SELECTION FOR DURATION OF COPULATION IN RELATION TO MATING SPEED AND SPERM EFFICIENCY IN DROSOPHILA MELANOGASTER

H.M. El-Wakil* and H.A. Hamza**

* Faculty of Agriculture, Department of Botany, University of Helwan, Alexandria.

** Faculty of Agriculture, Department of Genetics, University of Minufiya.

" الانتخاب لصفة فترة الجماع فى نبابة دروسوفيلاميلانوجستر وعلاقته بسرعة التلقيح وكفاءة الحيوانات المنوية "

(١) حسام الدين الوكيل — قسم النبات ـ فرع الوراثة ـ كلية الزراعة ـ جامعة حلوان .

(٢) حنفى أحمد حمزة — قسم الوراثة ـ كلية الزراعة ـ جامعة المنوفية .

ملخص البحث

تعتبر صفة فترة الجماع فى نبابة دروسوفيلاميلانوجستر صفة وراثية ذات معامل توريث منخفض . ولقد وجد أن الاستجابة للانتخاب لمثل هذه الصفة كانت مؤثرة فى الاتجاه العالى فقط وذلك خلال (١٠) أجيال انتخابية متتابعة . ولم يتحصل على أى استجابة فعلية طوال فترة التجربة على الاتجاه المنخفض ، ولوحظ أنه يوجد علاقة واضحة بين فترة الجماع وسرعة التزاوج بحيث أن الآباء المنتخبة لقصيرة فترة الجماع كانت أسرع فى تزاوجها من الآباء المنتخبة طويلة فترة الجماع . ظهر أيضا أن الحيوانات المنوية الناتجة من ذكور الخط المنخفض كانت أكثر كفاءة فى انتاج بيض مخصب وكذلك نسل وذلك بالمقارنة مع كل من الخط العالى والعشيرة المقارنة (الكنترول) .

Minufiya J. Agric. Res. Vol.13 No.1, 1988

ABSTRACT

Duration of copulation in Drosophila melanogaster is a genetically controlled character with a quite low heritability value. Selection for such character was effective for the high direction only, during selection progress for 10 successive generations. No selection response was observed for low direction. The relation between duration of copulation and mating speed was obviously noticed in which the extreme selected parents for low direction exhibited faster mating speed than the high line. Also the sperms of males from the low line were more efficient in producing fertilized eggs and progeny than both high and control lines.

INTRODUCTION

Invertibrate behaviour genetics is currently a very stimulating field with organisms and behaviours being offered as models for what goes on in higher animals (Hay, 1985). The behaviour most widly studied has been mating behaviour where Drosophila melanogaster and many related species show a complex but consistant pattern. Most of the behaviour traits are polygenic characters.

The response to selection for any quantitative trait depends mainly on the heritability of the trait and selection differential. Selection differential is dependent on the proportion of the population selected and the standard deviation of the trait.

Artificial directional selection has been successful for several behavioural traits, for example defection scores in rats (Broadhurst, 1960), geotaxis (Hirch, 1962; Dobzhansky and Spassky, 1962), mating speed (Manning, 1961, 1963) and duration of copulation (Mac Bean and Parsons, 1967; Ehrman and Parsons, 1981) in Drosophila. Mac bean and Parsons (1967) found that duration of copulation in Drosophila melanogaster was almost entirely male determined.

The selection for a behaviour trait in relation to other traits is very interesting. Creus and Marcos (1980) showed that there is a negative and significant regression in the relationship between mating speed and duration of copulation in D. melanogaster. Hay (1980) found that the selection for learning in D. melanogaster did not influence other behaviour traits and vice versa. Tully (1983) found that comparison of 10 different strains in olfactory learning task and in a visual learning task showed no relationship.

The main objective of the present investigation was to study the effect of response to artificial selection for duration of copulation as primary character on mating speed and some fitness components as secondary ones.

MATERIALS AND METHODS

The initial foundation population:

The natural population of D. melanogaster used in this experiment was collected from Sidi Bishr region in Alexandria, Egypt. The population was maintained by mass mating under an optimal feeding conditions at 25°C.

Selection procedure:

The experimental testing procedure followed Parsons (1964) and Mac Bean and Parsons (1967). Pairs of virgin flies aged about seven days were put together in vials without etherization and observed for 60 minutes. Pairs not mating within 60 minutes were recorded as unmated. Mating speed, which is the time until mating commences, and duration of copulation, which is the period between the time when the genitalia are first observed to lock until they disengage, were recorded in minutes. In the first generation the high and low lines were set up by selecting ten pairs from the base population with high and low duration of copulation out of 75 copulations. Control

line was set up choosing 20 pairs or more at random from the base population. In subsequent generations not less than 70 pairs of flies per line were tested. For each generation mating speed was recorded beside duration of copulation for all mated pairs. Selection procedure was carried out for ten sucessive generations.

At the tenth generation of selection, daily average egg production per female for 15 successive days and the percentage of emergence were estimated for the two selected lines and the unselected control. These two estimates were calculated from 15 females accompanied by 15 males during the full period of estimation. To study the effect of duration of copulation on the efficiency of the sperms of the males, series of 5 mated females representing the two extreems for the two selected lines and also for the control were transferred without males to ½ pint milk bottles immediatly after mating. They were transferred daily until no progeny was observed. The total number of progeny was counted per female.

RESULTS AND DISCUSSION

The mean duration of copulation for the low and high lines over 10 generations of selection and the control line are shown in Figure 1. The divergence between the two selected lines during selection progress is shown in Figure 2. It is interesting to note that the mean value for the base population is about 15 minutes compared with 25 minutes for the population which was used by Mac Mean and Parsons (1967). This could be an evidence for the genetic control of this trait in D. melanogaster. Hildreth (1962) found differences between Strains and Hosgood and Parsons (1965) found differences between strains derived from single inseminated female taken from natural population. Figure 1, clearly showed that the response to selection was not observed either for the high or low direction till

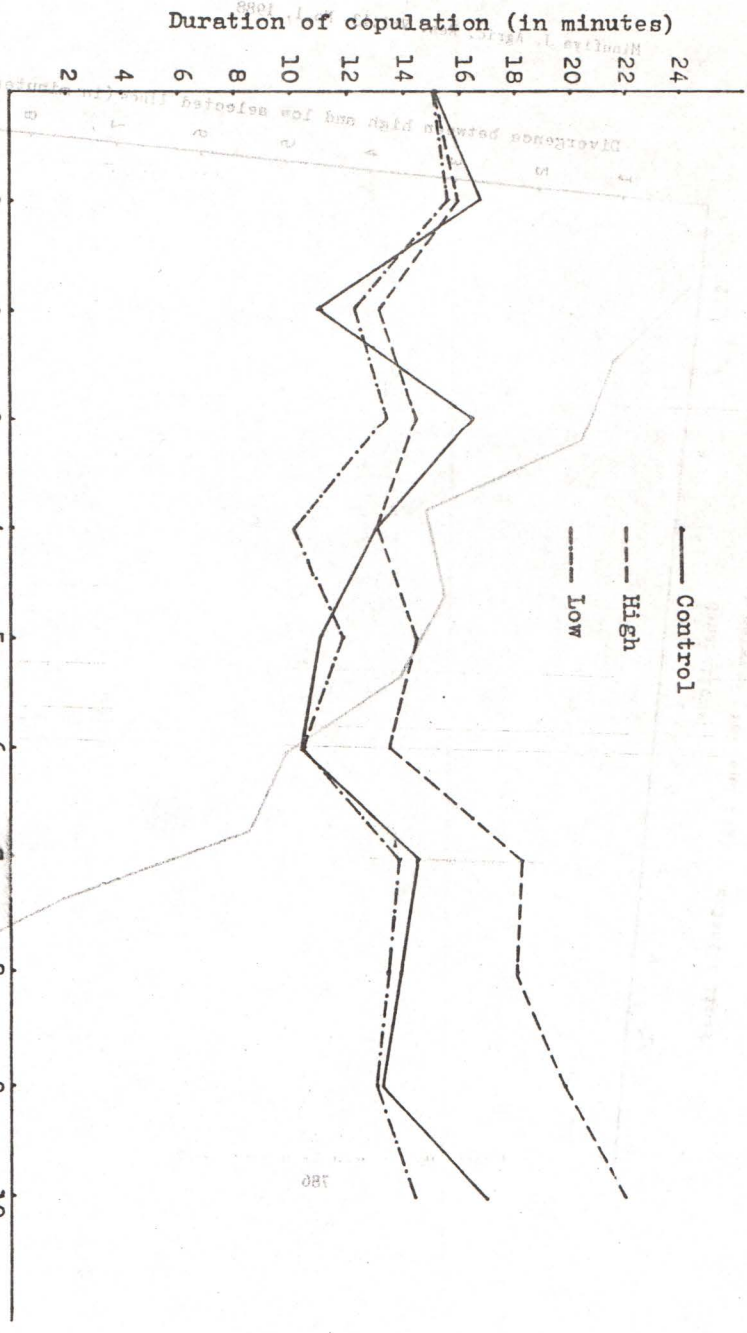

Figure 1 - The mean duration of copulation for low, high and control lines over 10 generations of selection.

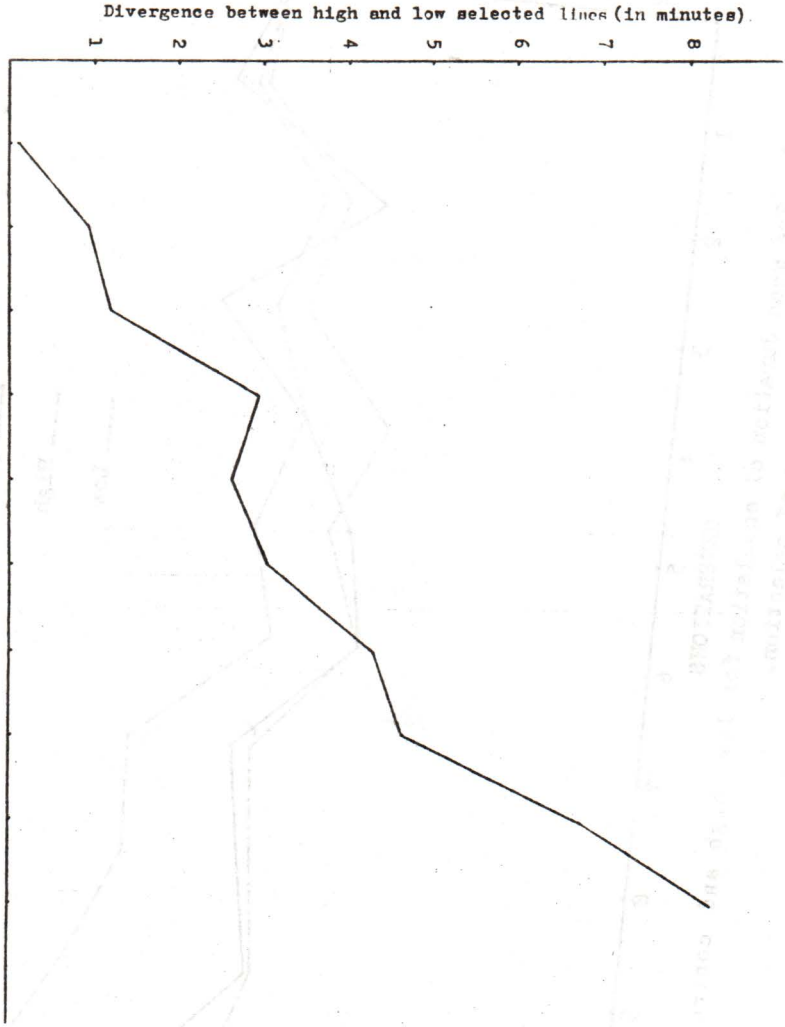

Figure 2- Divergence (in minutes) between low and high selected lines during selection progress.

the fourth generation, the two lines fluctuated around the control level. After which the high line showed gradual response till the end of selection procedure. On the contrary, the low line did not show any significant deviation from the control level for all generations. This asymmetrical response to selection in favour of one direction against the other has been discussed in details by Falconer (1983). The probable reason for this asymmetry may be due to that long copulation is not the fittest genotype in nature. So the frequencies for the genes supporting long copulation have low frequencies. This leads to a rapid response to selection.

The realized heritability for the high direction based on the ratio between response to selection to cumulative selection differntial for the average of the last 6 generations was about 18% (Table 1). Mac Bean and Parsons (1967) reached the same results on the value of heritability based on inbred strains and their hybrids. Their heritability estimates for such character ranged between 15% to 20%.

The effect of changing duration of copulation by selection on mating speed was previously shown by Mac Bean and Parsons (1967) based on the percentage mating within a 50 minute observation period in high, low and control lines. They concluded that there was no association between selection progress for duration of copulation and the percentage mating. Also they found that the percentage of mating was normally high in all lines. These results were also obtained in the present experiments in which the total averages of percentage mating within 60 minutes for the ten generations were 82.28, 85.63 and 81.78 for high, low and control lines respectively. In spite of these results, there was somhow positive correlation between duration of copulation and mating speed within the period of observation. Figure 3, showed that percentage mating within the

Table 1: Selection response, cumulative selection differential and realized heritability for the high selected line.

Generation	Deviation from control	Cumulative sel. differential	Realized heritability
5	3.41	13.59	0.25
6	3.11	17.08	0.18
7	3.67	24.05	0.15
8	4.22	29.55	0.14
9	6.62	34.56	0.19
10	6.92	42.32	0.16
Average			0.18

Table 2: Average mating speed in minutes for low and high ten extreme selected parents along selection procedure.

Generation	Low	High
1	6.12±1.79	20.29±6.83
2	31.11±10.18	42.86±9.37
3	8.46± 1.49	21.30±6.94
4	5.51± 0.46	63.25±10.38
5	9.96± 2.26	37.86±5.77
6	14.40± 3.03	35.22±6.66
7	32.72± 7.90	67.77±9.11
8	24.88± 7.48	41.05±7.26
9	13.18± 3.86	51.19±10.22
10	14.78± 5.67	19.89±3.85
Average	16.11± 3.16	43.07±7.52

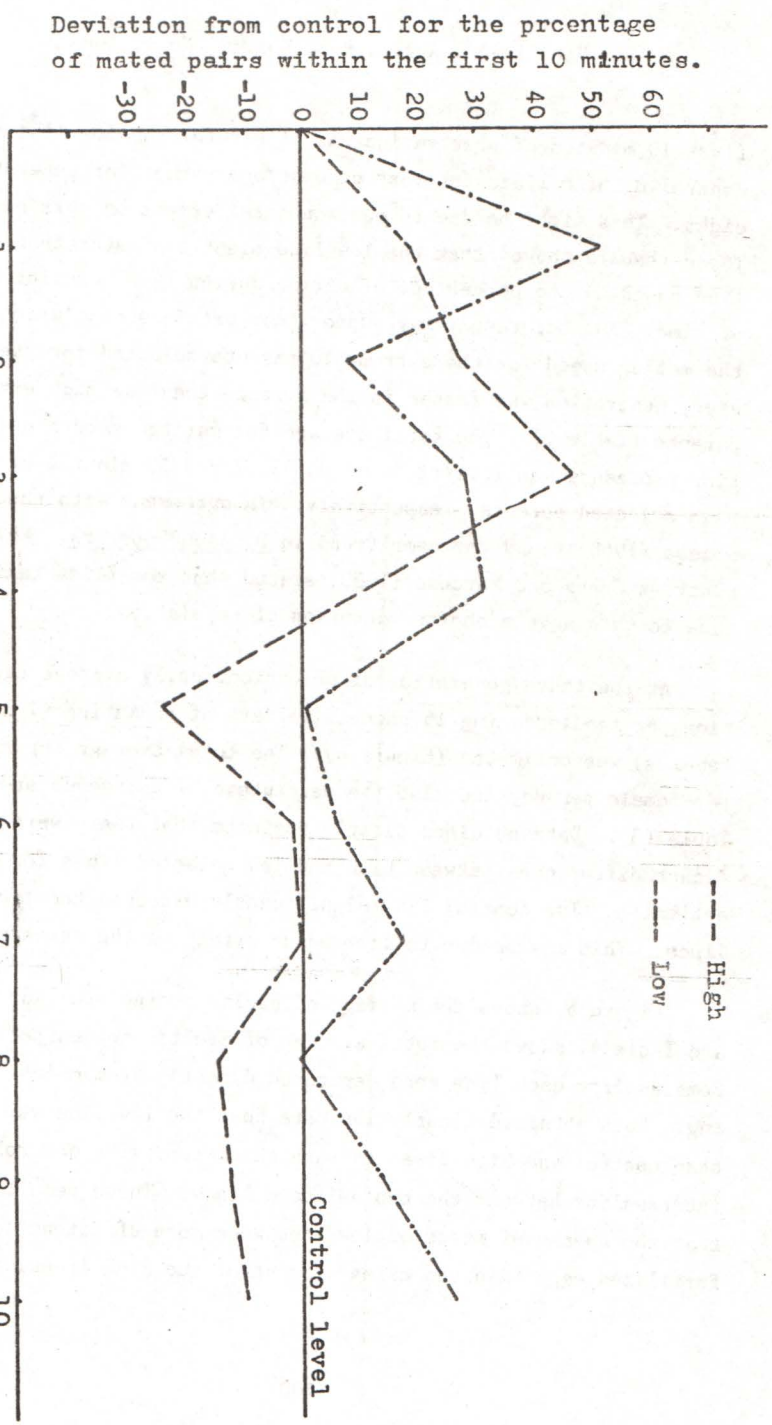

Figure 3- The deviation of percentage mating within the first 10 minutes of observation for high and low selected lines from control for the 10 generations of selection.

first 10 minutes of observation was higher for the low line than the control or high lines for most generations except for generation eight. This might be due to environmental effect on this generation. These results showed that the low line might be faster than the high line based on the percentage of mating during this restricted period of time. Another result may support our previous conclusion in which the mating speed for the extreme 10 parents selected for the low for every generation was faster in the average than the high extreme parents (Table 2). The total average for mating speed along selection procedure was 16.11 ± 3.16 and 43.07 ± 7.52 minutes of low and high selected parents, respectively. In agreement with these results, Spiess (1968) found the same trend in D. pseudoobscura. While, in contrast Creus and Marcoss (1980) stated that the flies taking a long time to mate have a shorter duration of copulation.

At the tenth generation of selection, daily average egg production per female during 15 successive days after mating (7 days old females) was estimated (Figure 4). The total average egg production per female per day and also the percentage of emergence are shown in Table (3). Data obtained clearly indicate that there were no significant differences between high and low selected lines for both estimates. The control line significantly exceeded the two selected lines. This may be due to inbreeding effect on the selected lines.

Figure 5, shows the average of adults emerged per day per female and Table 4, shows the total average of adults emerged per female. Females from each line were separated directly from males after mating. Data obtained clearly indicate that the low line was higher than control and high lines in such character. The control line was intermediate between the two selected lines. These results indicate that the sperms of males of low line were more efficient to produce fertilized eggs than the males of control and high lines. In spite

Table 3: Daily average egg production per female and percentage of emergence for the two selected lines and the unselected control.

Lines	Egg production/ female/day	% emergence
control	59.1+4.79	80.28+3.16
High	53.3+3.89	60.17+5.59
Low	50.9+4.34	65.71+4.17

Table 4: Total average of adults emerged per separated female from males after mating for high, low and control lines.

Lines	Mean duration of copulation in minutes	NO. of adults emerged/female
Control	13.95± 0.54	139.11
Long	20.21± 0.68	100.09
Short	13.21± 0.89	204.27

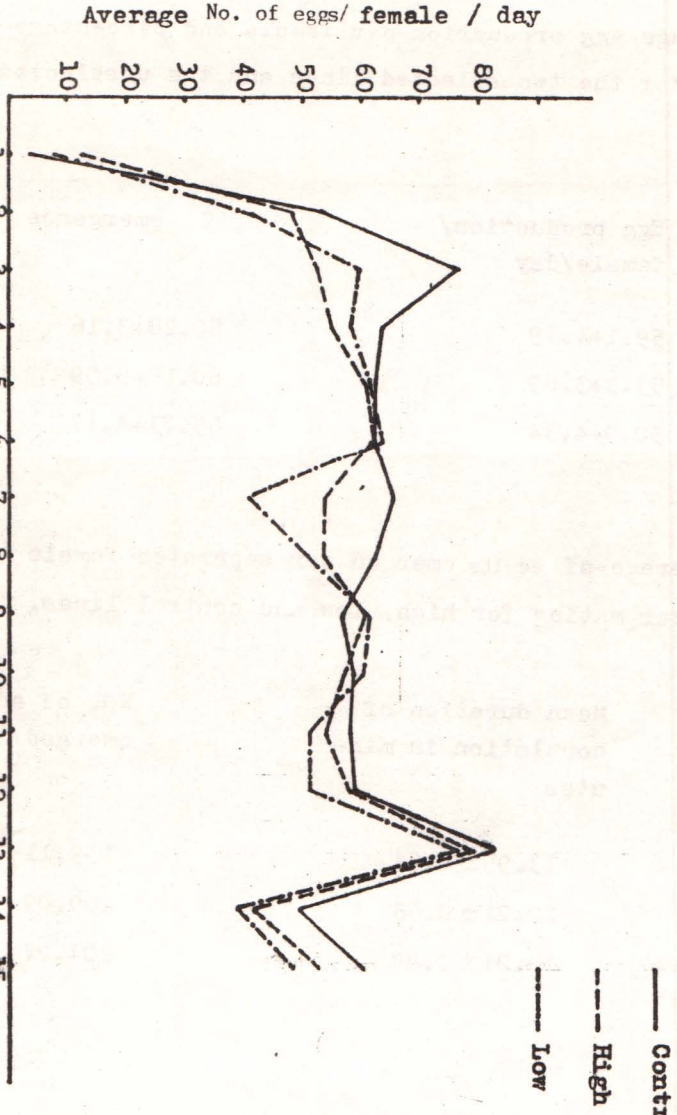

Figure 4- Daily average egg production per female in high, low and control lines

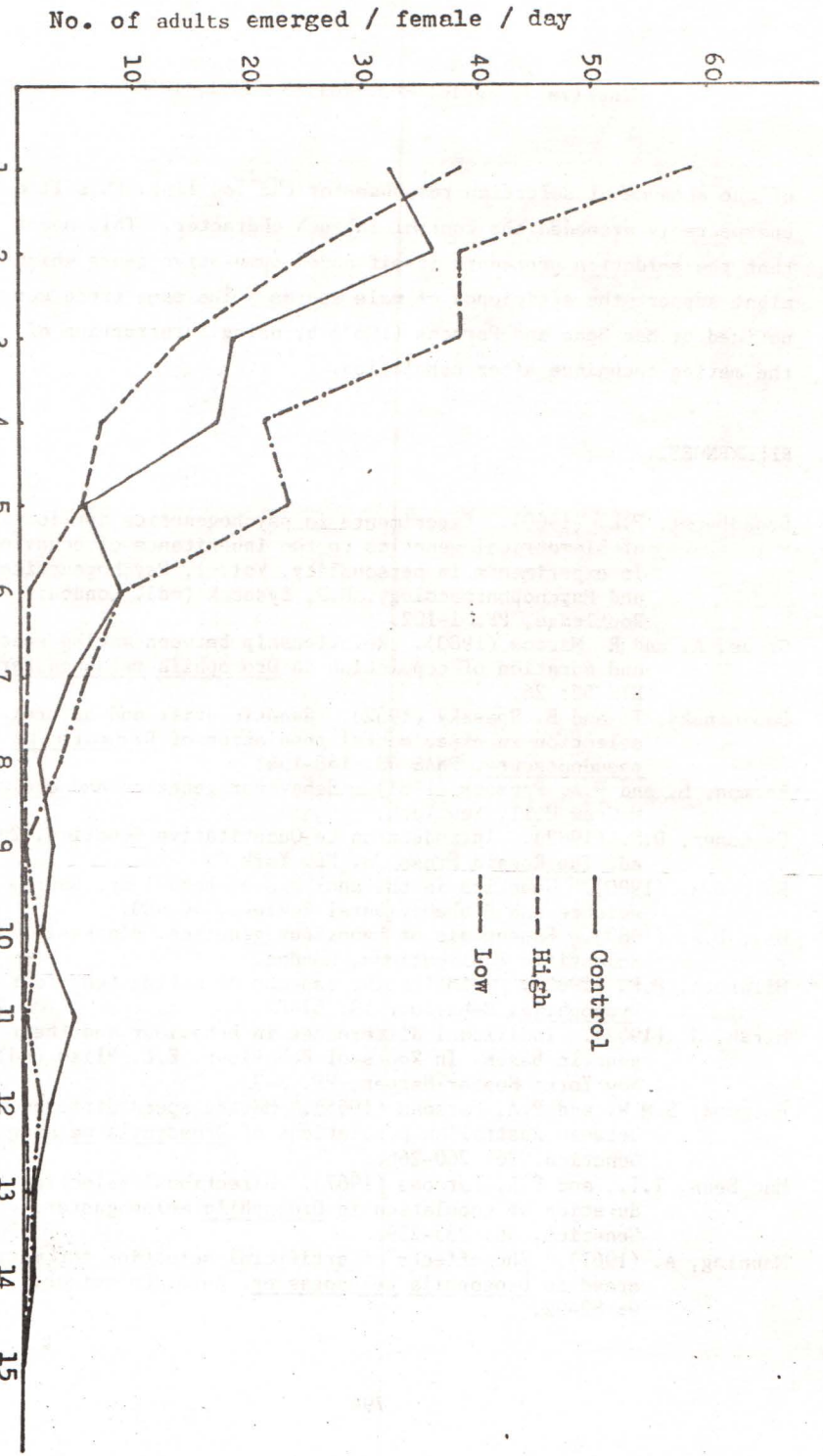

Figure 5- The average of adults emerged per day per female for high, low and control lines (females were separated from males after mating).

of the absence of selection response for the low line, this line unexpectedly exceeded the control in such character. This means that the selection procedure itself added cumulative genes which might support the efficiency of male sperms. The same trend was noticed by Mac Bean and Parsons (1967) by using interruption of the mating technique after copulation.

REFERENCES

Broadhurst, P.L. (1960). Experiments in psychogenetics applications of biometrical genetics to the inheritance of behaviour. In experiments in personality, Vol. 1, Psychogenetics and Psychopharmacology. H.J. Eysneck (ed). London: Routledge, PP. 1-102.

Creus, A. and R. Marcos (1980). Relationship between mating speed and duration of copulation in Drosophila melanogaster. DIS 55: 26.

Dobzhansky, T. and B. Spassky (1962). Genetic drift and natural selection in experimental population of Drosophila pseudoobscura. PNAS 48: 148-156.

Ehrman, L. and P.A. Parsons (1981). Behaviour genetics and evolution. McGraw Hill, New York.

Falconer, D.S. (1983). Introduction to Quantitative Genetics, 2nd ed. The Ronald Press Co. New York.

Hay, D.A. (1980). Genetics in the analysis of behaviour. Neuroscience and Biobehavioural Reviews, 4, 489.

Hay, D.A. (1985). Essentials of behaviour genetics. Blackwell Scientific Puplications, London.

Hildreth, P.E. (1962). Quantitative aspects of mating behaviour in Drosophila. Behaviour 19: 57-73.

Hirsh, J. (1962). Individual differences in behaviour and their genetic bases. In Roots of Behaviour. E.L. Bliss (ed) New York: Hoeber-Harper, PP. 3-23.

Hosgood, S.M.W. and P.A. Parsons (1965). Mating speed differences between Australian populations of Drosophila melanogaster. Genetica, 36: 260-266.

Mac Bean, I.I., and P.A. Parsons (1967). Directional selection for duration of copulation in Drosophila melanogaster. Genetics, 56: 233-239.

Manning, A. (1961). The effects of artificial selection for mating speed in Drosophila melanogaster. Anim. Behaviour. 9: 82-92.

Manning, A. (1963). Selection for mating speed in Drosophila melanogaster based on the behaviour of one sex. Anim. Behaviour, 11: 116-120.

Parsons, P.A. (1964). A diallel cross for mating speed in Drosophila melanogaster. Genetics, 35: 141-151.

Spiess, E.B. (1968). Low frequency advantage in mating of Drosophila pseudoobscura karyotype. Am. Nat., 102: 363-379.

Tully, T. (1983). Properties of retention of a classically conditioned olfactory response in wild-type and mutant in Drosophila melanogaster. Behaviour Genetics, 13: 555.