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TASTE PREFERENCE BEHAVIOR OF LABORATORY VERSUS WILD NORWAY RATS[1]

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Brief-exposure taste preference tests with simultaneous presentation of treated and standard foods were administered to 24 Long-Evans hooded and 24 laboratory-reared wild Norway rats (*Rattus norvegicus*). Four different taste stimuli representing the four taste qualities (sweet, sour, salty, and bitter) were each tested at four different concentrations. Responses to each taste stimulus differed significantly between concentrations, but there were no pronounced qualitative or quantitative differences between the taste preference responses of the two strains of Norway rats. Domestication, therefore, has not led to substantial changes in genetically determined taste preference behavior.

The excessive and often exclusive use of the domesticated Norway rat for laboratory research in physiology and behavior has been criticized by Richter (1954) and Lockard (1968). Although their commentaries may be justified in terms of undue concentration on a few selected strains of rats, the statement that the albino rat is an indefensible choice (Lockard, 1968), not only in species-typical behavior, but also for dietary and taste preference behavior, is apparently based on opinion and not on empirical evidence. In a bibliography of over 3,000 references on the sense of taste (Pangborn & Trobue, 1967), no reports were found indicating a direct comparison of the taste preference responses of wild and domesticated Norway rats to stimuli representing the four basic taste qualities.

Only a few published reports on taste preference behavior have dealt directly with the effects of domestication. For sweet-tasting stimuli, Maller and Kare (1965) found that albino rats showed greater preference for each of seven sweetening agents in water than did a group of wild Norways. Qualitatively, however, the taste preference profiles were similar for the two strains. Maller (1967) reported that quinine sulfate, a bitter-tasting stimulus, caused a temporary but statistically significant decrease in food intake in the laboratory rat, but no change in intake in the wild rat. Richter and Mosier (1954) showed that both wild and domestic strains would drink large amounts of water containing up to 50%–70% salt, but that salt did not produce as much thirst for untreated water in the domesticated Norways as in wild strains. No research comparing the taste preference responses of the two strains to sour-tasting stimuli has been reported.

These reported taste preference comparisons for sweet, bitter, and salty stimuli were not sensitive because, in some cases, no choice was allowed the animals, and all tests were carried out with 24-hr. consumption measures. The major difficulty in evaluating 24-hr. consumption data is that the results reflect not only initial taste preference behavior but also postingestional effects such as caloric regulation or physiological aversion.

To prevent this confounding, a short initial preference test design is a necessity for separating the taste effects from the postingestional effects. The present study used a taste preference apparatus for solid-food media developed by Thompson and Grant (1971) utilizing the foods-together brief-exposure concept described by Young and Kappauf (1962). Both strains were tested for taste preference responses to the four

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basic taste qualities, each at four different concentrations, in order to investigate the following questions:

1. Does either strain of rat require a higher concentration of a compound to effect a change in taste preference?

2. Is there a Taste Quality × Rat Strain interaction as indicated by the taste preference profiles of the two strains for the four taste qualities?

3. Does the domesticated strain exhibit less sensitivity and more variability in the taste preference response than the wild Norway rat, as Lockard (1968) contended?

METHOD

Subjects

Twenty-four wild Norway (18 males and 6 females) and 24 male Long-Evans hooded rats were used. The wild rats had been born and reared in the laboratory and were the progeny of mated pairs of live-trapped wild Norways. All rats were about 150 days old and weighed 175–200 gm. Each rat was maintained on ad-lib food and water between tests, with the restriction that animals with extremely slow preference responses in the training period were deprived of food for 12 hr. before testing.

Media

Each of the four taste stimuli was tested in food pellets at four concentrations (shown in the abscissas in Figure 1). The concentration limits for each stimulus were chosen by examining Pfaffmann's (1963) preference data for sucrose and sodium chloride and Koh and Teitelbaum's (1961) rat behavioral threshold data for the four taste qualities. The lowest concentrations of all four stimuli were near or below the threshold, and the highest value for sucrose was chosen to reflect preference rather than aversion. For quinine hydrochloride, all concentrations were reduced by 1.0 log unit to prevent total aversion.

All pellets were based on ground wheat and weighed 30 mg. each. Within each test, the basic pellet formulation was the same for the treated and standard (untreated) foods. For sucrose and sodium chloride, a mixture of 25% wheat and 75% Avicel[3] (an odorless, tasteless, nonnutritive bulk filler) was used to prevent the taste of wheat from masking the sweet and salty stimuli. For citric acid and quinine hydrochloride, 100% wheat pellets were used to increase palatability.

[3] Trade name of FMC Corporation, American Viscose Division, Newark, Delaware. Reference to trade names does not imply endorsement of commerical products by the Federal Government.

Apparatus and Procedure

The 24 hooded and 24 wild Norway rats were each divided randomly into four groups of 6 rats each. Each group received a different stimulus, but all four concentrations were tested on each rat.

Preference behavior for each animal was measured using an automated taste preference apparatus which has been previously described in detail (Thompson & Grant, 1971). The apparatus is programmed such that the animal briefly samples each food alone before the two foods are presented together for choice behavior. Temporal and spatial position habits are minimized by alternately presenting the foods with sequence and positions reversed. The apparatus (three of which were used) basically consists of two interconnected modules; the preference tester (Module 1) and the relay-programming, photocell-amplified, and impulse-counter unit (Module 2) which is located in an adjoining sound-attenuated room. The preference tester (Module 1) is placed directly into the cage of each rat so that no animal handling is necessary. Module 1 is composed of photocell sensors, a limit switch, a reversible electric motor, and a gear-driven circular feeding tray divided into quadrants. Each quadrant of the feeding tray contains a removable stainless-steel cup for weighing purposes. Only one of the feeding quadrants is presented to the rat at a time, and the eating time limit (photocell break time) allowed the animal in the quadrant is predetermined by a criterion counter in Module 2. When the criterion counter registers the required eating time exposure, the next quadrant rotates into position allowing access by the rat to the next food or foods in that quadrant. Two of the quadrants (A and B) are used for the nonchoice food sampling positions, and the remaining two quadrants (A/B and B/A) are bisected for the choice positions. In a typical choice cycle, the rat samples Food A (accumulates 3 sec.), samples Food B (accumulates 3 sec.), chooses between A and B presented simultaneously (accumulates 6 sec.), samples Food B, samples Food A, and finally chooses between B and A (i.e., positions reversed).

Before preference testing, each rat was conditioned to eat untreated pellets from the device. All food compartments contained 1.25 gm. of 30-mg. 100% wheat pellets, and Module 1 was placed in the animal's cage each day until 16 cycles had been completed. When the animal appeared to have become accustomed to the sounds and movements of the device (16 cycles achieved in about 30 min.), uniformity data (consumption and time spent eating) were tabulated for that animal.

After the uniformity data appeared to be stable and unbiased by the movement of the apparatus, preference testing was initiated. To determine preference, 1.25 gm. of the standard food was placed in each of the three A (or B) compartments, and an equal amount of treated pellets at the lowest of the four concentrations was placed

in the three B (or A) compartments. For alternate rats, the placement of the standard and treated foods was interchanged. When at least 16 cycles (32 choices) had been completed, the device was removed from the rat's cage, and the time it had spent eating the standard and treated foods (nearest .1 sec.) and the amounts consumed (nearest 1.0 mg.) were recorded. To minimize any position habits or bias the animal might have had with respect to the movement of the food compartments, it was retested the next day with the same concentration but with the position of the standard and treated foods reversed. Tests with progressively higher concentrations were conducted in this same manner, with no more than 2 days between tests, until each animal had received all four concentrations.

Preference scores were computed for each animal on each test day by the equation $P = 100\ T/(T + U)$, where P is the percentage preference for the treated food, T is the weight of treated food consumed (or the time spent eating the treated food), and U is the weight of untreated food consumed (or the time spent eating the untreated food).

Results

Both the Long-Evans hooded and wild Norway strains adapted to the taste preference devices with 3 or 4 days of conditioning. For all eight groups of rats the uniformity data indicated that there were equal preferences based on consumption and time for the A and B choice compartments when the choice positions were reversed upon replication and mean values computed. It was noted that the preference scores based upon consumption were more sensitive and reliable indicators of preference. The time measures may not have necessarily reflected only ingestion behavior but also olfactory sampling or random head movement by the rat. All preference scores for treated pellets were therefore based on consumption rather than time measures.

A comparison of the mean preference behavior of the two strains for the four taste qualities at each of the four concentrations is indicated in Figure 1. When the mean percentage preference scores at the highest concentration of each taste stimulus are ordered from greatest to least preference, the stimuli form the following pattern for both hooded and wild rats: sucrose, sodium chloride, citric acid, and quinine hydrochloride. In the case of sucrose, the preference for treated pellets increased significantly ($F = 166.67$, $df = 3/8$, $p < .01$) in direct proportion to the concentration for both strains. Although the wild rats showed slightly more preference for the sucrose-treated pellets throughout this concentration series, the difference between strains was not statistically significant ($F = .74$, $df = 1/8$, $p > .1$). The citric-acid-treated pellets produced progressive decreases in preference across the four concentrations. The concentration effects were significant ($F = 66.05$, $df = 3/8$, $p < .01$), whereas the strain effects were not ($F = 1.06$, $df = 1/8$, $p > .1$). Both strains showed progressive aversion to the higher concentrations of sodium chloride ($F = 18.06$, $df = 3/8$, $p < .01$) and again there were no strain differences ($F = 1.59$, $df = 1/8$, $p > .1$). Similarly, with quinine hydrochloride, a marked taste aversion developed in both strains at the higher concentrations. There was a statistically significant concentration effect ($F = 107.71$, $df = 3/8$, $p < .01$) and no strain effect ($F = 2.39$, $df = 1/8$, $p > .1$).

The mean preference scores are shown in Table 1, along with the standard deviations, coefficients of variation, and mean differences for each stimulus, concentration, and strain. With six animals per treatment, the standard deviation values were quite large, but did not appear larger in relation to the mean for one strain than the other. Coefficients of variation were highly similar for both strains throughout the conditions of the experiment. In 10 of the 16 cases, the preference scores of the wild Norways exceeded those of the hooded rats. This may indicate that small differences do exist in the gustatory systems of the two strains, but these differences are not distinct. It would be expected that the wild rats would show more sensitivity to different tastes, since this would be an asset for survival in the wild. However, with the three taste stimuli that lead to progressive aversion at the higher concentrations (salt, quinine, and citric acid), the preference scores of the wild Norways exceeded those of the hooded rats in only 6 of the 12 conditions.

Discussion

From both the qualitative and quantitative aspects of taste preference behavior,

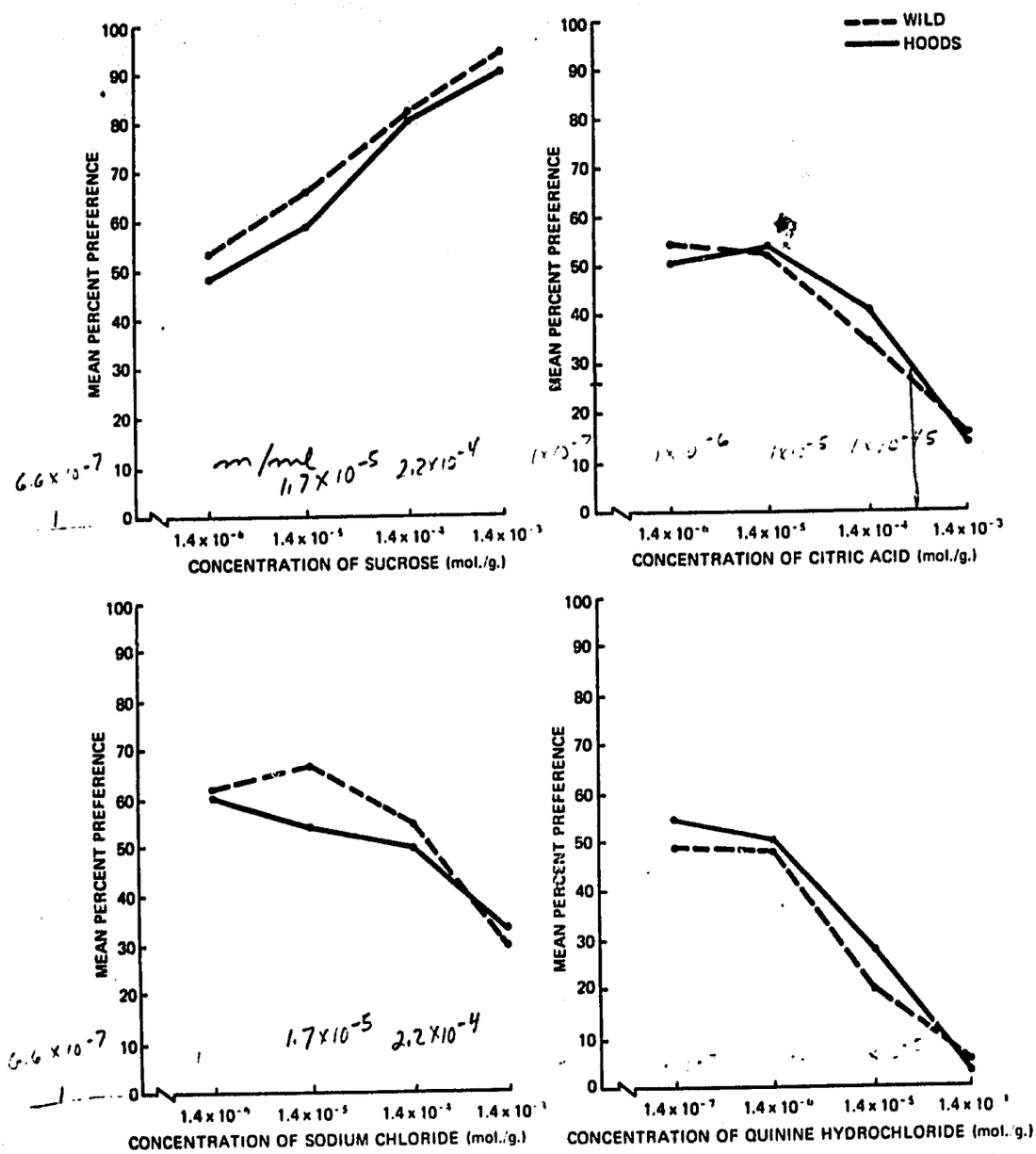

FIG. 1. Mean percentage preference response of hooded and wild Norway rats to four concentrations of four taste stimuli representing the four taste qualities.

the domesticated Long-Evans hooded rat does not seem to differ appreciably from the wild Norway rat. Since Lockard (1968) claims that most albino rats are black and hooded, although the coat color is not phenotypically expressed, this similarity to wild rats in taste preference response may be generalized to other domesticated strains.

Through low or neutral selection pressure, the domestic strains should exhibit greatly increased variability over the wild strains in sensory function and dietary preference

(Lockard, 1968). As indicated in Table 1, however, both strains showed quite similar coefficients of variation throughout the experiment. A regression analysis on the coefficients of variation for these two strains, in fact, indicated that the variations were highly correlated ($r = .92$, $df = 30$, $p < .01$) with a regression-line slope close to 1.0 ($b = 1.20$, $C[-.27 \leq \beta \leq 2.67] = .95$).

Although previous reports (Maller, 1967; Maller & Kare, 1965; Richter & Mosier, 1954) have indicated qualitative and quantitative differences in taste preference behavior between wild and domestic rat strains, these studies were deficient in two respects. The wild rats were live trapped, giving this strain the advantage of a more diversified taste history, and 24-hr. consumption tests were used, which confounded taste preference behavior with postingestional factors.

In the present study, a brief-exposure foods-together preference test was used with wild and domesticated strains that had both been reared in the laboratory on identical diets. If differences in the taste preference behavior of these two strains had been observed, a true genetic effect would have been implied. In the absence of these differences, it must be concluded that the domestication of the Norway rat has had few if any genetic effects on taste preference behavior.

The results of the present study must be restricted to taste preference and do not necessarily indicate equal taste sensitivity for the two strains. It is apparent, however, that the taste thresholds, as roughly estimated by preference behavior, are not extremely different. Fish and Richter (1946) found that the number of foliate papillae on the tongues of the two strains appeared to be the same but that the domestic rats had 17% fewer fungiform papillae than the wild rats. The relation between taste sensitivity and number of papillae, however, is still relatively unknown. Neither behavioral nor electrophysiological taste threshold comparisons between wild and domesticated Norway rats for the four basic taste qualities have been reported.

Whether or not to use a particular strain of Norway rat is a question that is not often carefully considered in behavioral and physiological research (Lockard, 1968). Without the support of comparative data, however, it should not be assumed that the wild strain is always genetically superior to the domesticated strain.

TABLE 1

MEAN PREFERENCE RESPONSES, STANDARD DEVIATIONS, COEFFICIENTS OF VARIATION, AND MEAN DIFFERENCES FOR FOUR TASTE STIMULI, FOUR CONCENTRATIONS, AND TWO STRAINS OF RATS

Statistic	Concentration 1		Concentration 2		Concentration 3		Concentration 4	
	Hooded	Wild	Hooded	Wild	Hooded	Wild	Hooded	Wild
Sucrose								
$\bar{X}$[1]	47.39	52.30	57.87	64.74	78.87	79.15	88.71	91.88
SD	19.68	19.67	23.84	26.08	28.31	29.31	30.63	28.60
CV	.42	.38	.41	.41	.36	.37	.35	.31
$\bar{X}_H - \bar{X}_W$	−4.91		−6.87		−2.80		−3.17	
Sodium chloride								
$\bar{X}$	59.25	60.30	52.98	65.41	49.39	53.84	31.91	29.76
SD	20.08	23.26	17.32	28.11	18.98	28.44	17.96	19.45
CV	.34	.26	.31	.43	.39	.59	.56	.62
$\bar{X}_H - \bar{X}_W$	−1.05		−12.43		−4.45		2.15	
Quinine hydrochloride								
$\bar{X}$	53.43	47.84	48.93	46.85	27.04	19.20	1.92	4.01
SD	20.64	15.72	17.58	15.05	17.60	19.03	4.26	6.45
CV	.39	.33	.36	.32	.65	1.00	2.22	1.61
$\bar{X}_H - \bar{X}_W$	5.59		2.08		7.84		−2.09	
Citric acid								
$\bar{X}$	50.41	54.03	53.57	52.14	40.95	34.64	13.81	15.79
SD	15.87	18.38	18.39	17.55	15.38	19.48	14.64	17.01
CV	.31	.34	.34	.30	.38	.56	1.06	1.08
$\bar{X}_H - \bar{X}_W$	−3.62		1.43		6.31		−1.98	

Note.—Abbreviations: CV = coefficient of variation; H = hooded; W = wild.

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