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EFFECT OF LARVAL DENSITY ON BODY SIZE IN *DROSOPHILA IMMIGRANS*

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ABSTRACT

Many environmental factors, biotic and abiotic interact to influence the organismal development. Organisms respond to environmental stresses with behavioral, physiological or morphological adjustment to counter its effects and maintain normal functioning. In the present study, the high parental density results in offspring with smaller body size compared to offspring from parents that reproduced at lower densities.

INTRODUCTION

The rate of development and survival of organisms can vary greatly in response to many biotic and abiotic factors of the environment. Higher temperatures are often associated with faster development rate and have variable impacts on immature survival in insects. Density-dependent competition in insects is also associated with delayed maturity and increased juvenile mortality. Similarly, food availability and nutrient quality have known associations with development rates and mortality. Despite the demonstrated associations of diet and density with developmental life-history traits, temperature remains a primary focus to explain development rate variation in insects (Mueller and Joshi, 2000). Body size has profound consequences for animal ecology, so it is very important to understand exactly how natural selection acts in the evolution of this character. Temperature may be an agent of natural selection in producing evolutionary changes in the developmental mechanism that control growth rate and adult size and the thermal conditions during an individual's development may affect its final adult size. Because phenotypic differences in body size may have impact on resistance to temperature extremes, body size variation among high and low density grown flies was compared and the correlation with stress resistance analysed.

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Size variations may not be easily separated from variation in resistance, as geographical clines for body size follow temperature gradients in several *Drosophila* species (Stalker and Carson, 1947; Prevosit, 1955; David and Capy, 1988; Capy *et al*., 1993). A genetic and phenotypic relationship between body size and temperature also has been shown in the laboratory (Anderson, 1973), where adult body size negatively correlated with temperature except at temperatures approaching the limit for development (David *et al*., 1994).

MATERIALS AND METHODS

Flies were collected from Rohtak fruit market and mass cultures were established after identification of species. Flies were reared at two densities. Low density flies were produced by placing mature adults, 10 females and 10 males, in each of four milk bottles with corn flour medium. High density flies were produced similarly, but 100 females and 50 males per bottle and the time of egg laying was increased by one day as compared to low density. Flies of both densities were serially transferred to new bottles with dead females replaced, and their progeny were used for the tests. The experiment was done at different growth temperatures (12, 14, 17, 21, 25 and 28°C). Average body weights of flies reared under high or low density were determined in each experiment. Groups of 20 flies, for each replicate, density and sex, were collected, stored as the experimental flies, and then weighed in an electronic precision balance and the weights were calculated in mg x

Table 1. Data on m±SE and CV of four morphometrical traits at two different densities in males of *D.immigrans* at six different growth temperatures

Population	Trait	12°C		14°C		17°C		21°C		25°C		28°C	
		m±SE	CV	m±SE	CV	m±SE	CV	m±SE	CV	m±SE	CV	m±SE	CV
Low	WL	364.60±.91	1.92	375.13±0.92	1.90	349.26±0.80	1.78	332.66±0.58	1.35	314.93±0.74	1.82	303.33±0.72	1.83
	TL	133.60±.48	2.84	135.60±0.54	3.13	134.80±.046	2.64	129.20±0.43	2.57	126.00±0.35	2.15	124.40±0.10	2.63
	W/T	2.75±.01	2.03	2.70±0.00	2.07	2.55±0.00	1.74	2.50±0.00	1.57	2.46±0.00	1.66	2.40±0.00	1.86
	BW	210.66±4.94	5.58	230.33±3.07	1.25	220.33±3.33	3.65	200.66±2.10	2.49	200.00±4.28	5.11	185.66±3.33	4.15
High	WL	350.60±1.15	2.48	352.33±0.94	2.07	340.60±1.00	2.32	319.06±1.04	2.56	304.26±0.79	2.02	292.26±0.86	2.28
	TL	129.86±.04	2.44	131..33±0.42	2.52	129.40±.054	3.21	127.86±.046	2.82	124.06±0.41	2.55	121.86±0.47	2.99
	W/T	2.77±.01	2.15	2.72±0.00	1.60	2.57±0.00	1.65	2.52±0.00	1.53	2.48±0.00	1.87	2.42±0.00	2.11
	BW	198.00±3.65	4.25	208.33±4.77	5.61	200.33±3.33	4.01	180.00±3.65	4.96	170.33±3.07	4.22	160.33±3.07	4.47

Table 2. Data on m±SE and CV of four morphometrical traits at two different densities in females of *D.immigrans* at six different growth temperatures

Population	Trait	12°C		14°C		17°C		21°C		25°C		28°C	
		m±SE	CV	m±SE	CV	m±SE	CV	m±SE	CV	m±SE	CV	m±SE	CV
Low	WL	392.60±0.78	1.54	400.00±1.12	2.16	366.46±0.92	1.95	353.26±0.63	1.39	344.13±0.69	1.56	335.20±0.64	1.49
	TL	148.40±0.42	2.20	15040±0.54	2.78	146.13±0.41	2.16	145.20±0.42	2.23	141.13±0.49	2.72	139.33±0.53	2.95
	W/T	2.64±0.00	1.25	2.65±0.00	2.12	2.50±0.00	1.45	2.45±0.02	1.63	2.43±0.00	1.80	2.38±0.00	2.58
	BW	325.00±4.47	3.42	335.66±3.33	2.49	320.00±4.28	3.22	310.00±2.23	1.73	300.66±2.11	1.68	285.00±3.65	3.08
High	WL	383.46±1.17	2.37	385.53±0.99	1.99	360.80±0.85	1.87	345.20±0.77	1.74	336.20±0.73	1.69	321.60±0.78	1.89
	TL	142.60±0.69	3.75	145.73±0.64	3.43	143.93±0.47	2.53	141.26±0.52	2.83	135.93±0.53	2.99	134.26±0.42	2.41
	W/T	2.67±0.00	2.05	2.68±0.00	1.87	2.53±0.00	1.66	2.47±0.00	1.60	2.44±0.00	2.01	2.39±0.00	2.01
	BW	300.00±3.65	2.98	310.33±4.21	3.40	295.00±2.58	2.18	291.66±3.07	2.58	271.66±3.07	2.77	240.00±3.65	3.72

Table 3. Results of ANOVA applied to test the variability due to temperature, density and sex in four morphometrical traits of *D.immigrans*

Source of variation	df	WL		TL		W/T		BW	
		MS	%var	MS	%var	MS	%var	MS	%var
Temperature (1)	5	2828.006	72.128	62.394	19.367	.06906	90.850	1116.67	8.170
Density (2)	1	977.927	4.988	95.880	5.952	.00166	.438	3750.00	54.877
Sex (3)	1	4207.143	21.460	1182.589	73.418	.02801	7.371	58016.67	84.902
1 x 2	5	19.755	.503	1.207	.374	.00089	1.270	100.00	.737
1 x 3	5	24.948	.636	.663	.205	.00154	.193	46.67	.341
2 x 3	1	8.497	.043	3.399	.211	.00326	.859	66.67	.097
1 x 2 x 3	5	9.347	.238	1.513	.470	.00113	.149	36.67	.268

100. Wing lengths were measured up to the tip of third longitudinal vein from the base of attachment of wings to thorax by the eyepiece occulometer and the readings were calculated in mm x I00. Thorax length is measured from the anterior margin to the tip of post scutellum from lateral view.

RESULTS AND DISCUSSION

Files grown at different densities were markedly different in their morphology (Table 1 and 2, Fig. 1 and 2). Males were generally small in both the densities as compared to females. The variation in body size due to density was highly significant (Table 3).

The difference of various traits between high and low density flies were more significant at higher temperatures as compared to lower temperatures. The evolution of *Drosophila* life history in response to variation in larval density is quite well studied. High larval densities lead to the evolution of reduced larval development time and a smaller adult and of more rapid rates of larval feeding , which are associated with less efficient use of food in growth . Reciprocally, higher larval feeding rates have been shown to lead to increased competitive ability. Also, a direct environmental effect of high larval density is to increase larval metabolic rate, which may result from higher larval feeding rates and perhaps additional costs such as an increased need for detoxification of ingested larval waste products.

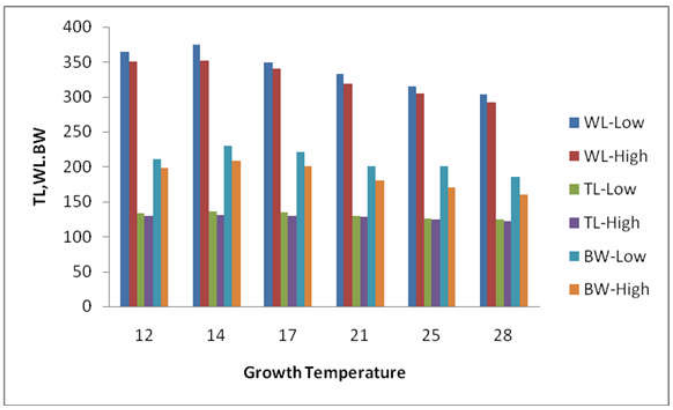

Fig. 1. Comparison of morphometric traits at different growth temperatures at Low and High larval density in males of *D.immigrans*

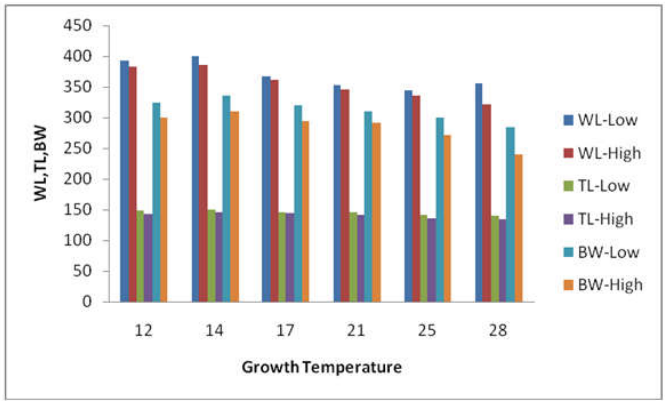

Fig. 2. Comparison of morphometric traits at different growth temperatures at Low and High larval density in females of *D.immigrans*

A possible scenario, then, for thermal evolution in *Drosophila* is that low temperature reduces the impact of larval competition, and hence the need for the metabolically costly activities associated with high competitiveness. This allows the larva to evolve a pattern of increased allocation of nutrients to growth, which in turn increases growth rate and allows the production of a larger adult, even in the face of the reduced growth efficiently that is a direct environmental effect of low temperature. The increased growth efficiency and larger adult body size of the low temperature thermal lines and southerly Australian strains are therefore consistent with an evolutionary history of low larval competition.

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