Israel Journal of Entomology Vol. V - 1970

A STUDY OF COLOUR INHERITANCE IN PLODIA INTERPUNCTELLA (LEPIDOPT: PYRALIDAE)

I. Relationship between colour inheritance and viability.

H. Gelti-Douka, H . A . Pataryas and M. Lambropolou
(Department of General Biology, University of Athens, Athens, Greece)

ABSTRACT

Heredity of colour polymorphism is studied, which is evident in the abdomen of Plodia inter- punctella, ranging from black to bright yellow. The individuals were classified into four groups of phenotypes: black (++++), grey (+++), yellow (++) and bright yellow (+). From crosses it was found, that this polymorphism is an inherited character, and there is a relationship between the colour of the insects and their viability; namely that the bright yellow (+) individuals were weaker than all the others ++++, +++ and ++, presenting very often body malformations and tumors. It was found also that the male + individuals were weaker than the female +, as it was shown from the proportion of the number of the sexes, which is significantly different from the ratio 1 : 1 .

Introduction

From the observation made on a population of the moth Plodia inter- punctella Hbn. it was confirmed that the insect presents a colour polymorphism on the abdomen of both male and female adults. By microscopic observation it was found that this polymorphism consists of colour differences spanning from black, to bright yellow. For the genetic investigation of colour inheritance a grouping of the different degrees of colour is required. This, was not an easy task due to both the many shades of colour and the reflexion of light exhibited by the scales. We were able to make only a rough classification of colour into black, grey, yellow and bright yellow individuals the phenotypes of which are symbolized by ++++,+++, ++ and + correspondingly. It was observed that the yellow individuals were fewer in number than the blacks and that as one descends, the colour scale from yellow to bright yellow the number of individuals are significantly reduced in the population. The fact that the above polymorphism persists under different rearing condition i.e. fluctuating illumination, humidity and tem- perature, led us to suppose that this character is in all probability inherited.

Material and Methods

In the present investigation we used the pyralid moth Plodia interpunctella. For a successfu control of insect abdominal colour individuals obtained from experimental crosses, were chosen less than two days old so that scale shedding which is significant after the second day of life would not influence the results. The insect nutrient medium according to Tzanakakis (1959) was modified as follows: 10 parts chicken mash, 1 part glycerol and 1 part honey by volume. This medium had previously been sterilized to prevent any infection. The photoperiodism remained constant during the experiment; the temperature was maintained between 28-30°C and humidity between 40-50%. The individuals intended for crossing experiments were virgin (Richards and Thomson, 1932) and each pair was placed in glass containers. Under the above experimental conditions the developmental cycle was 28 to 30 days.

Results and Discussion

From the crosses which were made for many generations we obtained results which appear in Table I. In this and the following tables F_1 - F_4 indicates the number of inbred generation while the following number gives the breeding number of the individual pair. In those crosses, the phenotype but not the genotype of the parents is known. It should be noted that the identification and separation of individuals of a definite genotype is very difficult first because of the great variation in colour which may be due to the possibility of the existence of a number of genes which control this colour polymorphism. Because the separation of homozygous strains is not yet possible, we cannot assertain the type of inheritance, but only show that the abdominal colour is the result of an inherited trait. Thus, Table I clearly shows that some of the crosses of type: +++, X ++++ produced offspring entirely of phenotype ++++ (F_5 2, F_2 3) whereas others gave offspring the majority of which resembled the phenotype of the parents i.e. ++++ and +++ (F_2 19 to F_4 30). In addition, some of the crosses ++ X ++ gave offspring all of which were entirely of phenotype ++ (F_3 31 to F_4 18) whereas others gave offspring the majority of which resembled the phenotype of only one the parents i.e. ++(F_3 3 to F_5 15). Finally, most of the offspring of the crosses ++++ X ++, ++++ X +++ and +++ X ++ resembled or both parents (Table II). From this table it is evident that the majority of the progeny phenotypically resembled one or both of the parents. That is the progeny colour of the offspring does not seem to depend upon the sex of the parent which possesses the same phenotype, i.e. it is not sex linked (Table II).

Also of interest is the fact that the number of bright yellow individuals (+), is significantly smaller than the number of individuals of the remaining phenotypes++, +++, ++++. In addition, from 65 fertile crosses of all of the types, only 23 gave progeny among which were individuals of phenotype +, however in a very small proportion. In all, from the above crosses we obtained 96 individuals +, in a male to female ratio of 10 : 86. On the other hand, from 7 crosses in which at least one parent was +, only two gave progeny (table III). In spite of the fact that the number of these crosses was relatively small, we are able to suggest that the viability of individuals +, is decreased in comparison with that of the individuals ++. +++, and ++++. This fact is evidenced from the observation that: (a) many of the bright yellow individuals, presenting also abnormalities in wing and body morphology, died almost immediately after emerging. Very often,. these individuals presented tumors which seldom were observed in black individuals, (b) the males +, are significantly fewer in number than the females +, whereas the proportion, with regard the sex, in the other colour groups of the crosses from which these bright yellow individuals are derived is I : I (table IV). Similar cases are described as sex - limited lethality (Steinhaus, 1963). Mohr and Sturtevant (1919) described an autosomal recessive gene in Drosophila funebris which causes pupal lethality almost exclusively in females. This factor probably acts on a system present in one of the sexes only. In Ephestia the mutant gene, he, causes in homozygous condition a suppresion of the pigmentation of the wings; Hehe and hehe moths show also a lower viability than normal (HeHe) moths (Kühn, 1934, 1939). The sex-linked gene d darkens either certain veins of the wings or areas between them, or produces both effects. Like gene he, d retards development. Development is retarded cumulatively by dhe, which however, has normal viability in contrast to low viability of Dhe (Kühn and Henke 1935). In Bombyx the dominant factor Ml enhances the effect of several dark pigment mutations. It acts as a recessive semilethal factor in females only (Beliajeff, 1937). The above facts led us to suggest that there exists a clear relationship between colour and viability of Plodia; in addition, the viability of the male + is less than that of the females +.

Comparative studies with regard to colour and viability are described. in mice in the agouti series (Grüneberg 1952). The alleles of the agouti series determine the distribution of black, brown and yellow pgiments in the individuals hairs. The yellow mice are heterozygotes for yellow gene (A^Y), and it is impossible to obtain a true-breeding strain of this variety because the A^Y gene is lethal in homozygous condition. Yellow mice, particularly the females, tend to get very fat from the age of about two moths onwards. According to Dickenson and Gowen (1946-17) yellow mice have an increased appetite combined with reduced energy requirements and the basal metabolism is lower than in normal mice. A possible secondary effect of the obesity of yellow mice is the fact that the A^Y gene influences the succeptibility to tumors (Grüneberg 1952). A similar case to the above is presented in this paper, a fact which demonstrates that possibly a gene or genes which control the colour also influence by way of an mechanism not yet known the viability of these individuals. Further investigation of this relationship requires a biochemical study and determination of the substance or substances responsible for the final phenotype for colour.

Possibly, inquiry into the metabolism of these substances would give an answer with regard to their relationship to the viability and in general the regular development of this insect.

REFERENCES

Beliajeff, N.K. 1937: A genetic analysis of the colour paterns in the silkworm moth (Bombyx mori L.) Biol. Zhur. 6, 51-68.

Dickenson, G.E. and Gowen, J.W. 1946: Food utilization in genetic obesity of mice. Genetics, 31, 214-215 (Abstr.).

Dickenson, G.E. and Gowen, J.W. 1947: Hereditary obesity and efficient food utilization in mice. Science, 105, 496-498.

Grüneberg, H. 1952: The genetics of the mouse. 2nd ed. pp. 34-42. The Hague Nijhoff Martinus.

Kühn, A. 1934: Genetische und entwicklungsphysiologische Untersuchungen an Ephestia kühniella Zeitschr. Induct. Abstamm. u. Vererbungsl. 67 197-200.

Kühn, A. und Henke, K. 1935: Ueber einen Fall von geschlechtsgekoppelter Vererbung mit wechselnder Merkmalsausprägung bei der Mehlmotte Ephestia kühniella Zeller. Nachrichten Ges. Wiss. Göttingen, Math. - Phys. Kl. VI, Biol. I(14) 247-259.

Kühn, A. 1939: Ueber die Mutation he (gehemmte Ausfärbung) bei Ephestia kühniella Z.. Zeitschr. Indukt. Abstamm. - u. Vererbungsl. 77 337-385.

Mohr, O.L. and Sturtevant, A.H. 1919: A semi-lethal in Drospophila funebris that causes an excess of males. - Proc. Soc. Exp. Biol. Med , 16, 95-96.

Richards, O.W. and Thomson, W.S. 1932. A contribution to the study of the genera Ephestia, Gn. (including Strymax, Dyar), and Plodia, Gn. (Lepidoptera, Phycitidae), with notes on parasites of the larvae. Trans. Entomol. Soc. London, 80, 169.

Steinhaus, A.E. 1963: Insect pathology Vol. I. pp. 168-174. Academic Press Inc. (London) Ltd.

Tzanakakis, M.E. 1959: An ecological study of the Indian meal moth Plodia interpunctella (Hübner) with emphasis on diapause. Hilgardia 29, 5.

TABLE I. Results of experimental crosses showing that the abdominal colour is inherited.

	Phenotypes of			
Parent cross	Offsprings			
	++++	+++	++	+
$F_5$2 ++++ X ++++	51			
$F_5$3 "	38			
$F_2$19 "	100	33		
$F_2$21 "	154	15		
$F_2$22 "	70	9		
F_3 9 "	109	24	.5	
F_4 I "	90	8		
F_4 2 "	98	16		
$F_4$27 "	97	9		
$F_4$30 "	111	17		
$F_3$31 ++ X ++			106	
F_4 3 "			20	
F_4 6 "			32	
$F_4$18 "			30	
F_3 3 "	1		55	
F_3 4 "		23	112	
$F_3$12 "		36	61	
$F_3$25 "		2	45	2
$F_3$28 "			154	2
F_4 4 "	1	1	72	2
$F_4$16 "	2		20	2
$F_4$32 "		64	106	
$F_4$36 "		7	142	
$F_4$37 "			159	6
$F_4$38 "			172	6
$F_4$40 "			159	2
$F_4$43 "			222	4
$F_4$45 "			161	3
$F_4$50 "			129	7
F_5 8 "			263	9
F_5 9 "		1	166	2
$F_5$15 "			122	7

TABLE II. The relation between colour combinations of male and female parents and colour of the offspring.

Types Crossed ♂ ♀		Progeny Phenotypes ++++	+++	++
F_2 6	++ X +++		39	199
F_3 5	+++ X ++	1		39
$F_3$16	++++ X +++	8	169	1
F_4 8	++++ X +++	93	1	3
F_4 9	+++ X ++++	28	49	24
$F_4$17	+++ X ++	2	9	158
$F_4$20	++ X +++	25	53	2

TABLE III. Crossing between + females and +, ++, +++, ++++ males.

Types Crossed ♂ ♀		Progeny Phenotypes ++	+
$F_4$38	++ X +	172	6
$F_5$11	++ X +	101	5
$F_4$11	+ X +	0	
$F_4$13	+ X +	0	
$F_4$15	++++ X +	0	
$F_4$41	++ X +	0	
$F_4$48	++++ X +	0	

TABLE IV. Results showing the relation between ♂ : ♀ in each phenotype

	♂	♀	♂	♀	♂	♀	♂	♀
$F_3$15 ++ X ++	2	2	16	26	6			1
$F_3$25 "	2		20	25	2			
$F_3$27 "	1	-	73	63				
$F_3$28 "		2	82	72				
$F_3$29 +++ X +++	1	1	80	87	48	50		
$F_3$32 ++ X ++		2	97	95				
$F_4$4 "	2		38	34	1	1		
$F_4$16 "		2	6	14			2	
$F_4$37 "		6	74	86				
$F_4$38 + X ++		6	91	81				
$F_4$38 ++ X ++	1	9	87	55		1	1	
$F_4$40 "		2	75	84				
$F_4$43 "		4	99	123				
$F_4$44 "		1	72	69			1	3
$F_4$45 "		3	65	96				
$F_4$46 "	1	6	149	141	1			1
$F_4$50 "		7	61	68				
F_5 6 "		1	46	52				1
F_5 8 "		9	132	131				
F_5 9 "		2	72	94	1			
$F_5$11 + X ++		5	49	52				
$F_5$15 ++ X ++		7	71	51				
$F_5$16 "		9	104	95			1	
Total	10	86	1659	1694	59	52	5	6
	$x^2 = 60,16$		$x^2 = 0,3447$		$x^2 = 0,3243$		$x^2 = 0,3666$	
			$0,50 < p < 0,70$		$0.50 < p < 0,70$		$0.50 < p < 0,70$	