EPISTATIC RATIOS INVOLVING TWO PHENOTYPES

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1. INTRODUCTION

MANY characters require the normal (wild-type) reactions of many nonallelic genes in serial order for the production of a normal phenotype; these normal reactions may be engendered by dominant or recessive genes. Those alleles of the normal genes that inhibit, prevent, or obscure any reaction in such a series are epistatic and result in the absence of the normal character. In cases where several pairs of normal and epistatic alleles segregate, the characteristic polyhybrid segregation ratios may be considerably modified. The calculation of these complex F_2 or testcross epistatic ratios by means of the dichotomous, algebraic, or checkerboard methods is onerous and usually somewhat protracted. The following methods for determining epistatic ratios involving two phenotypes are short, accurate, and relatively simple; and they may be employed practically in breeding programmes and for Chi Square tests.

2. CALCULATING F_2 PHENOTYPIC RATIOS INVOLVING EPISTASIS

These F_2 ratios may be calculated as follows:

- (1) Determine the F_2 combinations that permit the expression of the character, *i.e.* the hypostatic combinations.
- (2) Determine the total F_2 genotypic combinations involved in the cross from 4^n , where n = the number of segregating pairs.
- (3) Determine the hypostatic phenotypic coefficient of the combination or combinations permitting the expression of the character from 3^d , where d = the number of allelic pairs that may be represented by one or two dominant genes.
- (4) Determine the phenotypic coefficient of the epistatic class or classes by subtracting the hypostatic phenotypic coefficient from the total F_2 genotypic coefficient.

Therefore, the F_2 ratio is equal to

$$3^d : 4^n - 3^d.$$

The following examples illustrate the use of this method:

Illustrative Problem: In a species of plant the production of coloured flowers requires the simultaneous presence of the normal dominant allele of three genes, namely, A , B , and C , and of the normal recessive alleles of two genes homozygously, namely ii and jj . If the recessive

alleles of any or all of the first three named genes are homozygous, *i.e.* *aa*, *bb*, or *cc*, or one dominant allele of either of the last two named genes is present, *i.e.* *I* or *J*, no pigment will be produced, and the flowers will be white.

What F_2 phenotypic ratios would be expected from each of the following crosses?

$$(a) AAbb \times aaBB$$

$$(b) AABBCC \times aabbcc$$

$$(c) AAii \times aaII$$

$$(d) IIJj \times iijj$$

$$(e) AABBii \times aabbII$$

$$(f) AABBCCii \times aabbccII$$

Solution:

Colour produced by	Total F_2 Genotypic Combinations (4^n)	Phenotypic Coefficient of those coloured (3^d)	Phenotypic Coefficient of those not coloured ($4^n - 3^d$)	F_2 Phenotypic Ratio coloured : white
(a) <i>A-B-</i>	$4^2 = 16$	$3^2 = 9$	$16 - 9 = 7$	9 : 7
(b) <i>A-B-C-</i>	$4^3 = 64$	$3^3 = 27$	$64 - 27 = 37$	27 : 37
(c) <i>A-ii</i>	$4^2 = 16$	$3^1 = 3$	$16 - 3 = 13$	3 : 13
(d) <i>iijj</i>	$4^2 = 16$	$3^0 = 1$	$16 - 1 = 15$	1 : 15
(e) <i>A-B-ii</i>	$4^3 = 64$	$3^2 = 9$	$64 - 9 = 55$	9 : 55
(f) <i>A-B-C-ii</i>	$4^4 = 256$	$3^3 = 27$	$256 - 27 = 229$	27 : 229

3. CALCULATING TESTCROSS PHENOTYPIC RATIOS INVOLVING EPISTASIS

These testcross ratios may be calculated as follows:

- (1) Determine the testcross combination that permits the expression of the character, *i.e.* the hypostatic combination or genotype.
- (2) Determine the total testcross genotypic combinations involved in the cross from 2^n , where n = the number of segregating pairs.
- (3) The hypostatic phenotypic coefficient of the combination permitting the expression of the character is always 1.
- (4) Determine the phenotypic coefficient of the epistatic classes by subtracting the hypostatic phenotypic coefficient from the total testcross coefficient.

Therefore, the testcross ratio is equal to

$$1 : 2^n - 1.$$

The following examples illustrate the use of the testcross method:

Illustrative Problem:—Using the same genes as those used in the previous problem, what testcross ratios would be expected from testcrossing the F_1 's from each of the following crosses?

$$(a) AAbb \times aaBB$$

$$(b) AABBCC \times aabbcc$$

$$(c) AAii \times aaII$$

$$(d) IIJj \times iijj$$

$$(e) AABBii \times aabbII$$

$$(f) AABBCCii \times aabbccII$$

Solution :

Colour produced by	Total Testcross Genotypic Combinations (2^n)	Phenotypic Coefficient of those coloured (r)	Phenotypic Coefficient of those not coloured ($2^n - r$)	Testcross Phenotypic Ratio coloured : white
(a) $AaBb$	$2^2 = 4$	1	$4 - 1 = 3$	1 : 3
(b) $AaBbCc$	$2^3 = 8$	1	$8 - 1 = 7$	1 : 7
(c) $Aaai$	$2^2 = 4$	1	$4 - 1 = 3$	1 : 3
(d) $aiij$	$2^2 = 4$	1	$4 - 1 = 3$	1 : 3
(e) $AaBbii$	$2^3 = 8$	1	$8 - 1 = 7$	1 : 7
(f) $AaBbCcii$	$2^4 = 16$	1	$16 - 1 = 15$	1 : 15

4. SUMMARY

Short methods are presented for determining F_2 and testcross epistatic ratios involving two phenotypic classes. These methods may be used conveniently for a great variety of combinations embracing epistasis.