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Food and water intake prior to parturition in the rat*

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Food and water intakes were measured in pregnant rats to determine whether parturition in rats is preceded by significant changes in food and water intake. Three diets of different palatability and caloric value were used. Over the last 5 days of pregnancy, pregnant rats were found to ingest more calories/day than nonpregnant rats, and females with prior parturitional experience (multiparous) ingested more than virgin or primiparous females. Pregnant rats also ingested significantly greater amounts of fluid when compared to nonpregnant rats, and multiparous rats (pregnant or not) ingested greater amounts of fluid than did virgin or primiparous pregnant rats. On the last day of pregnancy, the intake of solid foods or a liquid diet did not change significantly, but the intake of either water or 5% sucrose solution was significantly reduced.

Little is known about the ingestive antecedents of parturition. Examining immediately prepartum ingestive behavior may provide clues to internal physiological changes taking place as well as providing information about the female's motivation to eat placenta.

Decreases in food intake just prior to parturition have been reported in certain of the ungulates such as the cow and mare (Fraser, 1968). These periods of hypophagia, however, are usually intermittent, are a characteristic of the late prepartum period, and are usually accompanied by the discomfort of labor (Fraser, 1968). Changes in food and water intake in rodents during late pregnancy have received little or no attention in the literature. Graphs presented by Barnett and Burn (1970) to describe various oral behaviors (chewing, feeding, and drinking) during late pregnancy and early lactation indicate that mice exhibit a slight decrease in food and water intake on the last day of pregnancy, but this phenomenon was not described in detail. We expected that rats would demonstrate the same decrease in food and water intake observed in mice prior to parturition, but preliminary observations in our laboratory indicated that rats manifest a relatively normal level of food intake in the last 24 h of pregnancy. The present study was then undertaken to examine food and water intake in the rat over the last 5 days of pregnancy.

To test for a change in ingestion brought about by an alteration of taste preference during the last 24 h of pregnancy, three diets of different degrees of palatability were used.

METHOD

Subjects

Thirty-nine female rats of a Sprague-Dawley-derived strain (Carworth CFE), 100-150 days of age and weighing 250-350 g, were used. Twenty-three of these were virgins (inexperienced), and 16 had given birth to more than one litter (multiparous). The females were housed in individual wire-mesh cages and maintained on a 12/12-h day-night cycle throughout the experiment. Vaginal smears were taken daily from the nonpregnant females, and intakes on the day of estrus were excluded to eliminate the depression in food and water intake observed during estrus (Tarttelin & Gorski, 1971).

Procedure

Nine virgin females and six experienced females were time-bred with proven breeder males. When copulation was indicated by the presence of sperm in the vagina, the female was considered to be in the first day of pregnancy. The ad lib diet of tap water and food pellets (Purina Lab Chow) was continued until the 14th day of pregnancy, the beginning of the third trimester. At that time, the pregnant females were assigned to one of three diet groups, each comprising three inexperienced and two experienced females. The first group (Diet 1) received a premeasured quantity of tap water and food pellets each day, the standard laboratory diet. A sheet of paper was placed under the cage to catch spillage. The paper was removed each day and dried for 24 h before the amount of spillage was determined. Tap water was presented in 100-ml glass founts (Wahmann, Baltimore), which were refilled each morning in conjunction with the presentation of pellets.

The second group (Diet 2) received a more palatable diet, consisting of a drinking solution of 5% sucrose and a high-fat diet made of two parts of ground laboratory chow (Purina) and one part vegetable shortening (Crisco) (Corbit & Stellar, 1964). Paper was placed under each cage to catch spillage. The dish was weighed each morning and replaced every third day. The sugar water was presented in 100-ml glass founts and replenished twice daily.

The third group (Diet 3) received a less palatable and less caloric dense form of the "eggnog" developed by Teitelbaum and Epstein (1962), consisting of 240 ml Similac (Ross), 50 ml reconstituted whole egg, 100 ml of 50% (w/v) sucrose solution, 9 g dry ground baby cereal (Gerber Mixed Cereals), 150 ml distilled water, and 1 ml/100 ml solution of 10% Formalin as a preservative.

Fourteen virgin and 10 multiparous females were used as nonpregnant controls. The females were divided into the following groups: five virgin and three multiparous females received a diet of pellets and tap water (Diet 1); four virgin and three multiparous females received a diet of high-fat mash and sucrose solution (Diet 2); and five virgin and four multiparous females received a diet of eggnog (Diet 3). Each nonpregnant female received 11 or 12 days of constant exposure to the diet. All food and water intake determinations were made at the same time daily.

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Table 1
Daily Food and Water Intake of Nonpregnant and Pregnant Female Rats on Three Diets

Group	N	Diet 1 Pellets*	Diet 1 Tap Water†	N	Diet 2 High-Fat Mash*	Diet 2 Sugar Water†	N	Diet 3 Eggnog†
Nonpregnant-Without Estrus								
Virgin	5	16.3 ± 0.37	32.5 ± 1.22	4	8.9 ± 0.42	77.5 ± 5.57	5	65.8 ± 1.42
Multiparous	3	17.7 ± 0.55	46.1 ± 3.49	3	10.6 ± 0.49	112.3 ± 12.72	4	92.2 ± 2.17
Combined	8	16.8 ± 0.32	37.9 ± 1.79	7	9.7 ± 0.34	92.3 ± 6.64	9	77.9 ± 2.03
Pregnant (Base Level)								
Primiparous	3	20.5 ± 0.75	40.4 ± 4.54	3	12.0 ± 4.17	86.7 ± 16.43	3	79.9 ± 8.09
Multiparous	2	28.1 ± 3.61	68.2 ± 17.15	2	14.6 ± 2.50	195.4 ± 13.61	2	61.5 ± 6.00
Combined	5	23.5 ± 2.22	51.5 ± 9.04	5	13.0 ± 2.50	130.2 ± 28.44	5	72.6 ± 6.60
Pregnant (Last Day)								
Primiparous	3	19.3 ± 2.88	14.0 ± 9.08	3	8.3 ± 0.20	19.3 ± 11.39	3	55.3 ± 10.49
Multiparous	2	27.5 ± 0.60	43.0 ± 15.00	2	15.5 ± 10.25	45.0 ± 33.01	2	65.0 ± 23.01
Combined	5	22.6 ± 2.55	25.6 ± 9.88	5	11.2 ± 3.70	29.6 ± 13.69	5	59.2 ± 9.57

*$\bar{X}$ *gm/day* ± *SE* †$\bar{X}$ *ml/day* ± *SE*

RESULTS

Food intake on all three diets remained relatively stable over the last trimester of pregnancy; therefore, only the last 5 days prior to parturition were used. Days 2-5 prior to parturition were used to compute the base level intake for the pregnant females, and the last 24 h of pregnancy are referred to as the last day or Day 1. The raw daily food and fluid intake values for all groups are presented in Table 1.

To equate all three diets, daily intake was converted to caloric intake for certain analyses. The caloric values of dry pellets and of high-fat mash are 3.61 kcal/g and 5.50 kcal/g, respectively (Corbit & Stellar, 1964). The caloric values of 5% sucrose solution and of eggnog were computed to be 0.2 kcal/ml and 0.87 kcal/ml, respectively. The daily total caloric intake values for all groups are presented in Table 2.

The elimination of intake values on the days of estrus in the nonpregnant group resulted in a mean increase in daily intake values of 4.14% ± 1.44%. The increase was reliable in that the mean raw-intake values of all 10 cells in Table 1 increased after the removal of estrus days.

An analysis of variance (ANOVA) applied to the pregnant base level (Days 2-5) caloric intake and nonpregnant level of caloric intake indicated that pregnant females ingested a significantly greater number of calories per day on all diets ($F = 29.60$; $df = 1,27$; $p < .001$). When the three diets were compared, both pregnant and nonpregnant females exhibited differences in base level intake ($F = 18.13$; $df = 2,27$; $p < .001$). A Duncan multiple range test indicated that the total daily caloric intake was significantly greater on Diet 2 (high-fat mash and 5% sucrose) in both pregnant and nonpregnant females than it was on Diet 3 (eggnog) or on Diet 1 (pellets and water), but the caloric intake on Diet 1 did not differ from that of Diet 3. Caloric intake of multiparous females was significantly greater than that of inexperienced females ($F = 26.82$; $df = 1,27$; $p < .001$) when both pregnant (base level) and

Table 2
Daily Caloric Intake of Nonpregnant and Pregnant Female Rats on Three Diets

Group	N	Diet 1* Total kcal/Day $\bar{X}$ ± SE	N	Diet 2** Total kcal/Day $\bar{X}$ ± SE	N	Diet 3† Total kcal/Day $\bar{X}$ ± SE
Nonpregnant-Without Estrus						
Virgin	5	58.8 ± 1.33	4	64.6 ± 6.62	5	57.3 ± 1.23
Multiparous	3	63.7 ± 1.98	3	81.3 ± 10.28	4	80.2 ± 1.88
Combined	8	60.8 ± 1.15	7	71.7 ± 11.78	9	67.7 ± 1.76
Pregnant (Base Level)						
Primiparous	3	74.0 ± 2.71	3	83.3 ± 21.27	3	69.5 ± 7.04
Multiparous	2	101.4 ± 12.97	2	119.4 ± 11.03	2	53.5 ± 5.22
Combined	5	85.0 ± 8.01	5	97.7 ± 15.03	5	63.1 ± 5.75
Pregnant (Last Day)						
Primiparous	3	69.8 ± 10.39	3	49.5 ± 2.91	3	48.1 ± 9.13
Multiparous	2	99.3 ± 2.16	2	94.5 ± 62.98	2	56.6 ± 20.01
Combined	5	81.6 ± 9.22	5	67.5 ± 22.80	5	51.5 ± 8.32

Diet 1: pellets = 3.61 kcal/gm
**Diet 2: high-fat diet = 5.5 kcal/gm; 5% sucrose in water = 0.2 kcal/ml*
†Diet 3: eggnog = 0.87 kcal/ml*

Table 3
Daily Caloric Intake Per Gram of Body Weight of Nonpregnant and Pregnant Female Rats on Three Diets

Group	Diet 1 N	Diet 1 $\bar{X}$ kcal/gm body weight/day ± SE	Diet 2 N	Diet 2 $\bar{X}$ kcal/gm body weight/day ± SE	Diet 3 N	Diet 3 $\bar{X}$ kcal/gm body weight/day ± SE
Nonpregnant-Without Estrus						
Virgin	5	.277 ± .024	4	.300 ± .014	5	.293 ± .019
Multiparous	3	.193 ± .015	3	.247 ± .037	4	.257 ± .011
Combined	8	.246 ± .048	7	.277 ± .037	9	.277 ± .042
Pregnant (Base Level)						
Primiparous	3	.217 ± .017	3	.203 ± .089	3	.189 ± .012
Multiparous	2	.259 ± .017	2	.313 ± .036	2	.133 ± .029
Combined	5	.234 ± .027	5	.247 ± .089	5	.167 ± .035
Pregnant (Last Day)						
Primiparous	3	.194 ± .036	3	.120 ± .021	3	.129 ± .031
Multiparous	2	.240 ± .021	2	.242 ± .224	2	.137 ± .073
Combined	5	.212 ± .038	5	.169 ± .131	5	.133 ± .043

nonpregnant groups on all three diets were combined. However, the mean body weight of multiparous rats was significantly higher than that of virgin or primiparous rats ($t = 22.9$; $df = 24$; $p < .001$). Table 3 summarizes the daily intake of the pregnant and nonpregnant females on the basis of calories ingested per gram of body weight.

An ANOVA applied to the caloric intake level of the nonpregnant females and the last-day caloric intake of the pregnant females would seem to indicate that on the last day of pregnancy, females decrease their caloric intake to a level not significantly different from that of nonpregnant females ($F = 0.13$; $df = 1,27$; $p > .1$). However, analysis of the number of kcal/day derived on Day 1 from the solid components of Diet 1 and Diet 2 indicated that caloric intake of the solid component on Day 1 is not significantly different between Diets 1 and 2 ($F < 1.0$) and does not change from pregnant base level ($F < 1.0$). Therefore, the decrease in total caloric intake to nonpregnant levels on the last day was due primarily to the decrease in intake of the fluid component of Diet 2 (5% sucrose solution). The decrease on the last day of the kcal/g body weight values (see Table 3) can be accounted for by the rapidly increasing body weight during the last 5 days of pregnancy.

When it was found that caloric intake was reduced on Day 1 prepartum because of a reduction in intake of 5% sucrose solution, the raw fluid-intake values of Diet 1 and Diet 2 were compared directly. Because of the greater palatability of the sucrose solution, the base level intake of sucrose (Diet 2) for all females was significantly greater than the base level intake of tap water (Diet 1) for all females ($F = 95.77$; $df = 1,17$; $p < .001$). Pregnant base level fluid intake on both diets was significantly greater than the nonpregnant fluid intake level ($F = 16.26$; $df = 1,17$; $p < .001$). Experienced females ingested greater amounts of fluid, regardless of pregnancy or diet, than did inexperienced females ($F = 40.79$; $df = 1,17$; $p < .001$). Furthermore, there was a significant interaction between pregnancy and experience ($F = 9.47$; $df = 1,17$; $p < .01$) in that pregnant, experienced females ingested greater amounts of fluid than did either nonpregnant, experienced females or pregnant, inexperienced females. There was also a significant interaction between diet and experience ($F = 12.59$; $df = 1,17$; $p < .01$); the greatest amount of fluid ingested was by experienced females on Diet 2.

Absolute intake of both tap water and sucrose solution decreased significantly in pregnant females on the last day prior to parturition (see Table 1), as compared to the respective pregnant base levels (tap water: $F = 99.65$; $df = 1,4$; $p < .001$; sucrose solution: $F = 16.31$; $df = 1,4$; $p < .05$). To eliminate the possibility that the marked decrease in fluid intake observed in the last day of pregnancy was merely the result of a steady decrease in intake over the preceding 4 days, analyses of trend were performed on Days 2-5 for each group. No significant linear, quadratic, or cubic component was found in any group.

Since the fluid intake of pregnant females was greater than that of nonpregnant females, further analyses were performed comparing the intake on the last day of pregnancy with the nonpregnant levels. Although last-day sucrose solution intake was significantly lower than the nonpregnant level for sucrose solution ($t = 2.789$; $df = 10$; $p < .02$), it was not significantly different from last-day tap-water intake ($t = 0.24$; $df = 8$; $p > .1$) or from nonpregnant, tap-water intake level ($t = 0.742$; $df = 11$; $p > .1$). Furthermore, last-day tap water intake of the pregnant females was not significantly different from nonpregnant tap-water intake level ($t = 1.383$; $df = 11$; $p > .1$). The fluid intake of the pregnant females on both diets over the last 5 days of pregnancy is presented in Fig. 1.

The pregnant base level of eggnog intake (see Table 1) was not significantly greater than the nonpregnant level ($t = 0.604$; $df = 12$; $p > .1$). The last day's intake decreased to a level below, but not significantly different from, either pregnant base level or nonpregnant level. The decrease from pregnant base level may be

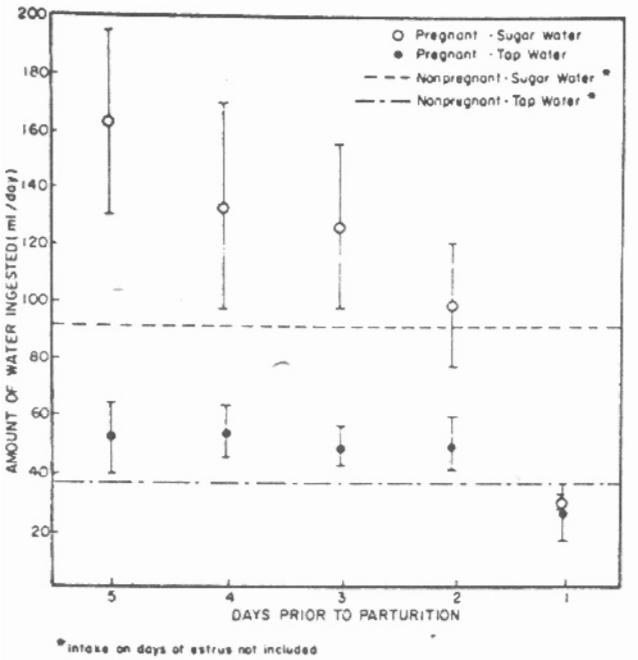

Fig. 1. Intake of tap water and sucrose solution in pregnant females prior to parturition and in nonpregnant females.

attributable to the high water content of the diet.

In summary, (1) pregnant females ingested a greater number of calories per day than did nonpregnant females; (2) females with prior parturitional experience ingested a greater number of calories per day than females which had never given birth; (3) females ingested a relatively constant number of calories per day regardless of the palatability of the diet; (4) pregnant females ingested a greater amount of fluid than did nonpregnant females; (5) pregnant females exhibited a significant decrease in intake of water or 5% sucrose solution, but not of solid food or eggnog, on the last day prior to parturition; (6) the intake levels of tap water and of sucrose on the last day of pregnancy did not differ, regardless of the magnitude of the difference seen in pregnant females prior to the last day; and finally, (7) when only a fluid diet was available, caloric intake was stable through the last day of pregnancy and did not decrease on the last day as did fluid intake on Diets 1 and 2.

DISCUSSION

The caloric intake of the pregnant and nonpregnant rats on all diets in the present experiment is in general agreement with gross energy intake values of pregnant and nonpregnant adult rats reported by Warner (1962). Warner reported that nonpregnant female rats ingest about 52 kcal/day and that pregnant rats ingest about 76 kcal/day while feeding on a diet of pellets and water. The greater intake of the pregnant females is expected, because the pregnant females are laying down body fat, manufacturing milk, and sustaining fetuses. The higher intakes of multiparous females can be attributed to the significantly higher body weights of those females when compared to virgin or primiparous females.

Although the total caloric intake of the pregnant rats on Diet 2 in the present experiment was greater than the values reported by Warner, the increased caloric intake may be attributed to the higher palatability of both high-fat diet (vs pellets and eggnog) and of 5% sucrose solution (vs water). On the last day of pregnancy, the intake of the fluid component of Diets 1 and 2 decreased, but no change was observed in the intake of the solid component of the diets. At that time, the total caloric intake value of Diet 2 returned to a level closer to that reported by Warner. The decrease in the caloric intake of Diet 2 on the last day of pregnancy is the result of a substantial decrease in the intake of 5% sucrose solution.

The present experiment provides clear evidence that the intake of fluids of low caloric density decreases sharply on the last day prior to parturition. When a fluid of higher caloric density is presented and no alternative diet is available, the diet appears to be treated by the rat as if it were solid food, and no significant decrease is seen on the last day. The lower intake of eggnog (Diet 3) by multiparous pregnant females (base level), in comparison to other rats on the same diet, is inconsistent with that of the other groups (see Table 1), but may be attributed to the small N. One of the two females showed unusually low intake values.

On a diet of pellets and water, the normal water/food ratio for rats of approximately 2 ml water/gram of food eaten is markedly reduced on the last day of pregnancy, while the absolute level of solid food ingested remains constant. This decrease in fluid intake cannot be attributed to the discomfort of labor or to the lack of time available to devote to ingestion, since either condition would also produce a decrease in food intake.

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