ANGLIA RUSKIN UNIVERSITY

SCHOOL OF LIFE SCIENCES

Principles of Genetics MOD002804 (2024) Element 010- Lab Report

1. **Present the results of the D. melanogaster breeding experiment in a suitable tabulated format as given below. Include whole class results (cross A and B) for both F1 and F2 generations. (5 marks)**

Table 1. Results of Offspring Sex and Eye Colour from Genetic Crosses in *D. melanogaster*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Cross | Cross A | Cross A | Cross B | Cross B |
| Phenotype | F1 generation | F2 generation | F1 generation | F2 generation |
| Male red eyes | 132 | 150 | 0 | 101 |
| Female red eyes | 135 | 295 | 110 | 95 |
| Male white eyes | 0 | 147 | 105 | 99 |
| Female white eyes | 0 | 0 | 0 | 93 |

1. **Using “+” to indicate the wildtype red-eyed allele and “w” to indicate the mutant, white-eyed allele, state the genotypes of the following:**
2. **Wildtype red-eyed and white-eyed parental flies from cross A and cross B.**
3. **Males and females from the F1 generation flies from cross A and cross B.**
4. **Males and females, F2 generation flies from cross A and cross B. (10 marks)**

a) Wildtype red-eyed and white-eyed parental flies from cross A and cross B.

Cross A: Parent

* Wild-type Red–eyed fly: X+ X+
* White–eyed fly: Xw Y

Cross B: Parent

* Wild-type Red–eyed fly: Xw Xw
* White–eyed fly: X+ Y

b) Males and females from the F1 generation flies from cross A and cross B.

Cross A (F1):

* Male Wildtype red eyes: X+ Y
* Female Wild type red eyes: X+ Xw

Cross B (F1):

* Male White Eyes: Xw Y
* Female Wild type red eyes: X+ Xw

c) Males and females, F2 generation flies from cross A and cross B. (10 marks)

Cross A (F2):

* Male Wildtype Red eyes: X+Y
* Female Wild-type Homozygous Red eyes: X+X+
* Female Wild-type Heterozygous Red eyes: X+ Xw
* Male White eyes: Xw Y

Cross B(F2):

* Male Wildtype Red eyes: X+ Y
* Female Wild-type Heterozygous Red eyes: X+ Xw
* Female Homozygous White eyes: Xw Xw
* Male White Eyes: Xw Y

1. **Draw Punnett squares to show the ratios expected in the experiment for   
   a) Parental to F1 generation for cross A and cross B.  
   b) F1 to F2 generation for cross A and cross B  
   Note: There should be a total of 4 Punnett squares, and they should show both the genotype AND phenotype. (20 marks)**
2. Parental to F1 generation for cross A and cross B.

Cross A Parents to F1:

* Female: X+ X+ (wildtype red eyed)
* Male: XW Y (white-eyed)

Table 2. Punnet Square Showing Cross A Parental to F1 Generation

|  |  |  |
| --- | --- | --- |
| Gametes | X+ | X+ |
| XW | X+ Xw  (heterozygous)  Female, red eyes | X+ Xw  (heterozygous)  Female red eyes |
| Y | X+Y  (hemizygous)  Male, red eyes | X+Y  (hemizygous)  Male, red eyes |

Genotypic ratio: 1:1

* Female heterozygous wild type red eye: 50%
* Male hemizygous Wild Type Red Eyes: 50%

Phenotypic ratio:

1 red eye female: 1 red eye male

Cross B Parent to F1:

Table 3. Punnet Square Showing Cross B Parental to F1 Generation

|  |  |  |
| --- | --- | --- |
| Gametes | Xw | Xw |
| X+ | X+ Xw  (Heterozygous)  Female Wild type red eyes | X+ Xw  (Heterozygous) Female Wild type red eyes |
| Y | Xw Y  Male, White eyes | Xw Y  Male, White eyes |

Expected Genotypic ratio: 1:1

* Female heterozygous Wild type red eyes: 50%
* Male hemizygous White Eyes: 50%

Phenotypic ratio:

1 red eye female: 1 white eye male

1. F1 to F2 generation for cross A and cross B Note: There should be a total of 4 Punnett squares, and they should show both the genotype AND phenotype. (20 marks)

F1 to F2 Generation (Cross A)

Table 4. Punnet Square Showing Cross A F1 to F2 Generation

|  |  |  |
| --- | --- | --- |
| Gametes | X+ | Xw |
| X+ | X+X+  Female homozygous wild type red eyes | X+ Xw  Female heterozygous wild type red eyes |
| Y | X+ Y  Male Wildtype Red eyes | Xw Y  Male White eyes |

Expected genotypic ratio: 1:1:1:1

* Female homozygous wild type red eyes: 25%
* Female heterozygous wild type red eyes: 25%
* Male Wildtype Red eyes: 25%
* Male White eyes: 25%

Phenotypic ratio:

2 red eye female: 1white eye male: 1 red eye male

Cross B F1 to F2:

Table 4. Punnet Square Showing Cross B F1 to F2 Generation

|  |  |  |
| --- | --- | --- |
| Gametes | X+ | Xw |
| Xw | X+Xw  Female Heterozygous wild type red eyes | XwXw  Female Homozygous Wild-type White eyes |
| Y | X+Y  Male Wildtype Red eyes | XwY  Male White eyes |

Expected genotypic ratio: 1:1:1:1

* Female homozygous white eyes: 25%
* Female heterozygous wild type red eyes: 25%
* Male Wildtype Red eyes: 25%
* Male White eyes: 25%

Phenotypic ratio:  
1 red eye female: 1white eye female: 1white eye male: 1 red eye male

1. **Carry out a suitable statistical test on the whole class results of F2 for both cross A and cross B, using gender and eye colour. Your answer should include: a null hypothesis degrees of freedom level of significance observed and expected numbers of flies the critical value (from a statistical table) Show all of the steps clearly. State whether you should accept or reject the null hypothesis. State your conclusion and how this relates to the genetic basis of white eyes. Include a brief discussion of the results with relevant references. (15 marks)**

Cross A F2  Chi Squared Test

Table 5. Chi-Squared Test for Eye Colour Phenotypes in Second Filial (F2) Generation of Cross A

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Phenotype | Observed numbers (O) | Expected  Numbers (E) | O-E | (O-E)2 | (O-E)2  E |
| Female Wildtype Red Eyes | 295 | 296 | -1 | 1 | 0.0038 |
| Male Wildtype Red Eyes | 150 | 148 | 2 | 4 | 0.027 |
| Male White Eyes | 147 | 148 | -1 | 1 | 0.0068 |
| Total | 592 | 592 |  |  | 0.0376 |

Null hypothesis: There is no significant difference between the observed values and the expected values based on the ratio 2 red eye female: 1 white eye male: 1 red eye male

* Degrees of Freedom (df): (n-1, where n is the number of observed categories), 3-1=2
* Significance level: 0.05
* Critical Value for df = 2, at significance level of 0.05 is approximately 5.991. See figure 1(Turney, 2022).

0.0376 is much less than 5.991, we accept the null hypothesis. This suggests that there is no significant difference between the observed and expected frequencies, meaning the observed distribution aligns with what we would expect by chance for this genetic cross. These results confirm that the mode of inheritance is sex linked recessive for the allele causing eye colour trait, aligning with the observed data.

Table 6. Chi-Squared Test for Eye Colour Phenotypes in Second Filial (F2) Generation of Cross B

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Phenotype | Observed numbers (O) | Expected  Numbers (E) | O-E | (O-E)2 | (O-E)2  E |
| Female Wild Type Red Eyes | 101 | 97 | 4 | 16 | 0.165 |
| Male Wild Type Red Eyes | 95 | 97 | -2 | 4 | 0.041 |
| Female White Eyes | 99 | 97 | 2 | 4 | 0.041 |
| Male White Eyes | 93 | 97 | -4 | 16 | 0.165 |
| Total | 388 | 388 |  |  | 0.371 |

Null hypothesis: There is no significant difference between the observed values and the expected values based on the ratio 1 female wild-type red eyes :1 female white eye :1 male wildtype red eye :1 male White Eyes.

* Degrees of Freedom (df): 4-1=3
* Significance level: 0.05
* Critical Value for df = 3, at significance level of 0.05 is approximately 7.815. See figure 1 (Turney, 2022).
* 0.371 is less than critical value 7.815

The null hypothesis is accepted because the chi-squared value for Cross B for F2 is smaller than the critical value at 0.05. This indicates no statistically significant difference between the observed and expected ratios derived from the Cross-B Punnett square for F2. These results confirm that the mode of inheritance is sex linked recessive for the allele causing white eyes, aligning with the observed data.

A table of numbers with a green line

Description automatically generated with medium confidence

Figure 1. Chi-Square Distribution Table, showing the degrees of freedom for the right tail test. To determine if the observed data significantly differs from the expected data (Turney, 2022).

**Genetics Basis of White Eyes in Drosophila**

**Hypothesis:** Eye colour trait is X- linked. White eye and red eye appear only in males.

The pedigree culture experiment aimed to determine the inheritance of eye colour. The findings revealed that the red-eyed (wild-type) trait is dominant to the white-eyed trait. This dominance means that the red-eyed phenotype is expressed when an individual carries at least one dominant allele (X⁺) and because this trait does not skip any generation. Hence, individuals can exhibit red eyes if they are either heterozygous (X⁺ Xʷ) or homozygous (X⁺ X⁺) for the dominant allele. In contrast, the white-eyed phenotype, which is recessive, requires the presence of two recessive alleles (Xʷ Xʷ) to be expressed (Dobyns et al., 2004).

If a trait is X-linked, such as in this experiment, recessive characteristics are observed predominantly in males due to their hemizygous nature for the X chromosome (i.e., males possess only one X chromosome). Since males inherit their X chromosome exclusively from their mother, they cannot mask a recessive allele with a second copy of the X chromosome. In females, however, the presence of two X chromosomes means that a recessive allele on one chromosome can be masked by a dominant allele on the other chromosome (Sun, Ting and Wu, 2024).

In Cross A, the experiment began by crossing a purebred, red-eyed female with a purebred, white-eyed male to produce the F₁ generation. All F₁ offspring displayed the red-eyed phenotype, with both males and females exhibiting red eyes. The F₁ generation was then interbred to produce the F₂ generation, which displayed the following phenotypic distribution:

* 295 red-eyed females
* 147 white-eyed males
* 150 red-eyed males
* 0 white-eyed females

**Interpretation of Results**

The results strongly support the hypothesis that eye colour in this model organism (likely *Drosophila melanogaster*) is X-linked. Male offspring exhibited both the red-eyed and white-eyed phenotypes, while females exhibited the red-eyed phenotype. This outcome aligns with the principles of X-linked inheritance, as males inherit their X chromosome from their mothers and Y chromosomes from their father, while females inherit one X chromosome from each parent. The imbalance in the phenotypic expression of eye colour between males and females highlights the role of the X chromosome in sex-linked inheritance. If the eye colour trait were autosomal linked, the phenotypic distribution would have been expected to affect males and females equally, which was not observed (Sun, Ting and Wu, 2024).

**Additional Considerations**

The experiment does not account for the potential effects of gene dosage on male eye colour. Since males possess only one X chromosome, they lack a second copy to balance gene expression, which might influence the phenotypic outcomes. Furthermore, this experiment provides an opportunity to compare the XY sex determination system with the ZW system, where females have heterogametic sex chromosomes (ZW) and males are homogametic (ZZ) (Dobyns et al., 2004).

These findings contribute to our understanding of X-linked inheritance and reinforce the significance of chromosome biology in determining phenotypic traits.

**Reference List**

1. Dobyns, W.B., Filauro, A., Tomson, B.N., Chan, A.S., Ho, A.W., Ting, N.T., Oosterwijk, J.C. and Ober, C. (2004). Inheritance of Most X-linked Traits Is Not Dominant or recessive, Just X-linked. *American Journal of Medical Genetics*, [online] 129A(2), pp.136–143. doi:https://doi.org/10.1002/ajmg.a.30123.
2. Sun, S., Ting, C.-T. and Wu, C.-I. (2024). Selection with Two Alleles of X-linkage and Its Application to the Fitness Component Analysis of *OdsH* in *Drosophila*. *G3 Genes Genomes Genetics*, [online] 14(9). doi:https://doi.org/10.1093/g3journal/jkae157.
3. Turney, S. (2022). *Chi-Square (Χ2) Table | Examples & Downloadable Table*. [online] Scribbr. Available at: https://www.scribbr.com/statistics/chi-square-distribution-table/ [Accessed 21 Nov. 2024].