# A STUDY OF GENETIC CORRELATIONS UNDER FULL-SIB MATING SYSTEM (TWO LOCI CASE) 

# By <br> KHIN MOE MOE <br> <br> THESIS <br> <br> THESIS <br>  

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Certified that this thesis entitled "A study of Genetic Correlations under Full-sib Mating System (two loci case)" Is a record of rescarch work done independently by Smit. Ehan moe fioe under my gutdance and superviston and that it has not previously formed the basis for the awarc of any degree, fellowship, or ascoctateghip to her.

Mannuthy, 16-9-1905.


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## DECLARATION

I hereby declare that this thesis ontitied "A Study of Genetic Correlations under Fullosib Mating System (two loci case)" is a bonafide record of reseerch work done by mo during the course of research and that the thests had not previously formed the basis for the award to mo of any degree, diploma, associateship, fellowship, or ather similar title, of any other University or Society.

fannuthy. KHIN MOE MOE $16-9-1985$

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## INTRODUCTION

## GHAPTER I

## INTRODUCTION

In quantitative genetic studies resemblance between two relatives is used for estimating genetic paremeters, such as heritability and genetic correlation. In such cases it is assumed, that the individuals in the population mate at random. The correlation between common relatives, such as full-sib or parentwoffspring thus take a simple value of half. But when regular syetens of inbreeding is prectised, these correlations are increased. The increase in correlation between the relatives depends on the number of generations, during which the inbreeding is practised. Of special interest in quantitative genetics, is the case of correlation between one relative and a number of individuals as the other relative. For instance, the correlation between one parent and several of its offspring is a major determinant in increasing the response to selection. The behaviour of such correlations in inbred populations is not fully known.

The characters may be correlated because of comon genetic factors or common environmental factors or both. It is necessary to distinguish these two causes of correlation between characters-genetic and environmental. The genetic cause of correlation may be chiefly due to three different causes: pleiotropy, linkage and hetorozygosity. Pleiotropy is simply the property of a gene whereby it affects two or
more characters, so that if the gene is segregating it causes simultaneous variation in the character its effect. imerease For example, genes which increase grouth raten both stature and welght so that they tend to cause correlation between these two chasacters. Linkage is usually a minor cause of genetic correlation with transitory effect, as cnossing over In a freely interbreeding population tonds to make the coupling and repulsion heterozygote equally frequent, and once the linkage equilibriumnestablished the correlation becomes zero. Thus traces of association fron this caube may be detectable only for some generations in populetions derived from crosses between divorgent strains. Sometimes heterom zygosity at loci controlling one character may increase the general vigour. Heteratic effects of these genes may influence the expression of the other trait;

Genetic correlation gives an Idea about the extent to which the characters are undex the control of the same set of genes or have the same physiological basis for their expressions. If the correlation is high then probably pleiotropy is more important, if the correlation is low then we might say that the . traits are inherited independently or they are under the control of different sets of genes.

A knowledge of its magnitude and sign helps in judging how the improvement in one character will cause simultaneous change in the other characters. If the genetic correlation
is positive, then the selection practised for the improvement of one character will automatically result in the improvement in the others even though direct selection for its improvement has not been made. If it is negative, then selection fos the improvement of one character, if successful, will result in a decline in the others.

In this investigation, an attempt is made to study (i) genetic correlation between fullwsib pairs under fullmsib mating system, (1i) genetic corrolation betweon parent-offspring pairs under full-sib mating system, (iii) genetic correlation between fullmsib pairs under parent-offepring mating system and (iv) genetic correlation between pasentoffspring pasirs under parent-offspring mating system in the case of two loci with two alleles at each locus with the following objectives.
i) To derive the joint distribution (cosrelation table) and to find the correlation between full-sib pairs undex full-sib mating system in the case of two loci when there is no linkage as well as when thore is complete linkage.
ii) To derive the joint distribution (correlation table) and to find the correlation betwoon parent-offspring pairs under fullusib mating system in the case of two loci when there is no linkage as well as when there is complete linkage.
i1i) To derive the joint distribution (correlation table) and to find the correlation between fulimsib pairs under parent-offspring mating system in the case of two loci when there is no linkage as well as when there is complete linkage.
iv) To derive the Joint diatribuetion (corralation table) and to find the correlation between parent-offspring pairs under parent-offspring mating oystem in the case of two loci when there is no linkage as well as when there is completa linkage.

## REVIEW OF LITERATURE

## CHADTER II

## REVIEN OF LITERATURE

Generally, there are two different methods for obtainIng the genotypic correlation between two relabives. In one of the methods the frequencies of various combinations of the given relatives in a population are first obtained and then the correlation is calculated from such a "correlation tablen. The correlation between full-sib pairs under different generations of fullmsib mating system have been obtained by Li (1955, Population Genetics, page: 119) by this method. The procedure of obtaining the freguencies of uncle-nephew or first cousin combinations is entirely too tedious even with the help of matrix notations (Hogbon, 1933). Thus, when the more complex or irregular inbreeding syetem 18 practised or for more than one palr of genes, the algebraic methods become cunbersome.

The other method utilizes the concept of path coefficients developed by Wright (1921). By using this method, the correlation coefficients between relativos under different system of mating can be easily worked out. Eventhough this mothod is vory easy for the calculations of the corrolation between relatives, it does not give any information about the fxequencies of the various combinations of the relatives in the population and also the joint distribution between the two relatives cennot be obtained by this method.

Fisher (1949) developed a generation matrix theory for working out the frequencies of different types of mating under regular systems of inbreeding. The method is siriple and flexible for finding the frequencies of different types of mating. The method was first presented in the literature apparently by Bartlett and Haldane. The progress towards homozygosis for sex-linked character was studied by Haldane (1937, 1955), he gave only a general treatment of the subject. Fishor derived the generation matrir for fullmstb mating by considering a single locus wh tho alleles ' $N$ ' and 'a'. However; he consldered only the mating types and did not make eny distinction between the kinds of mating such as $A A \times A A$ and aa $x$ aa.

Kempthorne (1955) calculated the correlation of parent-offspring pairs and full-sib pairs in generations of fullusib mating by making use of the generation matrix. By this method he could derive the joint distribucion of the pairs of relatives at any generation of a specified system of mating and thus the correlation is worked out directly from the twoway table of the relatives; known as the "correlation table". By using the generation matrix theory for full-sib mating system, he employed lind of matings rather than types viz., mating types $A A \times A A$ was considored different from the kind of mating aa $x$ aa. But he did not make any difference between nating types $A A \times A a$ and $A a \times A A$ as well as $A a x$ aa and aa $x$ Aa.

Horner (1956) worked out the correlation of parentoffspring pairs and full-sib palis in generation of parentoffapring mating. Korde (1960) worked out the correlation between relatives for a sex-11nked character under full-sib mating by making use of generation matrix theory.

The generation matrix method is based on the primitive concepts of the genotype and the results of Mendelian segregation. The method gives the mating types in an axbitrary goneration arising from an arbitrary population by a regular system of inbreeding. If the frequencies of mating types are arranged as a column vector, say, $£$ and generations are denoted by subscripts in parenthesis, then $f^{(n)}=A f^{(n-1)}$ where $A$ is the generation matrix. Hence it follows that $f^{(n)}=A^{n_{f}(0)}$. This shows that frequencies in the $n^{\text {th }}$ generation can be morked out if one knows the matrix $A$ as well as the initial vector $f^{(0)}$. By this method the joint distribution of pairs of relatives at any generation of a specified system of mating is obtained and thus the corrolation is worked out directly from the twoway table of the relatives, known as the "correlation table".

The use of the stochastic matrices in determining the correlation between relatives introducod by Li and Sacks (1954) under the name I.T.O. method, provides an easy alternative, to the laborious method of preparetion of correlation tables for various types of relatives and
calculation of correlation coefficients therefrom. The stochastic matrices $\underset{\sim}{I}, \underset{\sim}{T}$ and $\underset{\sim}{\mathbb{O}}$ are matrices of conditional probabilities. From these three babic matrices, the matrix of conditional probabilities for unileneal relatives or bileneal relatives can be worked out. Using them "the correlation table" as well as the correlation between relatives can be easily worked out.

Eventhough Fisher, Haldane and Li derived generation matrix for full-sib mating with sex-linked genes, it is in fact Korde (1960) and George (1974) who made use of this genoration matrix technique in studying the inbreeding systems. George (1974) conducted a detalled study of the parent-offspring and full-sib correlations separately under full-sib mating and parent-offepring mating system, both for autosomal as well as sex-linked genes. Two methods, viz., the I.T.O. method, employing stochastic matrices, as well as generation matrix methodology, have been studied. The I.T.O. method applicable for the case of single locus with two alleles has been generalised to the case of oingle locus with multiple alleles under random mating. Further, he found that in general, the I.T.O. method is not applicable to inbred populations. However, for autosomal geneo and in the case of parent-offspring mating systom (mating betweon a fixed sire and his daughter, grand-daughter, great-grand daughter, otc.), the joint distribution of the parent-of fspring relationship could be expressed in terms of $T$ and $F$ (suitably
defined) matrices. In the case of sex-linked genes the I.T.O. method was found to be applicoble in finding the joint distribution and correlation coefficient for brotiser-brother and father-son relationships, both for the fullmsib as well es parent-offspring mating systems. He also developed a general theory for obtaining the correlation between one parent and $k$ offopzing as well as the correlation between both the parents and $k$ offspring under a given system of mating both for autosomal as well as sex-linked genes.

George and Narain (1975) developed a general theory for obtaining the correlation between one parent and $k$ offspring, as well as the corrolation betwoen both the parents and $k$ offapring under a given system of mating, both for autosomal as well as sox-linked genes. They evolved parentoffopring correlations under full-sib mating and parentoffspring mating system with the help of this theory and the genaration matrices for different mating types in case of autosomal as well as sex-linked genes.

In the light of various correlacion coefficiente obtained under continued full-sib mating or parent-offspring mating, with autosomal or sox-linked genes, it has been found that the correlation increase with increase in the generations of inbreoding, but the mode of increase is different under different systens and depends on whether the case is of autosomal or sex-linked gones. It is also
found that in case of autosomal, the increase in corrolation is more under fullmalb mating than under parentm offspring mating.

George (1979) conducted the study of parent-offspring correlation under half-sib mating system. He evolved the correlation between both the parents and $k$ offspring and between one parent and $k$ offspring in the linee of George and Nasain (1975). He performed the tables of correlations of the above two cases when the number of offspring varying between 1 to 10. He has reported that the correlation increases as the number of offepring increases, but the rate of increase of the correlations were more in the cose of both the parent and $k$ offspring than that of one parent and $k$ offepring case and the rate of increase is almost nil after the second genoration of full-sib mating in the one parent case.

George (1983a) developed the calculation of joint distribution of full-sib pairs and parent-offspring pairs under fullmsib and parent-offspring mating systems by the generation matrix technique and also calculated the correlation of these pairs therefrom. He found that the method is tedious in the case of fullmsib mating, but it is comparatively eabler in the case of parent-offspring mating, as the conditional probability matrix in this case can be easily generated. He calculated the correlation between
full-sib pairs and parent-offspring pairs under full-sib and parent-offspring mating systers for ten generations of continued mating of that particular system of mating. Further, he seported that the correlation increases as the number of generation increases and uitimately reaches the limit unity when the number of generation increases inderinitely large, He observed that the parent-offopring corrom lation is higher in magnitude than that of the full-sib correlation under both the syotems of mating. It is also observed that the parent-offspring correlation under parentoffopring mating increases at a rapid rate than all the other three types of correlations even at the first generation of parent-offepring correlations and become almost unity at the tenth generation.

George (1983b) conducted the study of correlation between various full-sib pairs and parent-offspring pairs by evolving joint distribution of relative pairs in case of sex-linked genes. He noted that sister-sister pair correlation is maximum at every generation of full-sib mating followed by mother-son and father-daughtor correlation. He also reported that the correlation between mother-son pair and father-daughter pair axe identical. He mentioned the important point, that father and sons are uncorrelated under random mating, but as the inbreeding starts the pairs become corrolated and the amount of
correlation increases as the number of generations of inbreeding increases, He also mentioned that the correm lation increases at a rapid rate in the case of motherdaughter pairs than that of brothermbother pairs. Further, he reported that the correlation coefficients of all these types of pairs will be tending to unity as the number of generation of inbreeding increases inciefinitely.

All these authors have studied correlation between different relatives under different inbred system only in case of single locus with two alleles. hit, in his book entitled 'Population Genetics (1955)' have established a general formula to determine the correlation coefficient between different relative pairs such as suilmsibs, parent and offspring, half-sibs in different generations of the specified mating systom, from the corresponding inbreeding coofficient, fe is given for fullmoib pairs as,

$$
m=\frac{1+2 F^{\prime}+F^{\prime \prime}}{2\left(1+F^{\prime}\right)}-(1)
$$

and for parentmoffspring pairs

$$
m=\frac{1+2 F!}{2 \sqrt{2}\left(1+F^{\prime}\right)}-(2)
$$

where

$$
F=\text { inbreeding coefficient in the } n^{\text {th }} \text { generation }
$$

$$
F^{\prime}=\text { inbreeding coefficient in the }(n-1)^{\text {th }} \text { generation }
$$ $F^{\prime /}=$ inbreeding coefficient in the ( $\left.n-2\right)^{\text {th }}$ generation and $m=$ corralation coefficient in the $n^{\text {th }}$ generation.

The inbreeding coefficient in the different generam tLons of full-sib mating can be obtained using the recurrence relation

$$
F=\frac{1}{4}\left(4+2 F^{1}+F^{11}\right)-(3)
$$

and the inbreeding coefftelent in the different generations of parent-offepring mating (a fixed sire and his daughter, grand-daughter, great-grand daughtex, ete.) can be obtalned using the recurrence relation

$$
x=\frac{1}{4}\left(1+22^{1}\right)-(4)
$$

established by $L$ i, by uging path method.
Thus by using the relationships (1), (2) and (3), (4) Li could obtain the correlations between fullmsib paiss and parent-offispring pairs in different generations of Pullesib mating and parentmofrspring mating, directly. Ao for the numerical values of the correlation coefficient the method is quite simple, but it does not give any information about the absolute irequencies of the full-sib mating types, the parent-offspsing mating types and their joint distribution in the different generation of full-sib mating and parent-offspring mating.

In the present investigation an attempt is made to ertend the study of genetic correlations under fullmsib mating svotom as well as parent-ofropring mating system
to two loci case with two alleles at each locus, when there
is no linkage. An attempt is also made to oxtend this theory in case of two loci when there is complete linkage.

MATERIALS AND METHODS

## CHAPTER XII

MATERIALS AND METHODS

Since the present investigetion 19 of purely theom retical nature, the matexials in the sonse of numexical data is not required; as such materlals are not discussed here and only mothods of approach to the problem are discussed in some detail.

In this investigation, an attempt has been made, employing the method of generation matrix, to develop the following oorrelations.

1) Correlation of fullmsib palsa uncer full-sib mating system.
2) Correladion of parent-offspring pairs under full-s2b mating system.
i4i) Coxrelation of full-sib paiss under perent-offepring mating system.
iv) Correlation of parent-offspring pairs under parent-affepring mating system.

In considering the full-s5b mating oystem, 45 genotypic mating types are brought out from ten classes of phenotypic mating types, from which a generation matrix A of dimengion ( $45 \times 45$ ) $\mathbf{4 9}$ obtained.

In considering the parent-offopring nating system, guch as the mating of fixed sire with daughtex, grend-daughter,
great-grand daughter, etc., 81 genotyplc mating types are brought out from ten classes of phenotypic moting typos. There is a problem that some perentoffspring pairs cannot De brought out from any of 81 genotyplc thating type in any generation. This problem is solved by doveloping a genefation matrix in which the columns of the unevailable pazentoffepring pairs having zero elenento are eliminated. ThoreFore, tho dimenston of goneration matrix A* for the parentmoffopring mating type reduced to ( $34 \times 49$ ) , instead of original dimension of ( $81 \times 81$ ).

Denoting the vector of frequencies for $n^{\text {th }}$ generation under sull-sib nating syetem by $\underline{U}^{(n)}$, the vector of frequencles zor the succescive generations undex the systom of full-olb mating 18 computed by the following recurrence relation given by

$$
\begin{equation*}
\underline{U}^{(n)}=A U^{(n-1)} \tag{3.1}
\end{equation*}
$$

Erom this recurrence relation, corralation tables for full-3ib paire for any generation under fullosib mating system can be easily worked out. The corrolation tables for parentorfepring pairs under any genoxation of full-gib mating system can also be developed from the recurxence relation

$$
\begin{equation*}
\underline{U}^{l(n) *}=A^{*} \underline{u}^{(n-1)} \tag{3,2}
\end{equation*}
$$

Denoting the vector of frequencies for $n^{\text {th }}$ generathon under parent-ofespring mating system by $\underline{y}^{(n)}$. the vector of freguencies for fullmib pairs for $\mathrm{n}^{\text {th }}$ generation under pazent-offepring mating systom can be obtained from the recurrence relation given by

$$
\begin{equation*}
U^{(n)}=A U^{(n-1)} \tag{3,3}
\end{equation*}
$$

Erom the above relation, correlation tables for full-sib pairs under parent-offspring mating system can be worked out easily. Similarly, the correlation tables for parentmofespring pairs under parent-offspring mating system can also be directly worked out from the following selation, givon by

$$
\begin{equation*}
\underline{u}^{(n) *}=A_{\underline{u}^{*}}^{(n-1)} \tag{0,4}
\end{equation*}
$$

Denoting, in the above correlation tables, sib $I$ by $x$ and sib If by $y$ in the case of fullmsib pairs as well as parent by $x$ and offspring by $y$ in the case of parent-offispring pairs and scoring and ordering the genotypes according to their number of dominant genes involved for example, assigning 4 to $A A B B, 3$ to $A A B b$ and $A a B B, 2$ to $A a B b, A A b b$ and aeBb, 1 to $A a b b$ and $a a b b$ and 0 to aabb), assuming additive gente effect, the simple crossmproduct correlation ls computed with the following equation

$$
\begin{equation*}
P=\frac{\Sigma f x y-(\Sigma f x)(\Sigma f y)}{\sqrt{\left\{\Sigma f x^{2}-(\Sigma f x)\right\}\left\{\Sigma f y^{2}-(\Sigma x y)^{2}\right\}}} \tag{3.5}
\end{equation*}
$$

Some salient features of method of generation matris which is used in working out the vector of the frequencies of different meting types for successive generations is briefly discusoed as follows:

1. The generation matrix racthod is based on the paimitive concepte of the genotype and the results of Mencellan segrogation and also lgnozes mutation.
2. The generation matzis method gives the mating types (or whatever else is considered) in an arbitrary genexation arising from an arbitrary population by a regular syotem of inbreeding. We find In fact that, tif the frequencios of mating types are arranged as a column matrix $E$ say; and generationo are denoted by superecsipts in parentheses, then

$$
E^{(n)}=A E^{(n-1)}
$$

where A is the generation matrin. A typisal equatan in the totality sepresonted by the onematrix equation is $f_{j}(n)=a_{j 1} f_{1}(n-1)+a_{j 2^{f_{2}}}(n-1)+\cdots=-m+a_{j m^{2}}(n-1)$ Where $f^{(n-1)}$ is the frequency of the $r^{\text {th }}$ mating type in generation ( $n=1$ ).

RESULTS

## CHAPTER IV

RESULTS

### 4.1. Full-siomating

Fuil-sibs are those individuals whose pasents are in common.

If the two loci case is considered. it has to be taken account of the fect that those loci may be linked. Hence the stetistical and probabilisttc treatment of the problems may be dealt with by ueing the two rulea.

Consider the case of two loci each with two alleleg $8 a y(A, a)$ and ( $0, b$ ) at each Locus

1) An individual of type Ab/ab produces gametes in the following proportions or with the following probebi11せさes:

| $A B$ | $A b$ | $a b$ | $a b$ |
| :---: | :---: | :---: | :---: |
| $(1-p) / 2$ | $p / 2$ | $p / 2$ | $(1-p) / 2$ |

24) An individual of type $\mathrm{Ab} / \mathrm{aB}$ produces gametes in the following proportions:

| $A B$ | $A b$ | $2 B$ | $a b$ |
| :---: | :---: | :---: | :---: |
| $p / 2$ | $(1-p) / 2$ | $(1-p) / 2$ | $p / 2$ |

'p", called the recombination sraction, 19 the proportion of crossmover gametos. There are on the whole nine genotypee with two loci with two alleles per locus, but
because of differences in gamete production betwoen the two types of double heterozygotes, there are in fact ten classes of individuals, with regards to breeding behaviour. To facilitate the presentation, the genotypes shald be opecified in usual may, vit." the heterozyootes in the couping phase by $A B / a b$ and the heterozygotes in the repulsion phase by $\mathrm{Ab} / \mathrm{aB}$.

The matrix of genotypes along with their pzoportions (in coupling phase) under random mating is shown in table 4.1.

Tab2e 4.1. Ganotype matris

| $q^{0^{7}}$ | $\begin{gathered} A B \\ (1-p) / 2 \end{gathered}$ | $\begin{array}{r} A b \\ \mathrm{p} / 2 \end{array}$ | $\begin{array}{r} a B \\ p / 2 \end{array}$ | $\begin{gathered} a b \\ (1-p) / 2 \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: |
| $\begin{gathered} A B \\ (1-p) / 2 \end{gathered}$ | $\begin{gathered} A A B B \\ \left(1-p^{2} / 4\right. \end{gathered}$ | $\begin{gathered} A A B B \\ p(1-p) / 4 \end{gathered}$ | $\begin{gathered} A a_{3} \\ p(1-p) / 4 \end{gathered}$ | $\begin{gathered} A=13 b \\ (1-p)^{2} / 4 \end{gathered}$ |
| $\begin{aligned} & \mathrm{Ab} \\ & \mathrm{p} / 2 \end{aligned}$ | $\begin{gathered} A A B b \\ p(1-p) / 4 \end{gathered}$ | Aabl <br> $\mathrm{p} / 4$ | $\begin{aligned} & \mathrm{AaBb} \\ & \mathrm{p}^{2} / 4 \end{aligned}$ | $\begin{gathered} A a b b \\ p(1-p) / 4 \end{gathered}$ |
| ab $p / 2$ | $\begin{gathered} A a B B \\ p(1-p) / 4 \end{gathered}$ | $\begin{aligned} & \mathrm{AaBb} \\ & \mathrm{p}^{2} / 4 \end{aligned}$ | $\begin{aligned} & \operatorname{aabB} \\ & p^{2} / 4 \end{aligned}$ | $\underset{p(1-p) / 4}{a a s b}$ |
| $\begin{aligned} & a b \\ & (1-p) / 2 \end{aligned}$ | $\begin{gathered} A B B b \\ (1-p)^{2} / 4 \end{gathered}$ | $\begin{gathered} \text { Aabla } \\ p(1-p) / 4 \end{gathered}$ | $\begin{gathered} 3 a 5 b \\ p(i-p) / 4 \end{gathered}$ | $\begin{gathered} \text { aabb } \\ (1-p)^{2} / 4 \end{gathered}$ |

From this toble, the frequencies of nino genotypes can be obteined as follows:

AABB $(1 m p)^{2} / 4$ AaBb $\left(2 p^{2}-2 p+1\right) / 2$ aaBB $p^{2} / 4$
AABb $p(1-p) / 2$ AAbb $p^{2} / 4$ aaBb $p(1-p) / 2$
AaBB $p(1-p) / 2$ Aabb $p(1-p) / 2$ aabb $(1-p)^{2} / 4$
In the case of repulsion phase, the frequencies of genotypes of $A A B O, A A B b$, aaBB and aabb whil change as $p^{2} / 4$, $(1-p)^{2} / 4,(i-p)^{2} / 4$ and $p^{2} / 4$ respectively and others remain unchanged. But for finding the genetic correlations there will be no difference in coupling phase and repuleion phase. Hence the frequencies of genotype in coupling phase axe used here.

Now the ten classes of phonotypic mating and the various genotypic mating under each class can be considered as Pollows:

## 1. $A B \times A B$

$A B$ can be of the genotypes: AABB, AABb, AaBB and AaBb. Consider the mating type (i) AABS $x$ AABB, Each AABS produces $A B$ gamete with proportion 1 . Thus their offspring will be of genotype AABE with proporition 1. This cen be shown as follows


Thus fullmaib pais produced in this case will be (AABO, AABB) with proportion i.

Then consider the mating type (ii) AABA $x$ AABD. AABD produces gamete $A B$ whth proportion 1 and AABb produces gametes $A B$ and $A B$ wth propoxtion 72 each. Hence their offsprings are of genotypes. $A A B B$ and $A A B b$ with proportion y/ each. This can be shown as follows:

1i)


Thus full-aib pairs 2se (AABB,AABB) (AADB,AABb) and (AABB,AABb) with proportion $/ 4,1 / 2$ and $/ 4$ mespectively.

In the same way, the other genotypic mating typos can be obtained as follows:


Thus full-sib paiss along with their proportions are as follows:

| $(A A B B, A A B B)$ | $(A A B B, A A B B)$ | $(A B A B, A Q B B)$ |
| :---: | :---: | :---: |
| $1 / 4$ | $/ 2$ | $y_{4}$ |



|  | $A B(1 / 4)$ | $A D(1 / 4)$ | $a B(1 / 4)$ | $a b(1 / 4)$ |
| :---: | :---: | :---: | :---: | :---: |
| $A B$ | $A A B B$ | $A A B D$ | $A Q B B$ | $A a B b$ |
| 1 | $1 / 4$ | $1 / 4$ | $1 / 4$ | $1 / 4$ |

Thus fullusib pairs along with their proportions are as follows:
( $A A B B, A A B B)(A A B C, A A B b)(A A B B, A A B B)$ ( $A A B B, A B B D)(A A B b, A A B b)$
$\begin{array}{lllll}116 & 18 & V_{8} & \text { Ve } & 16\end{array}$
( $A A B b, A a B B)$ ( $A A B b, A a B b)(A a B B, A O B B)$ ( $A a B D, A O B b$ ) ( $A a B b, A a B b$ )

| 18 | 18 | $1 / 6$ | 16 | 16 |
| :--- | :--- | :--- | :--- | :--- | :--- |

v) $A A B D X A B B$


|  | $A B(1 / 2)$ | $A B(1 / 2)$ |
| :---: | :---: | :---: |
| $A B$ | $A A B B$ | $A A B D$ |
| $1 / 2$ | $1 / 4$ | $1 / 4$ |
| $A D$ | $A A B D$ | $A A b b$ |
| $1 / 2$ | $1 / 4$ | $1 / 4$ |

offepsings along with thelr proportions are AABB(14), $\mathrm{AABb}(12)$ and $\mathrm{AAbb}(1 / 4)$.

Thus fullosib pairs along with theix proportions are as followe:
( $A A B B, A A B B)(A A B B, A A B b)(A A B B, A A D D)(A A B b, A A B b)(A A B b, A A D B)$
$\begin{array}{lllll}1 / 6 & 14 & 10 & 1 / 4\end{array}$
(AAbb, AAbb)
116

| vi) |  |  |
| :---: | :---: | :---: |
|  | $A B$ (V/2) | $\mathrm{Ab}(1 / 2)$ |
| $A B$ | AADD | AADb |
| (V2) | $1 / 4$ | $1 / 4$ |
| aB | AaBE | AOBb |
| (1/2) | 74 | $1 / 4$ |

Offsprings axe $A A B D, A A B b, A a B E$ and AaBb with proportlon $7 / 4$ each.

Thus full-sib paire along with their proportions are as follows:

| ( $A A B B, A A B B$ ) | (AABS, AABb $)$ | ( $A A B D_{0}$ AaBS) | ( $A A B D, A \square B b)$ | ( $A A B b, A A B b)$ |
| :---: | :---: | :---: | :---: | :---: |
| \%16 | 78 | Y8 | 78 | 116 |
| ( $\left.A A B b_{\square} A, A B B\right)$ | $(A A B b, A a 3 b)$ | ( $\mathrm{AaBB}, \mathrm{AaBB}$ ) | ( $\mathrm{AaBD}, \mathrm{AaBD}$ ) |  |
| 78 | 76 | 716 | 18 | 716 |



|  | AE(V4) | Ab (/4) | $2 \mathrm{~B}(1 / 4)$ | ab(1/4) |
| :---: | :---: | :---: | :---: | :---: |
| A0 | AndB | AABb | AmBA | AaBb |
| $1 / 2$ | V8 | 78 | Y8 | 78 |
| Ab | AABD | AABD | AaBb | Aabb |
| 12 | Y® | 18 | 18 | 78 |

Offeprings along with thetr proportions are as followst
$A A B B \quad A A B b \quad A a B B \quad A a B b$ AAbb Aabb
$\begin{array}{llllll}18 & 1 / 4 & 1 / 6 & 18 & 18 & 18\end{array}$
Thus full-sib paiss along with their proportlons are as follows:
( $A A B B, A A B B)(A A B B, A A D B)(A B B, A a B B)(A A B B, A B B b)(A A B B, A A D b)$ $\begin{array}{lllll}164 & y 16 & 132 & y 16 & 132\end{array}$
( $\left.A A B B_{B}, A a b b\right)(A A B b, A A B b)(A A B b, A a B C)(A A B b, A B B D)(A A B b, A A b b)$ $\begin{array}{lllll}\text { V32 } & 196 & 16 & 16\end{array}$
(AABb, Aabb) (AaBB, AaBB) (AaBB, AaBb) (AaSB, AAbb) (AaBB, Aabb)
$\begin{array}{lllll}116 & 764 & 16 & 732 & \text { 132 }\end{array}$
( $A a B b, A a B b)(A a B b, A A b b)(A a B b, A a b b)(A A b b, A A b b)$ ( $A A b b, A a b b)$ $\begin{array}{lllll}16 & 16 & 16 & 164 & 162\end{array}$
(Aabb, Aabb)
164


Offapringe are AABB, ABB and aabB with proportions /4, 72 and $/ 4$ respectively.

Thus full-sib pasrs along with their proportions axe as follows:

$\begin{array}{lllll}1 / 6 & 1 / 4 & 18 & 1 / 4 & 1 / 4\end{array}$
(aas3; ancu)
$1 / 16$
ix) $\begin{gathered}A a_{i g B} \\ \\ A B\end{gathered}$


V2 $1 / 2$
$\begin{array}{llll}1 / 4 & 1 / 4 & 1 / 4 & 1 / 4\end{array}$

|  | AB(14) | $\mathrm{Ab}\left(\mathrm{y}_{4}\right)$ | ab (Y4) | ab(1/4) |
| :---: | :---: | :---: | :---: | :---: |
| $\overline{A B(12)}$ | AABA | AABb | Аавв | Aabi |
|  | \%8 | y8 | 78 | $1 / 8$ |
| $a \mathrm{~B}(12)$ | Aaba | Aabb | amas | a3bi |
|  | 18 | 78 | 78 | 78 |

Qffsprings along with their proportions are as follows:
$A A D E, A A B b, A a B B, A a B b, ~ a a B O, ~ a a B b$
$\begin{array}{llllll}1 / 8 & 1 / 8 & 1 / 4 & 1 / 4 & 18 & 1 / 8\end{array}$
Thus fullestb pairs along with their proportions aro
as follows:
( $A A B B, A A B B$ ) ( $A A B B, A A B b$ ) ( $A A B B, A A B B$ ) ( $A A B B, A D B B$ ) ( $A A B E, a A B B$ )
Y64 1/32 1/16 196 1/32
$(A A B B, a a B b)(A A B b, A A B b)(A A B b, A a B B)(A A B b, A A B b)(A A B b, a q B B)$
Y32 164 1/6 16 16 16

$\begin{array}{lllll}1 / 32 & 16 & 16 & 16 & 16\end{array}$


| (AABD, ACBb ) | (AABb, aabb) | (AaSn, AaSB ) | ( $\mathrm{AaBB}, \mathrm{AaBb}$ ) | ( $A Q B B, A A B b$ ) |
| :---: | :---: | :---: | :---: | :---: |
| V/32 | $\gamma 64$ | 164 | $\gamma 16$ | Y64 |
| ( $A B B B, A, A b b$ ) | ( $\mathrm{AaBB}, \mathrm{a} \times \mathrm{BB}$ ) | (Aasb, abibl | ( $A, B B, a \mathrm{abb}$ ) | ( $\mathrm{AaDb}, \mathrm{AaBb}$ ) |
| 732 | 164 | V/32 | 964 | $1 / 9$ |
| ( $\mathrm{AaBb}, \mathrm{AAbb}$ ) | (Aabb, Aabb) |  | ( $\mathrm{AaBb}, \mathrm{aaBb}$ ) | ( $A a B b, a \mathrm{abb}$ ) |
| $\gamma_{32}$ | $1 / 16$ | $\gamma 32$ | 116 | $\gamma^{3} 2$ |
| (AAbb ${ }^{\text {A }}$ A ${ }^{\text {b }}$ ) | (AAbb,Aabb) | ( $\mathrm{AADD}, \mathrm{CaBB}$ ) | $\left(A A D b_{i} a \mathrm{abb}\right)$ | (AAbb, aabb) |
| 1256 | 764 | 7128 | V64 | 7128 |
| (Aabb, Aabb$)$ | (Aabb, aaba) | ( $\mathrm{Aabb}, \mathrm{aabb}$ ) | (Aabb;abb) | (aabs,anse) |
| V64 | 7/64 | $\gamma 32$ | 764 | 7256 |
| (asbib, aceb) | ( $9 \mathrm{abe}, \mathrm{aabb}$ ) | (aabb,abib ) | (aasb, aabi) | (aabi, aabb) |
| V/64 | V128. | 1/64 | Y64 | $1 / 256$ |

In a similar manner, the other genotypic mating types under the nine classes of phenotypic mating can be obtained as rollows
II. $A B \times A b$

1) $A A B S \times A A b b$

Full-sib pair along with its proportion is (AABb, AABD).
11) AABC $x$ Aabb

Fullosib paiss (AABb,AABb) (AABb,AaBb) (AaBb,AaBb)
Proportions $y_{4} . y_{2} . y_{4}$
iii) AABD $\times$ AAbD

Full-sib palxs ( $A A B b, A A B b$ ) ( $A A B b, A A B b)$ ( $A A b b, A A b b)$
$\begin{array}{llll}\text { Proportions } & 1 / 4 & 1 / 2 & 1 / 4\end{array}$
iv) $A A B b \times A a b b$

Full-Bib pairs (AABb,AABb) (AABb,AAbb) (AABb,AaBb)
Proportions $\quad$ y16 Va
( $A A B b, A a b b)$ ( $A A D D, A A D D)$ ( $A A D D, A a B b)$ ( $A A D D, A a b B)$$\begin{array}{llll}10 & 196 & 18 & 1 / 8\end{array}$
(AaBb,AaBb) (AaBb,Aabb) (Aabb,Aabb)
$\begin{array}{lll}1 / 6 & 18 & 716\end{array}$
v) $A a B B \times A A b b$
Fuilesib paiss ( $A A B b, A B B$ ) ( $A A B b, A a B b)(A a B D, A a B b)$
$\begin{array}{lllll}\text { Proportions } & 1 / 4 & 1 / 2 & 14\end{array}$
vi) $\mathrm{AaBB} \times$ Ablo
Full-shb paics ( $A A B b, A B E$ ) ( $A A B b, A B B b$ ) ( $A A B$, aABb)
$\begin{array}{llll}\text { Pxoportions } & 1 / 6 & 14 & 16\end{array}$
( $\mathrm{A} a \mathrm{~B} \mathrm{~b}, \mathrm{AaBb}$ ) (AaBb,aaBb) (aaBb, aaBb)
$\begin{array}{lll}1 / 4 & 1 / 4\end{array}$
via) AaBb \# AAbb
Full-sib pairs ( $A A B b, A A B b$ ) ( $A A B b, A A b b$ ) ( $A A B b, A B B b$ )
Proportions V16 VB
( $A A B b, A a b b)(A A b b, A a b b)(A A b b, A a B b)(A A b b, A a b b)$
$\begin{array}{llll}18 & 16 & 18 & 18\end{array}$
(AaBb, AaSb) (AaBb,Aabb) (Aabb, Aabb)
$\begin{array}{lll}\eta 16 & \eta B & 16\end{array}$
viLis) Aabb $\times$ Aabb
Fullmsib pairs ( $A A B b, A A B b$ ) ( $A A B b, A a B b$ ) ( $A A B b, A A B b)$
Proportions y $1 / 64$ /32
( $A A B b, A a b b)(A A B b, a a B b)(A A B b, a a b b)(A B B b, A a B b)(A a B b, A A B b)$
$716 \quad$ V32 $\quad 132 \quad y 16 \quad 716$
$(A a B b, A a b b)(A a B b, a a B b)(A a B b, a a b b)(A A b b, A A b b)(A A b b, A a b b)$
$\begin{array}{lllll}18 & 16 & 116 & 164 & 1 / 6\end{array}$
( $A A b b, a a b b)$ ( $A B b, a a b b)$ ( $A a b b, A a b b)$ ( $A a b b, a a B b)$ (Aabb, $a a b b)$
y/32 y/32 ..... Y/6
116 ..... $\gamma 16$
(aabb,aabb) (aabb, aabb) (abb, aabb)$\gamma 64$ 732 V64
III. $\underline{A B \quad \mathrm{X}} \mathrm{B}$

1) $A A B B \times a B B$
Fuilmsab pais (AaBE,AaBB)
Proportion ..... 1
ii) $\mathrm{AAPB} \times \mathrm{aaBb}$Fullmsib pairs (AaBB ${ }_{0} A a B B$ ) (AaBB, AaBb) (AaBb, AaBb)
Proportzons $y_{4}$ ..... V/2 ..... 14
2ii) $A A B D x \triangle A B B$
Full-sib pairs (AanB, AaBB) (AaBB, AaBb) (AaBb,AaBb)
Propertione ..... $\% 4$
V/2 ..... 14
iv) $A A B b \times a a b$
Full-sib palis ( $\mathrm{AabB}, \mathrm{AaBB}$ ) ( $\mathrm{AaBB}, \mathrm{AaBb}$ ) ( $\mathrm{AaBB}, \mathrm{Aabb})$ Proportions $1 / 6$ ..... 14 ..... Yo
(A0Bb,AaBb) (AaBb,Aabb) (Aabb,Aabb)
14 ..... 14 ..... 1/6
v) Aab日 $\times \mathrm{aaBB}$
Full-sib pairs (AaBB $A \times A B B)(A a B B, a a B B)(a A B B, a a B B)$ Proportions 14 ..... V2 ..... 14
vi) Aaps $x$ aasb
Full-sib palrs (AabB,AaBB) (AaBB,AaBb) (AaBB,aaBB)Proportions $\quad$ /ic 16 18$\begin{array}{llll}\text { V8 } 8 & \text { Vig } & \text { V8 } & \text { V日 }\end{array}$

```
    \(\begin{array}{lll} & 16 & \text { y }\end{array}\)
```

vii) $\mathrm{AaBb} x$ adebFull-sib palss (AaBB, AaBB) (AaBB,AABD) (AaBB, $2 a B B$ )Proportions $1 / 6$ ye $1 / 8$Y8 18 16 18 18

y16 18 1/6
viii) AaBb $x$ aabb
Fuil-gib pairs (AaBB, AaBB) (AaBB,AaBb) (AaBE, Aabb)
Proportions ..... VE4
716 ..... V32
 $\begin{array}{lllll}\text { \% } 32 & \text { 1/6 } & \text { /32 } & \text { 1/16 } & 16\end{array}$
( $\mathrm{AaBb}, \mathrm{aaBB})(\mathrm{AaBb}, a \mathrm{aBb})(\mathrm{AaBb}, \mathrm{aabb})(\mathrm{Aabb}, \mathrm{Aabb})$ (Aabb,aaBb)$\begin{array}{lllll}1 / 6 & 1622 & 1 / 64 & 116 & 1 / 32\end{array}$
(aabb,aaBb) (aabb,aabb) (aabb,aabb)16 'V64
IV. $A B \times a b$

1) $A A B B x a a b b$
Full-sib palr (AaBb,Aa9b)
Proportion ..... 1
1i) $A A B b \times a a b b$
Full-sib pairs (AaBb, AaBb) (AaBb,Aabb) (Aabb,Aabb)
Proportions ..... $1 / 4$ ..... $y 2$ ..... 14
iii) $A a B D \times a b b$
Full-sib pairs ( $A a B b, A a B b$ ) ( $A a B b, a a B b$ ) ( $a A B b, a \in B b$ )
Proportions ..... 14 y2 ..... 14
iv) $A a B b \times a a b b$Full-sib pairs ( $\mathrm{AOBb}, \mathrm{AaBb}$ ) ( $\mathrm{AaBb}, A a b b)(A a B b, a \mathrm{aBb})$
Proportzons 716 18 ..... 78
(Aabb, aabb) (Aabb, Aabb) (Aabb, aaBb) (Aabb, abblb)
78 V/16 VB ..... 78
(aabb,aabb) (aabb,aabb) (aabb,aabb)$\begin{array}{lll}1 / 6 & 18 & 16\end{array}$
V. $A b x$ ab
2) $A R D D=x a a b B$
Fullmsib pair (AaIb, AaBb)
Proportion ..... 1
2i) $A A B b \times a \in B$
Full-sib pairs (AaBb,AaBb) (AaBb,Aabb) (Aabb, Aabb)
Proportions ..... /4
$1 / 2$ ..... $1 / 4$
3) Aabb $\times$ aabB
Full-sib pairs (AaBb, Aabb) (AaBb,aaBb) (aadb,aabb)Proportions$\gamma_{4}$$\gamma_{2}$14
iv) $\mathrm{Aabb} \times$ aabbFull-stb pairs (AaBb, AaBb) (AaBb,Aabb) (AaBb,aaBb)
Pzoportions ..... 116
Y8 ..... 18
( $A a b b, a a b b)(A a b b ; A a b b)$ ( $A a b b, a a b b)(A a b b, a b b b)$
18 V16 Y8 ..... 78
( $a, a b, a \operatorname{abb}),(a a b b, a a b b)(a a b b, a a b b)$$\begin{array}{lll}16 & 1 / 8 & 1 / 6\end{array}$
VI. Ab Y AB
4) AAbb $x$ AAbb
Fuld-sib pais ( $A \mathrm{Abb}, A \mathrm{Abb}$ ) Proportion ..... 1
1i) $A A b b=A a b b$
Fulu-sib patrs (AAbD, AAbb) ( $A A b b, A a b b$ ) (Aabb, $A a b b)$ Proportions ..... 74
$1 / 2$ ..... $1 / 4$
5) Aabb $\times$ Aabb
Full-92b palrs (AAbb,AAbb) (ANbb,Aabb) (AAbb,aabb)
Proportions ..... Y/ 16
44 10
(Aabb, Aabb) (Aabb, aabb) (aabb, eabb)$\begin{array}{lll}1 / 4 & 16\end{array}$
VII. Abx ab
i) AAbo $x$ aabb
Full-sib padx (Aabb,Aabb)
Proportion ..... 1
6) Aabb $x$ aabb
Full-sib paiss (Aabb, Aabb) (Aably, abab) (adbb,aabb)
Proportions $1 / 4$ 42 ..... 14
VIIT. $a$ x XB
7) aeBts $x$ aasB
Fuilmaib pair (aasB, anjb)
Proportion ..... 1
8) aaab $\%$ aabb

Proportions 14 $1 / 2$ ..... 1/4
```
4is) aa8b x aaib
    Fullmsib paizs (aaBB,aaBB) (aaBB,aaBb) (aaBB,aabb)
    Proportione y/16 /4 /8
    (aaBb,aaBb) (aaBb,aabb) (aabb, aabb)
        1/4 1/4 1/16
    IX. AB X Ab
    i) aaBB x aabb
    Full-sib patr (aasb,aaBb)
    Proporition 1
44) aebb x aabb
    Fullmsib pairs (aaBb,aaBb) (aaBb,aabb) (aabb,aabb)
    Proportions 1/4.
X. ab xab
8) aabb & aabb
    Full-3Ib pair (abbb;aabb)
    proporelon1
```

In the mating type mentioned above, the reciprocal crosses as woll as recsprocal full-sib pairs axe not separately considered, because in the case of fullugib mating the freguencies for fullmib pairs of dixect crosses and reciprocal crosses axe the same in all generations. By taking only direct croseos and multiplying these srequencies by two and the equilibrium proportion is obtazned. Thus fortyive mating types as well as fortyfive fullmsto pairs are obrained.

From the above fuil-sib mating type; the generation matrix A for full-bib mating can bo obtainod.

Deroting the vector of fxequorcies for the $n^{\text {th }}$ gereration as $4^{(n)}$ the recurzence relation for the voctor os Erequencies is given by

$$
\begin{equation*}
y^{(n)}=\Delta u^{(n-1)} \tag{4.1.1}
\end{equation*}
$$

where $A^{\prime}$ is given in appendis 1.

### 4.1.1. Fult-sib corxalation

Conster the case of two loct ach wht two alleles say ( $A, a$ ) and ( $B, b$ ) writh proportions for AB as ( $1 \times p$ )/2. for Ab as $\mathrm{p} / 2$, for aB as $p / 2$ and for ab as $(1-\mathrm{p}) / 2$.
$\underline{U}^{(0)}$, the vector of the sxequencies of the fortyfive meting types undor sandom mating from equasibsitum population would De.

$$
U^{(0)}=\left[\begin{array}{l}
(1-p)^{4} / 16 \\
p(1-p)^{3} / 4 \\
p(1-p)^{3} / 4 \\
\therefore \\
(1-p)^{2}\left(2 p^{2}-2 p w 1\right) / 4 \\
p^{2}(1-p)^{2} / 4 \\
p^{2}(1-p)^{2} / 2 \\
p(1-p)\left(2 p^{2}-2 p+1\right) / 2 \\
p^{2}(1-p)^{2} / 4 \\
p(1-p)\left(2 p^{2}-2 p+1\right) / 2 \\
\left(2 p^{2}-2 p+1\right)^{2} / 4
\end{array}\right.
$$

$$
\begin{aligned}
& p^{2}(1-p)^{2} / 8 \\
& p(1-p)^{3} / 4 \\
& p^{3}(1-p) / 4 \\
& p^{2}(1-p)^{2} / 2 \\
& p^{3}(1-p) / 4 \\
& p^{2}(1-p)^{2} / 2 \\
& p^{2}\left(2 p^{2}-2 p+1\right) / 4 \\
& p(1-p)\left(2 p^{2}-2 p+1\right) / 2 \\
& p^{2}(1-p)^{2} / 8 \\
& p(1-p)^{3} / 4 \\
& p^{3}(1-p) / 4 \\
& p^{2}(1-p)^{2} / 2 \\
& p^{3}(1-p) / 4 \\
& p^{2}(1-p)^{2} / 2 \\
& p^{2}\left(2 p^{2}-2 p+1\right) / 4 \\
& p(1-p)\left(2 p^{2}-2 p+1\right) / 2 \\
& (1-p)^{4} / 8 \\
& p(1-p)^{3} / 4 \\
& p(1-p)^{3} / 4 \\
& (1-p)^{2}(2 p 2-2 p+1) / 4 \\
& p^{4} / 8 \\
& p^{3}(1-p) / 4 \\
& p^{3}(1-p) / 4 \\
& p^{2}(1-p)^{2} / 2 \\
& p^{4} / 16 \\
& p^{3}(1-p) / 4
\end{aligned}
$$

$\left[\begin{array}{l}p^{2}(1-p)^{2} / 4 \\ p^{2}(1-p)^{2} / 8 \\ p(1-p)^{3} / 4 \\ p^{4} / 16 \\ p^{3}(1-p) / 4 \\ p^{2}(1-p)^{2} / 4 \\ p^{2}(1-p)^{2} / 6 \\ p(1-p)^{3} / 4 \\ (1-p)^{4} / 16\end{array}\right.$

Now the vector of frequencies of the full-sib paits from this fortyfive matings can be obtained as

$$
\left[\begin{array}{l}
\frac{1}{1024}\left(4 p^{4}-40 p^{3}+136 p^{2}-180 p+81\right) \\
\frac{1}{256}\left(-4 p^{4}+24 p^{3}-30 p p^{2}+8 p+9\right) \\
\frac{1}{256}\left(-4 p^{4}+24 p^{3}-36 p^{2}+8 p+9\right) \\
\frac{1}{126}\left(4 p^{4}-16 p^{3}+20 p^{2}-12 p+5\right) \\
\frac{1}{256}\left(4 p^{4}-8 p^{3}-20 p^{2}+24 p+5\right) \\
\frac{1}{128}\left(4 p^{4}-16 p^{3}+20 p^{2}-12 p+5\right) \\
\frac{1}{64}\left(-4 p^{4}+8 p^{3}-8 p^{2}+4 p+3\right) \\
\frac{1}{256}\left(4 p^{4}-8 p^{3}-20 p^{2}+24 p+5\right) \\
\frac{1}{64}\left(-4 p^{4}+8 p^{3}-8 p^{2}+4 p+3\right) \\
\frac{1}{64}\left(4 p^{4}-8 p^{3}+24 p^{2}-20 p+11\right) \\
\frac{1}{512}\left(4 p^{4}-8 p^{3}+4 p+1\right) \\
\frac{1}{256}\left(-4 p^{4}+8 p^{3}-4 p^{2}+1\right)
\end{array}\right]
$$

$\frac{1}{256}\left(-4 p^{4}-8 p^{3}+12 p^{2}+9 p+1\right)$
$\frac{1}{128}\left(4 p^{4}-4 p^{2}+4 p+1\right)$
$\frac{1}{256}\left(-4 p^{4}+8 p^{3}-4 p^{2}+1\right)$
$\frac{1}{128}\left(4 p^{4}-8 p^{3}+4 p^{2}+1\right)$
$\frac{1}{128}\left(4 p^{4}-4 p^{2}+4 p+1\right)$
$\frac{1}{64}\left(-4 p^{4}+8 p^{3}-8 p^{2}+4 p+3\right)$
$\frac{1}{512}\left(4 p^{4}-8 p^{3}+4 p+1\right)$
$\frac{1}{256}\left(4 p^{4}+8 p^{3}-4 p+1\right)$
$\frac{1}{256}\left(-4 p^{4}+8 p^{3}-4 p^{2}+1\right)$
$\frac{1}{128}\left(4 p^{4}-6 p^{3}+4 p^{2}+1\right)$
$\frac{1}{256}\left(-4 p^{4}-8 p^{3}+12 p^{2}+8 p+1\right)$
$\frac{1}{128}\left(4 p^{4}-4 p^{2}+4 p+1\right)$
$\frac{1}{128}\left(4 p^{4}-4 p^{2}+4 p+1\right)$
$\frac{1}{64}\left(-4 p^{4}+8 p^{3}-6 p^{2}+4 p+3\right)$
$\frac{1}{512}\left(4 p^{4}-3 p^{3}+3 p^{2}-4 p+1\right)$
$\frac{1}{256}\left(-4 p^{4}+8 p^{3}-4 p^{2}+1\right)$
$\frac{1}{256}\left(-4 p^{4}+8 p^{3}-4 p^{2}+1\right)$
$\frac{1}{128}\left(4 p^{4}-16 p^{3}+20 p^{2}-12 p+5\right)$
$\frac{1}{512}\left(4 p^{4}-8 p^{3}+8 p^{2}-4 p+1\right)$
$\frac{1}{256}\left(4 p^{4}+8 p^{3}-4 p^{2}+1\right)$
$\frac{1}{256}\left(-4 p^{4}+8 p^{3}-4 p^{2}+1\right)$
$|$

$$
\begin{aligned}
& \frac{1}{128}\left(4 p^{4}-16 p^{3}+20 p^{2}-12 p+6\right) \\
& \frac{1}{1024}\left(4 p^{4}+24 p^{3}+40 p^{2}+12 p+1\right) \\
& \frac{1}{256}\left(-4 p^{4}-8 p^{3}+12 p^{2}+8 p+1\right) \\
& \frac{1}{256}\left(4 p^{4}-8 p^{3}-20 p^{2}+24 p+5\right) \\
& \frac{1}{512}\left(4 p^{4}-8 p^{3}+4 p+1\right) \\
& \frac{1}{256}\left(-4 p^{4}+24 p^{3}-36 p^{2}+8 p+9\right) \\
& \frac{1}{1024}\left(4 p^{4}+24 p^{3}+40 p^{2}+12 p+1\right) \\
& \frac{1}{256}\left(-4 p^{4}-8 p^{3}+12 p^{2}+8 p+1\right) \\
& \frac{1}{256}\left(4 p^{4}-8 p^{3}-20 p^{2}+24 p+5\right) \\
& \frac{1}{512}\left(4 p^{4}-8 p^{3}+4 p+1\right) \\
& \frac{1}{256}\left(-4 p^{4}+24 p^{3}-36 p^{2}+8 p+9\right) \\
& \frac{1}{1024}\left(4 p^{4}-40 p^{3}+136 p^{2}-180 p+81\right)
\end{aligned}
$$

The colum vector of the freguencied of the full-sib palrs after the first generation of full-sib mating can be obtained in the previous case as;

$$
\left|\begin{array}{c}
\underline{v}^{(2)}=A v^{(1)} \\
\frac{1}{36384}\left(4 p^{4}-136 p^{3}+1144 p^{2}-2612 p+1739\right) \\
\frac{1}{4096}\left(-4 p^{4}+72 p^{3}-232 p^{2}+63 p+161\right) \\
\frac{1}{4096}\left(-4 p^{4}+72 p^{3}-232 p^{2}+68 p+161\right) \\
\frac{1}{2086}\left(4 p^{4}-40 p^{3}+72 p^{2}-52 p+43\right) \\
\frac{1}{4096}\left(4 p^{4}-8 p^{3}-160 p^{2}+464 p+131\right)
\end{array}\right|
$$

$\mathrm{u}^{(2)}=\begin{aligned} & \frac{1}{2048}\left(4 p^{4}-8 p^{3}+16 p^{2}-12 p+19\right) \\ & \frac{1}{2049}\left(4 p^{4}+24 p^{3}-24 p^{2}+12 p+27\right)\end{aligned}$
$\frac{1}{1024}\left(-4 p^{4}+8 p^{3}+16 p^{2}-20 p+41\right)$
$\frac{1}{8192}\left(4 p^{4}-6 p^{3}-80 p^{2}+92 p+43\right)$
$\frac{4}{4096}\left(-4 p^{4}+8 p^{3}+8 p^{2}-12 p+17\right)$
$\frac{1}{4096}\left(-4 p^{4}+8 p^{3}+8 p^{2}-12 p+17\right)$
$\frac{1}{2048}\left(4 p^{4}-8 p^{3}+10 p^{2}-12 p+19\right)$
$\frac{1}{4096}\left(-4 p^{4}-56 p^{3}-40 p^{2}+196 y+65\right)$
$\frac{1}{2048}\left(4 p^{4}+24 p^{3}-24 p^{2}+12 p+27\right)$
$\frac{1}{2048}\left(4 p^{4}+24 p^{3}-24 p^{2}+12 p+27\right)$

$$
\begin{aligned}
& \frac{1}{1024}\left(-4 p^{4}+8 p^{3}+16 p^{2}-20 p+41\right) \\
& \frac{1}{8192}\left(4 p^{4}-8 p^{3}+24 p^{2}-20 p+11\right) \\
& \frac{1}{4096}\left(-4 p^{4}+8 p^{3}+8 p^{2}-12 p+17\right) \\
& \frac{1}{4096}\left(-4 p^{4}+8 p^{3}+8 p^{2}-12 p+17\right) \\
& \frac{1}{2046}\left(4 p^{4}-40 p^{3}+72 p^{2}-52 p+43\right) \\
& \frac{1}{6192}\left(4 p^{4}-8 p^{3}+24 p^{2}-20 p+41\right) \\
& \frac{1}{4096}\left(-4 p^{4}+8 p^{3}+8 p^{2}-12 p+17\right) \\
& \frac{1}{4096}\left(-4 p^{4}+8 p^{3}+8 p^{2}-12 p+17\right) \\
& \frac{1}{2048}\left(4 p^{4}-40 p^{3}+72 p^{2}-52 p+43\right) \\
& \frac{1}{16364}\left(4 p^{4}+120 p^{3}+760 p^{2}+716 p+139\right) \\
& \frac{1}{4096}\left(-4 p^{4}-56 p^{3}-40 p^{2}+196 p+65\right) \\
& \frac{1}{4096}\left(4 p^{4}-8 p^{3}-160 p^{2}+164 p+131\right) \\
& \frac{1}{8792}\left(4 p^{4}-8 p^{3}-88 p^{2}+92 p+43\right) \\
& \frac{1}{4096}\left(-4 p^{4}+72 p^{3}-232 p^{2}+68 p+161\right) \\
& \frac{1}{16384}\left(4 p^{4}+120 p^{3}+760 p^{2}+716 p+139\right) \\
& \frac{1}{4096}\left(-4 p^{4}-56 p^{3}-40 p^{2}+196 p+65\right) \\
& \frac{1}{4096}\left(4 p^{4}-9 p^{3}-160 p^{2}+164 p+131\right) \\
& \frac{1}{8192}\left(4 p^{4}-8 p^{3}-88 p^{2}+92 p+43\right) \\
& \frac{1}{4096}\left(-4 p^{4}+72 p^{3}-232 p^{2}+68 p+161\right) \\
& \frac{1}{16364}\left(4 p^{4}-136 p^{3}+1144 p^{2}-2612 p+1739\right)
\end{aligned}
$$

Honce the joint distribution (correlation table) of full-sib pairs after the first generation of full-silb mating is written as in table 4.2.

From this dable, the cosrelation coorficient between full-sib pates after the first generation of full-sib mating can be directiy worked out by assuming additive genic effects.

Taking sib $I$ as $x, ~$ sib II as $y$ and scoring the genom types according to the number of dominant genes present such as $A A B B$ as 4, AABb, $A B B B$ as 3, $A A D b, a A B B$, AOBb as 2, Aabb, aBBb as 1 and dabb as 0 and by using simple correlation coefficient formula the correlation coefficient can be obtained.

Were, the correlation coefflctent can be of two values depending upon the value of $p, p$ is ranging from 0 to 0.5 . Then there is complete linkage p eakes the value 0 and when thare ls no inltage $p$ takes the value 0.5 .

The correlation coefracient botween fullmsib pairs in the inittal population is worked out from the vector $\underline{U}^{(1)}$. in the similar manner as montioned above, is $\frac{3-2 p}{3-2 p}$. Thus it can be geen that when there is no lintage, the value of cosrelation coefficiont is 0.5 and when there is complete 15nkage it will be 0.6667.

The correlation coefficiont between fulimsib pairs after the first generation of full-sib mating $\boldsymbol{s}^{2} \mathrm{~F}_{\mathrm{F}} \mathrm{S}$ is obtained as

$$
\begin{equation*}
s^{x}(1) \tag{4,1,3}
\end{equation*}
$$

Thus in case of complete linkege, the value of cosrelation coefficient is 0.7143 and in case of no 1 intage, the value of correlation coefficient is 0.6 .

Simalarly the correlation table for full-sib pairs, after the 2nd, 3rd ........ atc** generations of fullmsib mating can be worked out assuming additive genic effecta, Correlation coefficients of fullesib pairs upto ton genorathons of fullestb mating in general and in case of complete linkage as well as in case of no linkage, thus worked out, are given in table 4.3.

The above correlations heve been graphically sepresented and shom in $\mathrm{Hig}, 1$, curve (1) and (2).

### 4.1.2. Rarent-orfenminn coxcelathon

The joint distribution of paront and offspsing after the first generation of full-sib mating with two loci $A$ and $\theta$ with two alleles $A, a$ and $B, b$ at each locus with proporthons of $A B$ as $(4-p) / 2, A b$ as $p / 2$, ab as $p / 2$ and ab as ( $1-p$ )/2 can be obtained by pafring one of the parents with an offspsing obtained from the respective mating, out of the 45 types of fust-sib matings, whose frequencieg ase given by the elements of vector $\underline{U}^{(1)}$. in táble 4.4.

The corrolation coofficient $s^{r_{p=0}^{(1)}}$, between parent and offopring after the firat generation of full-gib mating is obtoined direatly from the dorrolation table, by considering

Table 4.3
Corrolation coefticient of fullamsib pairs in ten generations under fullmsib meting syotem

| $\begin{aligned} & \text { Generam } \\ & \text { tyon } \end{aligned}$ | Corveletion coefficient | Value of corxalation coefficient |  |
| :---: | :---: | :---: | :---: |
|  |  | Complete innkage ( $\mathrm{p}=0$ ) | No innkage ( $\mathrm{p}=12$ ) |
| 0 | $\frac{2-2 p}{3-2 p}$ | 0.6667 | 0.5 |
| 1 | $\frac{3-4 p}{7-4 p}$ | 0.7443 | 0.6 |
| 2 | $\frac{12-8 p}{15-8 p}$ | 0.9 | 0.7273 |
| 3 | $\frac{37-16 p}{32-16 p}$ | 0.9438 | 0.7917 |
| 4 | $\frac{59-32 p}{57-32 p}$ | 0.8806 | 0.3431 |
| 5 | $\frac{126-64 p}{139-64 p}$ | 0.9065 | 0, 8785 |
| 6 | $\frac{265-129 p}{286-128 p}$ | 0.9266 | 0.9054 |
| 7 | $\frac{551-256 p}{505-256 p}$ | 0.9419 | 0.9256 |
| $B$ | $\frac{1136-512 \mathrm{p}}{1191-572 p}$ | 0.9538 | 0.9412 |
| 9 | $\frac{2327-1024 \mathrm{p}}{2416-1024 \mathrm{p}}$ | 0.9632 | 0.9533 |
| 10 | $\frac{4743-2049 p}{48 \mathrm{E} 7-2048 p}$ | 0.9705 | 0.9627 |

as in case of $\mathfrak{c} u l$ losib pairs, assuming the additive genic effect as

$$
\begin{equation*}
s_{p-0}^{x^{(1)}}=\frac{5-4 p}{\sqrt{(6-4 p)(7-4 p)}} \tag{4.1.4}
\end{equation*}
$$

Thus the value of correlation coerficient $s_{p-0}^{(1)}$ is 0.7715 when there is complete linkage and it is 0.6708 when there is no linkage.

Here alvo it can be seon that under the random mating population the correlotion coestictent is 0.5 when there is no linkage and it is 0.5773 when there is Inkoye.

In a similar manner, the joint distribution and the correlation coefficient for parent and offspring pairs after the second generation of full-sib mating can be obtained by using the vector of frequencies $\underline{4}^{(2)}$ of the second generation of full-sib mating as in tablo 4.5.

Similarly, the joint dietribution and the correlation coefficient for perent and offepring for the $3 r d_{0}$ 4th etc., generations of fullosib moting can be worled out. The correlation coefficients between perent and offspring upto ten generations of full-sib mating in general and in case of compiete linkage as well as in case of no linkage, thus worked out, are given in table 4.6.

The above cozrelations have been graphically repre sented and are shown in $[i g .1$, curve (3) and (4).

Table 4.6
Correlation coefficient between parent and offopring in ten generations of full-3ib mating

| Generation | Correlation coefficient | Value of correlation coefficient |  |
| :---: | :---: | :---: | :---: |
|  |  | Complete <br> inkage <br> ( $\mathrm{p}=0$ ) | $\begin{gathered} \text { No } 1 \text { Inkage } \\ (p=y / 2) \end{gathered}$ |
| 0 | $\frac{1-p}{\sqrt{(1-p)(3-2 p)}}$ | 0.5773 | 0.5 |
| 1 | $\frac{2-4 p}{\sqrt{(6-4 p)(7-4 p)}}$ | 0.7715 | 0.6708 |
| 2 | $\sqrt{\frac{12-8 p}{\sqrt{(14-3 p)(15-6 p)}}}$ | 0.8281 | 0.7628 |
| 3 | $\int \frac{27-16 p}{\sqrt{(30-16 p(32-16 p)}}$ | 0.8714 | 0.8269 |
| 4 | $\sqrt{\frac{52-32 p}{(64-32 p)(67-32 p)}}$ | 0.9009 | 0.8691 |
| 5 | $\sqrt{\frac{126-64 p}{\sqrt{(134-64 p)(139-64 p)}}}$ | 0.9232 | 0.3998 |
| 6 | $\sqrt{\frac{265-128 p}{(27 \varepsilon-128 p)(286-128 p)}}$ | 0.9398 | 0.9222 |
| 7 | $\sqrt{\frac{351-250 p}{(572-256 p)(585-256 p)}}$ | 0.9525 | 0.9391 |
| 8 | $\sqrt{\frac{1136-512 p}{(1170-512 p)(1191-512 p)}}$ | 0.9623 | 0.9519 |
| 9 | $\sqrt{ } \sqrt{(2382-1024 p)(2416-1024 p)}$ | 0.9700 | 0.9619 |
| 10 | $\frac{4743-2048 p}{\sqrt{(4832-2048 p)(4887-2048 p)}}$ | 0.9757 | 0.9697 |



### 4.2. Farent-offepryng mating

There are two types of parent-offspring mating systems. In one, a fixed sire is mated repeatedly to his daughter, grandmdaughter, great-grand daughter, etc., whereas in the other, each individual is mated successively with his(her) younger parent and with his(her) offspsing.

Here the first type of parent-offspring mating is considered, $\mathrm{i}_{0} \mathrm{e}_{\mathrm{n}}$, the mating between a fixed sire and his daughter, grand-daughter, etc.

These types of matings are consicered under the ten classes of phenotypic mating as follows:

1. Constcer the mating of the type $A B \times A B$
$A B$ can be of genotypes $A A B B, A A D D, A a B E$ and $A a B b$.
First, the mating of AABB $x A A B B$ is considered. The former AABB denotes the older parent and the latter donotes the younger parent. The former produces ganeto $A B$ with prom portion 1 and the latter produces gemete $A B$ with proportion 1. Thus their offopring will be of genotype AABB with proportion 1. This can be shown as folloms:
i)




Thus the parent-offspring pair will be (AABE, AABB) uith proportion.1.

Second, the mating of AABB $\times$ AABb is considered. Nere the former AABB is older parent and AABb is younger paront. AADS produces gamete $A B$ with proportion 1 and AABD produces $A B$ and $A b$ with proportion $\frac{1}{2}$ each. Thus their offoprings will bo of genotype AABB and AABD with proportion $\frac{1}{2}$ each. This can be shown as follows:
i1)


Thus the parent-offopring pairs will be (AADB, AABB) and (AABB,AABD) with proportion $\frac{1}{2}$ each. In à similar manner the following mating types can be considered.
123)


The parent-offspring pairs with respective proportions ase as follows:

$y_{2} \quad 1 / 2$
iv)


The parent-offopring paixs with respective proportions are as follows:

$$
\begin{array}{cc}
(A A B B, A A B B) & (A A B D, A a B E) \\
y 2 & . / 2
\end{array}
$$

v)


The parent-offspring pairs with respective proportions are as follows:

$$
\begin{array}{cc}
(A a B B, A A B B) & (A a B B, A a B B) \\
12 & y 2
\end{array}
$$



Thus the parent-offspring pairs with respective proportions are as follows:

| ABB, $A A B B$ ) | ( $A A B B, A A B b)(A B B B, A B B B)$ | $\left(A A B B{ }_{*} \mathrm{ABBb}\right)$ |
| :---: | :---: | :---: |
| 14 | 1/4 | 14 |

viis)

$A B, A B, a B, a b$
$A B$
$\begin{array}{llll}1 / 4 & y_{4} & y_{4} & y_{4}\end{array}$
1

|  | $\mathrm{AB}(/ 4)$ | $\mathrm{Ab}(/ 4)$ | $\mathrm{AB}(/ 4)$ | $\mathrm{ab}(/ 4)$ |
| :---: | :---: | :---: | :---: | :---: |
| AB | AABB | AABb | AaBB | AaBb |
| 1 | $1 / 4$ | $1 / 4$ | $1 / 4$ | $1 / 4$ |

Thus the parent-offspring pairs with respective proposm tlons ase as follows:
( $\mathrm{A} A B \mathrm{~B}, \mathrm{AABB}$ ) ( $\mathrm{A} a \mathrm{Bb}, \mathrm{AABb})$ ( $\mathrm{AaBb}, \mathrm{AaBB})(\mathrm{AaBb}, \mathrm{AaBb})$

| $1 / 4$ | $1 / 4$ | 14 |
| :--- | :--- | :--- | :--- |

vili)


|  | $A B\left(y_{2}\right)$ | $A B(/ 2)$ |
| :---: | :---: | :---: |
| $A B(/ 2)$ | $A A B B$ | $A A B b$ |
|  | 14 | $1 / 4$ |
| $A b(/ 2)$ | $A A B b$ | $A A B b$ |
|  | 14 | $1 / 4$ |

The offsprings are $A A B B, A A B b$ and $A A b b$ with proportions $/ 4,1 / 2$ and $/ 4$ respectively.

Thus the parent-offspring pairs with respective proportions are as follows:
( $A A B b, A A B B)(A A B b, A A B b)(A A B b, A A b b)$
$\begin{array}{lll}1 / 4 & 1 / 2 & 1 / 4\end{array}$
ix)

y2. $1 / 2$
$1 / 2 \quad 12$

|  | $A B(y 2)$ | $A b(/ 2)$ |
| :---: | :---: | :---: |
| $A B(/ 2)$ | $A A B B$ | $A A B b$ |
|  | $1 / 4$ | $1 / 4$ |
| $a B(/ 2)$ | $A a B B$ | $A a B b$ |
|  | $1 / 4$ | $1 / 4$ |

The offsprings are $A A B B, A A B b, A a B B$ and $A a B b$ with proportion $/ 4$ each.

Thus the parent-offsping pairs with respective proportions are as follows:
( $A A B b, A A B B)(A A B b, A A B D)(A A B b, A a B B)(A A B b, A a B b)$
$\begin{array}{llll}1 / 4 & 1 / 4 & 1_{4} & 1_{4}\end{array}$
x)


The offsprings are $A A B B, A a B B ; A A B b$ and $A a B b$ with proportion 14 each.

Thus the parent-offspring pairs with respective prom portions are as follows:
( $\mathrm{AaBB}, \mathrm{AABB})(\mathrm{AaBB}, \mathrm{AaBB})(\mathrm{AaBB}, \mathrm{AABb})(\mathrm{AaBB}, \mathrm{AaBb})$

| 14 | $y$ | 14 | $1 / 4$ |
| :--- | :--- | :--- | :--- |

xi)

$\begin{array}{llllll}y_{2} & y_{2} & y_{4} & 1 / 4 & 1 / 4 & 1 / 4\end{array}$

|  | $A B(14)$ | $A b(14)$ | $a B(1 / 4)$ | $a b(1 / 4)$ |
| :---: | :---: | :---: | :---: | :---: |
| $A B(/ 2)$ | $A A B B$ | $A A B b$ | $A A B B$ | $A a B b$ |
|  | $y_{8}$ | $y_{B}$ | $y_{8}$ | $y_{8}$ |
| $A b(1 / 2)$ | $A A B b$ | $A A B b$ | $A a B b$ | $A a b b$ |
|  | $y_{8}$ | $y_{8}$ | $y_{8}$ | $y_{8}$ |

The offsprings are $A A B B, A A B D, A a B B, A O B b, A A B b$ and Aabb with proportions $\gamma_{8}, \gamma_{4}, \gamma_{B}, \gamma 4, y_{8}$ and $\gamma_{8}$ respectively.

Thus the paront-offepring pairs with respective prow portions are as follows:

```
(AABb,AABB) (AABb,AABb) (AABD,AaBB) (AABb,AaBb)
    y% %/ 1/8 /4
(AABb,AABb) (AABb,Aabb)
    % V0
```

$x \neq 1) \quad \mathrm{AcBb} \times \mathrm{AABb}$
In this mating type, the offsprings with respective proportions are same as in the cese of AABbxAaBb. Here the older parent will be Aabb and the younger parent will be AABD. Thus the parentooffopring pairs with respective prom portions are as follows:

| (AaBb, $A A B B)$ | $(A a B b, A B b)$ | $(A a l B, A a B B)$ | $(A a B b, A a B b)$ |
| :---: | :---: | :---: | :---: |
| 18 | $1 / 4$ | 18 | $V 4$ |

(AaBb, AAbb) (Aabb,Aabb)
$\% 8 . \quad 18$
xitit)


| $1 / 2$ | $1 / 2$ | $1 / 2$ |
| :--- | :--- | :--- |
| 1 |  |  |


|  | $A B(/ 2)$ | $a B(/ 2)$ |
| :---: | :---: | :---: |
| $A B(/ 2)$ | $A A B B$ | $A a B B$ |
|  | $1 / 4$ | $1 / 4$ |
|  | $A B(/ 2)$ | 14 |
|  | 14 | $\sqrt{2} 4$ |

The offsprings axe $A B B, A B B$ and aabis with proportions $V / 4,1 / 2$ and $1 / 4$ reopectivel $\gamma$.

Thus the parent-ofespring pairs with respoctive proportions are as follows:

$$
\begin{array}{ccc}
(\mathrm{AaBB}, \mathrm{ABB}) & (\mathrm{AaBS}, \mathrm{AOBB}) & (\mathrm{AaBB}, \mathrm{aaBB}) \\
14 & 12 & 14
\end{array}
$$

xiv)


|  | $A B(/ 4)$ | $A B(/ 4)$ | $a B(14)$ | $a b(14)$ |
| :---: | :---: | :---: | :---: | :---: |
| $A B(/ 2)$ | $A A B B$ | $A A B b$ | $A a B B$ | $A a B b$ |
|  | $1 / 8$ | $1 / 8$ | $1 / 8$ | $/ 8$ |
| $a B(12)$ | $A a B B$ | $A a B b$ | $a a B B$ | $a a B b$ |
|  | $y_{8}$ | 18 | $1 / 8$ | $1 / 8$ |

The offoprings are $A A B B, A A B b, A a B B, A a B b$, a $A B B$ and aabb with proportions $\gamma_{8}, \gamma_{8}, \gamma 4, \gamma 4, \gamma_{8}$ and $\gamma 8$ respectively.

Thus the parent-offspring pairs with respective proportions axe as follows:

$\begin{array}{llll}18 & \gamma_{8} & 14 & 14\end{array}$
( $\mathrm{AaBB}, a \mathrm{aBB}$ ) ( $\mathrm{AaBB}, \mathrm{aabb}$ )
$\begin{array}{ll}18 & y_{8}\end{array}$
xv) AaBb x AaBb

The offsprings with respective proportions of this mating type will be same as of above case Aabl $x$ AaBb. In this mating type, older parent will be Aasb and younger parent will be AaB3. Thus the parent-of sapring pairs with respective proportions are as follows:

# ( $A a B b, A A B B)(A a B b, A A B b)(A a B b, A a B B)(A a B b, A a B b)$ $\begin{array}{llll}18 & 18 & 1 / 4\end{array}$ <br> (AaBb,aABB) (AaSb,aaBb) <br> $\% 8 \quad 18$ 

xvi)


$$
\begin{array}{llllllll}
1 / 4 & 1 / 4 & 1 / 4 & 1 / 4 & 1 / 4 & 1 / 4 & 1 / 4 & 1 / 4
\end{array}
$$

|  | $A B(/ 4)$ | $\mathrm{Ab}(1 / 4)$ | ab (1/4) | $a b(1 / 4)$ |
| :---: | :---: | :---: | :---: | :---: |
| $A B$ | AABB | AABb | Aasis | Aabb |
| 14 | 7/16 | 816 | 116 | \%16 |
| Ab | AABb | AAbb | Aabo | Aabb |
| $1 / 4$ | 116 | 816 | $\gamma 16$ | \%16 |
| as | Aabs | Aabb | aอв | a 2313 |
| 14 | 716 | \%16 | 176 | y16 |
| ab | AaBb | Aabl | 2asb | aebl |
| $y_{4}$ | \%16 | $\gamma 16$ | $V 16$ | \%16 |

The offspringe are $A A B B, A A B b, A a B B, A a B b, A A b D, ~ A a b b$, $\mathrm{a} A B B$, aabb and abb with proportions $1 / 16, \gamma 8,1 / 8,1 / 4,1 / 16,18$, Y16, $y_{8}$ and 116 respectively.

Thus the parent-offspring pairs with respective prow portions ase as follows:

( $\mathrm{AaBb}, \mathrm{Aabb}$ ) ( $\mathrm{A} a B b, a \mathrm{aBB})(\mathrm{AaBb}, a \mathrm{aBb})$ (AaDb,aabb) $\begin{array}{llll}18 & 16 & 16 & 16\end{array}$

In a similar mannor the other mating types under the nine classes of phenotypic mating can be considered as
II. Consider the mating of the type $A B \times A B$
i) $A A B B \times A A b D$
Parent-offspring pair (AABA,AABb)
Proportion1
11) AABb $\times \mathrm{AABB}$
Parent-offspring pair (AAbs,AAEb)
Proportion ..... 1
1ii) $A A B B \times$ Aabb
Pazent-offopring pairs ( $A A B B, A A B b$ ) ( $A A B B, A a B b$ )
Proportions ..... y2 ..... 12
iv) Aable $x$ AABE
Parent-offspring pairs (Aabb,AABb) (Aabb,AaBb)
Proportion ..... y/2 ..... 12
v) $A A B b \times A A B b$
parent-offspring pairs (AABb,AABD) (AABb,AABD)
Proportions ..... 12 ..... $1 / 2$
vi) AABb $\times A A B b$
Parent-offspring pairs ( $A A B b, A A B b$ ) ( $A A B b, A A b b$ )
Proportions ..... V2 ..... $\gamma 2$
vis) AABb $x$ Aabb
Parentmoffspring pairs (AABb, $A A B b$ ) ( $A A B b, A a B D$ ) (AABb,AABb)
Proportions ..... y 4 ..... $1 / 4$ ..... 14
(AABb, Aabb)
14
viii) $A a b b x A A B b$Parent-offspring pairs (Aabb, AABb) (Aabb,Aaibb)
Proportions 14 ..... 74
(Aabb, $A A b b)(A a b b, A a b b)$
$1 / 4$ ..... $1 / 4$
ix) AaBB $x$ AAbb
Parent-offopring pairs ( $A a B B, A A B b$ ) ( $A B B B, A B B b$ )
Proportions ..... 12 ..... 12
x) $\triangle A b b x A a B B$
Parent-offspring pairs (AAbb,AABb) (AAbb,AaBb)
Proportions ..... V/2 ..... $y 2$
x1) AagB $\times$ Aabb
Parentwoffopring pairs (AaBB,AABb) (AaBB,AaBb) (AaBB, aaBb)
Proportions ..... $1 / 4$
$1 / 2$ ..... $\gamma_{4}$
x41) Aabb $\times A a B B$
Parent-offspzing pairs (Aabb,AABb) (Aabb,AaBb) (Aabb,aaBb)
Proportions ..... $1 / 4$
$1 / 2$ ..... 14
xisi) Aabl $\times$ AADb
Parent-offspring pairs (AaBb,AABD) (AaBb, AAbb) (AaBb,Aazb)
Psoportions $1 / 4 \quad 14$ ..... 14
(AaSb,Aabb)14
xiv) $A A b b \times A a B b$
Paront-offspring pairs (AAbb,AABb) (AAbb,AAbb) (AAbb,ABBb)
Proportions $1 / 4 \quad 14$ ..... $1 / 4$
(AAbb,Aabb)
zv) $A a B b x$ Aabb
Parent-offspring pairs (AaBD,AABb) (AaBb,AaBb) (AaBb,AAbb)
Proportions 18 $1 / 4$ ..... $1 / 3$( $\left.\mathrm{AaBb}_{s} \mathrm{Aabb}^{2}\right)(\mathrm{AaOb}, a \mathrm{aBb})(\mathrm{AaBb}, a \mathrm{abb})$
$\gamma_{4}$ ..... /6 ..... 18
xvi) Aabb $x$ Aabb
Parenteoffspring pairs (Aabb;AABb) (Aabb,AaBb) (Aabb,AABb)
Proportions 18 14 ..... $\gamma 8$
(Aabb,Aabb) (Aabb, aabb) (Aabb,aabb)
Y4 y 78
III. Consider the mating of the type $A B \times a B$
2) $A A B B \times a a B B$
Parent-offspring pairs (AABB,AaBB)
Proportion1
11) $\operatorname{aCBB} \because \mathrm{AABS}$
Parent-offspring pair (aabB,AaBB)
Proportion ..... 1
1ii) $A A B B \quad x a A B b$
Parent-offspring pairs (AABB,AaBB) (AABB,AaBb)
Proportions ..... $y_{2}$ ..... $1 / 2$
iv) $a \mathrm{aBb} \times \mathrm{AABB}$
Parent-offspring pairs (aaBb,AaBB) (aaBb,AaBb)
Exoportions ..... $1 / 2$ ..... 12
v) $A A B b \times a A B B$Parent-offepring paiss ( $\mathrm{AABb}, \mathrm{AaBB}$ ) ( $\mathrm{AABb}, \mathrm{AaBb}$ )
8 soportions ..... 72 ..... 12
vi) วaBg $x \mathrm{AABb}$
Parent-offspring pairs (aaBB,AaBB) (aBBg,AaBb)
proportions $V 2$ ..... /2
vii) AABD 3 aaBb
Pasent-offspring paiss (AABb,AaBB) (AABb,AaBb) (AABb,Aabb)
Proportions ..... 14
Y2 ..... 14
viil), aBBlo AABb
Parent-offopring pairs (aaBb,AaBB) (aaBb, AaBb) (aaBb,Aabb)
Proportions ..... 14
12 ..... 14
2x) Aabl $\times$ adB
Parent-offspring paira (AaBB,AaBB) (ABBB, aABB)
Proportions ..... 12 ..... $1 / 2$
x) $a \operatorname{ABB} \times \mathrm{AaBB}$
Parentwoffspring pairs (aaBB,AaBB) (adBB,aaBB)
Proportions ..... I/2 ..... $1 / 2$
42) ABBB 8 aabb
Parent-offspring pairs (AaBB,AaBB) (AalB8, AaBb) (AaBB, aaBB)
Proportions ..... Y4
14 ..... 14
(AaBB, a@Bb)14
xis) $\mathrm{aaBb} \times \mathrm{AaBB}$
Parentwoffspring pairs (aaBb,AaBB) (aaBb,Aalbb) (aabb,aabB) Proportions ..... 14
V4 ..... $\gamma_{4}$
( $\mathrm{aaBb}_{\mathrm{g}} \mathrm{aaBb}$ ) ..... $1 / 4$
x1si) Aabb $x a a b B$
parent-offspring paiss (AaBb, AeBB) (AaBb,AaBb)
Proportions ..... 14 ..... V 4
(AaBb, aniB) (Aagb, aabb)
$1 / 4$ ..... 14
$x i v)$ adic $x A a B b$parent-orfspring pairs (abill,Aabs) (aona,AaBb)
Proportions $y_{4}$ ..... y,
(aBBis,abB) (acBn, aabb)
$1 / 4$ ..... 14
zv) Aabb $\%$ aabb
Parentorfopring pairs (Aabb,AaBB) (Aabb,AaBb)
Proportions y ..... 14
( $\mathrm{AaBb}, \mathrm{Aabb}$ ) (AaBb,aAB3) (AaBb, aabb) (AaBb, abb) 78 ye $y_{4}$ ..... Y8
सv1) aasb : AaBb
Parentmoffopring pairs (aobb,AaBB) (azB,Aabb) Proportions 78 ..... $1 / 4$
 ..... 18
$1 / 8$ ..... 14 ..... 18
IV. Consider the matings of the type $A B \times$ ab

1) $A A B B \times a a b b$
Parent-offspring paiz (AABA,AaBb)
Proportion ..... 1
4i) aabb $\times$ AABg
Parent-offspring pair (aabb,AaBb)
Proportion1
iii) AADb $:$ aabb
Parentmotispring pairs (AABb,AaBb) (AABb,Aabb)
Proportions ..... y/ ..... V2
iv) aabl $\times A A B b$
Parent-offspring pairo (aabo,AaBb) (aabb, 10 bb )
Propostions $y 2$ ..... $7 / 2$
v) $A a B E x$ aabb
Parent-offspring pairs (A坃B, AaBb) (AaBB, aaBb)
Proportions 12 ..... 12
vi) aabb $\times$ AaBbParent-offspring pairs (aabi, AaBb) (aabb,aebb)
Proportions ..... $\begin{array}{ll}1 / 2 & 1 / 2\end{array}$
viL) Aabb $x$ aabb
Parentwoffspring pairs (AaBb,AaBb) (AaBb,Aabb) (ABBb,aaBb)
Proportions $\gamma_{4}$ ..... $1 / 4$ ..... 14
(AaBb,aabb)$1 / 4$
vii1) aabb $\times$ Аавb
Parenkoffspring pairs (aabb, AaBb) (aabb, Aabb)
Psoportions ..... $1 / 4$ ..... Y4
(aabb, aadb) (aabb,aabb) $1 / 4 \quad 1 / 4$
V. Consider the matings of the typo $A b \times a B$
2) $\mathrm{AAbb} \times \mathrm{ab} \mathrm{B}$
Parent-offepring pair (AAbb,AaBb)
Praportzon ..... 1
i3) aasb x AAbb
Parent-offspring pair (aabB,AaBb)
Psoportion ..... 1
iia) AAbb $x$ aabb
Parent-offspring pairs ( $\mathrm{AAbb}, \mathrm{AaBb}$ ) ( $\mathrm{AAbb}, \mathrm{Aabb}$ )
Proportions ..... /2 ..... 12
1v) aảb $x$ AAbbParent-offspring pairs (aabb,AaBD) (aaBb,Aabb)
Proportiona ..... $1 / 2$ ..... /2
v) $\mathrm{Aabb} x a \mathrm{aBB}$
Parent-offspring pairs (Aabb,AaBb) (Aabb, aaBb)
Psoportions ..... 72 ..... $1 / 2$
vi) aeBB $\times$ Aabb
Parent-offspring pairs (aabB,AaBb) (aabB,aaBb)
Proportions ..... 12 ..... V 2
vii) Aabb $x$ aabb
Parent-offspring pairs (Aabb,AaBb) (Aabb,Aabb)
Proportions ..... 14 ..... 14
(Aabb,aeab) (Aabb,aabb)
14 ..... $1 / 4$
v1\$1) asBb $x$ AabbParent-offopring pairs (a@b,AbBb) (aaBb,Aabb)
Proportions 14 ..... 74
(aabb,aabb) (aaBb,aabb)1414
VI. Consider the matings of the type Ab X Ab
i) $A A D b \times A A B b$
Parent-ofispring paix (AAbb,AAbb)
Proportion ..... 1
ii) AAbb $x$ Aabb
parentooffopring pairs (AABb,AAbb) (AAbb,Aabb) Proportions ..... $1 / 2$ ..... 12
iis) Aabb $\times$ AAbb
Parent-offspring pairs (Aabb,AAbb) (Aabb,Aabb)
Proportions ..... 72 ..... $1 / 2$
iv) Aebb x Aabb
parent-offspring pairs (Aabb,AAbb) (Aabb,Aabb) (Aabb,aabb) Propartions ..... $1 / 4$
$\sqrt{2}$ ..... $1 / 4$
Vil. Consider the matings of the type Ab ab
3) $A A b b \times a a b b$Paxent-offspring pais (AAbb;Aabb)Proportion1
4) $a a b b * A A b b$
Parent-offspring pair (aabb,Aabb)
Proportion ..... 1
111）Aabb $x$ aabb
Parentmofrgpring pairs（Aabb，Aabb）（Aabb，aabb）
Proportions ..... $V 2$ ..... 12
むv）aabb $\times$ AabbParentooffspring pairs（aabb，Aabb）（aabb，aabb）Proportions $\quad / 2$$1 / 2$
VIII．Consider the matings of the type 0 en eB
2）$a \operatorname{aBB} \times \operatorname{abB}$
Parontmoffopring pair（aabB，aaBB）
Proportion1
14） $\operatorname{aaBg} \times \operatorname{aaBb}$
Parentoffspring pairs（acBB，aaBB）（a＠B，aaBb）
Proportions ..... $1 / 2$ ..... $8 / 2$
むi土）aasb x aeBb
Parent－offspring pairs（aabb，aaBe）（aaBb，aaBb）
Proportions ..... ／2 ..... $1 / 2$
iv）agab $x$ aabb
Parent－offspring paiss（aaBb，aaBB）（aaBb，aaBb）（aaBb，aabb）
Proportions ..... Y4 $1 / 2$ ..... 84
IX．Consides the matings of the type ab $x$ eb
5）aabs $x$ aabb
parent－offspring pair（aaBB，aakb）
Proportion ..... 1
5) aabb $x a a b B$
Parent-offopring pair (aabb,aabb)
Proportion 1

1i土) aals $\%$ aabb
Parent-offspring pairs (aabb,aabb) (aabb,aabb)
Propoctions $1 / 2$ /2
2v) $a \mathrm{abb} \times \mathrm{aabb}$
Parent-offspring pairs (aabb,adsb) (aabb,aabb)
Proportions $\quad 12 \quad y 2$
X. Consider the mating of the type ab a ab

1) aabb $\times$ aabb

Pasent-offspring pais (aabb; aabb)
Pxoportion 1
In the mating types montioned above, all posstible crosees
are constdered. Thus 81 typos of matings are obtalnod. gut we cannot get ef parent-offspring pairs becauso some of the parent-offopring paiss such as (AABB,AABb), (AABS,Aabb). (Aa53, AADb), (AaBB, Aabb), (AABS, aabB), (AABB, aabb), (AABb, aasb), $(A A B b, a a B b),(A A B B, a a b b),(A A B b, a a b b),(A O B B, a O b b),(A A b b, a a B B)$, (AAbb, $a b B b),(A a b b, a a B B),(A A b b, a a b b),(a a C B, a a b D)$ and their respective reciprocal patrs (on the whole there are 32 euch pairs) cannot be obteined from any of 81 types of matings for the successive generetions. Theis frequencies will be always zoro in all generations. Thus eliminating these
tramepose of
32 columns of parent-offspring pairs, the, generation matrix $\times\left(A^{* \prime \prime}\right)$ for the pasent-offspring mating type can be obtained as shown in appendix II.

With the help of this generation matrix and the prom cedure given in the case of full-sib mating, the vector of frequencies after the $n^{\text {th }}$ gencration of parent-offspring mating ean be calculated.

### 4.2.1. Eull-sib correlation

As in the case of full-sib mating systet, the parento offspring mating systen is also developed from the 81 mating types from the equilibrium random mating population.

Now the vector of irequencias, $\underline{u}^{(1)^{*}}$, of the of parentoffspring mating types can be obtained as

$$
\begin{equation*}
\underline{u}^{(1) *}=\underline{a}^{*} \underline{u}^{(0)} \tag{4.2,1}
\end{equation*}
$$

where $\underset{\sim}{\sim}$ is the generation matrix for parent-offspring mating syoters. Thus it can be written as,

$$
u^{(1)^{7}}=\left[\begin{array}{l}
\frac{1}{32}\left(-2 p^{3}+7 p^{2}+8 p+3\right) \\
\frac{1}{32}\left(2 p^{3}-3 p^{2}+1\right) \\
\frac{1}{32}\left(2 p^{3}-5 p^{2}+3 p\right. \\
\frac{4}{32}\left(2 p^{3}-3 p^{2}+1\right) \\
\frac{1}{32}\left(2 p^{3}-5 p^{2}+3 p\right)
\end{array}\right]
$$

$$
\begin{aligned}
& \frac{1}{32}\left(-2 p^{3}+7 p^{2}-8 p+3\right) \\
& \frac{1}{64}\left(-4 p^{3}+10 p^{2}-8 p+3\right) \\
& \frac{1}{8}\left(-p^{2}+p\right) \\
& \frac{1}{32}\left(-2 p^{3}+p^{2}+p\right) \\
& \frac{1}{32}\left(-2 p^{3}+p^{2}+p\right) \\
& \frac{1}{8}\left(-p^{2}+p\right) \\
& \frac{1}{16}\left(2 p^{2}-2 p+1\right) \\
& \frac{1}{8}\left(-p^{2}+p\right) \\
& \frac{1}{8}\left(-p^{2}+p\right) \\
& \frac{1}{16}\left(2 p^{2}-2 p+1\right) \\
& \frac{1}{8}\left(2 p^{2}-2 p+1\right) \\
& 0 \\
& 0 \\
& 0 \\
& 0 \\
& \frac{1}{32}\left(-2 p^{3}+p^{2}+p\right) \\
& \frac{1}{32}\left(-2 p^{3}+3 p^{2}\right) \\
& \frac{1}{32}\left(2 p^{3}-5 p^{2}+3 p\right) \\
& \frac{1}{32}\left(2 p^{3}-5 p^{2}+3 p\right) \\
& 0 \\
& 0 \\
& 0 \\
& 0
\end{aligned}
$$



$$
\begin{gathered}
\frac{1}{5}\left(-p^{2}+p\right) \\
0 \\
0 \\
\frac{1}{32}\left(2 p^{3}-5 p^{2}+3 p\right) \\
\frac{1}{32}\left(2 p^{3}-3 p^{2}+1\right) \\
\frac{1}{32}\left(-2 p^{3}+7 p^{2}-3 p+3\right)
\end{gathered}
$$

Now the jolnt dictribution (correlation table) of 4ullmbib patra maner the first generttion of parontofespring mating can be obtained by pelring the ofsspring in the fixst Genesotion of the patent-oxfspring mating within emch of the vector $\mathrm{S}^{(4)^{3}}$. as given in table 4.7 .

The correlation coesciciont $p-0^{(T)}{ }^{(4)}$, between fullweib palre modex the first generation of perent-osespetng mating $2 s$ obtainod directly from the cospelation teble by enploying the aethod explaned tn fallmsib matingo assuning the addithve genic effeces as

$$
\begin{equation*}
p-0^{3}(1)=\frac{11-10 p}{15-10 p} \tag{4,2,2}
\end{equation*}
$$

The value of cosreleston coestacient is 0.733 when there 4 e complete linkage and 18 is 0.6 when there is no linkage.

In a nimilar manner the colum vector, $\hat{U}^{(2)}$ of the Srequencien of bhe gi pazentoosespring mating types in the
second generation of parent-offspring mating can bo obtained a日.

$$
\begin{equation*}
\underline{\underline{U}}^{(2) *}=A^{*} \underline{y}^{(1) *} \tag{4,2,3}
\end{equation*}
$$

Hence $\underline{u}^{(2) *}$ can be obtained,

\[\)| $\left[\begin{array}{l}\frac{1}{128}\left(-2 p^{3}+23 p^{2}-40 p+19\right) \\ \frac{1}{126}\left(2 p^{3}+p^{2}-3 p+5\right) \\ \frac{1}{128}\left(2 p^{3}-15 p^{2}+13 p\right) \\ \frac{1}{128}\left(2 p^{3}+p^{2}-8 p+5\right) \\ \frac{1}{128}\left(2 p^{3}-15 p^{2}+13 p\right) \\ \frac{1}{128}\left(-2 p^{3}+7 p^{2}-8 p+3\right) \\ \frac{1}{256}\left(-4 p^{3}+22 p^{2}-20 p+9\right) \\ \frac{1}{16}\left(-3 p^{2}+3 p\right) \\ \frac{1}{128}\left(-2 p^{3}-p^{2}+3 p\right) \\ \frac{1}{128}\left(-2 p^{3}-p^{2}+3 p\right) \\ \frac{1}{16}\left(-p^{2}+p\right) \\ \frac{1}{16}\left(2 p^{2}-2 p+1\right) \\ \frac{1}{16}\left(-3 p^{2}+3 p\right) \\ \frac{1}{16}\left(-p^{2}+p\right) \\ \frac{1}{16}\left(2 p^{2}-2 p+1\right) \\ \frac{1}{8}\left(2 p^{2}-2 p+1\right) \\ 0 \\ 0\end{array}\right.$ |
| :--- |\(|

\]

$\left|\begin{array}{cc}0 \\ 0 \\ \frac{1}{128} & \left(-2 p^{3}-9 p^{2}+14 p\right) \\ \frac{1}{128} & \left(-2 p^{3}+7 p^{2}\right) \\ \frac{1}{126} & \left(2 p^{3}-7 p^{2}+5 p\right) \\ \frac{1}{126} & \left(2 p^{3}-7 p^{2}+5 p\right) \\ 0 \\ 0 \\ 0 \\ 0 \\ \frac{1}{256} & \left(4 p^{3}+10 p^{2}-12 p+7\right) \\ \frac{1}{128} & \left(2 p^{3}+p^{2}\right) \\ \frac{1}{16}\left(2 p^{2}-2 p+1\right) \\ \frac{1}{16} & \left(-p^{2}+p\right) \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 & \left(-2 p^{3}-9 p^{2}+11 p\right) \\ 0\end{array}\right|$

$$
\left\{\begin{array}{c}
\frac{1}{128}\left(-2 p^{3}+7 p^{2}\right) \\
\frac{1}{128}\left(2 p^{3}-7 p^{2}+5 p\right) \\
\frac{1}{129}\left(2 p^{3}-7 p^{2}+5 p\right) \\
\frac{1}{256}\left(4 p^{3}+10 p^{2}-12 p+7\right) \\
\frac{1}{128}\left(2 p^{3}+p^{2}\right) \\
\frac{1}{16}\left(2 p^{2}-2 p+1\right) \\
\frac{1}{16}\left(-p^{2}+p\right) \\
0 \\
0 \\
0 \\
0 \\
0 \\
0 \\
\frac{1}{256}\left(-4 p^{3}+22 p^{2}-20 p+9\right) \\
\frac{1}{128}\left(-2 p^{3}+7 p^{2}-8 p+3\right) \\
0 \\
0 \\
0 \\
0 \\
0 \\
0 \\
\frac{1}{128}\left(-2 p^{3}-p^{2}+3 p\right) \\
\frac{1}{128}\left(-2 p^{3}-p^{2}+3 p\right) \\
0
\end{array}\right.
$$

$$
\left\lvert\, \begin{gathered}
\frac{1}{128}\left(2 p^{3}+17 p^{2}\right) \\
\frac{1}{126}\left(-2 p^{3}+7 p^{2}\right) \\
\frac{1}{128}\left(-2 p^{3}-9 p^{2}+11 p\right) \\
\frac{1}{16}\left(-3 p^{2}+3 p\right) \\
0 \\
0 \\
\frac{1}{128}\left(2 p^{3}-19 p^{2}+13 p\right) \\
\frac{1}{128}\left(2 p^{3}+p^{2}-3 p+5\right) \\
\frac{1}{126}\left(2 p^{3}+17 p^{2}\right) \\
\frac{1}{128}\left(-2 p^{3}+7 p^{2}\right) \\
\frac{1}{128}\left(-2 p^{3}-9 p^{2}+11 p\right) \\
\frac{1}{16}\left(-3 p^{2}+3 p\right) \\
0 \\
0 \\
\frac{1}{128}\left(2 p^{3}-15 p^{2}+13 p\right) \\
\frac{1}{128}\left(2 p^{3}+p^{2}-8 p+5\right) \\
\frac{1}{126}\left(-2 p^{3}+23 p^{2}-40 p+19\right)
\end{gathered}\right.
$$

Now as in the provious case, by pairing and pooling the frequencies of respective fullosib pairs from the offspring of the second goneration of parent-offspring mating, the joint distribution of fuilmsib pairs in the second genaration of parentwoffersing mating can bo obtained as in table 4.8.

The correlation coorticient $p-0^{2}(2)$, between the quil-ath patrs aster the second generation of parentoffe spring mating is obtained directly by asouming adoztive genic efrect as

$$
\begin{equation*}
p-0^{\min }(2)=\frac{95-50 p}{65-60 p} \tag{4.2.4}
\end{equation*}
$$

The value of correlation coexfickent is 0.7971 when there is cotalete Intege and it is 0.6019 when there is no 3knkage.

Similarlys the joint fistribution and correlation coeffictents for fullmbib pairs, in the $35 d$, 4 th. ...... etc. genorations of parent-offopring nathing con be worised out. The corrolation coefficients betweon fullmitib paiss upto fon genertuions of parent-orforing, in genoral and in case of complote linkage as toll as in case of no linkage are worted out and are given in table 4.2.

The above cosrelathons have been oraphically sapzesonted ond are shown in F1g.2, eurve (1) and (a). 4.2.2. Eareat-affortha corselgition
warentionfogeng gorghation that the colum vector of ifoguencios of the parent-offersing paire from an oquiLibrium zancom mating poputation wae given by $\underline{u}^{(9)}$. Again the colurn vecter of irequencies of the parentmoffoping nating type in the first genoration of parentwofepsing mating, $\underline{y}^{(2)}$, has been given in (4.2.3).

Table 4.9
Corralation cocfelotents between full-sib patrs in ten generations of parent-offspring mating

| Generation | Corfelation coefficient | Value of correlation coefricient |  |
| :---: | :---: | :---: | :---: |
|  |  | Complete Innkage ( $\mathrm{p}=0$ ) | No linttage ( $p=7 / 2$ ) |
| 0 | $\frac{1-p}{\sqrt{(1-p)(3-2 p)}}$ | 0.5773 | 0.5 |
| 1 | $\frac{11-10 p}{15-10 p}$ | 0.7333 | 0.6 |
| 2 | $\frac{53-50 p}{69-50 p}$ | 0.7971 | 0.6818 |
| 3 | $\frac{245-929 p}{297-226 p}$ | 0.8249 | 0.7174 |
| 4 | $\frac{1033-962 p}{1233-962 p}$ | 0.8378 | 0.7340 |
| 5 | $\frac{4241-3970 \mathrm{p}}{5025-3970 \mathrm{p}}$ | 0.8440 | 0.7421 |
| 6 | $\frac{17189-161300}{20289-16130 p}$ | 0.8470 | 0.7461 |
| 7 | $\frac{69485-65026 p}{81537-65026 p}$ | 0.8485 | 0.7480 |
| 8 | $\frac{277633-2611220}{326913-261122 p}$ | 0.3493 | 0.7490 |
| 9 | $\frac{1112321-10465300}{1309185-10465300}$ | 0.8496 | 0.7495 |
| 10 | $\frac{4453865-4190210 p}{5239609-4190210 p}$ | 0.8499 | 0.7498 |

By uring this vector or frequencies, $\underline{u}^{(2) *}$, shown in section 4.2.1, the correlation table of parent-offspring pairs in the first generation of parent-offspring mating can be worked out as in table 4.10.

The correlation coefficient $p-0^{r^{(1)}}{ }^{(1)}$ can be worked out directly from the above table and it is given as
$p-0_{p m 0}^{(1)}=\frac{3(1-p)}{\sqrt{(1-p)(15-10 p)}}$
The value of correlation coefficient is 0.7746 when there is complete linkage and it is 0.6708 when there is no. 14nkage.

Stmilarly, the correlation coefricients of parentoffepring pairs under parent-offspring mating for and, 3rd, *e...... etc., can be worked out from correlation tables by assuming additive genic effecto.

The corvolacion coefficients between parent and offspring upto the ten generations of parent-offepring mating in general and in case of complete linkage as woll as in case of no linkage are worked out and are given in table 4.11.

The above correlations have been graphically xepresented and are show in Fig. 2, curve (3) and (4).

## Table 4.11

Correlation cocificients between parent and offspring in ten generation of parent-offipring mating

| $\begin{aligned} & \text { Genaxam } \\ & \text { tion } \end{aligned}$ | Correlation coefficient | Value of correlation coefficient |  |
| :---: | :---: | :---: | :---: |
|  |  | Complete <br> 1inkage ( $\mathrm{p}=0$ ) | $\begin{aligned} & \text { No linkage } \\ & (p=y 2) \end{aligned}$ |
| 0 | $\frac{1-p}{\sqrt{(1-p)(3-2 p)}}$ | 0.5773 | 0.5 |
| 1 | $\frac{3(1-p)}{\sqrt{(1-p)(15-10 p)}}$ | 0.7746 | 0.6708 |
| 2 | $\frac{7(1-p)}{\sqrt{(1-p)(69-50 p)}}$ | 0.8427 | 0.7462 |
| 3 | $\frac{15(1-p)}{(1-p)(297-226 p)}$ | 0.8704 | 0,7819 |
| 4 | $\frac{\sqrt{31(1-p)}}{\sqrt{(1-p)(1233-962 p)}}$ | 0.8828 | 0.7994 |
| 5 | $\frac{63(1-p)}{\sqrt{(1-p)(5025-3970 p)}}$ | 0.3887 | 0,8079 |
| 6 | $\frac{127(1-p)}{(1-p)(20289-16130 p)}$ | 0.8916 | 0.8122 |
| 7 | $\frac{255(1-p)}{(1-p)(61537-65026 p)}$ | 0.8930 | 0.8144 |
| 8 | $\frac{511(1-p)}{\sqrt{(1-p)(326913-269122 p)}}$ | 0.8937 | 0.8154 |
| 9 | $\frac{1023(1-p)}{\sqrt{(1-p)(1309185-1046530 p)}}$ | 0.8942 | 0.8160 |
| 10 | $2047(1-p)$ | 0.8943 | 0.8162 |
|  | $\sqrt{(7 \mathrm{pp})(5239809 \mathrm{m490210p})}$ | 0.0943 | 0.8102 |



DISCUSSION

## CHAPTER V

DISCUSSLON

In the prosent investigation an attempt was made to study the genetic correlations of fullmsib pairs and parent-offspring pairs under full-sib mating systom and parent-offspring mating system in case of two loci with two alleles at each locus. The study of correlations of fuil-sib pairs and parent-offspring pairs under full-sib mating system were carried out in section 4.1.1 and section 4.1.2. Similarly the study of correlations of full-sib pairs and parent-offspring pairs under parent-offspring nating systom were carried out in section 4.2.1 and section 4.2.2.

In section 4.1.1, the joint distribution of full-sib pairs in the first generation of full-sib mating was derived using generation matrix and the corresponding correlation was worked out therefrom. Further, a series of full-sib correlation coefficients for first ten generations of fullsib mating in general and in case of complete linkage as well as in case of no linkage was obtained as given in table (4.3). It could be observed from this table that when there was no linkage, the correlation coefficient steadily increased from 0.5 under random mating to 0.9627 , and when there was complote linkage it increased from 0.6667 under random mating to 0.9705 , in tenth generation of full-sib
mating. This was fully in agreenent with the principles of inbreeding.

It was also observed that (i) even under random moting the value of correlation coerficient was 0.5 when there was no linkage, (ii) it was 0.6667 when there was complete IInkage and (iii) the values of correlation coefficient in complete linkage vore greater than the values of the correlation when there was no linkage in all generations.

Section (4.1.2) concerned with the derivation of joint distribution of parent-offspring pairs and the calculation of parentoffspring correlation under full-sib mating, adopting generation metrix approach. The correlation coefficients of parent-offspring pairs in the first ten generations of fullosib mating in general and both cases of complete linkege and no linkage were worked out in table (4.6). The table indicated that when there was no kinkage, the correlation increased from 0.5 under xandom meting to 0.9697 and when there was complete inkage, it incroased from 0.5773 under random mating to 0.9957 in the tenth generation of full-sib mating. Theso findings were also In full agreement with the phenomena of inbreeding. Here also all the values of correlations in complete liniage were greater than the correlation coefficients in case of no linkage.

These four correlations, viz., full-sib corrclation (no linkago), full-sit correlation (complete linkago). parent-offspring correlation (no linkage) and parent-offo spring corrolation (complete lintage) wore exhibited graphically in Fig. 1 by curve (1), curve (2), curve (3) and curve (4) respectively. From these curves, it could be observed that inftially the increase was in linear fashion and ofter third generation it increased with decroasing rate in all cases. From the investigation of the correlation curves, eventhough the fulimib corrolation coofficient at the presence of lintage was greater than the parentoffspring correlation in initial generation (random mating), the latter incroased more rapidly than the former from the initial generation to first generation. It was revealed by the facts that (i) slope of curve (4) was steeper than thet of curve (2), (ii) curve (4) crossed the curve (2) between initial and first generation. Nevortheless, from the second generation onwards, the rate of increase in both of curves of correlation coefficients ware nearly the same upto tenth generation. From tho fourth generation onwards, correlation coefficients became neariy equal to each other and tond to unity in infinite number of gonerations.

A comparative study of these four curves revealed that the parent-offspring correlations were of comparatively higher order than the fullosib corrolations in ease of no inkage as woll as in case of complete linkage.

In section 4.2.1, the joint distribution of fullesib pairs under the first generation of parent-offspring mating was derived using generation matrix theory and the corresponding correlation was worked out therefrom. Proceeding from this, full-3ib correlation coefficients for first ten generations of parent-offspring mating in general and in case of complete inkage as well as in case of no linkage were obtained as given in table 4.9. Fron this tablo, it could be seen that, the correlation increased as the number of generation increased in both cases of complete linkage and no linkage, When there was no linkage the corrolation increased from 0.5 under random mating to 0.7498 and when there wes complete linkage it increased from 0.5773 undor random mating to 0,8498 in the tenth generation of parentoffspring mating. This finding was in full agreement with the principles of inbreeding. In this case also the values of correlation coofficients were more in complete linkage in all generations and it was found that even under random mating it was 0.5773.

Further the derivation of joint disiribution of parentoffopring pairs and the calculation of parent-offspring correlation under parent-offspring mating syotem were cerried out under the section 4.2.2. The correlation coefficients of parent-ofspring pairs in first ten generations of parent-offspring mating in general and in both cases of
complete linkage and no linkage were worked out in table 4.11. The table indicated that the correlation increased as the number of generation increased. It was also in full agroement with the phenomena of inbreeding. The graph exhibitIng the trends of full-sib corrolation (no linitage), fullusib correlation (complete linkege), pacent-offspring correlaikion (no linkage) and parent-offspring correlation (complete linkage) under parent-offspring mating was given in Fig. 2 by curve (1), curve (2), curve (3) and curve (4) respectively. From that figure it was seen that tho correlation Increased as the number of generation incroased, but the rate of increase gradually reduced as the number of goneration increased.

On comparing the parent-offspring cosrelation with the full-sib correlation, it was seen that the trend in both cases remain the same, but the value of parentwoffspring correlation was always greater than that of the full-sib correlation in case of complete linkage as well as in case of no Linkage.

In comparisori of all theoe correlations, one could easily observe that the correlations increased as the number of generation increased and ultimately reached the limit unity when the number of generations increased indofinitely large. It was intoresting to note that the parent-affspring correlation was higher in megnitude than that of full-sib
correlation under both systems of mating in case of no Inkage as well as in case of complete linkage. It was also observed that in case of complete linkage the magnitude of correlation was more than in case of no linkage even under the same system of mating. When there was corm plete linkage, the parent-offspring correlation under perent-offopring mating increased at a rapid rate than the parent-offspring correlation under full-sib mating upto third generation, but from fourth generation onwards the latter incroased at a more rapid rate than the former and became almost unity in the tenth generation. When there was no linkage, eventhough the parentmoffspring correiations under both syttens of mating were the same in both initial generation (randon mating) and the first generation, the parent-offspring correlation under full-sib mating system increased at a rapid rate than the parent-offspring correlation under parent-offepring mating system from second generation onwards and became nearly unity at the tenth generation.

Eventhough in the presence of linkage the values of full-sib correlations under full-sib mating was greater then that of fullmin correlation under parentoffispring mating in the initial generation (random mating), it was found that the latter became groater than the former in the first generation. However, from the second generation onwards
the full-sib correlation under full-sib mating increased nore rapidly than the full-sib correlation under parentoffspring nating, and tend to unity as the number of genem ration became indefinitely large.

It was also interesting to note that eventhough the above two correlations in the absence of linkage remain the same in initial and first generation, from the secand generation onwards the full-sib correlation under full-sib mating increased more rapidly than the full-sib correlation under parentwoffsping mating and tend to unity as the num ber of generation became indefinitely large,

SUMMARY

## CHABTER VI

## sumany

The objectives of the present Investigation entitled "A Study of Gonetic Correlations under Full-sib Mating Systen (two loci case)" were mainly four-fold, viz., (i) to derive the joint distributionmcorrelation table and to find the correlation between fullwsib pairs under full-sib mating system in the case of two loci, when there is no linkage as well as when there is complete linkage, (i1) to dexive the joint distribution-correlation table and to find the correlation between parent-offopring pairs under fulimsib mating system in the case of two loci, when there is no linkage as mell as, when there is complete linkage, (ili) to derive the joint distribution-correlation table and to find the correlation between full-sib pairs under parent-of fspring mating system in the case of two loci, when there is no linkage as well as, when there is complete linkage and (iv) to derive the joint distribution-correlation toble and to find the correlation batween parent-offspring pairs under parent-offspring mating system in the case of two loci, when there is no linkage as well as, when there is complete linkage.

The study of corxelation between relatives under diffem rent inbred systems so far had been made only in the case
of single locus with two alleles. Hence an attempt was made in this investigation to study the genetic correlations of fullmstb pairs and parent-offspring pairs under full-sib and pasent-offspring mating system in the case of two loci with two alleles at each hours, when there is no ilnkage as well as when there is complete linkage.

To find out these correlations, the generation matrix A for full-sib mating with dimension ( $45 \times 49$ ) was obtained From 45 genotypic mating types under ten classes of phenom typic mating types, Similarly the generation matrix $A^{*}$ for parent-offspring mating with dimension ( $81 \times 49$ ) was obtained from 81 genotypic mating types undor ten classes of phenom typic mating.

Denoting the vector of frequencios for $n^{\text {th }}$ generation under full-sib mating system by $\underline{y}^{(n)}$, the vector of frequenclee for the successive generations under fullasib mating systen was computed by the recurrence relation given by

$$
\underline{u}^{(n)}=A \underline{u}^{(n-1)}
$$

From this recurrence relation, the correlation tables for full-sib pairs for any generation of full-sib mating system could be easily worked out and the correlations were calculated thererrom. The correlations between full-sib pairs were calculated for the first ten gencrations of
full-sib mating in both the cases of complete linkage and no inkage. then there wac no 1inleage, the correlation betweon full-3sib paire under full-stb nating syarem ranged from 0.3 in initial generation to 0.9627 in tonth generation. When there was complete innkage. it sanged from 0.6607 in initial genesation to 0.0705 in tenit generation.

The correlation tebles for parent-offspring pairs under any generation of full-sity mating system was also dovoloped fron the recurrence relation

$$
\underline{U}^{(n) *}=A^{*} \underline{U}^{(\mathrm{Bm})}
$$

Fron this securrenco relation, the correlation tables for parentoonfopsing pairs for, tho first ten generations of full-sib mating were verted out and the correlations were calculated inerefrom in both the cases of complote linkago and no linkage. In case of no lintiege the correlation between parent-offspring pairs under full-sib mating oyster ranged fron 0.5 in instial generation to 0.9700 in tenth gencrailion, In case of cemplote linkoge it ranged from 0.5773 in initial generation to 0.9760 in tenth generation. then these was no linkege the valued of correlation coereso cients for fuldusib pairs and parentoofspring pairs were found to se 0.5 in indtial generation. However, when there was complete linkage the values of these correlations were found to be 0.0667 and 0.5773 respectively.

Denoting the vector of recguncies for $n^{\text {th }}$ generation under parent-ofspasing mating aystem by $y^{(n)}$, the vector of srequancies for fuli-sib patra for $a^{\text {th }}$ Generviten under parent-offering nating oysten conla bo obtatned arom tho zecurxence reletion glven by

$$
\underline{u}^{(n)} a y^{(n-1)^{m}}
$$

Hron the above relation, correlation tables for fullslb palrs for the first ten generathons of parentwoffoprimg mating were worked out and the corrolations were calculated theresmon in both cases of no linkage and complete linkage. When these was no linkage, the correlation between fullmsib paixs undar parentooffspring moting syotem zanged from 0.5 In intisal gencration to 0.749 s in tenth genesation. When there was complove Jinkage it sunged from 0.5773 in initias genesation to 0.e4ge in tenth generation.

Similarly, the corselation tebles ror pasent-offopring patre under any genewation of pesenteorfopseng mating syster could be obtodnod zron the recurrence relation given by

$$
\underline{U}^{(n)^{*}}=A^{*} U^{(n-1)^{*}}
$$

Fron this zecurrence relation, the corretation teblos for parent-ofispring paixs. for the fixst ton generathons of parent-othspring mating wero warkec out and the correlathons wore calculated thererrom in both cases of complete

Intage and no isntage. In case of no linkage the coxrelation between parentooffepring paizs untlex pasentomeapring mating syatem fanged from 0.5 In initial genexation to 0.0162 in eonth generation. In cooe of complete intage it menged from 0.5773 2n inittal goneration to 0.9943 in tenth generation.

Unces parontooffopring mateng systen also the values of correlation coefricients for fullasib patrs ancs parentoffepring pairs were found to be 0.5 in inttial generation when there was no 1 nnkage. Howevew, when thero was complete Linkage the values of these correlations were found to be 0.5773 each.

The corselathons such as fullatib correlation (no 1inkage) f ruldmble cosrelation (complets linkage), parentm offeprang correkthon (no linleage) and parentoofeprezng correlation (complete Linkage) were grophically represonted ageinst the first ten generations of fullosib mating in Figure i. sirdiaxly, the same typos of comedations under parentmorsopzing mathng wexe gxaphicanty repxasented agatnct the firet ten generetions in figure 2.

It was foumd that the costelations in complete linkage wase alwayo groatex than that of corxelatione in no innkage In both the syotem of mating. Tho valued of corrolettons For ruLl-sib patrs and parontoryspring pairs under
parent-ofepring mating were lower ordar than that of cozrelations under full-3ib mating syotem in both caoes of no lintage, and complete sintage, howevas all these correlations increased as the number or generation incseased and seached the limit unity when the number of genoration Enereased Incerinitedy large.

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# A STUDY OF GENETIC CORRELATIONS UNDĖR FULL~SIB MATING SYSTEM (TWO LOCI CASE) 

## By

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# ABSTRACT OF A THESIS <br> submitted in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE (AGRICULTURAL STATISTICS) 

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1985

## ABSTAACT

A purely thooretical investigation entitled "A Study of Cenetic Cormelations uncor fullosib Moting System (tuo Loci case) ${ }^{\text {n }}$ was carried out with the following objectives.
i) to derive the joint distribution (coxrelation table) and to sind tho corxeiatlon botween sullesio pairs uncer Full-sib mating system in the case of two loci whon there is no linkage as well as when there is complete linkage.

1i) to derive the joint distribution (corrolation table) and to find the corealabion between parentwoffspring pairs under fuil-stb mating sygtom ln the case of two loct when there is no linkage as well as when thore is complete linkage.
iii) to derive the joint diseribution (corretation table) and to find the correlation between fuil-sib pairs under perentorfopring roting systen in the case of two loct when thore is no inhage as well as when there is complete linkage.
iv) to derive the joint distribution (correlation fable) and to find the correletion between parontoffspring pairs under parent-offspsing nating sysem in the case of two logi when there is no Lintage as well as when there is comptete Linkege.

The joint distributions of fullwsib pairs and parentoffspsing paiss under full-sib moting system wore derived with the help of generation notriz techntque and the correLathons wose noxked out fhorefron, assuming additive genic effects and using the product-moment correlation coefficient formula. The correlathons were worted out for the first ten generations of full-sib nating in both cases of no linkage and complete linkege.

A comparative study of fullusib comsolations and parent-ofespring correlations, concucted both numorically and graphecally revealed that (i) eventhough full-oib correm lation was greater than parentmoffspang correlation in Initial generation (xandom mating) when thera was complete Inhage, the latter Increasod more rapidly than the former from intital generation to first goneration and (is) from the second gencrotion onvasclo the rate of increase in both of corzelations were neaxly the same upto tenth generation. It was Inseresting to note that the parent-ofespring comreLations wore of comparativaly highor arder then the fullemib comrelefione in both cases of complete ilnkage and no inkage.
similarly, the joint distributione (correlation tables) for full-sib paiss and parentosfspeing pairs under parentoffspring mating system were dersved employing generation matrix approach and the correlations for the first ten
generations of pasentwoffering meting in woth coses of no ainkege and conplote linkage were workod out therefrome. A comparative study of these corrolations vas carried out both numerically and graphically. It was found that the frend in both corrolation cusves zomain the some, but the value of parent-of fopling gorzolation was alwoys greater than that of full-sib corrolation in case of no linkage as well as in caso of complete linkage.

In comparison of all these correlations, it was found that the correlations increasod as the number of generation increased and ultmately reached the limit unity when the nunber of generations increased indefinitely large. It was also observed that the magnitule of corrolation in case of complete linkage vas nore than that of correlation in case of no linkogo even under the same systom of mating.

