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IMPACT OF POPULATION DENSITY ON BODY WEIGHT IN EXPERIMENTAL POPULATIONS OF *Drosophila ananassae*

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ABSTRACT

Impact of population densities on adult body weight was studied in both sexes of *Drosophila ananassae*. For this purpose, parental flies were cultured in the number of 5 pairs, 15 pairs, 25 pairs, 75 pairs and 125 pairs in culture bottles and their progeny (males and females separately) were weighed. Flies derived from 5 pairs of parents possessed maximum body weight and those obtained from 25 pairs of parents showed minimum weight indicating gradual decrease in their body weight. However, progeny obtained from 75 and 125 pairs of parents showed an increase in the body weight. Further, a significant difference was observed in the body weight of the two sexes in all the groups studied. These results indicate that varying density leaves its impact on the body weight.

KEYWORDS : *Drosophila ananassae*, population density, body weight, competition

Presence of large number of individuals within a single dwelling that restrict movement will result into a number of distinct happenings like poor hygiene, unrest and conflict. Population density is one of the environmental factors that is known to adversely affect a number of fitness parameters in diverse species of animals (Joshi and Mueller, 1997). Impact of high rearing density on population dynamics and life history parameters of insects have been studied in various species and such studies occupy an important place in evolutionary ecology. Some of such studies have been done in mirid bug, *Dicyphus tamaninii* (Agusti, 1998); leaf bug, *Macrolophus caliginosus* (Castane et al., 2007); desert locust, *Schistocerca gregaria* (Simpson et al, 1999); plant bug, *Lygus hesperus* (Brent, 2010); mealworm beetle, *Tenebrio molitor* (Barnes and Shiva-Jothy, 2000).

Drosophila has also been used for this kind of studies. It has been observed that *Drosophila* reared at relatively high densities experience high intra-specific (within same species) competition as a result of rapid food depletion. The effect of this competition has its clear cut impact on both the larval and adult fitness. Birch (1955) worked on *Drosophila pseudoobscura* and according to him intra-specific and inter-specific competitions do occur when the animals utilize common resources and in case if the supply of such resources are in shortage. Singh and Kumar (2013) studied interspecific competition between two species of *Drosphila* i.e. *D. melanogaster* and *D. ananassae* and reported that one of the species, *D. ananassae* faces acute competition at every level of its life cycle and gets eliminated in just first generation. Botella et al., 1985 performed experiments on *D. melanogaster* and based on the results they opined that apart from the food limitation, there are many other ecological consequences of high density in culture medium. They narrated that due to high population density the food medium becomes very moist and soggy due to accumulation of high level of toxic nitrogenous metabolic wastes like urea, uric acid and ammonia. Besides this, drowning especially of females, result into their mortality, presumably because they need to go to the surface of the medium to feed and to lay eggs. When a huge number of individuals share a small space, the consequence of this could be seen on the developmental stages as well as on adults. High population density results into high intra specific competition that in fact aggravates larval and adult mortality, reduced fertility, retarded development, and abnormal effect on body weight and body size (Peters and Barbosa, 1977; Clarke and McKenzie, 1992; Hoffman and Woods, 2001).

Experimental data accumulated from various *Drosophila* studies have shown that crowding leaves its effect on almost all the stages of the life cycle. These studies mostly dealt with effect of larval crowding on various life history traits such as egg-adult viability (Sang, 1949; Birch, 1955; Bakker, 1961; Bentvelzen, 1963; Lewontin and Matsuo, 1963; Barker and Podger, 1970a, b), adult body size, fecundity and developmental period (Alpatov,1932; Pearl, 1932) as well as on morphological traits (Imasheva and Bubliy, 2003). Compared to larval crowding, the effect of adult crowding in laboratory populations of *Drosophila*

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has not been studied very extensively. However, some studies have shown that adult population density affect mating rate (Moth, 1974; Eckstrand and Seiger, 1975; Marks et al., 1988) and longevity (Joshi and Mueller, 1997).

Drosophila ananassae is a cosmopolitan and domestic species. It belongs to the *ananassae* subgroup of the *melanogaster* species group. This species is one of the common species in India and is known to possess several genetical peculiarities, some of which are the spontaneous male meiotic recombination, parthenogenesis, varied chromosomal polymorphism, Y-4 linkage of nucleolar organizer (Singh and Singh 1987, 1988; Singh, 2010). In the present work the effect of different adult population densities on the body weight of next generation progeny (male and female separately) of *Drosophila ananassae* has been studied.

MATERIALS AND METHODS

The experiments were performed by using one of the laboratory stocks i.e. VNST of *Drosophila ananassae*. This stock was raised from the flies collected from the natural population of Varanasi (collected in 2011). It possesses standard gene arrangement in all the chromosomes and thus it lacks the presence of any of the known inversion arrangement in its chromosomes (Nanda and Singh, 2011).

Five sets of cultures were established by transferring 5 pairs, 15 pairs, 25 pairs, 75 pairs and 125 pairs of virgin flies. These flies were allowed to lay eggs for five days. Parents were discarded after 5 days. Virgin F1 progeny coming in the culture bottles were collected and were sorted according to their sex and aged for 7 days. Ten virgin flies of each sex were weighed from each set of experiment. In total 10 such observations were recorded for each sex and also for each set of experiment. The body weight was taken in grams to the precision of 4 decimal points. While doing these experiments all factors such as food medium (Standard simple yeast -agar medium), food volume, culture bottle size and rearing temperature (approximately 24˚C with 12 hr. light- dark cycle) were kept constant.

RESULTS

The mean body weight of males and females of F1 progeny obtained from the varying population density are shown in the figure 1. The highest body weight (0.0132gm) was observed in the F1 females of five pairs of parents. F1 males of this group (5 pairs) showed mean body weight to be 0.00978 gm and this comes to be maximum than other four groups (when only males are considered). Flies obtained from 25 pairs of parents showed mean value of their body weight to be 0.00791 and 0.00641 in females and males respectively. These values are the minimal values when

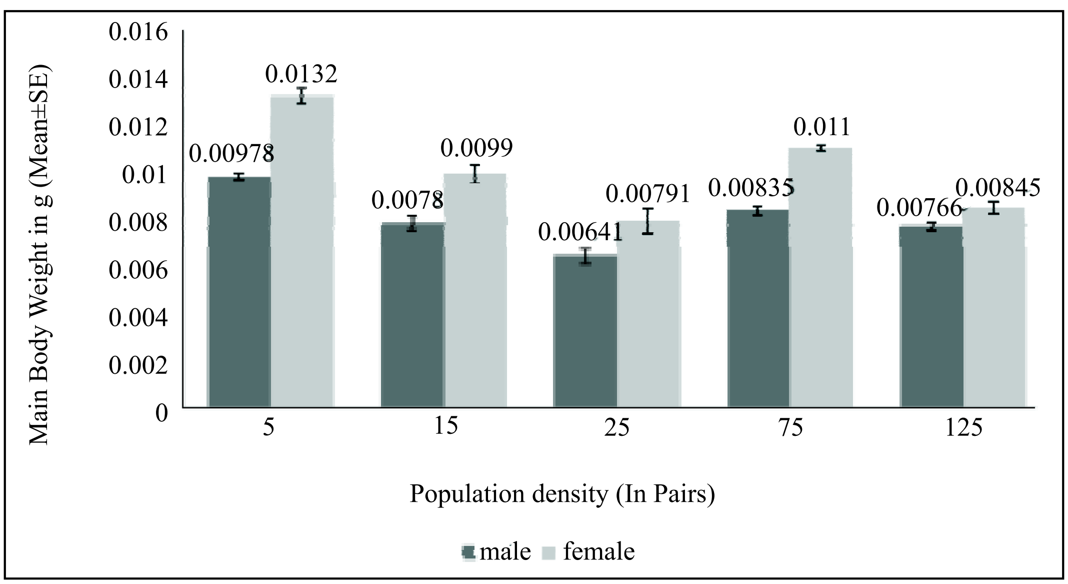

Figure1: Graph Representing Mean Body Weight (Mean ± SE) of Males and Females With Respect to Population Density

Table 1: Results of One Way ANOVA for Body Weight of Males and Females at Each Adult Population Density

Sex	Source of Variation	DF	SS	MS	F
Male	Total	49	0.0000851	_	_
	Between Treatments	4	0.0000597	0.0000149	26.469**
	Within Treatments	45	0.0000254	.000000564	_
Female	Total	49	0.000235	_	_
	Between Treatments	4	0.000180	0.0000451	37.038**
	Within Treatments	45	0.0000548	0.00000122	-

DF degree of freedom, SS Sum of Square, MS mean square, F variance ratio

**P<0.001= Highly significant

compared with other four groups. Progeny of 125 pairs of parents depicted the mean body weight 0.00845 and 0.00766gm in females and males respectively which is higher than the values obtained from 25 pairs of parents but less than the 75 pairs of parents.

Table 1 depicts the results of one way ANOVA for body weight in the two sexes at different population density. There is highly significant difference among the mean body weight of the five groups of both the sexes. To see that which of the pair groups show significant difference, a post-hoc analysis was performed. Table 2 and 3 incorporates the pair-wise multiple comparisons (Bonferroni t-test) in the males and females respectively. In case of males, out of 10 comparisons, three comparisons (15 vs. 75, 15 vs. 125 and 75 vs. 125) did not show significant difference. Similar test performed in case of females also indicate that in three cases (15 vs. 75, 15 vs. 125 and 25 vs. 125), there is insignificant difference in the mean body weight.

Table 2 : Pairwise Multiple Comparison (Bonferroni t-test) of Body Weight of Males Reared Under Different Densities

Comparisons	Diff. of Means	t	P<0.05
5 vs. 125	0.00212	6.310	Yes
5 vs. 75	0.00143	4.257	Yes
5 vs. 25	0.00337	10.031	Yes
5 vs. 15	0.00198	5.894	Yes
15 vs. 125	0.000140	0.417	No
15 vs. 75	0.000550	1.637	No
15 vs. 25	0.00139	4.138	Yes
25 vs. 125	0.000125	3.721	Yes
25 vs. 75	0.00194	5.775	Yes
75 vs. 125	0.000690	2.054	No

Results of t-test, performed to compare between the mean body weight of males and females in five varying population density groups in *D. ananassae* is presented in table 4. There is significant difference between the mean adult body weights of the two sexes in all the five group studied.

DISCUSSION

In the current work, we aimed to see the effect of

Table 3 : Pairwise Multiple Comparison (Bonferroni t-test) of Body Weight of Females Reared Under Different Densities

Comparison	Diff. of Means	t	P<0.05
5 vs. 125	0.00475	9.627	Yes
5 vs. 75	0.00217	4.398	Yes
5 vs. 25	0.00529	0.722	Yes
5 vs. 15	0.00330	6.688	Yes
15 vs. 125	0.00145	2.939	No
15 vs. 75	0.00113	2.290	No
15 vs. 25	0.00199	4.033	Yes
25 vs. 125	0.000540	1.094	No
25 vs. 75	0.00312	6.323	Yes
75 vs. 125	0.00258	5.229	Yes

Table 4: Result of t-test for Comparing Body Weight Between Males and Females of Different Density

Group	t	DF	P
5 pairs	9.865	18	<0.001**
15 pairs	4.120	18	<0.001**
25 pairs	2.441	18	= 0.025*
75 pairs	12.864	18	<0.001**
125 pairs	2.638	18	=0.017*

DF degree of freedom

*P<0.05=Significant, ** Highly Significant varying adult population density on the body weight of males and females of *D. ananassae*. The average body weights of both males and females were recorded to be maximum when only 5 pairs of parents were given chance to produce their progeny. Flies obtained from the 25 pairs of parents showed minimum body weight. The decrease in mean body weight as density was increased moderately (25 pairs) could be explained solely in terms of competition for food i.e. as adult density was increased, there would be increased egg laying resulting into indirectly high larval density. This increased larval density would have caused rapid food depletion and hence decrease in mean food supply per larva. As a consequence of this, the adult body weight decreased significantly. To our surprise, a sudden increase in body weight was observed in the progeny derived from 75 pairs of parents. This unexpected result may be due to behavioral adaptations. It seems that when population density was abruptly increased to 75 pairs, it resulted into more egg laying, dense larval population and thus larval competition for food. In fact, this larval competition might have resulted in them to develop a strategy of higher feeding rate and hence they might have become active foragers as larvae. This increase in feeding habit could be attributed to tendency of achieving higher minimum food requirement for pupation in crowded culture (Barker and Podger, 1970). Although flies derived from 125 pairs of parents showed further decrease in their body weight (in both sexes) when compared with the body weight of 75 pair group but this difference was insignificant in case of males. Further, it can also be considered that due to the fact that greater egg laying (in 125 pair group) resulting into higher larval density could cause more mortality. This brought the number of larvae equivalent to that of between 15 and 25 pairs and thus resulting in similar body weight as was observed in culture of 15 pairs. It has already been observed that larvae reared at high density typically show high cephalopharyngeal sclerite retraction per minute, which is an indirect measure of feeding rate (Joshi and Mueller, 1996; Shiotsugu et al, 1996). This behavioural activity is known to be correlated with high competitive ability (Sewell et al, 1974) to survive in crowded cultures.

Similar experiments conducted in other species of *Drosophila*: *D. melanogaster* and *D. simulan* have also revealed almost similar results (Barker and Podger, 1970; Chiang and Hodson, 1950. Besides *Drosophila*, other dipteran species have been explored for similar kind of observations. Vladimerova and Smirnov, 1938 working on *Musca domestica* and *Phormia groenlandica* observed the effect of larval density on the pupal weight and found that the average weight of the pupae dropped considerably with the increase of larval density but it increased significantly again when more number of larvae were introduced to similar experimental conditions. Tennis et al., 2001 selected house cricket i.e. *Acheta domesticus* to study the effects of population density and food surface area on body weight and reported that there is an increase in the mortality and decrease in the individual weight with increasing density. They compared the size of the emerging individuals and were able to record that the mean size of emerging adults of both sexes decreased with increasing density, and the mean size of females increased with decreasing food surface area. The results of the present study are consistent with the findings of the previous experiments performed in the other species of *Drosophila* and further study on physiological processes would provide more evidences in favor of such findings.

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REFERENCES

Agustı´ N., 1998. Biologia de *Dicyphus tamaninii* Wagner (Heteroptera: Miridae) i identntificacio´ molecular de les preses ingerides. Ph.D. thesis, University of Barcelona, Spain.

Alpatov W. W., 1932. Egg production in *Drosophila melanogaster* and some factors which influence it. J. Exp. Zool., **63**: 111.

Bakker K., 1961. An analysis of factors which determine success in competition for food among larvae of *Drosophila melanogaster*. Arch. Neerl. Zool., **14**: 200-281.

Barker J.S.F. and Podger R.N., 1970a. Interspecific competition between *Drosophila melanogaster* and *Drosophila simulans*: effects of larval density on viability, developmental period and adult body weight. Ecology, **51**: 170-189.

Barker J.S.F. and Podger R.N., 1970b. Interspecific competition between Drosophila melanogaster and *Drosophila simulans*: effects of larval density and short term adult starvation on fecundity, egg hatchability and adult viability. Ecology, **51**: 885-864.

Barnes A. I. and Siva-Jothy T. M., 2000. Density dependent porphylaxis in the mealworm beetle *Tenebrio molitor* L. (Coleoptera: Tenebrionidae): cuticular melanization is an indicator of investment in immunity. Proc. R. Soc. Lond., **267**: 177-182.

Bentvelzen P., 1963. Some interrelations between density and genetic structure of a *Drosophila* population. Genetica, **34**: 229-241.

Birch H.C., 1955. Selection in *Drosophila pseudoobscura* in relation to crowding. Evolution, **9**: 389-399.

Botella L. M., Moya A., Gonzalez M. C. and Mensua J. L., 1985. Larval stop, delayed development and survival in overcrowded cultures of *Drosophila melanogaster.* Effect of urea and uric acid. J. Insect Physiol., **31**: 179-185.

Brent C. S., 2010. Stage-specific effects of population density on the development and fertility of the western tarnished plant bug, *Lygus hesperus*. J. Insect Sci., **10**: 49.

Castane C., Alomar O., Riudavets J. and Gemeno C., 2007. Reproductive biology of the predator *Macrolophus caliginosus*: Effect of age on sexual maturation and mating. Biological Control, **43**: 278-286.

Chiang H.C. and Hudson A.C., 1950. An Analytical Study of Population Growth in *Drosophila melanogaster*. Ecol. Monogr., **20**: 173-206.

Clark A.G. and Feldman M.W., 1981. Density-dependent fertility selection in experimental populations of *Drosophila melanogaster*. Genetics, **98**: 849-869.

Clarke G.M. and McKenzie L.J., 1992. Fluctuating asymmetry as a quality control indicator for insect mass rearing processes. J. Economic Entomol., **85**: 2045-2050.

Eckstrand I.A. and Seiger M.B., 1975. Population density and mating rates in *Drosophila pseudoobscura*. Evolution, **29**:287-295.

Hoffmann A.A. and Woods R.E., 2001. Trait variability and stress: Canalization, developmental stability and the need for a broad approach. Ecol. Lett., **4**: 97-101.

Imasheva A.G. and Bubliy O.A., 2003. Quantitative variation of four morphological traits in *Drosophila melanogaster* under larval crowding. Hereditas, **138**:193-199.

Joshi A., 1997. Laboratory studies of density -dependent selection: Adaptations to crowding in *Drosophila melanogaster*. Curr. Sci., **72**: 555-562.

Joshi A. and Mueller L.D., 1996. Density -dependent natural selection in *Drosophila*, trade-offs between larval food acquisition and utilization. Evol. Ecol., **10**: 463-474.

Joshi A. and Mueller L.D., 1997. Adult crowding effects on longevity in *Drosophila melanogaster*: Increase in age-independent mortality. Curr. Sci., **72**: 255-260.

Lewontin R. C. and Matsuo Y., 1963. Interaction of genotypes determining viability in *Drosophila busckii*. Proc. Natl. Acad. Sci. USA, **49**: 270-278.

Marks R.W., Seager R.D., Ayala F.J. and Barr L.G., 1988. Local ecology and multiple matings in a natural population of *Drosophila melanogaster*. Am. Nat., **131**: 918-923.

Moth J. J. and Barker J. S., 1977. Interspecific competition between *Drosophila melanogaster* and *Drosophila simulans*: effects of adult density on adult viability. Genetica, **3**: 203-218.

Nanda P. and Singh B.N., 2011. Effect of chromosome arrangements on mate recognition system leading to behavioral isolation in *Drosophila ananassae*. Genetica, 139: 273-279.

Pearl R., 1932. The influence of density of a population upon egg production in *Drosophila melanogaster*. J. Exp. Zool., **63**: 57-84.

Peters T.M. and Barbosa P., 1977. Influence of population density on size, fecundity, and development rate of insects in culture. Ann. Rev. Entomol., **22**: 431-450.

Sang J.H., 1949. The ecological determinants of population growth in a *Drosophila* culture. III. Larval and pupal survival. Physiol. Zool., **22**: 183-202.

Sewell D., Burnet B. and Conolly K., 1974. Genetic analysis of larval feeding behaviour in *Drosophila melanogaster*. Genet. Res., **24**: 163-175.

Shiotsugu J., Leroi A.M., Yashiro H., Rose M. R. and Mueller L.D., 1996. The symmetry of correlated responses in adaptive evolution: an experimental study using *Drosophila*. Evolution, **51**: 163-172.

Simpson S. J., McCaffery A. R. and Hagele B. E., 1999. A behavioral analysis of phase change in the desert locust. Biol. Rev. Camb. Philos. Soc., 74: 461-480.

Singh A. K. and Kumar S., 2013. Suppression of *Drosophila ananassae* flies owing to interspecific competition with *D. melanogaster* under artificial conditions. Acta Zool. Mexi., **29**: 563-573.

Singh A. K. and Singh B. N., 1987. The effects of heterozygous inversions on crossing-over in *Drosophila ananssae*. Genome, **29**: 802-805.

Singh A. K. and Singh B. N., 1988. Heterozygous inversions and spontaneous male crossing-over in *Drosophila ananassae*. Genome, **30**: 445-450.

Singh B. N., 2010. *Drosophila ananassae*: a good model species for genetical, behavioral and evolutionary studies. Indian J. Exp. Biol., **48**: 333-345.

Tennis P. S., Koonce J. F. and Teraguchi M., 2001. The effects of population density and food surface area on body weight of *Acheta domesticus* (L.) (orthoptera: Gryllidae). Can. J. Zool., **55**:2004-2010.

Vladimerova M. S. and Smirnov E. S., 1938. The struggle for food in homogeneous and in mixed populations of *Musca domestica* and *Phormia groenlandica*. *Meditsinkaria Parazitologiia* i Paraztarnye bolezni,**7**: 755-777.