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ABDOMINAL PIGMENTATION IN SEASONAL POPULATIONS OF *DROSOPHILA TAKAHASHII*

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ABSTRACT : Body pigmentation (abdominal pigmentation) in animals is known to exhibit a range amount of variability resulting either from genetic or phenotypic plasticity. Increased melanization at lower temperatures is generally considered to be adaptive for thermoregulation and to improve metabolic activity in *Drosophila takahashii*. In the present study the data clearly shows that pigmentation was higher in winter populations for all the segments in comparison to summer at all growth temperatures ranges from 17°C to 31°C.

Key words : *Abdominal pigmentation, Melanization, Growth temperature, Drosophila.*

INTRODUCTION

According to the thermal budget adaptive hypothesis, a dark pigmentation should be favoured at low temperature and the reverse at higher temperature. Among Drosophila species, body color is permanently dark in some species endemic to temperate regions while species endemic to tropical regions are either yellowish brown (*i.e.* devoid of melanisation) or showed very little pigmentation. On the contrary, species occurring in mediterranean subtropical and regions displaying seasonal variations. Body pigmentation (abdominal pigmentation) is a highly variable trait. Such changes in body pigmentation vary in magnitude depending on the ambient temperature under wild conditions or due to overall mean values of different temperature variables (T_{max}, T_{min}, $T_{average}$ and T_{cv}) due to latitudinal and altitudinal location of a place. Thus, in order to adapt to changing thermal conditions, insects display variety of strategies out of several *Drosophila* species occurring in Northern India, *Drosophila immigrans, Drosophila takahashi* and *Drosophila melanogaster* characteristically demonstrate changes in body pigmentation. *Drosophila takahashii* are cold adapted species while *Drosophila melanogaster* occurs in temperate, subtropical and tropical regions. Two species *Drosophila takahashii* and *Drosophila melanogaster* exhibit sexual dimorphism in body pigmentation. In *Drosophila*, pigmentation can differ dramatically among closely related taxa, presenting a good opportunity to dissect the genetic changes underlying species divergence (Ng CS *et al.*,2008).

In numerous animal species, body pigmentation is a highly variable trait, due either to genetic variability or phenotypic plasticity. Three main mechanisms are known to provide some selective advantage in color variation : (1) Mate recognition, including sexual dimorphism (Lederhouse & Scriber,1996 and Ender & Houde,1995), (2) Protection against predation, including cryptism and mimicry (Kettlewell *et al.*,1971), (3) A physiological advantage in ectotherms, related to the thermal balance and absorption of light radiations (Watt,1969).

The frequencies of shell colour morphs in both *C.nemoralis* and *C.hortensis* are associated with climatic variables (temperature, shading, humidity), particularly over large areas that include a range of climatic conditions. Shell morphs differ in their absorption of solar radiation. Detailed field measurements of shell temperatures indicated that dark pigmented shells were almost always hotter than light shells, suggesting that they will be less resistant to high temperatures. Temperature extremes appeared to be particularly important in habitats representing the distribution margins of these species. In particular, the brown morph of *C.nemoralis* was abundant in sites with low night temperatures, while mid-banded forms were common in open habitats exposed to temperature extremes. Visual selection via predation appears unimportant at the distribution margins, although this factor affects morph frequencies in more beginning habitats.

MATERIAL AND METHODS

D.takahashii populations were collected by bait trap method from Rohtak fruit market during two seasons i.e. summers and winters. Isofemale lines were established and 10 females from each line were examined for body pigmentation. Each set of 10 pairs was allowed to oviposit for a few hours at 25°C in successive vials containing a killed yeast medium. Vials with eggs were then transferred to different growth temperatures 17° to 31°C to cover almost the full thermal range compatible with sufficient viability. For all the cultures, density was kept between 100-125 eggs per vial, and the use of axenic medium reduced crowding effect. On emergence, adults were transferred to fresh food and examined a few days later. From each line at each temperature 10 females and males were randomly taken and studied for pigmentation score. The population was analyzed for body pigmentation.

RESULTS AND DISCUSSION

Data on mean pigmentation score for different segments of females of two seasonal populations of *Drosophila takahashii* is shown in (Tables.1&2). Pigmentation was higher in winter population for all the segments (Figs.1&2).

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Table. 1 Data on mean ±SE of different segment 2, 3 and 4 in female individuals of isofemales lines growth at five different temperature for *Drosophila takahashii* from two different seasons.

Season	Segment	17°C	21°C	25°C	28°C	31°C
		m±SE	m±SE	m±SE	m±SE	m±SE
Summer	2	2.58±0.13	2.28±0.03	1.91±0.09	1.74±0.02	1.62±0.12
	3	4.00±0.15	3.01±0.04	2.70±0.06	2.28±0.04	2.12±0.3
	4	4.37±0.17	3.24±0.07	2.70±0.15	2.28±0.04	2.16±0.14
Winter	2	2.78±0.02	2.51±0.14	2.20±0.36	1.89±0.06	1.74±0.32
	3	4.58±0.09	3.77±0.06	3.16±0.14	2.71±0.18	2.60±0.11
	4	5.12±0.08	4.09±0.09	3.37±0.17	2.77±0.07	2.68±0.21

Table. 2 Data on mean ±SE of different segment 5, 6 and 7 in female individuals of isofemales lines growth at five different temperature for *Drosophila takahashii* from two different seasons.

Season	Segment	17°C	21°C	25°C	28°C	31°C
		m±SE	m±SE	m±SE	m±SE	m±SE
Summer	5	5.62±0.22	3.40±0.34	2.07±0.08	1.84±0.07	1.32
	6	9.20±0.10	6.27±0.21	3.085±0.13	2.11±0.31	1.92
	7	7.47±0.26	4.47±0.20	1.085±0.18	.3±0.15	.20
Winter	5	6.46±0.17	4.73±0.16	3.23±0.15	2.54±0.09	2.10
	6	9.55±0.11	7.92±0.25	4.31±0.25	2.93±0.35	2.26
	7	9.02±0.12	6.87±0.16	1.66±0.20	.6±1.00	.48

Table. 3 Results of ANOVA applied to test the variability in body pigmentation due to season temperature and isofemale lines in *Drosophila takahashii*.

Source of variation	df	Segment 2		Segment 3		Segment 4	
		MS	% var	MS	% var	MS	% var
Season (1)	1	1.201	7.031	4.514	13.342	6.930	14.158
Temperature (2)	4	3.678	64.622	8.348	74.023	12.097	74.146
Line (3)	6	.187	6.571	.146	2.584	.132	1.628
1 x 2	3	.253	4.454	.055	.491	.047	0.290
1 x 3	6	.151	5.324	.174	3.086	.162	1.988
2 x 3	18	.054	5.675	.090	4.817	.147	5.399
1 x 2 x 3	18	.060	6.320	.031	1.655	.065	2.388

Table. 4 Genetic correlation (rm) between pigmentation of body segments across five growth temperatures in two seasonal populations of *Drosophila takahashii*.

Source of	Segment 5-6	Segment 6-7	Segment 7-8
Within Seasons			
Summer	0.984	1.00	0.985
Winter	0.980	0.997	0.978
Between Seasons	Segment 5-5	Segment 6-6	Segment 7-7
Summer and Winter	0.986	0.985	0.987

Table. 5 Comparison of two body pigmentation (5, 6 and 7 segments) at five growth temperature, on the basis of students "t" test in two seasonal populations of *Drosophila takahashii*.

Temp°C	Summer			Winter			Comparisons of two species (t-test)		
	Segment 5	Segment 6	Segment 7	Segment 5	Segment 6	Segment 7	Segment 5	Segment 6	Segment 7
17	5.62±0.22	9.20±0.10	7.47±0.26	6.46±0.17	9.55±0.11	7.02±0.12	7.48**	2.95*	6.55**
21	3.40±0.34	6.27±0.21	4.47±0.20	4.73±0.15	7.92±0.24	6.87±0.16	4.05*	5.06**	11.62***
25	2.07±0.08	3.08±0.12	1.08±0.18	3.23±0.15	4.31±0.25	1.66±0.20	5.91**	3.17*	5.43**
28	1.84±0.07	2.11±0.31	0.30±0.15	2.54±0.08	2.93±0.35	0.60±0.09	4.42*	0.47	.56
31	1.32±0.12	1.92±0.11	0.20±0.14	2.10±0.10	2.26±0.23	0.48±0.06	4.12*	0.35	0.36

But the difference was more significant in segment 5, 6 and 7.

Drosophila takahashii is known for its sexual dimorphism. Males exhibit a black abdomen (tergites 5 and 6). Females exhibit yellow tergites with a black stripe at the posterior margin. The extension of the black pigmentation on female tergites is highly variable, due to both phenotypic plasticity and genetic variability. Phenotypic plasticity is mainly related to growth temperature : a lower growth temperature leads to increasingly darker flies, in agreement with the thermal budget adaptive hypothesis (David *et al.*,1990 and Gibert *et al.*,1996). At a given temperature, females from the same population are highly variable, due to genetic variation (Gibert *et al.*,1998). In natural population, body color appears as a quantitative polygenic trait with high heritability, superior to 0.50 (David *et al.*,1990 and Gibert *et al.*,1996,1998) although some genes with major effects have also been described (Robertson *et al.*,1997). Between populations, significant differences have been observed, for average abdomen pigmentation (Gibert *et al.*,1996) and also for thoracic pigmentation (David *et al.*,1985). In all these cases, darker populations are observed in colder localities, again in agreement with the temperature adaptive hypothesis. In case of the thoracic trident, latitudinal and altitudinal clines are well documented in various parts of the world (Brisson *et al.*,2005)

ANOVA (Table.3) shows the maximum variation in pigmentation was due to temperature. Variation due to reason

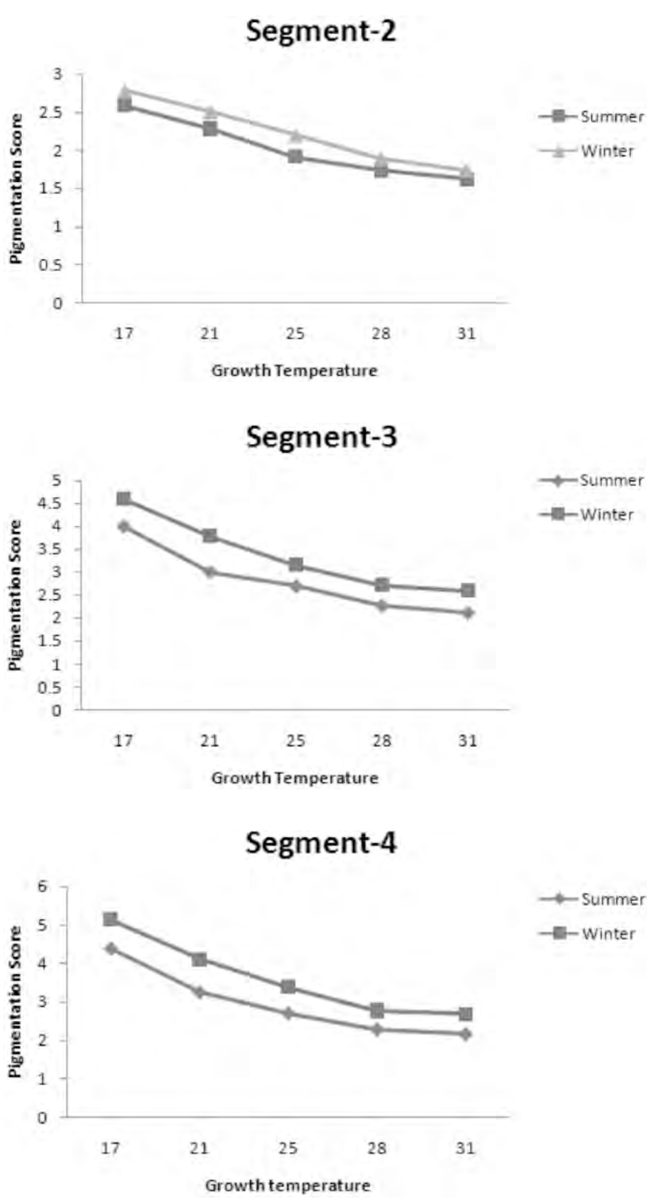

Fig. 1 Comparison of reaction norm of 2 to 4 segment of female individuals grown at five different temperatures of *D.takahashii* collected during summer and winter.

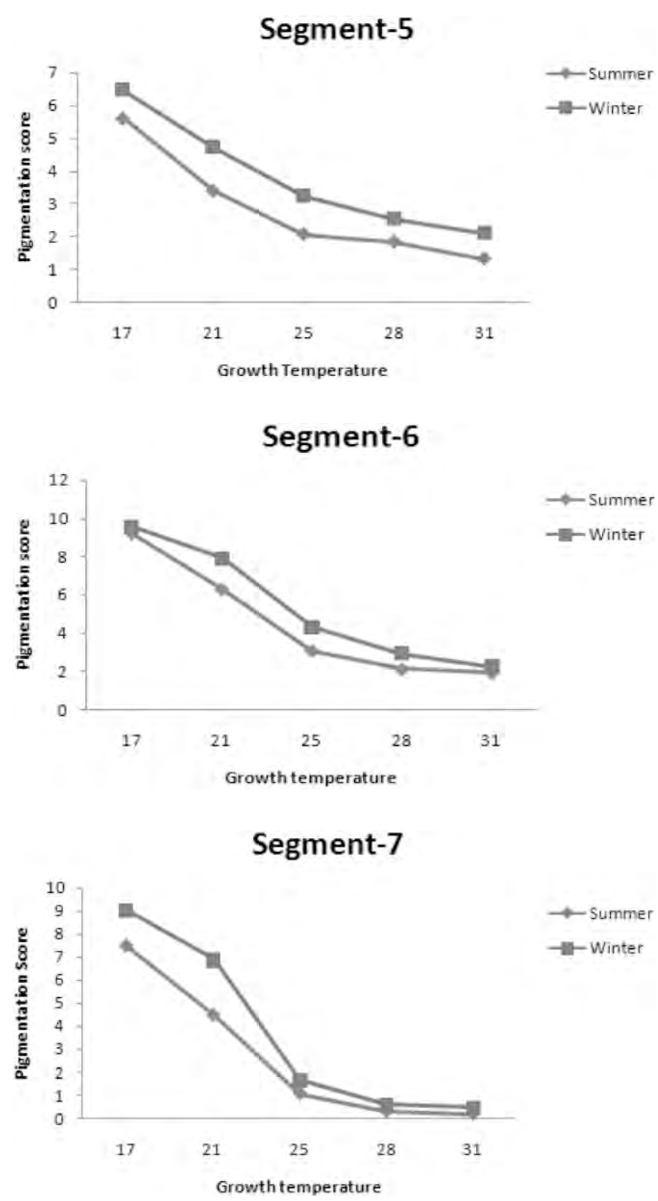

Fig. 2 Comparison of reaction norm of 5 to 7 segment of female individuals grown at five different temperatures of *D.takahashii* collected during summer and winter.

was (7 to 14%) significant. Genetic correlation (Table.4) between pigmentation of three segments of two seasonal populations of *D.takahashii* were highly significant (r=.98). Comparison of body pigmentation of three body segments (5, 6 and 7) at different growth temperatures for two seasonal populations of *D.takahashii* on the basis of t-test (Table.5) were found to be highly significant

Many other *Drosophila* species exhibit color variations. In several other species, only two color morphs are known in females only, while males are monomorphic (Payant,1986). In these species, of the *Sophophora* subgenus, the female dimorphism is mediated by two alleles of a single locus. In most cases, the dark allele is dominant, such as in *Drosophila kikkawai* (Freire-Maia,1964), *D.burlai* (Ohnishi and Watanable,1985), *D.auraria*, *D.rufa* (Oshima,1952), *D.andalusiaca* (Beardmore,1967). At least one exception is known, *D.jambulina* (Ohnishi and Watanable,1985) in which the light abdomen in dominant over dark. In all these species, males are monomorphic with generally a black abdomen as in *D.takahashii*. There are however a few exceptions such as *D.kikkawai*, where males are uniformly light.

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