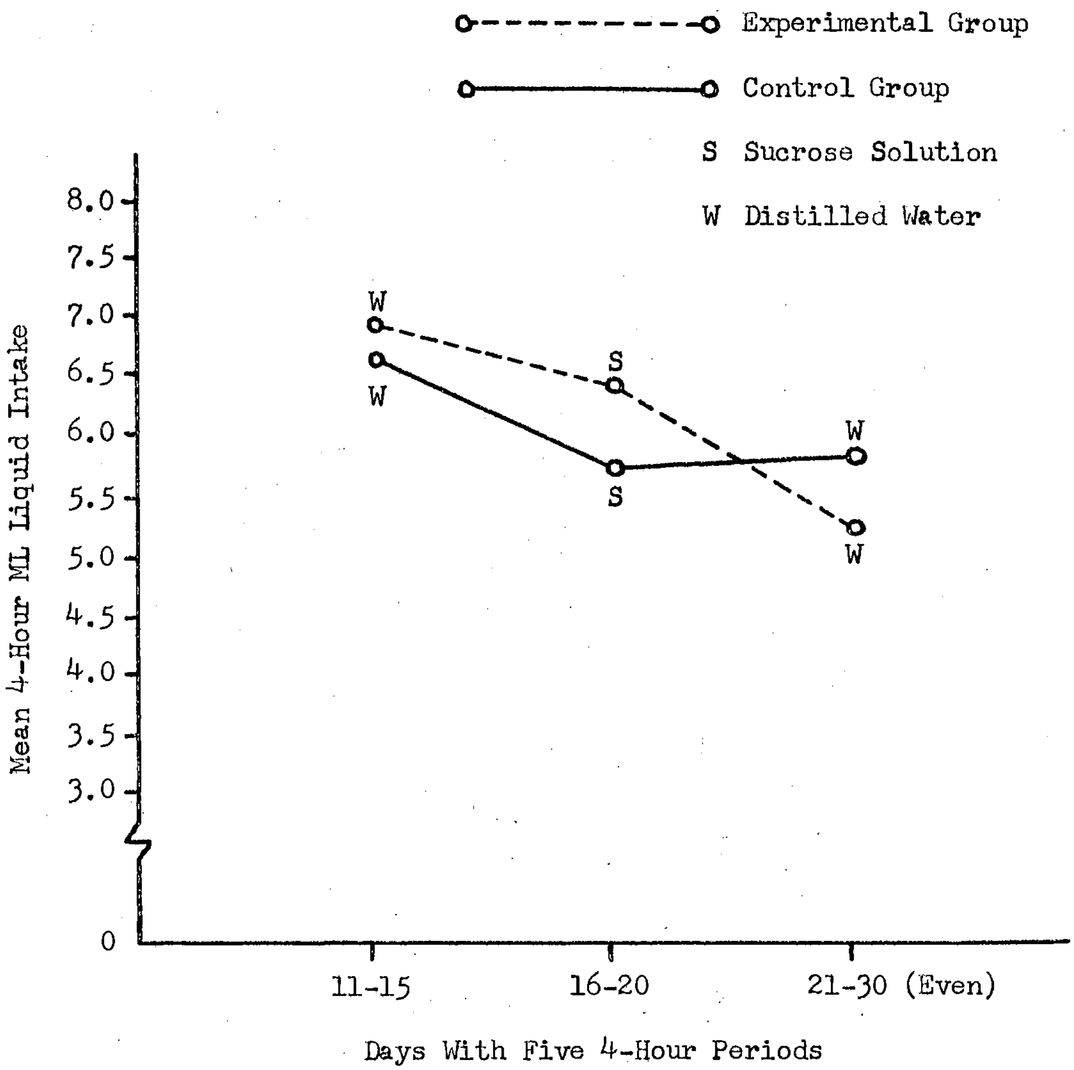

Figure 4. Mean 4-hour Fluid Intakes From Single Drinkers by Japanese Quail for Five 4-hour Periods

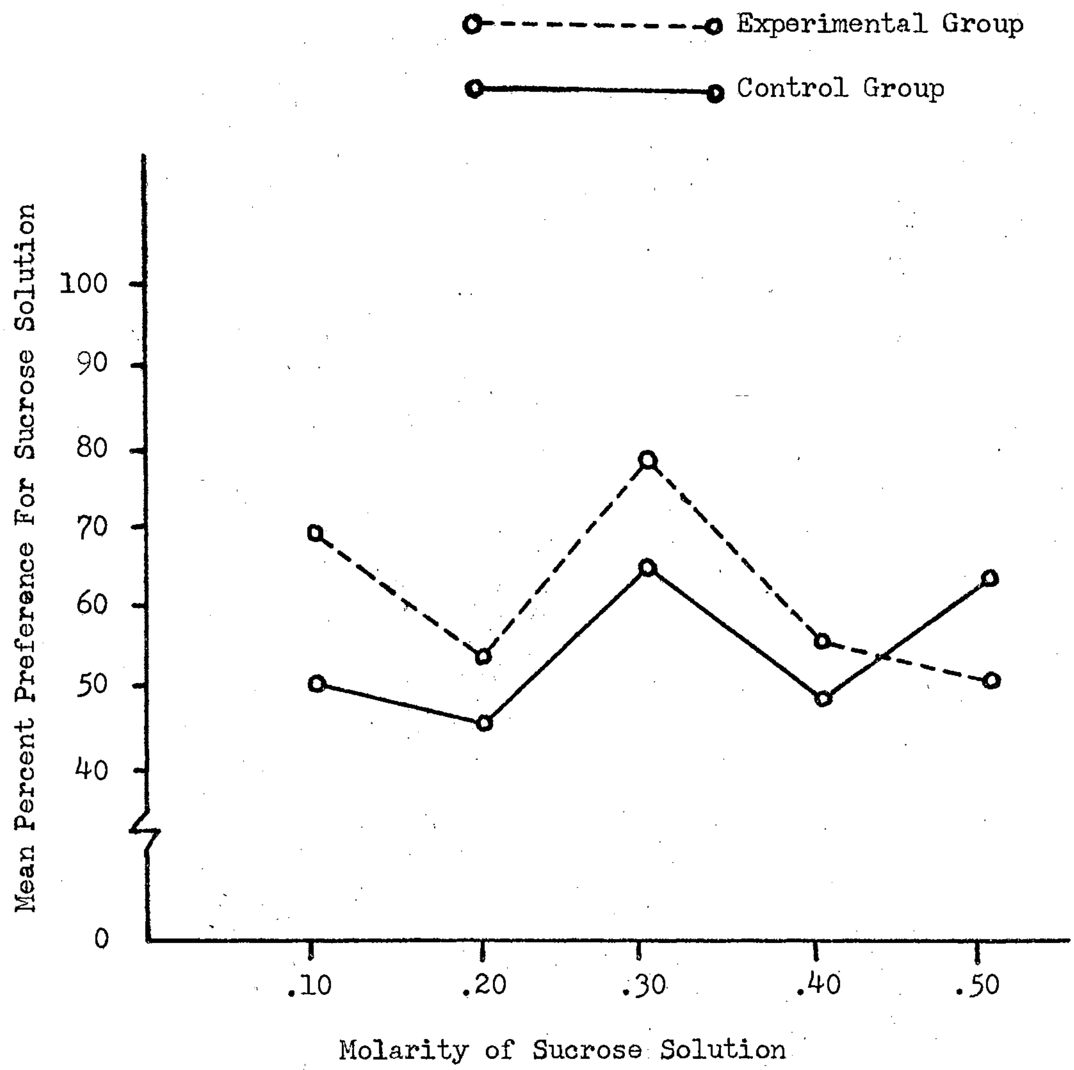

Figure 5. Mean Percent of Preference in Japanese Quail for Sucrose Over Distilled Water in Two-Bottle Drinking Preference Tests

TABLE V

SUMMARY OF THE ANALYSIS OF VARIANCE FOR SUCROSE PREFERENCE DURING THE PREFERENCE TESTING

Source				
Total	119	71,817.3807		
Between Subjects	23	7,471.4377		
Groups	1	1,280.9254	1,280.9254	4.5521*
Subjects within Groups	22	6,190.5123	281.3869	
Within Subjects	96	64,345.9430		
Concentrations	4	7,365.5374	1,841.3843	3.0332*
Groups X Concentrations	4	3,559.1202	889.9800	1.4657
Concentrations X Subjects within Groups	88	53,421.2854	607.0600	

*Significant at the .05 level

Table V indicates that the values for groups and for concentrations were significant ($P < .05$). Because the groups X concentrations interaction was insignificant ($P > .20$), only the main effects were investigated. Main effect means for concentrations are plotted in Figure 6. The main effects of concentrations were tested by means of the Duncan's Multiple Range test for individual comparisons (Winer, 1962). Table VI indicates that the 0.30 M concentration was preferred significantly more than were the 0.20 M, 0.40 M and 0.50 M concentrations. The difference between means was significant at the .05 level. No other concentration means were found to significantly differ ($P > .05$) from any other concentration mean.

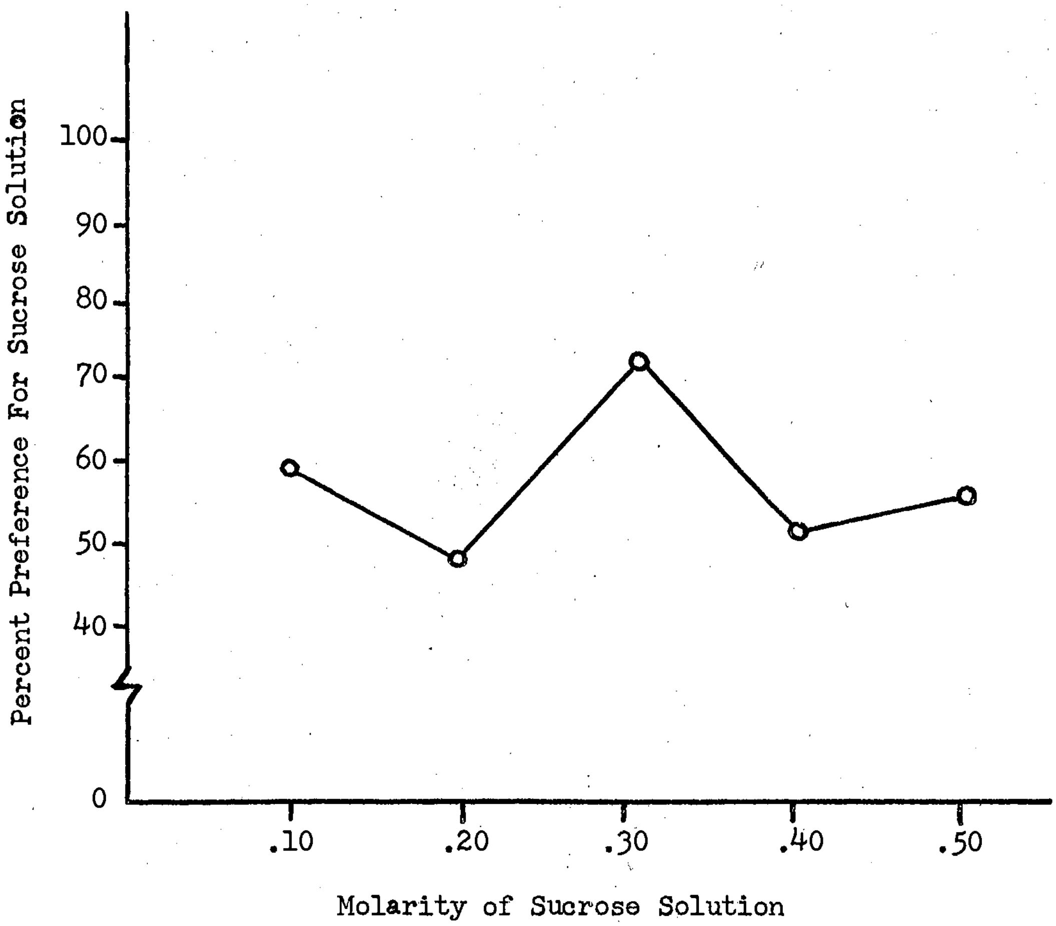

Figure 6. Mean Percent of Preference in Japanese Quail Offered Five Molarities of Sucrose in Two-Bottle Drinking Preference Tests

TABLE VI

DUNCAN'S MULTIPLE RANGE TEST ON THE MEAN PERCENTAGE OF SUCROSE INTAKE AT THE FIVE CONCENTRATIONS

Sucrose Concentrations	0.20	0.40	0.50	0.10	0.30
Means	49.65	52.78	56.96	59.98	72.34
49.65		3.13	7.31	10.33	22.69*
52.78			4.18	7.20	19.56*
56.96				3.02	15.38*
59.98					12.36

$S_{\overline{B}} = 5.02$	p = 2	3	4	5
SSR .95 (p, 88)	2.82	2.97	3.08	3.13
LSR	14.16	14.90	15.46	15.71

*Significant difference at the .05 level

CHAPTER IV

DISCUSSION

Sucrose Intake

Under the conditions of this study, there was little evidence to suggest that caloric need, *per se*, was a significant factor in the preference behavior of the quail. If caloric need had been the determinant of sucrose intake, the experimental group, which had had previous access to extra calories in the form of a .25 M concentration of sucrose presented *ad libitum* for four hours daily, would have been expected to consume smaller amounts of sucrose per 100 grams of body weight during the preference test period than the control birds. However, the analysis of variance presented in Table I does not show a significant difference at the .05 level between groups (Factor A) in the amount of sucrose intake per 100 grams of body weight.

Figure 1 indicates that for the first four molar concentrations the mean sucrose intakes of the experimental group actually exceeds the mean intakes of the control group. The control group had a greater intake only at the 0.50 M concentration. The analysis of the simple effects between groups within concentrations, shown in Table II, indicates that the only mean intake of the experimental group which significantly (.005 level) exceeded the mean intake of the control was at the 0.10 M concentration. Thus, the analysis of the main effects and simple effects indicates that caloric need was not a significant factor in the preference behavior of the birds used in the present study.

Concentration Preference

Although the F value for the main effects for concentration was not significant at the .05 level (Table I), individual comparisons appeared appropriate because of a seemingly large increase in sucrose intake at the 0.30 M concentration (Figure 2). The individual comparisons of the preference means (Table IV) indicate that the quail consumed significantly larger ($P < .05$) amounts of the 0.30 M concentration than they did of either the 0.20 M or the 0.40 M concentrations. Although the amount of sucrose solution intake was greater at the 0.30 M concentration than at either the 0.10 M or the 0.50 M concentration, differences between these concentrations were not significant at the .05 level. Thus, although it appears that quail may have a preference for the 0.30 M sucrose solution over other concentrations of sucrose, the observations are not conclusive.

Liquid Intake

Associated with caloric need in an animal is an increase in the total amount of daily liquid intake when additional calories are available in solution. Kare and Ficken (1963) report that chicks given a calorically limited diet exhibit a preference for sucrose and consume almost double their normal liquid intake. In the present experiment, the mean daily liquid intakes plotted for separate five day periods (Figure 3) do not indicate any large change in liquid consumption over days. The liquid intake in the periods during which sucrose was available showed only chance variation. Also, the mean four-hour liquid intakes plotted for five day periods (Figure 4) do not indicate any change over time.

Preference

The survey of the revelant research dictates that either indifference or preference to sucrose solution might have been expected. Kare (1965) reports that Japanese quail which are maintained on an adequate diet will not demonstrate a preference for sucrose. Thus, based on Kare's findings, a response of indifference (no apparent preference for the sugar solution or the water) toward the sucrose concentrations might have been predicted. In contrast, Brindley (1966) reports that Japanese quail will show a significant preference for a 10 percent glucose solution when maintained on an adequate diet. From Brindley's findings it might be expected that the quail would exhibit a preference for the sucrose solutions.

The mean percentages of sucrose preference for two groups at the five concentrations of sucrose are plotted in Figure 5. The data plotted in Figure 5 indicates that the experimental group exhibited a preference for sucrose at the 0.10 M and the 0.30 M concentrations and that the control group indicated a preference for the sucrose at the 0.30 M and 0.50 M concentrations. The analysis of variance presented in Table V indicates that the main effects due to groups and the main effects due to concentrations were significant at the .05 level. However, since the groups X concentrations interaction was not significant ($P > .05$), the reaction of the two groups to the different concentrations of sucrose was generally parallel or similar across concentrations even though the group main effects were different.

Thus, the preference data in this experiment support the general findings of Brindley (1966) who reported that the Japanese quail will prefer a "sweet" solution to water. Also, the results conflict with the findings of Kare (1965) who stated that the Japanese quail is indifferent to sucrose. Because Kare (1965) did not elaborate on his study or his support for the statement that Japanese quail are indifferent to sucrose, it is difficult to discuss the possible causes of the divergent findings.

At this point, consideration is given to the significant differences ($P < .05$) in sucrose preferences between groups (Table V). Even though the feeding experience of the quail prior to the experiment was similar, the concept of learning might be employed to explain the higher sucrose preference exhibited by the experimental group. One possible explanation is that when the quail were offered two drinkers (one with a sucrose solution and one with distilled water), the birds had to learn that they had a choice between two solutions and that, in some cases, one of the solutions was preferable to the other. Under these conditions, the experimental group which had had previous experience drinking a "sweet" sucrose solution, might be expected to discriminate between the two solutions quicker than the control group. The faster discrimination would result in the greater consumption of the preferred solution which was exhibited by the experimental group. This explanation is supported by the lack of significant difference in interaction effects which indicates that both groups responded in a similar manner across the concentrations and differed only in the degree of preference at each concentration.

The mean percentage preferences for the main effects of the different concentrations of sucrose are plotted in Figure 6. Figure 6 indicates that the quail were indifferent to the 0.20 M and to the 0.40 M concentrations of sucrose and, also, that the birds showed a slight preference for the 0.50 M concentration. Figure 6 further shows that the quail exhibited a strong preference for the 0.10 M and the 0.30 M concentrations. The test for differences between the means (Table VI) indicates that the 0.30 M concentration was significantly preferred over the 0.20 M, 0.40 M and 0.50 M concentrations. The difference between the 0.10 M and the 0.30 M concentrations, however, was not significant.

Thus, the results of the experiment indicate that Japanese quail exhibited differing degrees of preference for various concentrations of sucrose. Because caloric need has been demonstrated to be an insignificant factor in sucrose intake, it may be concluded that the birds' preference for sucrose was a function of the palatability (hedonic value) of the sugar and, possibly, of acquired feeding habits.

A final comment might be made on the experimental design used in this experiment. The factoral design with repeated measures on one factor is useful when a limited number of subjects are available relative to the number of treatment combinations to be studied and when time is limited. However, there is one important criticism of the repeated measures design that should be mentioned. The design tested for the between groups effects with less sensitivity than it tested for the within concentrations effects. Although it would require more subjects, the problem of differential sensitivity could be eliminated with the use of a complete factoral design without repeated measures.

Another possible solution would be the use of a Latin square design which would reduce the need for a large number of subjects. This design would tend to reduce any systematic treatment biases (carry-over effects) through counterbalancing. Also, the error variance would be reduced by the removal of variability due to the subject differences and to time effects.

CHAPTER V

SUMMARY

The study was performed to investigate the taste preference behavior of twenty-four Japanese quail (Coturnix coturnix japonica) when given a free choice between sucrose at five molar concentrations (0.10, 0.20, 0.30, 0.40 and 0.50 M) and distilled water, as well as, to study the possibility that caloric need may serve as the basis for the sugar preference. The review of the literature revealed that the behavioral data on the Avian preference for "sweetness" are contradictory. Specifically, the literature indicates that two different preference responses might be expected from Japanese quail. Kare (1965) has reported that Japanese quail, which are maintained on an adequate diet, will not demonstrate a preference for sucrose. In another study, Brindley (1966) reported that Japanese quail will show a significant preference for a 10 percent glucose solution when maintained on an adequate diet. Finally, Kare and Ficken (1963) have demonstrated that a dietary deficiency in fowl will lead to a preference for sucrose. They suggest that nutritional need might explain many of the discrepancies in the findings of behavioral taste work.

The experimental design was a two-factor factoral with repeated measures on one factor (concentrations). Twenty-four quail were randomly divided into an experimental group and a control group of equal size. During the initial ten days of the habituation period, all of the quail were presented with two graduated drinking tubes filled with distilled water. On the final five days of the 15-day habituation period (days 11-15), each quail was allowed access to the two drinking tubes with distilled water for twenty hours each day. In the remaining four-hour period, only one drinking tube with distilled water was presented to each bird. During the next five day period (days 16-20), the quail were again presented with a twenty-hour period of free choice between two drinkers filled with distilled water. However, during the remaining four-hour period, the experimental group was presented a single drinking tube containing a 0.25 M concentration of sucrose and the control group was presented a single drinking tube containing distilled water. During each of the 24-hour preference test periods, which followed the twentieth day, all of the birds were offered a free choice between one concentration of sucrose and distilled water. Five sucrose concentrations were presented to the quail in a random order, and each concentration was presented only once. Each 24-hour preference test period was followed by a 24-hour period which followed the liquid presentation schedule of days 16-20.

The results indicated that the amount of sucrose intake per 100 grams of body weight for the five concentrations by the experimental group and the control group during the preference test periods did not differ significantly. This was interpreted as indicating that caloric need was not a significant factor in the quail's preference behavior. The analysis of the mean percentages of sucrose preference for the two groups at the five concentrations was significantly different ($P \leqslant .05$). The difference between groups was attributed to the different feeding experience of the birds. Finally, the preference test data revealed that the quail manifested differing degrees of preference for the various concentrations of sucrose.

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