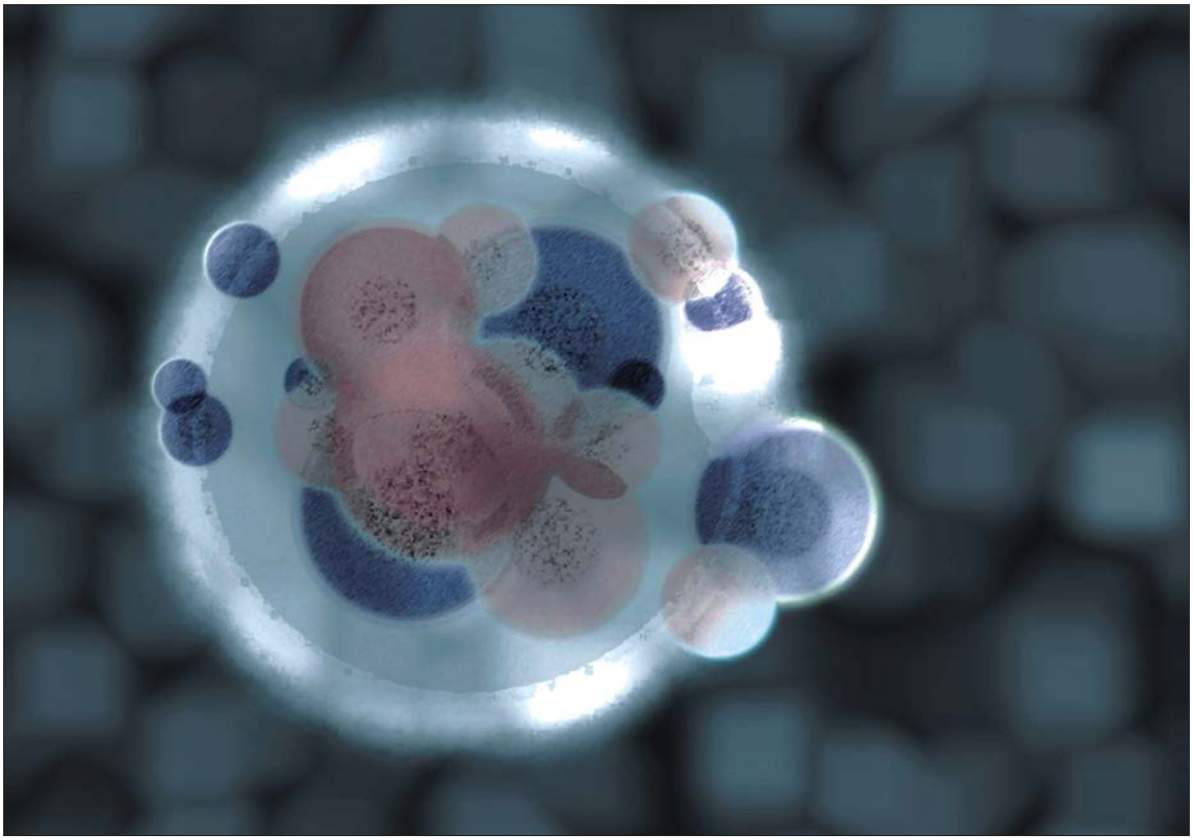

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Effect of Photoperiodism and Food Rations on the Population Density of the Albino Mice

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Abstract: The purpose of the present research is to study the effect of different photoperiodism; long (18L: 6D), medium (12L: 12D) and short (6D: 18L) as well as three levels of food (high, medium and low level) on the population density of albino mice (MFI). At medium food level, the onset of pregnancy delayed with decreasing photoperiodism and was proved statistically, r = -1.000 (p = 0.000) for the first and second generations of offsprings. There is an insignificant direct relationship between photoperiod and mortality rate (r = 0.997) for the first generation and no relationship between them for the second generation (r = 0.0). The surviving of population depends on the amount of available food whatever the photoperiod was long or short. It is obvious that when the females supplied with high level of food and exposed to long photoperiod is the best environmental condition for the earlier pregnancy onset (five weeks), larger numbers of neonates larger (42 individuals) and lower mortality rate (7.80%). Short photoperiod and low food level are considered as the bad condition and delayed the pregnancy onset (ten weeks), decreased the number of neonates (30 individuals) and increased mortality rate (93.4%).

Key words: Food level, mice, mortality rate, offsprings, photoperiodism

INTRODUCTION

Environmental variability affects processes at all levels and scales of ecological organization. Local variation, for example, probably accounts for much within population variation in birth and death rates. Incorporating environmental variation into theories of life histories, population dynamics and community organization requires a detailed understanding of how environmental factors influence physiology, development, behavior and the resulting life histories of individuals (Dunham *et al.*, 1989; Byholm *et al.*, 2007). To some extent, therefore, the phenotypic responses of a genotype to the environment may represent an adaptation to environmental variability (Schlichting, 1986; Stearns, 1989; Newman, 1992; Hines *et al.*, 2007). Investigations to organismal responses to environmental factors are crucial for understanding both immediate ecological consequences as well as long-term evolutionary effects of environmental variation.

Variation in food level may generate considerable variation in growth and consequently in surviving (Newman, 1989; Pfennig *et al.*, 1991). Variation in the environment may be a major contributor to variation in individual fitness and population dynamics (Newman, 1988; Berven, 1990). A long-standing problem in ecology is that of determining the factors that limit the growth of a population (Newman, 1988). Schoener (1982) recorded that there are obvious limiting factors which are food shortages and predation. There is growing evidence that animals can control, either behaviorally or ecologically, both the quality of food supply and their risk of predation and that there is a trade-off between these factors.

On the other hand, diversity of natural resources has an obvious effect on the population dynamic such as population density, age structure (number of mature and immature individuals) and competition. Most biological activities like growth, reproduction and other social activities (competition, migration, etc.) depends on the energy that the animals supplied it from their food (Boyce, 1988).

Food is considered as the most important ecological factor, as its shortage results in intraspspecific and interspecific competition. While its availability results in an increase in growth rate, acceleration in developmental rate reaching to the sexual maturity earlier and an increase in the population density (Boyce, 1988; Zubaid and Gorman, 1993, 1996; Predavec and Dickman, 1994; Van der Ziel and Visser, 2001). It was confirmed that cultures supplied with higher level of food, the surviving and reproduction of the mature females were higher than those supplied with medium level of food (Doonan, 1993; Hussein, 1997).

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MATERIALS AND METHODS

Albino mice (MFI) were chosen, at the weaning age, for the present study. Animals were reared in animal house at the center of king Fahad of medical researches in Jeddah, Saudi Arabia. They were maintained in polypropylene cages of 50×33×20 cm at a constant temperature (21±1°C). Tap water was provided *ad libitum* throughout the experiments.

Experimental design: To study the effect of photoperiod, cages were provided with fluorescent lamps and timer to control the timing of exposure to light. Three levels of photoperiodism were applied; long (18 Light: 6 Dark), medium (12 Light: 12 Dark) and short photoperiod (6 Light: 18 Dark). Three levels of nutrition were provided to the tested animals (high, medium and low level). In these experiments, the constituents of the used food are 20% protein, 4% fat, 3.5% fibers, 6% ash, 0.5% salt, 1.0% Calcium, 0.6% Phosphorus, 20 unit g^{-1} vitamin A, 2.20 unit g^{-1} vitamin D, 70 unit g^{-1} vitamin H and some rare elements.

To study the effect of crowding and competition, animals were housed in animal cages in a ratio of 1 female: 2 male and were left to reproduce. The time of the beginning of pregnancy, numbers of offsprings and mortality rate in the first and second generations were recorded.

Statistical analysis: Data were analyzed by using the program SAS (Institute Inc.1988, Cary, NC, USA), Where Pearson correlation coefficient was used to assess the significance of the effect of ecological parameters on the measured variables (Sokal and Rohlf, 1981). When $p<0.05$, a significant relationship is present and when $p>0.05$ the relationship is insignificant.

RESULTS AND DISCUSSION

Onset of pregnancy: It can be shown from Table 1 that the first day of pregnancy of females exposed to long photoperiod (18L:6D) and supplied with high level of food, was earlier at the fifth week age than those supplied with medium (six weeks) than low level of food (9 weeks). Statistically, the relationship between the onset of pregnancy and amount of food at long photoperiod was found to be inverse insignificant ($p = 0.311$ and $p = 0.453$), where the Correlation coefficient (r) values were -0.883 and -0.758 for the first and second generations, respectively.

Concerning exposure to the short photoperiods (6L:18D), it was noticed that females became pregnant faster at the seventh week age when they were supplied with high level of food than those supplied with medium food level at which the onset of pregnancy was observed after eight weeks. An obvious delaying in the onset of pregnancy was recorded for those females supplied with low level of food where they became pregnant after ten weeks. An insignificant inverse relationship between light and the onset of pregnancy of females where the Correlation coefficient was -0.912 ($p = 0.270$) for the first generation and -0.838 ($p = 0.368$) for the second generation.

When females were supplied with medium level of food, the onset of pregnancy was earlier for females exposed to long photoperiod than those exposed to short photoperiod. The strong reverse relationship between the onset of pregnancy and photoperiod was proved statistically, the values of the Correlation coefficient were -1.000 ($p = 0.000$) for the two generations. The exposure of females to longer photoperiods, the earlier the onset of pregnancy.

Number of neonates: The data of the neonates' number are shown in Table 1. It can be seen from these data that under long photoperiod (18L:6D), the number of neonates in the first and second generations in populations provided with high level of food is the highest (about 42 individuals), followed by those supplied with medium food (37.0±1.0 and 40.0±0.0 individual, for the first and second generation, respectively). While the cultures that were supplied with the low level of food,

Table 1: Effect of different levels of photoperiod and food on population density of MFI strain

		First generation				Second generation			
Photoperiod	Food level	Onset of pregnancy (weeks)	No. of neonates	No. of died individuals	Mortality rate (%)	Onset of pregnancy (weeks)	No. of neonates	No. of died individuals	Mortality rate (%)
Long	Hi.	5.00±0.00	42.67±1.15	3.33±0.58	7.80±0.23	10.33±0.58	42.00±0.00	37.00±0.00	88.09±2.22
	Med.	6.00±1.00	37.00±1.00	21.33±0.58	57.65±0.58	10.33±0.58	40.00±0.00	40.00±0.00	100.00±0.00
	Low	9.33±0.58	31.33±0.58	21.00±1.00	67.07±4.27	14.33±0.58	36.33±0.58	36.33±0.58	100.00±0.00
Med.	Med.	7.00±0.00	36.00±0.00	16.33±1.53	53.40±1.87	11.33±0.58	24.33±0.58	24.33±0.58	100.00±0.00
Short	Hi.	7.33±0.58	39.33±0.58	6.33±0.58	16.09±1.74	12.00±1.00	25.33±0.58	21.33±0.58	84.18±3.59
	Med.	8.00±1.00	34.67±0.58	19.33±0.58	58.17±0.66	12.33±0.58	15.00±0.00	15.00±0.00	100.00±0.00
	Low	10.00±1.00	30.33±0.58	28.33±0.58	93.40±0.12	15.33±0.58	11.00±1.00	11.00±1.00	100.00±0.00

Hi. = High, Med. = Medium

recorded the lowest number of neonates (31.33±0.58 and 36.33±0.58 individual, for the first and second generations, respectively). When these data were tested statistically, an insignificant reverse relationship was recorded where the values of the Correlation coefficient were 0.983 ($p = 0.119$) and 0.937 ($p = 0.226$) for the first and second generations, respectively.

The same trend was also recorded for the number of neonates under short photoperiod (6L:18D). At the high food level, the numbers of neonates were 39.33±0.59 and 25.33±0.58 individual for the first and second generations, respectively. Where for mice supplied medium level of food, the numbers of neonates were decreased to 34.67±0.59 individual for the first generation and 15.00±0.0 individual for the second generation. While the lowest numbers of neonates were recorded for those mice supplied with low food level (30.33±0.58 and 11.0±1.0 individual for the first and second generations, respectively).

On the other hand, females supplied with medium level of food and exposed to long photoperiod produced more individuals 37.0±0.0 and 40.0±0.0 individual for the first and second generations, respectively than those exposed to medium photoperiod which produced 36.0±0.0 individual at first generation and 24.33±0.58 individual at the second generation. Females exposed to short photoperiod (6L:18D) produced the lowest number of neonates (34.67±0.58 and 15.00 individual at the first and second generations, respectively).

There are insignificant reverse relationships between the photoperiod and the number of neonates, at the medium level of food. Where the Correlation coefficient values were 0.997 ($p = 0.052$) for the first and 0.989 ($p = 0.093$) for the second generation.

Mortality rate: The mortality rate varied obviously under the tested environmental factors (Table 1). For the first generation, under long photoperiod and low food level, the highest mortality rate was recorded 67.07±4.27%, followed with that group supplied with medium food level 57.65±0.58%. While that group provided with high food at long photoperiod, the mortality rate was the lowest 7.80±0.23%. Statistical studies proved insignificant inverse relationship between food level and mortality rate, where the Correlation coefficient (r) values were -0.982 ($p = 0.120$) and -0.944 ($p = 0.214$) for the first and second generations, respectively.

Under short photoperiods, the mortality rate followed the previous trend, as the highest rate 93.40±0.12% was recorded for the low food level and the lowest rate 16.44±1.74% was recorded for the high food. While the medium level of food recorded medium value of mortality rate for the first generation (58.17±0.66%). When these data were tested statistically, an insignificant inverse relationship was also recorded where the values of the Correlation coefficient were -0.996 ($P = 0.059$) and -0.929 ($p = 0.242$) for the first and second generations, respectively. Thus it may be said that mortality rate is more affected by the available food than the exposed photoperiod. The lower the food levels the higher the mortality rate of the population.

For the second generation, that present in the same cages with the first generation, the mortality rate in most cases reached 100% especially, when the mice were supplied with medium or low levels of food. However, lower mortality rate was recorded at high food under long photoperiod (rate is 88.09±2.22%) and at high food under short photoperiod (rate is 84.18±3.59%). Statistically, there is an insignificant direct relationship between photoperiod and mortality rate ($r = 0.997$) for the first generation while for the second generation there is no relationship between photoperiod and mortality rate($r = 0.0$).

It can be observed that the population density decreased due to presence of the first and second generation alive together, therefore, the mortality rate increased. It may be considered the crowding and presence of intraspecific competition are the reasons of higher rate of death.

This study agrees with the studies carried by Beebee (1983) and Griffiths (1991) who confirmed that biological and reproductive activity as well as the number of the neonates of animals varies due to some changes of their environment and they also concluded that the crowding between individuals resulted in inhabitation of reproduction as a result of some reasons as little volume or space per individual, lack of oxygen and frequent collisions between individuals. Murray (1990) mentioned that the available food and population density affects on sexual maturity of animals and the number of neonates decreased as a result of crowding although the presence of high food level and the growth rate was also directly related to the food level.

In this respect, there are other important factors such as territorial area, where a limited niche creates competition between individuals even in presence of sufficient food due to struggle for territorial area. Fretwell (1972) referred the high population density for some mammals, particularly rodents, to the high level of food and a wide niche.

Sullivan (1990), Zubaid and Gorman (1993) and Predavec and Dickman (1994) confirmed that an increase in food level resulted in an increase in population density, earlier maturation of the young individuals and increase in the reproductive rate of females in turn an increase in population density. They also said that the population dynamic in mammals increased as a response to an increase in the provided food and the rates of surviving and reproduction are affected by the variation in the body size and number of individuals of the population.

It can be confirmed from the present study that the high level of food in the first and second generations accelerated maturation and increased the number of neonates comparing with low level of food. On the other hand, Norman *et al.* (2004) found an increase in the quantity of provided food which cause obesity leads to a delay in the onset of pregnancy.

Thus, the present study found that sufficient food is considered as an important factor for the surviving of the individuals of the second generation, i.e. the surviving of population depends on the amount of available food whatever the photoperiod was long or short. This study agrees with previous study carried by Hussein (1997) who confirmed that additional food had an obvious effect on population density, where the number of individuals of rodents was duplicated as a response to sufficient food. Young and Stout (1986) and Boutin (1990) also confirmed that an increase in the population density of some terrestrial vertebrates may be due to sufficient food (medium or high). On the other hand, in some rodents, an increase in the population density may be due to sufficient food which attracts individuals from the neighboring districts.

This study concludes that females supplied with high level of food and exposed to long photoperiod is the best environmental condition for the earlier pregnancy beginning, larger number of neonates and lower mortality rate. The reverse was recorded under short photoperiod and low food level.

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