GROWTH PATTERNS AND REPRODUCTIVE BEHAVIOUR AS AFFECTED BY HIGH GRAVITY IN MALE AND FEMALE RATS*

By

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The attainable body mass and growth in the normal course of time have been shown by Oyama and Platt (1) to be repressed as a result of exposure of animals to simulated high gravity environment by centrifugation. Oyama and Platt (2) also studied the mating patterns. So far experimental studies of gravity effects on mammals have largely been concerned with various physiological responses and the determination of tolerance limits of animals, acutely exposed to simulated changes and gravity by centrifugation.

The present studies were carried out to find out the effect of high gravity on production and reproduction characteristics of male and female rats.

MATERIALS AND METHODS

Male and female alibino rats, 96 in number weighing on an average 115 *gm* were taken for the study. Only one rat was housed in each cage. The cages were mounted on a 28 cm radius centrifuge at a distance of 23.5 cm from the center of rotation to the center of outer cages and 12 cm. from the center of rotation to the center of the inner cages. Two cages (inner and outer ones) were mounted on the centrifuge so as to enable four rats at a time to be kept. The animals were subjected to a centrifugation rate of 300 rpm and 500 rpm, respectively as shown in Table I. The centrifuge was operated each experimental day for the only scheduled times as shown in Table 2. Cages (size 17.5 and 9.5 cm) large enough to hold single rat were suspended by means of a pivotal yoke assembly from each arm. Each cage assumed a final position such that the resultant of the centrifugal and gravitational forces was vertical to the cage floor. No artifical light was provided. All cages were illuminated with day light. Water and feed were available *ad-libitum*. The experiment was carried out for a period of six months. The animals were weighed on every 3-5 day intervals to find out the potential changes in the growth patterns. Animals were mated after two months of centrifugation.

At the end of the experiment, the animals were killed under ether anaesthesia and following organs: ovaries (right and left), testes (right and left), thyroids (right and left) and adrenals (right and left) were carefully excised, trimmed and weighed.

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TABLE I

Schedule of different 'g' values

Rpm	*Radius in cm*	*'g' value*	*Resultant 'g' value (gR)*	*Increase over 'g' value* (981)
300	12	12.07	981.08	0.08
300	23.5	23.64	981.28	0.28
500	12	20.12	981.21	0.21
500	23.5	39.40	981.78	0.78

RESULTS AND DISCUSSION

Growth Responses: The growth curves are shown in Figure I of control and experimental animals at different "g" loads. It is clear from these curves that there was a steep fall in weights as well as in the growth rates of experimental males as compared to normal males, experimental and control females, so much so that the average weights of experimental males ran practically with no difference ($P > 0.01$) to normal females after the start of the experiment till 22nd day after the end of the experiment. After this period there was an abrupt increase in growth rates though slow in control and experimental females while a steep rise took place in experimental males. After the start of the experiment, also there was a sudden decrease in body gains (weight) as compared to experimental females. This shows clearly that female rats were more resistant as compared to male rats so far as growth responses were concerned. This is a direct reflection of depressed or decreased growth rates, most probably because of the reduction in efficiency of feed utilization and decreased appetite which were noticed during the experiments. Since the depression of the growth rates took place during the postnatal acceleration phase of growth patterns, it is most important from the point of view of animal breeders as well as physiologists concerned mainly with reproductive efficiency that it is during this period or phase of growth that the females are bred for the first pregnancy and if this is being delayed certainly the harvest and the later potential of these animals will be interferred with.

There was a good survival rate obtained by Oyama and Platt (2) in rats as against depressed growth rates in this present investigation. This seems to be a reflection of high 'g' values in the present studies.

Brreeding Behaviour: The breeding performance of rats chronically exposed to four different 'g' loads is summarized in Table 3. Both females and servicing males were centrifuged at least two months before the matings were attempted. The data show that there was no pregnancy established by crosses between normal males and experimental females; between experimental males and experimental females as compared to 80% pregnancy in case of crosses between normal males and normal females; 50% pregnancy in crosses of experimental males and normal females. As is apparent from the table, both males and females are responsible for

TABLE II

Effect of increased 'g' loads on physical responses

'g'	*Exposure time in mt*	*No. of days exposed*	*Shivering*		*Erection of hairs*		*unconciousness*		*Death toll*	
			m	*f*	*m*	*f*	*m*	*f*	*m*	*f*
12.07 and	2.5	1	++	+	++	+				
23.64	5	2	++	++	++	++				
	10	2	++	++	++	+				
	15	2	++	+	++	+				
	30	2	++	±	++	±				
	40	2	±	±	± ±	±				
	50	2	±	±	±	±				
	60	2	±	±	±	±				
	90	2	±	±	±	±				
	120	2	±	±	±	±				
	150	2	±	±	±	±				
	180	7	±	±	±	±				
	180	7	—	—	—	—				
20.12	2.5	6	++	+	++	+	all unconscious		6	
	5	2	++	+	++	+				
	10	2	++	++	++	+				
	15	2	++	+	++	+				
	30	2	++	+	++	+				
	40	2	++	+	++	+			3	
39.4	2.5	6	++	+	++	+	all unconscious		6	3
	5	2	++	+	++	+				
	10	2	++	+	++	+				
	15	2	++	++	++	+				3
	30	2	++	+	++	+			3	
	40	2	++	+	++	+				

++Rapid movements of skin coat, + slow movement of skin coat
± very slow movement of skin coat, ++ shaking and erection of hairs
+ Erection of hairs, ± more than half hairs erect.

having no pregnancy in the crosses and pregnancy in the other two crosses ($P<0.01$). May be that the experimental females are responsible for a larger share in contribution to non-pregnancy. In that too, the state of the development or the physiological state of the graafian follicles may be a cause for non-pregnancy since the ovarian follicles of the controlled females were distinctly well marked and prominent as compared to experimental females. With respect to males it may be because of the less functional capacity of reproductive organs of the experimental males as compared to controlled male rats.

These results do not agree with Oyama and Platt (2) where reproduction was normal. This may be due to the fact that 'g' values to which their rats and mice were subjected were 2.5, 3.6 and 4.7 'g' as compared to 12.07, 20.12, 23.64 and 39.40 'g' values of this experiment

TABLE III

Effect of increased 'g' loads on reproduction

'g' value crosses between	*No. of rats mated*	*No. of preg. rats*	*Preg %*	*Survivors*	*No. died*
12.07 N.m. into N.f.	10	8	80	10	—
20.12 N.m. into E.f.	10	—	—	10	—
23.64 E.m. into E.f.	10	—	—	10	—
39.40 E.m. into N.f.	10	5	50	8	2

N-Normal, E-Experimental, m-males, f-females.

which are evidently quite high. Thus, here, again higher 'g' values seem to be responsible for nonestablishment of pregnancy.

Physical Responses: At 12.07 and 23.64 'g' loads all of the animals either males or females started adjusting to their environmental conditions to which they were exposed after 30 minutes exposure for two days. They were completely adapted by 90 minutes of exposure to this environment for two days and later on they easily withstood the exposure time even upto 180 minutes without showing any untoward signs even of shivering and hair erection at all. As shown under mortality statement in Table 2, there were no deaths reported under this period. However, at 20.12 and 39.40 'g' loads all the animals showed signs of shivering, unconciousness, hair erection and even deaths took place indicating the severity of exposure ($P<0.01$) as shown in Table 2. Deaths started taking place from the very first day of the start of the second phase of the experiment (500 rpm) and continued upto the end of the experiment and ultimately this resulted in termination of the experiment before the scheduled date as planned before. It is clear from the unconciousness and death toll statement that out of the males and females exposed to 39.40 'g' loads, most of the animals succumbed to death ($P\leqslant0.01$) and out of these also males were first to suffer indicating that females were more resistant to the exposure conditions of this experiment, again confirming the results as shown under growth responses.

Responses to Changing 'g' loads: At 20.12 and 39.40 'g' loads, maximum number of deaths ($P<0.01$ in males and females took place. Out of these, males outnumbered the females. Similar is the case with respect to the phenomenon of unconciousness.

Changes in different Organ Weights: As shown in Table 4, in males the thyroid glands of normals were heavier ($P<0.01$) than the experimental animals. Adrenals of the experimental males were heavier ($P<0.01$) than the normal males. Testicles of normal males were heavier ($P<0.01$) than the experimental males.

With respect to females, there was practically speaking no differences in any of the organs as reported above. However, the ovarian follicles of the controlled female rats were more distinct and prominent and well marked as compared to experimental rats. Ovaries were also heavier ($P<0.01$) in controlled females as compared to the experimental females.

For all the 'g' values the resultant 'g' (gR) was calculated as shown in Table I. It will be seen from this table that 'gR' increases only by a fractional value in each case as 0.08,0.28,

TABLE IV

Organ body weight ratios of centrifuged and controlled rats

Group	Control	Experimental
	Female	
No. of rats	10	10
Av. body weight	130 gm	127.5 gm
Organ, mg/100 gm body weight		
Thyroid	102±6	103.6±9
Adrenal (pr)	19.1±1.0	17.2∓0.5
Ovaries (pr)	305±19	297±18
	Males	
No. of rats	10	10
Av. body weight	150 gm	150 gm
Organ, mg/100 gm body weight		
Thyroid	124±8	104.1±6
Adrenal (pr)	17.8±0.05	26.3±1.5
Testis	560±19	490±16

0.21 and 0.78. Since the gravitational 'g' varies from equator to the poles in values ranging from 978 to 983 and yet it is a known fact that that this factor does not affect the normal physiological responses of the living beings. It may therefore, be stated over here that on the surface of the earth it is only the rotational 'g' which is responsible in changing the physiological responses by causing severe and immediate stress reactions even through fractional changes in its value as shown above.

SUMMARY AND CONCLUSIONS

The studies were conducted with 96 male and female rats to find out the effect of high gravitational environmental forces varying from 12.07 and 39.40 on production and reproduction characteristics. The following results were obtained:

1. Growth rates were depressed. Female rats proved more resistant in so far growth responses were concerned.

2. Exposure of 20.12 and 39.40 'g' loads proved to be the most severe and resulted in unconciousness and even deaths.

3. Between the crosses of normal males and experimental females, there was no pregnancy established as compared to 80% pregnancy in crosses of normal males and normal females. Females were responsible for non-pregnancy in a larger share in these crosses.

In conclusion, it may be stated that on the surface of the earth, it is only the rotational 'g' which is responsible for changing the physiological responses of these rats as shown in these studies.

REFERENCES

1. Oyama, J. and W.T. Platt. Effect of deceleration on rats exposed to prolonged centrifugation. *Nature*, **203** (4946): 766, 1964.
2. Oyama, J. and W.T. Platt. Reproduction and growth of mice and rats under conditions of simulated increased gravity. *Am. J. Physiol.*, **212** (1): 164, 1967.