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The Effect of Environment on Facet Number
in the Bar-Eye Mutant of *Drosophila*

THE EFFECT OF ENVIRONMENT ON FACET NUMBER IN
THE BAR-EYE MUTANT OF DROSOPHILA

BY

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THESIS

Submitted in Partial Fulfillment of the Requirements for the

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IN

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UNIVERSITY OF ILLINOIS
THE GRADUATE SCHOOL

June 1, 1917

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPER-
VISION BY Ernest Wilford Seyster
ENTITLED The Effect of Environment on Facet Number in the
Bar-Eye Mutant of Drosophila
BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE
DEGREE OF Master of Arts

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*Required for doctor's degree but not for master's.

376533

7 Feb. 17 Gilley

THE EFFECT OF ENVIRONMENT ON FACET NUMBER IN THE
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Contents.	Page
I. Introduction	1
II. Methods	3
III. Data	5
Tables	13
Plates	22
IV. Discussion	27
V. Summary	29
VI. Bibliography	30
VII. Appendix	31

THE EFFECT OF ENVIRONMENT ON FACET NUMBER IN THE
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I. Introduction.

For the past three years experiments have been in progress in this laboratory to determine the effect of selection upon the facet number of *Drosophila*. In connection with this rather extended series of experiments, the question of the effect of environment on facet number was taken up in order that the effect of such influences upon selection might be reduced to a minimum.

The general effect of temperature on insects is fairly well known, while but little is known about the effects of moisture. Loeb, working on *Drosophila*, found that between 28°C and 9°C the average duration of life is doubled by a fall of ten degrees. Little work has been done, however, on the effect of environmental influences on Mendelian characteristics in this form. Morgan states that in dry food the abnormal banding occurred very seldom, while in moist food this character was well developed and gave a regular Mendelian ratio, the effect of which was obscured by dryness in the food. A somewhat similar instance has been reported by Miss. Hoge, as regards the influence of temperature upon the production of supernumerary legs in a Mendelian ratio. In this case the factor for extra legs may be transmitted, but at

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ordinary temperatures the effect is obscured, and it is only at the lower temperatures that the factor shows itself.

The present paper deals particularly with the effect of temperature upon facet number.

Methods.

II. The long wing red "bar" eye *Drosophila* was used in these investigations with the exception of experiments 14, 15 and 17 in which the white bar eye stock was used, because of its greater viability. The flies were reared in either large mouth bottles of 140 c. c. or 230 c.c. capacity. The same size of bottle was used throughout each experiment.

Banana, which had been sterilized in a steam sterilizer, was used as food. In most cases a little yeast was added after the food had cooled, although development proceeded more rapidly and a larger number of individuals was obtained without the use of yeast provided mould did not develop too rapidly. The food proposed by Metz and agar-agar food were both tried but with little success. An attempt was made to keep the moisture the same in the different bottles of each experiment.

For the higher temperatures (27° -- 30° C) a bacteriological incubator was found very satisfactory, varying not more than 0.5° C. The room temperature, recorded by means of a thermograph, was, for the most part quite constant, and did not usually vary more than 2° C. A cold plate was easily arranged by allowing tap water to flow around a dish in which the *Drosophila* bottles were placed. The temperature here did not vary more than one degree during any experiment.

The parents in each experiment were taken from mass cultures or stocks, no attempt being made to obtain virgin females for this work. However, the average facet number of the parents of any two sets in an experiment differed but little, any difference occurring being much less than the difference between the averages of the offspring raised at different temperatures. In experiments 14, 15, 17, and 18 the parents were left in the bottles for one day only; in all other experiments they were allowed to remain for nearly the full developmental period of the fly at that temperature in order that a larger number of individuals might be obtained.

In counting, a No. 4 eye-piece and a No. 3 Leitz objective were used. The area of the eye in arbitrary units was found by making an outline camera lucida drawing of the eye and measuring the enclosed area with a polar planimeter, which instrument was found to give very accurate results to 1/100 of a square inch. In some cases the facets were counted after the flies had been preserved in alcohol but mostly the counts were made shortly after the emergence of the flies from the pupa cases. In order to determine the per cent of error made in counting a set of ten flies, (5 males and 5 females) was counted at two different times. The result was as follows:-

First count		Second count		Per cent error between two counts
158	135	156	137	
160	111	159	108	
153	115	151	114	
118	106	128	104	
169	122	178	121	
Total 1347		1356		0.82%

For a larger number of individuals the per cent^{of} error would probably be less than this; for single individuals it was found to average about 5% to 7%.

DATA.

III. Experiment 1,2,3. The effect of temperature on facet number. The first experiment tried was to test the effect of different amounts of food on facet number. Three bottles, each containing a different amount of food and thirteen pairs of flies as parents, were placed in a small well-lighted room where the temperature was kept at approximately 27 C. After seven days the parents were taken out and their facets counted. Offspring were removed from the bottles as they hatched and a count made of their facets. It was found that the facet number of the offspring in each of the three bottles differed slightly from each other but that their average facet number was decidedly lower than that of the parents. In the male flies this difference was 26, and in the female flies 35. A count of the stock was made at the end of the experiment, and it was found that here the facet number had increased greatly, the average for the males being 50 higher than that of the parents, and for the females 30. Previous to the time of the experiment, the stock had been kept in a room where the temperature was approximately 21 C - 23 C, while, during the time of the experiment, it was kept at

19 C - 21C.

Experiment 4. These experiments indicated that temperature was an important factor in facet variation of the bar-eye. To test this farther one set of *Drosophila* was placed in an incubator, where the temperature was 28.5 C, another was kept at room temperature, (22°), and a third set was placed on a cold plate at a temperature of 17 C. and the offspring ^{were} allowed to develop at these temperatures. In facet number those which developed at room temperature differed but little from the parents, those which developed at 17° were decidedly higher, while those which developed at 28.5° C showed a marked decrease in facet number. In this experiment, the electric current of the incubator was turned off for one and one half days so that the developing flies were at room temperature for that length of time. In the counts, the effects of this may be noted as about one ninth of the flies is much higher than the rest, the developmental period being nine days at a temperature of 28.5°C. The temperature of the cold plate was also allowed to rise to that of the room twice for about three hours each, so that the results from this experiment are somewhat less striking as regards the differences between high and low facet numbers.

Part of the offspring of 4.1 and 4.2 was used as parents

in similar experiments (experiments 4.1, 4.2) only here there was no room temperature. The results obtained from all four sets are analagous to those obtained from experiment 4. Whether or not the facet number of the F_2 flies is in any way affected by the temperature at which the F_1 's develop is yet to be determined although the following results and some of the other work would seem to indicate that the effect, if any, is slight. (See also experiment 5.1 and 5.2)

The following experiment is the most conclusive as a high temperature of 29 and a low temperature of 17.5 were maintained throughout the time of experiment. The male flies developing at a low temperature showed an average facet number three times as great as those developing at high; the female flies developing at a low temperature gave a facet number 4.7 times that of those developing at high. In the parents the difference between the averages of the sets was, in the males 2 and in the females 10, and in both males and females those having the highest facet average gave the lowest offspring, these being the ones that developed at 29°. The extreme variates (high, low) of the parents of the two sets are slightly greater in the case of those which developed at the lower temperature, but as the greater difference here is only eleven facets, and as the difference between the variates of the two sets of offspring is as great as 145, it is certain that selection can play no very great role in determining the facet number of the offspring here noted.

A part of the offspring from experiment 5.1 was continued as a "hot" line for five generations at 29 C. The fifth generation gave an average of 63, the females had an average of 35; the males were lower and the females higher than the first generation of offspring of 5.1.

In experiments 14, 15 and 17 the effect of temperature on the white bar-eye *Drosophila* may be noted, and the results are fully concurrent with the results obtained from the work on the red-eye. Experiment 18 also gives additional data on this question.

The above four experiments were made in order to determine the period of development when temperature was most effective. Is temperature effective throughout the larval and pupal stages, or is its major effect confined largely to the early stages of development? To determine this, five bottles with parents were placed in an incubator (29° C) and the developing flies in the different bottles allowed to pass different fractions of their developmental period here. They were then removed to the cold plate at 15° C, or room temperature (22° C), and allowed to complete their development at these temperatures. One bottle was kept on the cold plate throughout the period of development, and another was kept at 29° C. Other removals to a lower temperature were made as follows: Number 2 after one-half day; number 3 when the larvae

were about one-third grown, ($2-2\frac{1}{2}$ days); number 4, just before pupation had started; number 5 after the most of ^{the} larvae had transformed into pupae; and number 6 was kept at 29° . In experiment 18, the change from room temperature (22°) to 29° was made, and instead of using white bar-eye flies, the red bar-eyes were used. As the parents were allowed to remain in the bottles for one day, the length of time the developing flies were allowed to remain at the initial temperature was reckoned from the beginning of that day and not from the beginning, in order to give the mean time of development at that temperature for all the eggs laid during that day.

In experiments 14 and 15 the effect of temperature is to be noted early in the larval period; in 17 and 18 which were changed from 29° to 22° and from 22° to 29° respectively the effect of temperature is to be noted throughout the larval life. In no case was there any effect of temperature upon the facet number of the flies after the pupae had been formed. The parent flies of the different six sets differed but little in facet number. In experiments 14, 15, and 17 each set of parents was used once in each experiment. For instance, the parents of 14.1, 15.3, and 17.2 were identical, etc. In experiment 18 the same parents were used throughout. (See Exp. 14, 15, 17, 18)

The number of facets per degree change in temperature varies from 5.2 to 8.9 with one exception, and is fairly constant. Following is a list of factors found by dividing the difference in facet averages by the difference in degrees temperature at which the flies developed.

Experiment	Temperature difference	Facet difference	F/degree
123 males	22° -- 27°	26	5.2
123 females	22 -- 27	34	6.8
4 males	17.5-- 22	32	7.1
4 males	22--28.5	41	6.3
4 females	17.5-- 22	61	13.5
4 females	22-- 28.5	43	6.6
5 males	17.5-- 29	111	8.9
5 females	17.5-- 29	100	8.0

The relation between the facet number and a ten degree drop in temperature is also a very interesting one. Is the number of facets from two to three times as great with a ten degree drop centigrade? The following table gives the factor for facet increase per ten degree decrease C.

Experiment	Factor males	Factor females
1, 2, 3	2.6	3.5
4.0	1.7	3.0
5.0	2.5	3.9
5.1	3.0	3.2
Average	2.6	3.5

The relation of the area of the eye to facet number was found to be a constant within the range of error for flies with

an intermediate number number of facets. This constant has an average value of .685 for 43 individuals and was found by dividing the facet number by the area of the camera lucida drawing in 1/100 sq. in. In flies with a small number of facets the facet area was restricted; in too large an eye the curved surface made it very difficult to obtain accurate areas. However the above shows that the change in facets is accompanied by a change in the size of the eye, and that there is no change in the size of facets.

Acidity. But one experiment was completed on the effect of acidity of food and this gave no significant difference, although the differences in the food were greater than usual. The food of 11.1 was very acid in odor due to long fermentation, while no yeast was added to the food of 11.2 and consequently it developed no acid odor whatsoever. The data concerning this experiment are given below.

Parents				Offspring			
11.1		11.2		11.1		11.2	
115	68	102	63	62	32	65	41

In other experiments which were tried, the acidity was made stronger by the addition of glacial acetic acid. Mostly

the development proceeded through part of the pupal stage but no farther, the flies not emerging from their pupae cases. Here it is interesting to note, in connection with other work done on acidity, that the time of development is greatly lengthened in acid media.

13.

1,2,3, males

	Parents				Offspring				Dif.of F ₁ From P	Stock at end of exp.
Cat no	1	2	3	Total	1	2	3	Total		
Dev. t	---(21°--23°)---				-----27-----					19°--21°
No ind	11	10	8	29	25	20	21	66		24
Facet ave	105	112	106	108	85	86	77	82	26	164
Error±				3				1.7		
High	149	164	126	164	162	178	140	178	14	202
Low	77	86	84	77	39	45	36	36	41	112
Coef var				20				41		

1,2,3, females

	Parents				Offspring				Dif.of F ₁ from P	Stock at end of Stock at end of exp.
Cat no	1	2	3	Total	1	2	3	Total		
Dev. t	---(21°--23°)----				----27°-----					19°--21°
No ind	13	12	10	335	30	30	18	78		19
Facet ave.	75	89	83	82	47	54	42	47	35	109
Error ±				2.2				1.3		
High	100	127	98	127	88	102	86	102	25	146
Low	43	52	65	43	31	30	26	26	17	54
Coef var				24				21		

4.males

14.

	Parents				Offspring			Differences	
Cat.no.	4.1	4.2	4.3	Total	4.1	4.2	4.3		
Dev. t.	22°	22°	22°	22°	28.5°	17.5	22	17.52- 22.0°	22°-- 28.5
No. ind.	10	13	12	35	80	29	17		
Facet ave.	135	135	122	121	80	153	121	32	41
Error $\pm$			3.4	3.4	2.6				
High	192	174	180	192	161	202	186	16	25
Low	101	77	82	77	41	120	87	33	46
Coef var.				24.7	42.7				

4. females

No. Ind.	22	21	24	67	63	18	25		
Facet ave.	84	75	76	79	45	149	88	61	43
Error $\pm$				1.4	1.0				
High	120	109	113	120	83	188	128	60	45
Low	43	57	44	43	20	106	62	44	42
Coef. var				23	19.5				

Date		Description		Amount		Balance	
Jan 1		Balance					
Jan 2		...	...	...	...	...	...
Jan 3		...	...	...	...	...	...
Jan 4		...	...	...	...	...	...
Jan 5		...	...	...	...	...	...
Jan 6		...	...	...	...	...	...
Jan 7		...	...	...	...	...	...
Jan 8		...	...	...	...	...	...
Jan 9		...	...	...	...	...	...
Jan 10		...	...	...	...	...	...
Jan 11		...	...	...	...	...	...
Jan 12		...	...	...	...	...	...
Jan 13		...	...	...	...	...	...
Jan 14		...	...	...	...	...	...
Jan 15		...	...	...	...	...	...
Jan 16		...	...	...	...	...	...
Jan 17		...	...	...	...	...	...
Jan 18		...	...	...	...	...	...
Jan 19		...	...	...	...	...	...
Jan 20		...	...	...	...	...	...
Jan 21		...	...	...	...	...	...
Jan 22		...	...	...	...	...	...
Jan 23		...	...	...	...	...	...
Jan 24		...	...	...	...	...	...
Jan 25		...	...	...	...	...	...
Jan 26		...	...	...	...	...	...
Jan 27		...	...	...	...	...	...
Jan 28		...	...	...	...	...	...
Jan 29		...	...	...	...	...	...
Jan 30		...	...	...	...	...	...
Jan 31		...	...	...	...	...	...

4.1 males

15.

Cat. no.	Parents			Offspring		Differences in facet ave. from parents	
	4.11	4.12	Total	4.11	4.12		
Dev. t.	28.5°	28.5°	28.5°	28.5°	17°	28.5°-- 28.5°	17°-- 28.5°
No. ind.	10	13	23	19	5		
Facet ave.	89	72	79	66	135	19	56
High	140	120	86	86	148	54	28
Low	60	43	43	44	116	16	73

4.1
females

No. ind.	Parents			Offspring			
	13	17	30	21	4		
Facet ave.	54	46	49	58	115	9	66
High	83	76	76	94	122	11	46
Low	47	31	41	40	106	7	75

4.2 males

Cat. no.	Parents			Offspring		Differences in facet ave. from parents	
	4.21	4.22	Total	4.21	4.22		
Dev. T.	17.5°	17.5°	17.5°	28.5°	17°	28.5°-- 28.5°	17°-- 28.5°
No. ind.	13	11	24	31	9		
Average F.	158	151	155	94	185	61	30
High	202	172	202	138	228	64	56
Low	128	131	128	50	136	78	5
4.2 females							
No. ind.	10	8	18	38	18		
Facet ave.	142	136	139	55	99	84	40
High	163	165	165	74	121	89	44
Low	108	106	106	28	65	80	41

March 1891		March 1891		March 1891		March 1891	
Day	Wind	Temp.	Bar.	Humid.	Dir.	Day	Wind
1	SE	54	30.0	75	SE	1	SE
2	SE	54	30.0	75	SE	2	SE
3	SE	54	30.0	75	SE	3	SE
4	SE	54	30.0	75	SE	4	SE
5	SE	54	30.0	75	SE	5	SE
6	SE	54	30.0	75	SE	6	SE
7	SE	54	30.0	75	SE	7	SE
8	SE	54	30.0	75	SE	8	SE
9	SE	54	30.0	75	SE	9	SE
10	SE	54	30.0	75	SE	10	SE
11	SE	54	30.0	75	SE	11	SE
12	SE	54	30.0	75	SE	12	SE
13	SE	54	30.0	75	SE	13	SE
14	SE	54	30.0	75	SE	14	SE
15	SE	54	30.0	75	SE	15	SE
16	SE	54	30.0	75	SE	16	SE
17	SE	54	30.0	75	SE	17	SE
18	SE	54	30.0	75	SE	18	SE
19	SE	54	30.0	75	SE	19	SE
20	SE	54	30.0	75	SE	20	SE
21	SE	54	30.0	75	SE	21	SE
22	SE	54	30.0	75	SE	22	SE
23	SE	54	30.0	75	SE	23	SE
24	SE	54	30.0	75	SE	24	SE
25	SE	54	30.0	75	SE	25	SE
26	SE	54	30.0	75	SE	26	SE
27	SE	54	30.0	75	SE	27	SE
28	SE	54	30.0	75	SE	28	SE
29	SE	54	30.0	75	SE	29	SE
30	SE	54	30.0	75	SE	30	SE

March 1891		March 1891		March 1891		March 1891	
Day	Wind	Temp.	Bar.	Humid.	Dir.	Day	Wind
1	SE	54	30.0	75	SE	1	SE
2	SE	54	30.0	75	SE	2	SE
3	SE	54	30.0	75	SE	3	SE
4	SE	54	30.0	75	SE	4	SE
5	SE	54	30.0	75	SE	5	SE
6	SE	54	30.0	75	SE	6	SE
7	SE	54	30.0	75	SE	7	SE
8	SE	54	30.0	75	SE	8	SE
9	SE	54	30.0	75	SE	9	SE
10	SE	54	30.0	75	SE	10	SE
11	SE	54	30.0	75	SE	11	SE
12	SE	54	30.0	75	SE	12	SE
13	SE	54	30.0	75	SE	13	SE
14	SE	54	30.0	75	SE	14	SE
15	SE	54	30.0	75	SE	15	SE
16	SE	54	30.0	75	SE	16	SE
17	SE	54	30.0	75	SE	17	SE
18	SE	54	30.0	75	SE	18	SE
19	SE	54	30.0	75	SE	19	SE
20	SE	54	30.0	75	SE	20	SE
21	SE	54	30.0	75	SE	21	SE
22	SE	54	30.0	75	SE	22	SE
23	SE	54	30.0	75	SE	23	SE
24	SE	54	30.0	75	SE	24	SE
25	SE	54	30.0	75	SE	25	SE
26	SE	54	30.0	75	SE	26	SE
27	SE	54	30.0	75	SE	27	SE
28	SE	54	30.0	75	SE	28	SE
29	SE	54	30.0	75	SE	29	SE
30	SE	54	30.0	75	SE	30	SE

16.

5 males

	Parents			Offspring		Differences in facet ave.
Cat. no.	5.1	5.2	Total	5.1	5.2	17.5°--29°
Dev. t.	22°	22°	22°	29°	17.5°	
No. ind.	10	10	20	86	64	
Facet ave.	129	127	128	56	167	111
Error <u>±</u>			5.6	.9	3.0	
High	200	211	211	98	226	128
Low	90	80	80	34	74	40
Coef. var.			29	24	22.5	

5 females

	Parents			Offspring		Difference in facet ave.
Cat. no.	5.1	5.2	Total	5.1	5.2	17.5°-- 29°
Dev t	22°	22°	22°	29°	17.5°	
No ind	12	12	24	71	75	
Facet ave	97	87	92	27	128	101
Error <u>±</u>			3.0	0.5	1.5	
High	138	144	144	43	138	145
Low	34	53	34	16	83	67
Coef var			25	21	20	

Year

Month

Day

Hour

Minute

Second

Year

Month

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5.1 males

17.

	Parents from 5.1 offspring	Offspring		Difference in facet ave from parents	
		5.11	5.12		
Dev t	29°	29°	17°	29°	17°
No ind		7	21		
Facet ave		51	183	5	127
High		61	303	37	205
Low		38	127	4	93

5.1 females

No ind	16	26		
Facet ave	38	147	11	120
High	55	235	12	192
Low	27	111	11	95

Following counts are from three more generations at 29° C--
 continuations of 5.11 line.

Males

Females

Gen. no.	3	4	5	3	4	5
Facet ave	42	56	63	35	44	35
No ind	17	7	55	9	25	52
High	58	86	130	46	56	49
Low	32	43	31	28	25	20

Parents 14, 15 , 17. Developed at 27° C. 18.

Males

	14.1	14.2	14.3	14.4	14.5	14.6
Cat no.	15.3	15.4	15.5	15.6	15.1	15.2
	17.2	17.3	17.4	17.5	17.6	17.1
No ind	16	14	15	6	12	15
Facet ave	117	115	106	120	117	108
Error <u>+</u>	4.6	6.0	3.8	6.9	5.9	4.8
High	166	206	136	126	161	184
Low	56	60	72	82	82	75

Females

No ind	24	22	19	18	18	23
Facet ave	73	69	77	74	18	23
Error <u>+</u>	2.6	2.2	2.2	2.7	2.2	2.2
High	107	1 03	116	110	102	102
Low	44	44	57	48	38	40

Year	1890	1891	1892	1893	1894	1895
Jan	100	100	100	100	100	100
Feb	100	100	100	100	100	100
Mar	100	100	100	100	100	100
Apr	100	100	100	100	100	100
May	100	100	100	100	100	100
Jun	100	100	100	100	100	100
Jul	100	100	100	100	100	100
Aug	100	100	100	100	100	100
Sep	100	100	100	100	100	100
Oct	100	100	100	100	100	100
Nov	100	100	100	100	100	100
Dec	100	100	100	100	100	100

19.

14. Offspring--

--Part of development at 29° --rest at 15°

Males

Cat no	14.1	14.2	14.3	14.4	14.6	14.5
No das at 29°	0	1/2	2	4 1/4	6 1/2	7 1/2
Dev period das	33	31	28	21 1/2	10	8
No ind	6	9	13	6	37	22
Facet ave	282	272	352	57	64	76
Error $\pm$	13	7.3	9	2	2.4	1.7
High	366	325	414	65	130	161
Low	240	217	280	52	45	39

Females

No ind	10	21	18	10	25	21
Facet ave	215	266*	231	56	56	54
Error $\pm$	11	16	5	2.4	1.4	1.1
High	288	650*	281	84	86	80
Low	147	190	171	43	39	48

15. Offspring---Part of development at 29°--rest at 15°.

Males

Cat no	15.1	15.2	15.3	15.4	15.6	15.5
No days at 29°	0	1/2	2 1/2	4 1/2	9	all
Dev period days				21	11 1/2	9
No ind	4	17	4	2	21	19
Facet ave	304	271	293	76	63	54
High	324	324	402	326	88	98
Low	290	161	248	65	40	42

Females

No ind	2	18	8	2	27	32
Facet ave	172	188	233	41	41	43
High	180	233	289	47	66	63
Low	164	130	178	36	33	27

21.

Experiment 17 Part of development at 29° --rest at 22°.

Males

Cat no	17.1	17.2	17.3	17.4	17.5	17.6
No das at 29°	0	1/2	2 1/2	4 1/2	7 1/2	all
Dev period das	12	12	12	11	8 1/2	18 1/2
No ind	31	6	5	45	25	25
Facet ave	131	170	127	102	65	69
Error $\pm$	2.9	7.4	8.1	2.4	3.6	2.5
High	171	198	180	150	144	129
Lowl	102	125	96	36	32	42

Females

No ind	32	8	4	50	30	29
Facet ave	114	130	101	66	39	44
Error $\pm$	2.4	3.0	5.1	2.3	1.0	1.0
High	172	160	117	132	62	61
Low	80	112	80	32	25	31

Experiment 18 Part of development at 22° -- rest at 29°.
Red bar-eye.

Males

Cat. no.	18.5	18.2	18.3	18.4	18.1
No. das. at 22°	0	2 1/2	6 1/2	9 1/2	all
Dev. period das.	8 3/4	9 3/4	11	11 3/4	12 1/2
No. ind.	9	12	11	14	8
Facet ave.	89	98	146	175	189
High	167	166	164	210	291
Low	49	64	65	128	124

Females

No. ind.	4	11	13	19	12
Facet ave.	40	45	104	150	130
High	47	68	172	183	213
Low	35	35	52	120	101

Description of Plates.

Plate I-- Exp. 4. Effect of temperature upon facet number. Abscissa shows facet number; ordinate, number of individuals in each class. Curve to the right shows individuals raised at 17.5; dotted line, parents; curve at left, individuals raised at 28.5.

Plate II-- Exp. 5. Same as for 4. Curve at right, individuals raised at 17.5; dotted line, parents; curve at left, individuals developed at 29.

Plate III-- Period of development at which temperature is most effective. In 14, 15, 17, ordinates show facet averages of the different sets, abscissas show the number of days each set was kept at 29° before being transferred to a lower temperature of 15° for Expts. 14 and 15, and 22° for Expt. 17. Figures at the top of graph show the number of individuals used in each average.

Plate IV-- Relation of facet number to area of eye in white bar-eye. Distribution of forty-three cases around average represented by line. Camera lucida drawings of eye with facet number.

DISCUSSION

V. Effect of temperature on Facet Number. Observations upon which the red and white bar-eye show that temperature is an important factor in determining facet number of the flies taken at random from a general population. Flies raised at a higher temperature, however, do not have a higher number of facets, but, on the contrary, the higher the temperature of development, the lower the facet number. An explanation which may be offered presupposes the existence of a chemical factor or determiner which acts as an inhibitor of facet formation and that, at a higher temperature, the speed of reaction is much greater than at a low^{er}. Then, according to Van Hoff's law, with an increase of 10°C the speed of the reaction should be from two to three times as great and the number of facets one half to one third times as large, and vice versa. An examination of the data shows that this is true.

 In the males with a 10°C decrease the facet average is 2.6 times as great; in the females 3.5 times. Whether or not the high factor, 3.5, in the females is due to the fact that the bar-eye is a sex linked factor and the female receives two chromosomes containing this factor, where the male receives but one is a matter for speculation. Experiments are now in progress to determine whether the restraining factor is present in the full eye fly or not.

In ordinary banana food, acidity is probably a small factor in the regulation of facet number. By adding a weak acid, such as acetic, the time required for pupation was considerably lengthened. However under such conditions no flies hatched out and no counts were obtained.

That it is not light which is the important factor is shown by the fact that the effect of temperature is very marked whether both sets are reared in incubators at different temperatures, or in well-lighted rooms at different temperatures. Whether or not dryness plays any part in the regulation of facet number has not been decided although it is likely since there is no regular marked change in facet number as the food grows dryer, that moisture is not a very important factor.

Period of development at which temperature is most effective. Because of the fact that such Diptera as Culex, Corethra, Simulium, Chironomus, Ceratopogon and Muscidae, the facets are formed during the larval period, it was expected that any effect that temperature might have would be confined to the larval stage of development. It was found that the temperature was most effective during the first part of the larval life, and that it had no effect whatsoever during the pupal period of development. That its effect is negative or less strongly marked during the later part of the larval life is probably due to the fact that fewer facets are formed at this time.

Summary.

1. Temperature is an important factor in the determination of facet number in the bar-eye of *Drosophila*.

2. A lower developmental temperature results in a higher facet number, and conversely a higher temperature results in a lower facet number.

3. With each 10° drop in temperature between 29° and 15° , the facet number is increased 2.6 times in the males and 3.5 times in the females.

4. The increase in facet number is directly proportional to the increase in the area of the eye, and facet-size is therefore a constant.

5. Light, amount of food, dryness and acidity, as they ordinarily occur in *Drosophila* work, are not important factors in the determination of facet number in the bar-eye.

6. Temperature is effective thruout the period of larval development, but it is not as effective in the later as in the earlier part.

This work was done under the direction of Dr. C. Zeleny, and I wish to express my thanks to him for his interest in the problem and for his many suggestions while it was in progress.

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APPENDIX

(Containing record of counts.)

Parents, 1,2,3. Offspring, 1,2,3. (31.)

I.

...

Stock.

♂ 1.	♀	♂ 1.	♀	♀	♂	♀
149	43	72	60	..	50	185
77	65	78	42	..	40	202
77	46	99	88	..	72	175
79	60	103	43	..	58	112
84	79	111	47	..	58	200
107	62	78	43	..	57	152
132	56	69	68	..	69	130
92	98	82	41	..	58	200
88	100	82	56			145
125	97	81	35			165
145	196	64	59			137
	76	162	54	♂ 3.	♀	160
		39	50	107	40	166
		52	39	68	43	140
		59	49	92	62	156
♂ 2.	♀	140	45	56	86	194
100	127	100	41	80	44	161
104	115	71	42	54	39	186
164	62	94	41	100	52	134
125	111	69	39	72	42	130
91	102	72	56	54	41	176
106	98	91	44	78	32	192
86	70	85	45	74	33	157
119	74	105	38	140	35	123
124	110	58	40	138	40	
102	73		39	56	35	
	52		31	67	43	
	79		38	71	32	
			57	65	26	
				75	32	
				69		
				56		
				36		
♂ 3.	♀	♂ 2.	♀			
113	89	120	56			
125	98	178	70			
101	74	93	43			
103	84	56	46			
104	85	94	62			
84	72	106	44			
126	95	67	102			
94	87	117	85			
	65	54	48			
	78	90	62			
		45	30			
		67	55			
		71	44			
		94	47			
		75	35			
		99	61			
		88	44			
		72	43			
		58	43			
		68	35			
			51			
			52			

4.1 P ♂	4.1 P ♀	4.3 P ♀				4.2 F ♂ (4.2.1) P ♂	(4.2.1) P ♀	II.
136	90	68	43	59		156	141	
103	54	54	120	47		142	125	
137	54	58	55	54		150	106	
101	99	78	64	112		135	138	
120	110	84	54	131	59	128	165	
161	43	113	76	86	40	174	139	
192	102	72	69	89	50	202	156	
147	78	55	63	54	37	155		
136	81	112	93	64		186		
118	82	55		46		136		
	87	74		41		134		
	80	75		72		188		
	90	63		60		165		
	87	88		82			4.3 F ♂	
	61	93		42	39		132	
	114	107		43	34		111	
160	58	74	89	49	44		118	
77	68	89	63	77	43		107	
110	84	44	136	60	41	4.2.2 P ♂	87	
163	90	76	64	51	56	155	95	
121	121	68	45	60	54	162	109	
174	120	46	66	44	55	138	182	
161		89	85	4.1 ♀ F. (4.1.1 ♀ P)	37	146	120	
144		81	84	47	28	131	116	
144		—	63	48	39	135	126	
124			90	54	54	161	115	
114	4.2 P ♀	4.1 F ♂	58	20	158	172	186	
123		(4.1.1) P ♀	94	50	172	156	112	
146	72	80	123	60	47	143	104	
	92	80	64	59	48		121	
	72	118	71	83	28			
	59	86	70	47	32			
	109	77	47	53	26			
4.3 P ♂	61	68	97	48	31		4.3 F ♀	
	94	140	138	48	28		81	102
82	88	67	161	50	38		79	96
115	59	60	129	50	54	160	92	92
88	82	105	105		54	168	107	95
119	70	93	70		45	175	108	
89	79		62		46	120	75	
180	71		61	4.1.2 (P ♀)	23	178	97	
178	85		53	37	38		89	
86	57		55	32	73		62	
116	86	(4.1.2) P ♂	50	32	32	4.2 F ♀ (4.2.1) P ♀	83	
131	79		125	39	27	138	95	
150	69	60	55	61	45	154	84	
133	85	98	115	76	42	163	71	
	69	64	134	31	—	133	67	
	76	78	66	39		125	71	
			126	42		188	128	
				46		127	67	
				31		151	94	
				73		138	105	
				52		108	82	
				46			78	

THE HISTORY OF THE

REIGN OF

CHARLES THE FIRST

BY

JOHN BURNET

OF THE UNIVERSITY OF OXFORD

IN TWO VOLUMES

LONDON

4.11 F ♂	4.12 F ♂	4.21 F ♀	4.22 F ♀
	148	84	113
78	116	64	121
74	138	63	86
64	144	60	84
76	128	36	66
70		46	101
75		42	118
61		59	104
86		58	114
78	4.12	64	98
81	F ♀	48	103
60	117	64	91
64	122	73	106
44	106	51	88
62	116	57	90
54		46	121
60		48	112
46		71	65
51		69	
67	4.21	47	
	F ♂	74	
		52	
411	132	65	
F ♂	63	59	
	84	43	
	110	44	
62	94	48	
46	110	58	
64	105	66	
50	96	44	
52	121	51	
68	106	57	
57	113	54	
71	112	40	
57	117	28	
60	138	65	
72	76	47	
55	112	36	
58	74		
43	79		
59	96		
94	78	4.22	
46	85	F ♂	
60	97		
60	106	168	
40	79	182	
52	78	153	
	50	215	
	74	170	
	68	207	
	122	136	
	88	202	
	62	228	

5.1 P ♂	5.2 P ♀		5.1 F ♀		5.2 F ♀	
158	144	59	18	34	158	85
106	83	51	19	31	155	83
200	77	55	16	32	151	83
183	53	58	17	30	158	--
103	58	57	25	33	157	91
147	67	58	26	31	150	95
93	81	58	20	30	---	97
99	87	52	24	35	163	98
90	64	59	20	34	161	96
111	71	55	23	32	166	93
	128	54	28	32	168	--
		59	25	35	---	103
		55	20	35	176	105
		58	23	34	173	109
		54	27	30	174	109
		53	28	36	---	105
		58	26	40	187	101
		57	22	43	183	101
		52	28	41	183	101
		68	28	40	184	100
		65	23		182	107
		61	27		185	106
		64	24		185	100
		62	25	5.2	184	---
		62	27	F ♂	182	---
		64	26	74	---	111
		68	23	--	193	115
		66	28	108	196	112
		60	26	100	196	118
		68	20	107	190	117
		68	27	105	191	119
		60	21	---	---	119
		65	20	---	111	---
		61	24	116	201	119
		63	23	112	209	116
		63	21	114	205	111
		64	27	---	---	---
		64	26	123	219	123
		65	23	125	213	124
		71	24	122	214	121
		79	24	---	213	120
		75	24	135	12	125
		71	29	137	212	126
		78	24	131	214	---
		74	26	136	219	132
		71	23	---	---	138
		75	27	146	226	134
		84	29	142	224	138
		83	27	140	221	131
		87	30	148	220	135
		98	31	149	221	130
			34	140		130
			35			133
						134

5.11
F ♂46
43
61
58
53
59
38

		Gen 3	Gen 4	Gen 5	Gen 5
		29	29°	29°	29°
5.11	5.12	♂	♀	♂	♀
F ♀	F ♀				
27	150	34	37	51	38
36	116	44	25	69	36
33	149	39	54	59	23
37	198	58	27	130	49
32	156	50	56	31	42
34	118	41	31	47	38
55	123	43	47	91	20
43	140	41	31	69	41
40	169	37	30	74	37
55	125	44	51	63	35
33	125	38	33	39	39
36	140	45	51	45	28
38	156	40	33	46	36
34	141	40	47	66	43
41	122	50	51	66	30
27	146	44	56	60	31
	174	32	50	69	41
	143		47	96	29
5.12	170		43	44	33
F ♂	120		47	65	37
173	155	Gen 3	48	43	41
127		29°	54	47	35
226		♀	54	83	37
141		41	55	36	44
150	5.21	46	53	59	39
249	F ♂	36	37	74	25
178		37		42	35
240	57	30		72	33
137	54	31	Gen 5	94	34
200	50	28	29	54	26
158	43	31	♂	76	39
161	54	36		40	32
178	54		56	60	48
177	50		95	51	30
156	57		54	74	32
178	50		57	74	31
174	57	Gen 4	102		49
200		29°	40		35
140		♂	54	Gen 5	37
303	5.21	61	68	29°	43
206	F ♀	51	57	♀	44
		46	103		35
		86	52	36	
	38	61	40	39	
	40	43	48	38	
	40	45	73	33	
5.12	42		42	33	
F ♀	44		2	27	
235	45		78	29	
143	42		50	39	
151			49	27	
143			51	36	
111					

Exp.6

Males

93 138
 147 143
 125 197
 190 74
 143 117
 140 189
 155 158
 124 96
 121 117
 215 194
 167 122
 126 120
 113 114
 138 94
 92 108
 121 165
 140 136
 177 81
 102 128
 144 123
 87 166
 136 154
 107 146
 132 120
 137 112
 129 197
 145 97
 128 169
 131 113
 215 163
 180 229
 133 120
 122 119
 183 106
 132 140
 161 180
 90 101
 98 142
 120 98
 224 78
 99 97
 118 142
 123 135
 105
 106
 117
 144
 156
 119
 129
 91
 138

Female.

68 101
 99 96
 61 78
 72 56
 87 79
 78 98
 68 147
 81
 94 117
 51 71
 68 76
 108 102
 72 112
 85 125
 93 83
 94 107
 86 62
 104 120
 86 78
 87 141
 69 49
 93 84
 69 73
 92 65
 86 120
 70 74
 75 88
 92 99
 89 111
 93 86
 85 63
 101 83
 79 86
 93 81
 98 90
 99 84
 111 85
 36 73
 85 77
 81
 77
 80
 77
 84
 66
 78
 75
 94
 130
 69
 65
 93

Exp.7

Males.

180 100
 99 110
 144 117
 128 90
 164 91
 154 128
 35 93
 98 123
 78 117
 73 130
 138 94
 106 66
 103 127
 136 73
 97 122
 112 100
 146 70
 95 86
 89 111
 89 122
 180 138
 153 136
 104 77
 98 118
 182 195
 125 92
 89 81
 77 117
 101 86
 115
 77
 170
 150
 142
 81
 123
 92
 149
 123
 127
 106
 136
 166
 120
 116
 128
 98
 166
 104
 86
 146
 53

Females

46 51 34
 74 61 54
 72 51 42
 47 50 30
 69 52 50
 47 56 54
 71 54 86
 66 47 54
 63 47 43
 43 45 52
 60 48 60
 56 64
 85 55
 49 68
 64 60
 45 51
 56 70
 67 82
 49 67
 78 56
 75 63
 48 34
 108 29
 48 60
 35 70
 36 95
 46 44
 58 43
 73 78
 94 48
 60 39
 62 69
 45 46
 24 66
 47 81
 70 61
 68 76
 45 133
 54 45
 97 38
 72 68
 75 48
 57 42
 48 74
 74 99
 38 70
 67 66
 37 106
 70 57
 49 55
 60 49
 76

PARENTS)- 11

OFFSPRING. 11

OFFSPRING. 11

VII.

1.		1.		2.	
135	63	69	27	62	42
87	40	57	27	65	38
71	90	96	33	84	51
110	83	59	32	62	40
183	64	69	30	70	39
103		59	39	8	42
		41	27	57	33
		68	23	61	53
		67	38	56	42
		63	26	62	59
		58	20	67	48
		63	26	70	33
		68	32	61	62
		35	31	78	38
		60	29	72	54
			40	64	67
			40	78	34
			44	86	43
			36	70	62
			41	71	56
			31	67	43
			29	46	25
				71	36
				50	31
				79	42
				63	30
				62	30
				70	28
				65	33
				59	39
				63	33
				45	37
				69	38
				65	44
				70	33
				80	36
				63	36
				55	28
				53	43
				59	42
				74	54
				51	
				68	

2.	
131	78
98	75
83	69
97	50
95	68
146	59
68	55
94	46
123	
89	

Parents.		Parents		Parents		Parents	
14.1		14.3		14.5		14.6	
15.3		15.5		15.1		15.2	
17.2		17.4		17.6		17.1	
♂	♀	♂	♀	♂	♀	♂	♀
116	74	90	85	98	45	102	71
102	104	120	91	159	64	94	58
140	98	113	116	152	38	184	90
127	44	114	75	89	77	90	84
138	90	84	81	134	86	112	92
101	46	72	67	161	43	75	53
170	64	109	71	82	84	98	68
146	49	136	78	107	95	145	78
113	61	75	57	108	87	105	67
93	85	91	57	108	90	78	85
87	86	97	69	98	70	81	53
82	68	135	85	109	82	126	102
56	50	131	83		90	95	95
116	72	136	66		78	111	88
166	70	84	69		76	125	80
114	107		60		102	.	99
	89		76		72		71
	44		90		67		58
	78		90				75
	79						70
	63						76
	68						82
	108						40
	62						

Parents		Parents	
14.2		14.4	
15.4		15.6	
17.3		17.5	
♂	♀	♂	♀
81	78	126	70
89	45	99	66
60	103	82	52
140	85	110	56
138	83	112	47
133	60	93	57
118	74		63
107	55		71
122	81		97
99	53		75
92	62		104
107	54		102
206	58		110
117	44		71
	55		48
	72		85
	76		84
	67		
	94		
	48		
	83		
	84		

OFFSPRING.

14.1		14.3		14.6		14.5	
♂	♀	♂	♀	♂	♀	♂	♀
236	200	300	245	68	58	80	56
366	193	297	262	65	48	53	59
306	288	322	247	67	39	83	66
293	190	384	281	45	52	59	55
251	225	330	240	74	56	39	56
240	238	401	257	74	60	66	63
	273	345	210	69	55	52	67
	223	375	223	57	46	60	52
	172	414	255	70	41	64	53
	147	403	190	48	51	70	58
		280	240	75	60	97	57
		353	196	65	57	84	62
		382	205	46	48	98	56
			177	80	62	79	67
			171	72	49	161	56
			229	84	45	84	60
			173	72	74	79	53
			180	105	65	56	48
				72	56	68	50
				51	55	93	80
				69	54	76	66
				54	61	71	
				63	86		
				75	56		
				72	60		
				73			
				64			
				65			
				80			
				130			
				83			
				95			
				77			
				54			
				97			
				96			
				131			

14.2		14.4	
♂	♀	♂	♀
303	261	52	51
325	238	59	66
284	243	65	49
269	190	54	43
306	223	53	47
217	208	52	57
266	225		59
238	650*		84
246	262		56
	274		51
	209		
	197		
	244		
	246		
	276		
	252		
	277		
	269		
	281		
	294		
	270		

1877

1878

1879

1880

1881

1882

1883

1884

1885

1886

1887

1888

OFFSPRING

15.1		15.6		15.5	
♂	♀	♂	♀	♂	♀
290	180	40	66	48	39
312	164	51	33	53	41
324		50	40	50	55
292		52	36	54	52
		62	57	74	42
		73	36	81	32
		64	45	42	63
		66	37	49	27
		64	40	48	41
		71	53	43	41
		70	46	47	34
		57	45	61	51
		74	46	68	45
		58	35	43	52
		88	47	65	39
		72	40	48	35
		52	42	98	52
		47	49	89	39
		68	40	86	48
		69	39		48
		74	39		51
			47		44
			43		48
			49		46
			49		30
			41		29
					44
					30
					41
					49
					55
15.2					
♂	♀				
251	170				
402	200				
254	215				
201	196				
240	157				
260	201				
331	233				
298	181				
233	171				
207	188				
206	194				
286	199				
277	130				
308	188				
282	160				
161	198				
296	191				
	215				
15.3					
♂	♀				
274	180				
325	250				
248	268				
326	289				
	219				
	178				
	242				
	241				
15.4					
♂	♀				
65	36				
88	47				

OFFSPRING.

17.1		17.2		17.4		17.5		17.6	
♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
162	137	167	120	83	61	92	48	62	47
126	128	163	121	51	46	97	38	91	46
108	98	125	160	98	44	48	30	60	61
126	172	198	112	36	53	51	43	69	37
154	86	161	137	61	79	84	47	50	51
118	126	151	136	67	121	43	47	58	43
135	80		125	111	38	32	36	58	45
126	154		131	113	86	55	28	65	48
106	111			80	87	59	25	42	33
131	125			105	62	56	35	58	31
137	118			105	34	62	38	129	46
121	119			128	93	62	39	53	59
140	116			87	81	42	29	70	34
108	115	17.3		144	62	54	41	68	50
135	120	♂	♀	112	37	55	42	89	56
102	94	120	93	117	101	66	42	73	56
127	111	137	117	103	46	129	36	79	38
157	119	96	113	99	102	59	62	52	35
106	109	180	80	147	82	62	47	51	50
131	134	101		114	61	144	34	83	38
157	103			109	111	33	30	89	37
171	110			123	81	56	34	90	42
119	85			150	79	47	41	80	42
113	94			98	32	71	41	94	46
132	118			121	51	65	34	62	46
140	100			125	68		33		41
99	100			95	36		38		31
163	97			99	38		38		37
125	94			99	54		55		40
112	154			75	36		31		
164	130			101	68				
93				130	100				
				94	40				
				117	45				
				109	81				
				126	43				
				132	51				
				70	93				
				55	41				
				113	30				
				118	90				
				96	35				
				97	87				
				115	52				
				71	66				
					37				
					32				
					91				
					56				
					76				

F Facet No.	A Area	F/A k
200	268	.747
288	434	.664
366	635	.577
306	478	.640
190	310	.623
250	409	.623
303	508	.602
255	458	.556
257	405	.652
223	344	.667
190	300	.634
384	520	.739
330	516	.638
210	304	.691
225	363	.620
238	317	.751
273	391	.698
293	408	.694
62	90	.689
107	178	.607
117	226	.517

F Facet No.	A Area	F/A k
225	340	.662
261	420	.621
303	411	.730
238	343	.695
243	368	.661
325	434	.750
190	290	.655
223	306	.728
260	362	.718
208	351	.593
262	360	.745
225	334	.674
275	410	.670
216	372	.671
306	399	.767
251	371	.676
280	403	.690
290	398	.729
324	432	.750
401	510	.787
345	455	.758

XII.

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