Reports

Effect of Starvation on Sperm Count and Sexual Reflexes

The relationship between the state of nutrition and sexual fertility is quite controversial. Huxley (*1*), Mason (*2*), Rommer (*3*), and Henshaw (*4*) maintain that good nutrition increases fertility, while Doubleday (*5*), Reid (*6*), and De Castro (*7*) claim that inanition increases fertility, as is suggested by Adam Smith's (*8*) observation that poverty favors generation. Jackson (*9*) reports that, although extreme famine inhibits libido and fertility, certain wild animals, such as the salmon, goose, and fur-seal, fast during the mating season, as does the penguin, as was observed by Sladen (*10*). Katcher (*11*) has noted that plants raised in inadequate soil produce more seed than plants grown in fertilized soil. In a recent exhibit, we (*12*) demonstrated that starvation is associated with an increase in sperm count.

In 13 male dogs, five failed to respond with ejaculation on genital stimulation. These animals were shy and evasive and were fearful when they were handled. Of the remaining eight animals, three had clear semen devoid of sperm, and in the other five sperms were present.

The semen was collected and measured during 1 minute of genital stimulation three times a week. In addition to the sperm count, the degree of erection and the latency and duration of enlargement of the bulbus cavernosus were observed. Two experiments involving 5 and 10 days of starvation, respectively, were carried out 1 year apart.

With 5 days of starvation, the weight loss was as follows for the animals named: Sampson, 3 lb; Choptank, 6 lb; English, 3 lb; and Poco 8 lb. Three dogs showed an increase in sperm count per cubic centimeter during the starvation period, and one, Poco, about 14 years old, showed aspermia prior to, as well as during, starvation.

With 10 days of starvation the dogs showed the following weight loss: Sampson, 2 lb; Choptank, 3.5 lb; English, 2 lb; and Poco, 8.5 lb. Within 3 days after the end of starvation, these dogs gained 3.5 lb, 5 lb, 5.5 lb, and 6 lb, respectively.

Table 1 records the sperm counts of the four dogs studied. There were individual differences. Sampson again showed the greatest variation in sperm count prior to the starvation period. During the starvation period the count rose considerably. Following the starvation period the sperm count fell again to about the original level. In this experiment Choptank showed relatively less fluctuation in the control sperm count than in the preceding one. During starvation, the count rose considerably. Following the period of starvation the sperm count remained elevated for 4 days and then declined. English showed prestarvation sperm counts comparable to those of Choptank. During starvation the count rose consistently. Following starvation it fell and then rose again. The fourth dog, Poco, showed the same paucity of sperm in the control observations as in the earlier experiment. During starvation the count rose this time to a phenomenal 866 million per cubic centimeter on the tenth day. Following starvation there was an abrupt fall in sperm count. The latter counts were still quite in excess of the control counts observed in this dog.

In addition to the effects on sperm count per cubic centimeter, the effect of starvation on total sperm count was determined (Table 1). Sampson, English, and Poco showed significant increases in absolute sperm count during starvation, with diminution of sperm count subsequent to the starvation period. In the case of Choptank, the total sperm count failed to show any increase during starvation, even though he showed a significant rise in sperm per cubic centimeter. This discrepancy is due to the smaller volume of fluid produced during the starvation peroid, thus giving a higher count per cubic centimeter.

There was no significant correlation between the sperm count, volume of seminal fluid, and the duration of bulbar enlargement.

A review of the studies of a number of investigators—Jackson (*9*), Reid (*6*), Siperstein (*13*), Stone (*14*), Musgrave (*15*), Dunn (*16*), Mason (*2*), Flipse (*17*), Holt and Albanese (*18*), Asdell (*19*), and Robinson (*20*)—revealed that inanition owing to limited diets generally inhibited reproduction. The effects were found to vary in different animal species. Although these experimental data are not in agreement with our observations, Gantt (*21*) observed that sexual conditional reflexes are not abolished by 5 days of starvation. This contradicts the inhibitory effects of inanition reported by others.

Although we are fully aware of the potential pitfalls involved in interpreting human behavior on the basis of data derived from other species, the sociological implications of our findings are evident. Russell (*22*) found that subfertile men had lower sperm counts (below 50 million per cubic centimeter) than fertile men. There was no correlation between lowered fertility and malnutrition. Russell makes reference to the high birth rate of the undernourished in India, and he suggests that emotional stress may play a role in male subfertility. From a broad, biological point of view, one might ask whether increased fertility during the early period of starvation could not be a

Table 1. Sperm counts in millions per cubic centimeter and total sperm per ejaculate during the prestarvation period (20 May–3 June), ten days of starvation (7–17 June), and the poststarvation period (18–25 June).

Date (1954)	Sampson		Choptank		English		Poco	
	Count	Total	Count	Total	Count	Total	Count	Total
20 May	954	1908	195	705	387	340	28	17
24 May	175	503	337	1209	227	539	26	3
27 May	257	610	250	906	314	706	0	0
3 June	231	319	363	1270	201	653	9	1
Starvation started 3 June, 5 P.M.								
7 June	410	922	369	1014	183	477	146	18
10 June	475	1187	438	1095	321	1043	33	4
17 June	632	1264	513	831	507	1333	866	216
Starvation discontinued 14 June, 4 P.M.								
18 June	590	1475	438	1038	281	953	171	32
21 June	344	774	320	719	241	322	325	25
25 June	350	787	332	747	492	826	134	8

compensatory process in the maintenance of species homeostasis, as is suggested by Doubleday (*5*).

HARRY A. TEITELBAUM
W. HORSLEY GANTT
Pavlovian Laboratory, Phipps Psychiatric Clinic, Johns Hopkins University, Baltimore, Maryland

References

1. J. Huxley, *Harpers Magazine* 156, 42 (1927).
2. K. E. Mason, *Survey Biol. Prog.* 1, 89 (1949).
3. J. J. Rommer, *Sterility, Its Cause and Its Treatment* (Thomas, Springfield, Ill., 1952).
4. P. S. Henshaw, *Adaptive Human Fertility* (Blakiston-McGraw-Hill, New York, 1955).
5. T. Doubleday, *The True Law of Population Shown To Be Connected with the Food of the People* (London, 1853).
6. T. Reid, *J. Am. Vet. Med. Assoc.* 114, 158, 242 (1949).
7. J. de Castro, *The Geography of Hunger* (Little, Brown, Boston, Mass., 1952).
8. A. Smith, *An Inquiry into the Nature and Causes of the Wealth of Nations, 1759. Selections* (Regnery, Chicago, Ill., 1953).
9. C. M. Jackson, *The Effects of Inanition and Malnutrition upon Growth and Structure* (Blakiston–McGraw-Hill, New York, 1925).
10. W. J. L. Sladen, personal communication.
11. W. Katcher, personal communication.
12. H. A. Teitelbaum and W. H. Gantt, *Am. Physiol. Soc.* 13, 644 (1954).
13. D. M. Siperstein, *Anat. Record* 20, 355 (1920–21).
14. C. P. Stone, *J. Comp. Psychol.* 4, 195 (1924); 33, 97 (1942).
15. S. D. Musgrave, *thesis, Cornell University* (1951).
16. H. O. Dunn, *thesis, Cornell University* (1952).
17. R. J. Flipse *et al., Prog. Rept. 104, Penn. State Coll. School of Agr.* (1953).
18. L. E. Holt and A. A. Albanese, *Trans. Assoc. Am. Physicians* 58, 143 (1944).
19. S. A. Asdell, *Cattle Fertility and Sterility* (Little, Brown, Boston, Mass., 1955).
20. H. E. Robinson, in R. R. Williams, Ed., *Appraisal of Human Dietaries by Animal Experiments* (Williams Waterman Fund, 1947).
21. W. H. Gantt, *Proc. Assoc. Research Nervous and Mental Disease* 29, 1030 (1950).
22. J. K. Russell and R. G. Harrison, Eds. *Studies on Fertility* (Thomas, Springfield, Ill., 1954), pp. 115–158.

29 June 1956

Mobility of Calcium-45 after Injection into Western White Pine

Calcium is generally thought to be an immobile element in the plant (*1*), although a report of its redistribution in the peanut has been published (*2*). Williams, in a recent review of the literature on redistribution of minerals in plants (*3*), reported no instances of calcium mobility.

The use of calcium-45 in connection with other studies of mineral translocation in western white pine gave an unusual opportunity to study the mobility of this element (*4*). In 1951, 1952, 1953, and 1954, during July and August, trees of this species in various locations in northern Idaho were injected with solutions of calcium-45 in carrier solution. This was accomplished by attaching metal or tarpaper cups to the trees, sealing the junction between tree and cup, filling the cups with carrier solution, and then incising the tree with a wood chisel and hammer. At least 40 percent of the circumference was opened in this manner, with the chisel penetrating completely through the phloem and into the xylem about 1 to 1.5 in. The radioisotope solution was then pipetted into the carrier, mixed, and subsequently taken up by the tree with the carrier.

Trees of several sizes were used in the experiments. The Sands Creek, Three Mile Creek, and Clarkia Peak trees (Table 1) were all of pole size (50 to 70 years old and 65 to 90 ft tall), while the Hollywood trees were smaller, being 12 to 15 years old and 15 to 20 ft tall. The larger trees were injected with 1.25 to 3.78 mc of calcium-45 per tree, and the smaller trees received from 0.10 to 0.71 mc per tree. The carrier solution for the larger trees was introduced as a solution of 8 to 9 lit consisting of from 0.15 to 2 mole of Ca^{++}, 0.03 to 0.17 mole of K^{+}, 0.008 to 0.06 mole of NH_4^{+}, 0.32 to 2.5 mole of NO_3^{-}, and 0.002 to 0.02 mole of PO_4^{---}. The carrier solution for the smaller trees was introduced as approximately 0.5 lit of solution containing 0.04 to 0.4 mole of Ca^{++}, 0.03 to 0.04 mole of K^{+}, and 0.14 to 0.83 mole of NO_3^{-}. For both large and small trees, the solutions were made just acid to methyl red (*p*H 4 to 5) with HNO_3 and KOH.

Two weeks to a month after injection, the trees were climbed, and the foliage of the current year was sampled in various parts of the crown. The foliage samples were returned to the laboratory, dried at 70°C, and ground in a Wiley mill. A 2-g sample was then wet digested, the calcium was precipitated as the oxalate, and the precipitate was filtered off in small Buchner funnels and counted in a flow counter. Finally the precipitate was titrated to determine total calcium. The counts were corrected for coincidence, background, self absorption, half-life (to date of injection) and finally were expressed in counts per minute, per gram of dry tissue (70°C). These data are given in Table 1.

The year after injection, during the months of July, August, and September, most of the trees were climbed and sampled for the newly developed terminal and lateral buds. These buds were analyzed to determine whether they contained calcium-45; activity would indicate that the previously deposited calcium had moved into these tissues. These samples were analyzed as the foliage samples had been, and the results are given in Table 1. For a few trees it was possible to make a similar analysis of terminal and lateral buds developed and sampled 2 years after injection, and these are also listed in Table 1 for the trees for which data are available. For comparative purposes, it should be noted that the calcium activity in the buds is an appreciable percentage of the activity of the foliage accumulating calcium at the year of injection.

Data for one group of trees were calculated on a specific activity basis (counts per minute, per milligram of total calcium), and these are presented in Table 2. This calculation, which gives an estimate of the ratio of calcium-45 moving into the tissues compared with the total

Table 1. Calcium-45 activity in foliage and buds of western white pine at varying periods after injection.

Location of tree and year of injection	Counts/min g corrected to time of injection		
	Buds		Foliage
	1 yr. after injection	2 yr. after injection	In year of injection
1951, Sands Creek tree, No.			
1	41,400		86,000
2	27,300		92,000
3	46,300		48,000
1952, Sands Creek tree, No.			
4		17,400	3,900*
5		7,230	5,470*
6		2,410	5,180*
7		5,180	6,200*
1953, Hollwood tree, No.			
1	20,350	3,610	56,500
2	22,700	9,700	35,500
3	19,900	2,170	88,300
4	14,700	5,720	29,700
5	5,080	6,790	21,200
6	12,900	10,400	102,000
1954, Three-Mile Creek tree, No.			
1	16,100		59,000
2	36,100		13,710
3	2,680		4,920
1954, Clarkia Peak tree, No.			
1	6,600		13,240
2	4,410		4,800
3	15,730		31,400

* Foliage in year following injection.

Table 2. Specific activity (Ca^{45} counts per minute, per milligram of total Ca) in foliage and buds of western white pine at varying periods after injection.

Hollywood tree, No.	Counts/min mg total Ca corrected to time of injection		
	Buds		Foliage
	1 yr. after injection	2 yr. after injection	In year of injection
1	20,400	2210	8,940
2	22,700	5130	6,840
3	9,220	1270	16,900
4	12,200	3910	7,890
5	20,000	7900	5,300
6	11,300	7780	13,450