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Simulation of Mathematical Models in Genetic Analysis

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SIMULATION OF MATHEMATICAL MODELS IN GENETIC ANALYSIS

by

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of the requirements for the degree

of

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in

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Dinesh Govindlal Patel

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GLOSSARY

A or a: Symbols used sometimes to represent genes or their corresponding characters. AA represents dominant homozygous pair of genes or their corresponding characters.

Address: (1) An identification represented by a name, label or number, for a register or location in storage. Addresses are also a part of an instruction word along with commands, tags and other symbols. (2) The part of an instruction which specifies an operand for the instruction.

Address Indirect: An address in a computer instruction which indicates a location where the address of the reference operand is to be found.

Address Symbolic: A lavel, alphameric or alphabetic used to specify a storage location in the context of a particular program. Often, programs are first written using symbolic address in some convenient code which are translated into absolute addresses by an assembly program.

Allele: One of a pair of genes controlling an alternative and contrasting character.

Arithmetic floating point: A method of calculation which automatically accounts for the location of the radix point. This is usually accomplished by handling the number as signed mantissa times the radix raised to an integral exponent.

Assembler: A computer program which operates on symbolic input data to produce from such data machine instructions by carrying out such functions as: translation of symbolic operation codes into the computer operating instructions, assigning locations in storage for successive instructions or computation of absolute addresses from symbolic address.

Chromosome: One of several microscopic, thread-like bodies arising from the cell nucleus in nuclear division, then bear the genes in a linear order and are usually constant in number, size and form for each species.

Compiler: A computer program more powerful than an assembler. In addition to the translating function which is generally the same process as that used in an assembler. It is able to replace certain items of input with series of instructions.

Complement: (1) A quantity expressed to the base N, which derived from a given quantity by a particular rule; frequently used to represent the negative of the given quantity.

Cromatids: Either one of the two identical strand with which a chromosome splits in anticipation of cell division.

Crossover: An exchange of homologous segment between the cromatids of paired chromosomes.

Digital computer: It is a device for performing sequences of arithmetic and logical operations, not only on data but its own program.

Diploid: Having twice the gametic or haploid number of chromosomes as usually occur in somatic cells, having both number of pair of chromosomes present.

Dominance: The expression of a character to the exclusion of its allelic character.

Epistasis: The dominant action of a gene over a non-allelic gene located on a different chromosome or at a different locus on the same chromosome, in contrast with the dominance of a gene over its allele, both genes located at the same locus on the chromosome.

Field: Data in two or more adjacent core positions to be treated as a unit. A flag is used to define the high-order position of a field.

Fixation: Making a character, or a type of organism, dominant, usually by inbreeding and selecting.

Gamete: A mature, usually haploid, sex cell capable of fusing with a cell of similar origin but of opposite sex to form a zygote.

Gene: A heriditary element comprising a specifid location on a chromosome.

Genotype: A genetic constitution of an organism, or the hereditary properties and materials of an individual.

Haploid: Having the half on "n" number of chromosomes present (one of each pair), as usually occurs in reproductive cell (gametes) in contrast with the diploid or "2N" number of chromosomes in zygotes.

Heredity: The transmission of expressed and latent characteristics from parental organisms to their offsprings.

High-order: Left-most position of the data field.

Homologous chromosomes: The two chromosomes in each pair occuring in diploid. One chromosome of the pair is derived from one parent, the other chromosome from the other parent.

Homozygotes: An organism has inherited from its parents identical genes controlling a particular character.

Indicators: The device which register conditions resulting from a comparison of plus or minus conditions during computation. A sequence of operations within a procedure may be varied according to the position of an indicator.

Individual: The elementary unit of taxonomy, sometime extended to include any new unit formed by vegetative propagation after the unit breaks connection with the mother organism.

Instruction: A set of characters which defines an operation together without one or more addresses or no addresses and which as a unit causes the computer to perform the operation on the indicated quantities. The term instruction is preferable to the terms, commands and order.

Linkage: The occurance in inheritance, of characters together instead of in a random assortment, due to the genes for such characters being located on the same chromosome. A series of linked genes pairs on the same chromosome is known as a linkage group.

Locus: A definite point or region in a chromosome at which a gene is located.

Low-order: Unit position of the data field.

Magnetic core storage: A storage device on which binary data is represented by the direction of magnetization on each unit of an array of magnetic material usually in the shape of toroidal rings.

Module: An incremental block of storage for expanding the computer capacity.

Mutation: A change in the nuclear substances (genes, chromosomes) of an organism. It may arise from a change in the normal number of chromosomes, an alteration in a part of a chromosome, or an alteration at a particular gene or locus on a chromosome.

Operand: A quantity entering or arising an instruction. An operand may be an argument, a result, a parameter or an indication of the next instruction.

Object program: It is a machine language program ready for execution.

Phenotype: The total of character expressions of an individual, as contrasted with its genotype; individuals of the same phenotype look alike, but may have different genotypes.

Program: The complete plan for the solution of a problem which contains necessary instructions and routines.

Recessive: Pertaining to the number of an allelic pair of genes which does not produce its effect in the presence of the other number.

Reproduction: The process by which animals and plants give rise to offspring of similar kind.

Segregation: The separation of genes and of chromosomes in the formation of germ cell, each germ cell receiving one gene of each pair and one chromosome of each pair.

Selection: Any natural or artificial process which favors the survival and propagation of certain individuals possessing desirable traits, or which prevents certain individuals possessing undesirable traits from surviving and propagating.

Sex chromosome: Chromosomes that are particularly connected with the determination of sex and which are distinguished by shape and/or function from all chromosomes.

Subroutine: The set of instructions necessary to direct the computer to carry out a well defined mathematical or logical operation.

Table look up: To obtain a function value corresponding to an argument stated or implied from a table of function values stored in the computer.

Trait: A characteristic.

Transfer: To copy, exchange, read, record, store, transmit, transport, write data or instructions.

Variable word length: It is a property that machine word may have variable number of characters.

Zygote: A product of fused gametes or of nuclei of opposite sex, the individuals developing from fertilized cell.

CHAPTER I

INTRODUCTION

In recent years a new field of statistics has become of importance in many branches of experimental science. This is the Monte Carlo Method, so called because it is based on simulation of stochastic processes. By stochastic process, it is meant some possible physical process in the real world that has some random or stochastic element in its structure. This is the subject which may appropriately be called the dynamic part of statistics or the statistics of "change," in contrast with the static statistical problems which have so far been the more systematically studied. Many obvious examples of such processes are to be found in various branches of science and technology, for example, the phenomenon of Brownian Motion, the growth of a bacterial colony, the fluctuating numbers of electrons and protons in a cosmic ray shower or the random segregation and assortment of genes (chemical entities responsible for governing physical traits for the plant and animal systems) under linkage condition. Their occurrences are predominant in the fields of medicine, genetics, physics, oceanography, economics, engineering and industry, to name only a few scientific disciplines. The scientists making measurements in his laboratory, the meteriologist attempting to forecast weather, the control systems engineer designing a servomechanism (such as an aircraft or a thermostatic control), the electrical engineer designing a communication system (such as the radio link between entertainer and audience or the apparatus and cables that transmit messages from one point to another), economist studying price fluctuations in business cycles and the neurosurgion studying brain wave records, all are encountering problems to which the theory of stochastic processes may be relevant.

Let us consider a few of these processes in a little more detail. In statistical physics many parts of the theory of stochastic processes were developed in correlation with the study of fluctuations and noise in physical systems (Einstein, 1905; Smoluchowski, 1906; and Schottky, 1918). Consequently, the theory of stochastic processes can be regarded as the mathematical foundation of statistical physics. The stochastic models for population growth consider the size and composition of a population which is constantly fluctuating. These are mostly considered by Bailey (1957), Bartlett (1960), and Bharucha-Reid (1960). In communication theory a wide variety of problems involving communication and/or control such as the problem of automatic tracking of moving objects, the reception of radio signals in the presence of natural and artificial disturbances, the reproduction of sound and images, the design of guidance systems, the design of control systems for industrial processes may be regarded as special cases of the following general problem; that is, let T denote a set of points in a time axis such that at each point t in T an observation has been made of a random variable X(t). Given the observations $[X(t), t \in T]$ and a quantity z related to the observation, one desires to from in an optimum manner, estimates of, and tests of hypothesis about z and various functions $h(z)$. In the case of parameter estimation in signal extraction, detection and observation $[X(t), 0 \leq t \leq T]$ may be regarded as a sum,

$$X(t) = S(t) + N(t) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where S(t) represents the trajectory given by

$$S(t) = \chi_0 + \gamma t + (a/2)t^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

of a moving object and S(t) represents errors of measurements. One desires to estimate the velocity v and acceleration a of the object. More generally, one desires to estimate such quantities as S(t) and $\frac{dS(t)}{dt}$ at any time t in $0 \leq t \leq t$. Under the assumption that the signal S(t) belongs to known class of functions.

So far we have considered only one aspect of this involved problem and that is the proper recognition of the phenomenon to be the "dynamic" part of statistics, the stochastic process. The other major problem still remains and that is the solution of the foregoing problems. It is well known to mathematicians and statisticians that the solution of the problem depends upon the assumption one makes about the signals (in statistical term, the true effect), the noise (the error) received during the process and also on the criteria one adopts for an optimum solution. For example, let the stochastic variables X(t) be the number of calls during a time interval t at a telephone switchboard. If we consider X(t) be the number of calls during a time interval t at a telephone switchboard and assume that (a) the probability of a call in time t is proportional to dt, say λdt and (b) that the calls are independent, then we have the following differential equation:

$$P_i(t + dt) = P_i(t)\ (1 - \lambda dt) + P_{i-1}\ (t)\ \lambda dt \quad . \quad . \qquad (3)$$

$$i = 0,\ 1,\ 2\ .\ .\ .$$

Under the boundary conditions $P_i(0) = 1$ when $i = 0$ and $P_i(0) = 0$ when $i > 0$, where $P_i(t)$ is the probability of i number of calls in the interval t. For the case $i = 0$, $P_0\ (t) = e^{-\lambda t}$ and for $i = 1$, $P_1(t) = \lambda t e^{-\lambda t}$ and by the application of mathematical induction it is easily seen that

$$P_k(t) = \frac{(\lambda t)^k \quad e^{-\lambda t}}{K!} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (4)$$

$$K = 0,\ 1,\ 2\ .\ .\ .\ .\ .\ .$$

which can be recognized as the poisson process. Now suppose we relax the Bernoulli assumptions (original Bernoulli process) given in (a) and (b) above and to make it more realistic consider that in a large city the dependency has multifactorial functional relationship among the stochastic variable X(t). The solution of the problem becomes far-fetching. Now let's consider another example. Consider a large scale communication system, say a high speed digital computer which transmits the digits 0 and 1. Each digit transmitted must pass through several stages, at each of which there is a probability that the digit which enters will be unchanged when it leaves. Let X_0 denote the digit entering the first stage of the system and for $n \geq 1$, let Xn denote the digit leaving the n^{th} stage of the communication system. Now assume that the constant probability be p that the digit enters will be unchanged when leaving. The sequence X_0, X_1, X_2, ... is recognized to be Markov Chain (Markov Process) with transitional probability matrix (letting $q = 1 - p$)

$$P = \begin{bmatrix} p & q \\ & \\ q & p \end{bmatrix} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

The corresponding n step transition probability matrix P(n) may be written as

$$P(X_2 = 1/X_0 = 1) = P_{11}^{(2)} = 5/9 \quad . \quad . \quad . \quad . \quad . \quad (7)$$

$$P(X_3 = 1/X_0 = 1) = P_{11}^{(3)} = 14/27 \quad . \quad . \quad . \quad . \quad . \quad (8)$$

that is in words, if $p = 2/3$, then the digit entering the system as a 1 has probability 5/9 of being correctly transmitted after 3 stages. In fact a general solution exists for the conditional probability

$$P(X_0 = 1/X_n = 1) = \frac{\alpha + \alpha (p - q)^n}{1 + (\alpha - \beta)(p - q)^n} \quad . \quad . \qquad (9)$$

where $\alpha = P(X_0 = 1$ and $\beta = 1 - \alpha$. But now suppose we cannot make the Bernoulli assumption of constancy of the probability p from stages to stages and to make it more realistic, we assume that we are interested in multi-dimensional vector space where there are $X_1(t)$, $X_2(t)$ . . . $X_n(t)$ with n such vector functions for each of the stochastic variables $X_i(t)$, the correlation function is not one of the product moment type, then the solution of the problem will be very difficult to achieve.

So the moral of the story is that there are solutions to the problems, where the experimenter is willing to make rigid assumptions and the solution of the problem becomes far-fetching when one is realistic and tries to relax the assumptions that led to the solution.

The problem at hand, of genetics, is one of the types of the study in which relaxation of assumptions leads to a very realistic situation and the experimenter learns something about the phenomena, where as, making rigid assumption to yield the problem to a particular solution leads to very unrealistic solution.

Genetics deals with variations, which are the differences in characteristics of individuals. In dealing with these variations it attempts to determine how they are produced, how they may be classified and how they are inherited. By inheritance is meant the passing on of characteristics from one generation to another by means of the germ cells. The germ cells contain chromosomes. These are considered of very great importance in connection with heredity. The genetic evidence very greatly supports the assumption that the chromosomes are made up of hereditary genes arranged in linear order. Consider the fact that we have a population of live individuals. According to population genetic terminology, this is nothing but a pool of genes shared by several individuals in the pool.

Let two pairs of genes lie in a different chromosomes and each pair of genes is inherited independently of the other pair. During meiosis, the respective chromosome synapse and then separate so that each gamate gets one and only one of each kind. The law of independent segregation which states that the member of one pair of genes separate from each other in meiosis independent of the members of other pairs of genes and come to be assorted at random in the resulting gametes. In the similar way, more than one pair of genes in a chromosome may be taken into consideration. The probability that a gene is transmitted from the parent to the offspring is not the same for each gene and also the probability that a pair of genes being transmitted depends upon the probability of the transmission of the preceding pair in a chain of genes. The later probability is not constant from chromosome to chromosome (individuals have more than one chromosome. For example, man has 24 pair, Drosophila has 4 pair, etc.).

The sex of an organism is a trait which is determined genetically. In females there are two identical sex chromosomes called X chromosomes, but in males there is one chromosome called Y chromosome. The latter contains few or no genes and is, in most species, of a different size and shape from the X chromosomes. All eggs produced by females have one X chromosome. Half of the sperm produced by males contain an X chromosome and half contain a Y. The fertilization of an X-bearing egg by an X-bearing sperm results in a XX female zygote. The fertilization of a X egg by a Y-bearing sperm results in a XY male zygote. The X chromosome contains many genes; the Y chromosome contains only a few. The traits controlled by genes lying in the X chromosomes are called sex-linked, because their inheritance is linked with that of sex. There are relatively few chromosomes and many hundreds of different inherited traits, it is obvious that there must be many genes in each chromosome. All the genes in each chromosome tend to be linked. This is due to the fact that in meiosis the homologous pair of chromosomes separate as units and go to opposite sides. Therefore, all the genes lying in the chromosome go to one side to become incorporated in one gamete, and all the genes contained in the other member of the homologous pair go to other side and become incorporated in the other gamete. However, linkage between the genes in a given chromosome is usually not complete. During the process of synopsis the homologous chromosome frequently exchange whole segments of chromosome and the genes located in them. The exact mechanism of this exchange is still unknown, but it occurs at random along the length of the chromosomes. All the genes in a particular chromosome constitute a linkage group. These groups, which, of course, are determined by genetic tests, always equal to haploid number of chromosomes. It remains constant and only changed by translocation in which a piece of one chromosome breaks off and becomes attached to another non-homologous chromosome. The chromosomes occur in pairs in all the body cells of organism, as usually as an immature germ cell, and that during formation of the eggs and sperm. The chromosome constituting each pair in early reproductive cells separate so that each egg and sperm receives only one member of each pair. At fertilization they again come together in pairs.

A brief excursion in mathematics will show how it happens. If we consider, in a population, the distribution of single pair of genes, A and a, any member of the population will have the genotype AA, Aa, or aa. Let us suppose that their genotypes are present in the population in the ratio 1/4 AA; 1/2 Aa; 1/4 aa. If all the members of the population select their mates at random, without regard to whether they are AA, Aa, or aa, and if all the pairs produce comparable numbers of the pairs of offsprings, the succeeding generations will also have genotype in the ratio 1/4 AA; 1/2 Aa; 1/4 aa. This can be demonstrated by setting down all the possible types of matings, the frequency of their random occurrence, and the kinds and proportions of offspring produced by each type of mating and then adding up the kinds of offspring.

The frequencies of the members of a pair of allelic genes in a population are described by the expansion of a binomial equation. In the example just discussed we assumed that the population contained initially 1/4 AA, 1/2 Aa, and 1/4 aa. We can generalize this relationship if we let p be the proportion of A gene and q be the proportion of a gene. Since the gene must be either A or a, then $p + q = 1$, (and if we know either p or q we can determine the other). All the matings of any generation, a p number of A containing eggs and a q number of a containing eggs are fertilized by p number of A containing sperm: (pA + qa) X (pA + qA). The proportion of the types of offspring of all these matings is described.

Now let us consider the notion of independent assortment and linkage phenomena in genetics. Usually the genes of an individual are present in pairs of alleles and that one allele of each pair is obtained from the mother and the other from the father. When the individual produces eggs or sperm, only one allele of each pair is transmitted to a gamete in one-half of the cases, the maternal allele, and, in the other half, the paternal.

A child, therefore, receives only one allele of each of his mother's pairs of alleles and only one of each of his father's pairs. Whether this allele is the one which the parent received from his mother or from his father is a question which cannot be answered with certainty. It is a matter of chance, depending on whether the fertilizing gametes happened to contain the maternal or paternal allele. Chance is not a vague concept but can be expressed quantitatively. Its evaluation in terms of probability plays a major role in all human activities. The probability that a healthy person will still be alive the next day determines much of his behavior. It also determines the behavior of all the other persons with whom he has contact, although everyone is aware of the chance of death. In tossing a coin there is an even chance that heads or tails will turn up. The probability of throwing a head is, therefore, 1 out of 2 or 1/2. In throwing a die, the probability of obtaining a specific number is 1 out of 6 or 1/6. In general, probability is defined quantitatively as the fraction formed by the "favorable" event divided by all possible events—"favorable" being the event whose probability is under discussion. Applying the above to human genetics, we may ask: what is the probability of a child inheriting from his father the allele which the father received from his own father? or what is the probability of a child inheriting a certain allele from his paternal grandfather but not from his paternal grandmother? The answer is 1/2, since the child could receive either the "favorable" paternal allele or "unfavorable" maternal allele from his father. A frequent problem is to find the probability of two independent events occurring coincidentally. What, for example, is the possibility of a child obtaining from his mother the grandmother's allel and from his father the grandfather's allele? Let us enumerate all possible cases and then form the fraction of the favorable divided by all possible cases.

1. A child may receive the maternal allele of each parent.

2. A child may receive the paternal allele of each parent.

3. A child may receive the maternal allele of the mother and the paternal allele of the father.

4. A child may receive the paternal allele of the mother and the maternal allele of the father.

Obviously, the four combinations are equally probable. The third is the "favorable" combination whose probability we wish to determine. This event takes place in 1 out of 4 cases so that the probability is 1/4. We can derive this result in a different way: since the probability of obtaining the paternal grandfather's allele is 1/2 and that of obtaining the maternal grandmother's allele is, likewise, 1/2, only in 1/2 of the cases in which the first event is realized. Does the second occur? This means that the chance of both events happening together is 1/2 of 1/2 = 1/4. Generalizing, we obtain the theorem: the probability of two independent events occurring together is the product of the two separate probabilities. What is the probability of a child inheriting his two alleles either from the two grandfathers or from the two grandmothers and not one allele from a grandfather and the other fram a grandmother? Inheritance of his alleles from the two grandfathers has a probability of 1/4 and from the two grandmothers also of 1/4. The overall probability of the favorable cases is thus 1/4 + 1/4 = 1/2. The probability that one or the other of two (or more) mutually exclusive events will occur, is the sum of the separate probabilities.

It is interesting to note that it can be predicted, with certainty, that a child will receive from a parent one of the two alleles of all genic pairs, but that it cannot be predicted in the same way in which the specific combination of the maternal and paternal alleles of the parent will be received. In the gametes of an individual who is heterozygous for one pair of loci in each of the 24 chromosomes, 16,777,216 different combinations of allele are possible, and equally probable. Therefore, the probability that a child will inherit any one specified combination is 1/16,777,216.

Two different genes in man may either be located in two different chromosomes or at different loci in the same chromosome. If in different chromosomes, they are transmitted independently of each other. An individual who received the alleles A^1 and B^1 in two different chromosomes from his mother and A^2 and B^2 in the homologous chromosome from his father, forms four different kinds of gametes in equal numbers: A^1B^1, A^1B^2, A^2B^1 and A^2B^2. Thus, among the gametes, the "new" combinations, A^1B^2 and A^2B^1, are as frequent as the "old" combinations, A^1B^1 and B^2A^2. If the genes A and B are in the same chromosome, segregation in an individual who received A^1B^1 from his mother and A^2B^2 from his father might or might not result in equal numbers of gametes with old and new combinations. The old combinations A^1B^1 and A^2B^2 are formed by meiotic chromosome strands which do not undergo crossing over in the section between A and B, while the new combinations A^1B^2 and A^2B^1 are formed by cross over chromosome strands. Since the frequency of crossing over in the section between two loci, A and B, is positively correlated with the distance between them, the new crossover combinations of two closely linked loci are rare as compared with the old, noncrossover combinations; but the crossover combinations of two distinctly linked loci may be as frequent as the noncrossover combinations. It follows that chromosomal linkage between two genes can be easily recognized if an individual hetrozygous for two pairs of loci forms gametes in unequal numbers, namely, two, more frequent, crossover gametes. If, however, the four kinds of gametes are equally frequent, it is not obvious whether the two gene pairs are located in different chromosome pairs or whether they are in the same pair far away from each other. For an initial example of systematic deviation from independent assortment we may return to the already familiar frizzle fowl. In an experiment in chickens, colored frizzle females were crossed with a white Longhorn male. The male was homozygous for gene I, a dominant which acts as an inhibitor for melanin pigmentation, and for the normal, recessive allele of frizzle.

The hens were iiFF; that is, they did not have the dominant white gene but were homozygous frizzles. F_1 females obtained from the cross of colored, frizzle females X white, normal males were testcrossed. The crosses and their results are tabulated below:

P: iiFF (colored, frizzle) ♀♀ X IIFF (white, normal) ♂♂

F_1: IiFf (white, frizzle) ♀♀ and ♂♂

Testcross: IfFf ♀♀ X iiff ♂

White, frizzle	18
Colored, frizzle	63
White, normal	63
Colored, normal	13
	157

The results are markedly different from the 1:1:1:1 ratio we have learned to expect from testcrosses of dihybrid individuals. If frizzle and normal feathering are considered alone, however, the proportion of 76 colored to 81 white shows no greater deviation from expectancy than might reasonably be accounted for by chance. The real deviation from expectancy is, therefore, not in the behavior of either allelic pair alone, but in their behavior with respect to each other.

At this point the value of the testcross is conspicuous, since the male parent in the testcross was homozygous recessive, the respective frequencies of the different kinds of egg cells formed by the dihybrid females can be determined directly by inspection of the phenotype of the testcross progeny. Clearly, the F_1 females gave rise to egg cells in the following proportions: 63If, 63iF, 18IF, and 13 if. The two classes of gametes found in unexpectedly great numbers have the same allelic combinations as were present in the gametes formed by the two parents of the F_1 dihybrids. The new combinations (IF and if) make up only 19.7 per cent of the total.

The meaning of linkage is the tendency of parental combinations to remain together, which is expressed in the relative infrequency of new combinations, is the phenomenon of linkage. Genes show linkage because they are in the same chromosome. New combinations of linked genes are called recombinations.

For some of us who have been thinking independently about various aspects of segregation, an introduction to linkage will be the beginning of an answer to a troublesome question. We have said earlier that independent assortment of members of different allelic pairs depends upon independent assortment of members of homologous chromosome pairs at meiosis. But there are many more different genes than there are chromosome pairs in an organism, so that at least some chromosomes must carry many genes. Now then, we may have asked, can all genes segregate independently of one another? The answer is that they do not. You have just seen one illustration of this fact. The crosses summarized now will be shown in more meaningful fashion:

P: $\frac{iF}{iF}$ (colored, frizzle) ♀♀ X $\frac{If}{If}$ (white, normal) ♂

Eggs: iF   Sperm: If

F_1: $\frac{iF}{If}$ ♀♀ and ♂♂

Test cross: $\frac{iF}{If}$ ♀♀ X $\frac{if}{if}$ ♂

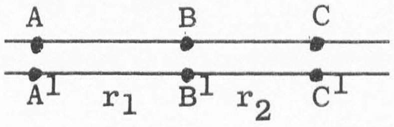
Eggs:	Sperm if	
IF	white, frizzle	(18)
iF	colored, frizzle	(63)
If	white, normal	(63)
if	colored, normal	(13)

Here our attention should be towards the way of representing linked genes. For instance, the genotype of colored, frizzle females in the parental generation is written as $\frac{iF}{iF}$. This is simplification of $\frac{iF}{if}$, where the two horizontal lines represent the homologous chromosomes in which genes i and F are studied. The designation of F_1 individuals as $\frac{iF}{If}$, then, indicates that genes i and F are in one homologous and genes I and f are in the other.

Examination of this new summary of the crosses will make it clear that the colored frizzles and the white normals occurring in the testcross progeny are determined by egg cells having the same allele-in-chromosome combinations as found in different gametes of the P generation, and also in the chromosomes of the F_1 females used as parents in the testcross. Egg cells giving rise to colored normals or to white frizzles in the testcross progeny show recombination of the original parental arrangement of alleles.

Now that we have some understanding of independent assortment and linkage behavior of genes we may be able to express them in a probability model. This was first achieved by Bohidar (1960). A mathematical expression of this kind enables one to have an insight into the mechanism of the process.

Consider three alleles in a chromosome given in the following diagram:



If r_1 represents the proportion of recombinations between A and B loci and r_2 represents the proportion of recombinations between B and C loci, then according to Bohidar (1961) we generate the following conditional probability for the formation of a gamete,

P (that the new gamete has A or A^1) = 1/2

P (that it has B given that it had A^1) = r_1

P (that it has B^1 given that it had A^1) = $1 - r_1$

P (that it has B given that it had A) = $1 - r_1$

P (that it has B^1 given that it had A) = r_1

P (that it has C given that it had B^1) = r_2

P (that it has C^1 given that it had B^1) = $1 - r_2$

P (that it has C given that it had B) = $1 - r_2$

P (that it has C^1 given that it had B) = r_2

This process was recognized by Bohidar (1960) as the Bernoulli dependent Markov Process, more particularly it is a random walk with absorbing barrier. This was the crux of the problem of solving mathematical simulation of gamete systems and this was fully solved by Bohidar (1960).

In studies of genetics, where tests matings are impossible, statistical methods based on this law have enabled investigators to determine the method of inheritance of many traits and to predict the proportion of types of offspring. The system undergoes more complication in a deterministic manner, and in a stochastic manner, the inclusion and exclusion of the individuals for the next generation are considered under existing circumstances. Here a gene or two are not selected but a pool of genes are excluded or included. In population genetics the deterministic manner of inclusion or exclusion is called artificial selection, the stochastic manner of inclusion or exclusion is called natural selection. Now suppose the population have gone through the inclusion or exclusion process for 20 generations in a deterministic and stochastic manner, what would be the answer to the following questions:

a) What is the probability that 10 percent of the original genes from the initial pool is still present in the pool after k^{th} generation of selection.

b) What is the probability of gene extinction.

c) What is the probability of gene fixation.

d) Is the population reached a plateau for the characteristics of interest.

e) What is the influence of a linked group of genes on the characteristics of interest.

f) What is the role of different genetic models on the gene pool at the k^{th} generation.

g) What is the optimum combination of linkage and selection for the best response.

The experimentor, here the population geneticist, likes to know the answers to the above questions as realistically as possible so that he can use this information to launch an efficient selection program. The mathematical formulation and statistics became too cumbersome to attempt simple interpretation.

Simulation is a technique of setting up a stochastic model of a real situation, and then performing sampling experiments upon the suggested models. It entails first of all the construction of an abstract model of the system to be studied. Simulation by method of Monte Carlo takes into account all the various stochastic processes involved and provides the experimentor with numerical solution to the problem that yields to practical interpretation. The stochastic elements in genetics are considered to yield to mathematical models for biological phenomena.

The computer offers to man a means to increase his efficiency in computing. This is accomplished in five ways:

1) Computers through their speed alone enables man to increase his output per hour.

2) Computers enable man to make use of many mathematical methods that were previously impractical due to the length and time consuming calculation involved.

3) Computers have enabled man to develop new mathematical techniques to solve problems previously thought to be beyond the realm of practical mathematics.

4) Computers increase accuracy.

5) Computers increase productivity. An input may consist of any type of data: commercial, scientific, statistical, engineering, genetics, etc. Processing is carried out by a pre-established sequence of instructions that are followed automatically by computers. These instructions are the result of an analysis of the desired output by a programmer. The computer utilized in this study is IBM 1620. Repetative sequences leading to the simulation processes of genetic problems are described and solved numerically in this thesis. This thesis is divided into five parts, the first part deals with review of literature, the second part describes the basic concept and programming language of the IBM 1620 computer, the third part describes the various models which are employed in this study, fourth part describes the simulation procedure and techniques, and the fifth part discusses results. The

Appendix, which appears at the last part of the thesis, contains (i) all essential numerical results in tabular form that are necessary for the interpretation, (ii) the entire program and its flow chart diagram written in symbolic programming language (SPS), (iii) probability tables used in generating genotype of initial population and (iv) the procedure for preparing parameter cards.

CHAPTER II

REVIEW OF LITERATURE

Fraser (1957) was the first one to introduce the application of Monte Carlo methods to problems of genetic selection. He was also the first one to identify a genetic structure by the binary representation of the alleles. He introduced the logical operation by which heterozygous loci and homozygous loci can be identified for a given genotype. For the determination of phynotype he assumed the following relationship of genotype to phenotype.

Genotype	Additive	Dominance
1/1	2a	2a
1/0 or 0/1	a	2d
0/0	0	0

He used the following formula to evaluate the phenotype

$$\operatorname{diag}(A \,\&\, B) \cdot \operatorname{diag}(ai) + \operatorname{diag}(A \equiv B) \cdot \operatorname{diag}(ai) \cdot \operatorname{diag}(di) = \operatorname{diag}(pi) \quad . \quad . \quad . \quad . \quad . \quad (10)$$

The genetic recombination was simulated by first listing the vector of frequencies of recombinations and non-recombination classes and by assigning r_1 to the combination between first and second loci, assigning r_2 to the recombination between second and third loci, then calculating the frequencies of each gamete, such as

000 $\quad 1/2\,(1 - r_1)(1 - r_2) = f000$ . . . (11)

001 $\quad 1/2\,(1 - r_1)r_2 = f001$ . . . (12)

010 $\quad 1/2\,r_1 \cdot r_2 = f010$ . . . (13)

011 $\quad 1/2\,(r_1)\cdot(1 - r_2) = f011$ . . . (14)

100 $\quad 1/2\,r_1(1 - r_2) = f100$ . . . (15)

101 $\quad 1/2\,r_1 \cdot r_2 = f101$ . . . (16)

110 $\quad 1/2\,(1 - r_1)r_2 = f110$ . . . (17)

111 $\quad 1/2\,(1 - r_1)(1 - r_2) = f111$ . . . (18)

After that he formed the cumulative sum of the respective gametes such as,

$$f00,\ f000 + f001,\ f000 + f001 + - - -;\ \Sigma f i \qquad (19)$$

He picked a random number (r) which was between 0 and 1. Fi gamete was selected if

$$Fi \leq r \leq Fi + 1 \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ (20)$$

The selection was simulated by arranging all the phenotypes in ascending order and then selecting the required number of individuals from the top of the list, bottom of the list or middle of the list, Fraser used a digital computer called SILLIAC. Martin and Cockerham (1958) introduced the simulation of genetic system in IBM 650. Their method of simulation was almost similar to that of Fraser.

Bohidar (1960) first time introduced the stochastic approach to mathematical simulation of genetic systems. His great interest was to minimize the computer time for generation which the first three authors were failed to do so. For the first time he introduced the linear arrangement of gene structure, which helped extremely to increase the length of genotype without bounds. The structure looked like

$$g_{11}g_{12}g_{13} \cdots \quad \cdots g_{1n}, g_{21}g_{22}g_{23} \cdot \cdot \cdot \cdot g_{2n}$$

$$i = 1, 2, . . . n.$$

This method can be conveniently adopted to any computer system. The binary representation of genetic structure was achieved by assigning 0 and 1 to the alternate alleles of a locus, where 1 implies the plus gene and 0 implies the non plus gene. The paternal genotype and the maternal genotype of an individual are placed side by side so that the genes were in linear arrangement. The advantage of this arrangement was that the complete genotype can be stored in one memory location.

The simulation of recombination and formation of gametes was handled as follows. He considered a genotype with three loci with the following structure,

$$\frac{T\ T\ T}{B\ B\ B}$$

where T and B stand for top and bottom, respectively. The frequencies of the recombination for first and second loci be r_1 and for second and third loci be r_2, that is the probability associated with a chosen gamete say, BTT is $1/2\ r_1(1 - r_2)$. In this situation then we have the following conditional probability relations in the gametic formation.

P(T or B at first locus) = 1/2

P(T in the second locus/the first locus has a B) = r_1

P(T in the second locus/the first locus has a T) = $(1 - r_1)$

P(T in the third locus/the second locus has a B) = r_2

P(T in the third locus/the second locus has a T) = $(1 - r_2)$

If we interchange T for B and B for T we have the same results. A gamete is produced from an individual what may be called a random mask method.. For every individual, a random mask is constructed taking into account the probability relation appropriate to each locus. For example, a mask is of the following type for a genotype with 5 loci

BBTBT

means that a random gamete from a genotype consists of the bottom gene at the first locus, bottom gene at the second locus, the top gene at the third locus, the bottom gene at the fourth locus and top gene at the fifth locus. The consideration of the probability relation existant at each locus assures that the probability associated with the random mask and the probability associated with the random gamete produced by the mask are equal. Now suppose the genotype has the following structure

$$\frac{11010}{10011}$$

then the random mask obtained above is applied on the linearly arranged genotype and by the extraction process, which is a command, we have the following random gamete

$$10010$$

and the probability associated with the gamete is the same as the probability associated with the mask namely $1/2(1 - r_1)\, r_2\, r_3\, r_4$ where r_1, r_2, r_3, and r_4 are the recombination frequencies between the first and second, second and third, third and fourth, and fourth and fifth loci, respectively. So a mask is dependent upon the linkage relations under consideration and not the genotypic constitution of the individual. Most of the time consumed in constructing a mask in generating n random numbers for n loci. The users of this method came to the conclusion that the use of the random masks was one of the fastest methods for extracting a random gamete from the individual under consideration.

The mechanism involved in evaluating a phenotype of a given genotype will be illustrated by example. Suppose the dominance relationship of two alleles at a locus are as follows:

$1/1 = \alpha$, $0/1 = \beta$. $1/0 = \beta$, and $0/0 = e$

and genotype under consideration has four loci with the following structure,

$$\frac{1001}{1101}$$

He then shifted the genotypic structure to the sign bit for the purpose of evaluation of the phenotype, two bits representing the alleles were shifted one after the other for each locus, to the sign bit position. The phenotype was then recorded by the branching process which took into account α, β, β, e and in this particular case $2\alpha + \beta + e$ was recorded.

For the case where epistacy was involved the bits that were in epistatic relationship, were brought to the sign bit one after the other by the help of branching process, a value for that order epistacy was added to the phenotype. In general, then the value of the n^{th} order apistacy was incorporated into the cumulating phenotype by bringing the bits with epistatic relationship successively, to the sign bit position and by taking the appropriate decision after $(n + 1)^{th}$ bit which arrived at sign bit position.

He developed the following formula to simulate selection by truncation.

$$I = - \left| \left| X - C \right| - K \right| \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (21)$$

that is, the index I is equal to the negative absolute value of the absolute value of (X - C) minus K and where

X is the phenotype of an individual under consideration.

C is the numerical point around which the individuals are selected which we call the selection point.

K = 0, 1, 2 . . . and so on in succession if the phenotypes are expressed in discrete values and takes continuous values if the phenotype are expressed on a continuous scale.

For a given value of C, the individual is selected when I becomes non-negative. The formula is rather general with regard to any level of truncation.

As far as simulation of recombination is concerned he was the first one to recognize that the process was Bernoulli dependent discrete Markov process.

CHAPTER III

THE IBM 1620 COMPUTER

The IBM 1620 is an electronic digital computer designed for technological and commercial applications. The system consists of a central processing unit, which houses the arithmetic and logical units, the magnetic core storage, console panel and typewriter. Expansion of the basic system is possible by increasing the size of the magnetic core storage in increments of 20,000 positions. The central processing unit is augmented by the 1622 card Read-Punch unit. A variety of several special devices and additional instruction is available to increase the flexibility of the system.

Data and instructions entered in the system are placed in core storage as decimal digits. Each digit is in a binary coded form represented by a 6 bit numeric code. Each core position can be referred to individually and can store one digit of information. The addressing system provides for the selection of any digit or group or digits in storage.

The arithmetic and logical section of the computer is directed by the stored program. The IBM 1620 has more than 30 different operations in its repertoir. Among these is a powerful set of branching instructions that make logical decision based on the results of tests performed on a system of indicators or switches.

Addition, subtraction and multiplication operations are performed by table look-up method. Addition and multiplication tables stored in specified areas of storage and are automatically referred to when one of the arithmetic operations is being performed. Division is accomplished by an automatic division feature.

The IBM 1620 is a variable field computer in the complete sense of term. Not only can data fields be of different lengths, but these same variable length fields can also be factors in all arithmetic operations without editing for size or position. Accuracy of the results insured by automatic internal checking that operates when data is being entered, read out, or processed by the system.

The console of the IBM 1620 consists of control keys, switches, indicator panel, and typewriter. The control keys and switches are used for manual or automatic operation of the system. The console panel provides a visual indication of the status of various registers and control circuitry within the computer. The typewriter is used for permanent logging of the operators intervention during the execution of a program.

Information is entered into the system by the 1622 card Read-Punch unit. Eighty column cards are read at the rate of 500 cards per minute. The recording of processed information is accomplished by the 1622 card Read-Punch unit. Cards are punched at the rate of 125 per minute.

The computer can do nothing on its own, but must depend upon instructions supplied by programmers to perform a given task. Thus, a communication takes the form of a set of formal instructions to which the computer responds. Once the computer has received its instructions, it can perform its task at a speed measured in microseconds. These instructions fall into five general categories:

A. Arithmetic
B. Internal data transmission
C. Branch
D. Input-output
E. Miscellaneous

The computer utilizes a 12 digit instruction which is divided into three parts: (a) 2 digit operation (OP) code, (b) a 5 digit P address (P operand), and (c) a 5 digit Q address (Q operand). Each of the 12 digits making up an instruction is assigned a unique notation so that easy reference may be made to any part of an instruction. The 2 digits constituting the operation code will be referred to as 0_0 and 0_1. The 5 digits comprising the P address will be referenced as P_2, P_3, P_4, P_5 and P_6. Similarly, the 5 digits comprising Q address will be referenced as Q_7, Q_8, Q_9, Q_{10} and Q_{11}. Figure 1 illustrates the format of an instruction. The 2 digit operation code specifies which operation is to be executed. The 5 digit P operand has many functions depending on the instruction. It may represent core location (a) that data is transmitted to, (b) that data is transmitted from, (c) that the program branches to, or (d) of data to be processed.

O_0 O_1	P_2 P_3 P_4 P_5 P_6	Q_7 Q_8 Q_9 Q_{10} Q_{11}
OP Code	P Address	Q Address

Figure 1. Instruction format

Likewise, the Q operand has many functions, depending on the instruction. It may represent (a) the address from which data is transmitted, (b) the input-output device that is employed, (c) the address of the data to be processed, or (d) the indicator that is interrogated.

The computer has extremely powerful and flexible instruction repertoir. Certain arithmetic and data transmission instructions are immediate. These instructions use part of the instruction itself as a data field. The right most position of the data field is the Q_{11} position of the instruction itself. It conserves storage locations by storing constants as part of the instructions. The computer has also indirect address instruction. It saves program steps and computer time by providing a direct method of address modification. Its primary use in a multiple-instructions-program is to modify the instructions in the manner specified by the program. An instruction address (P and/or Q) is the location of data to be used during the execution of the instruction. This is known as "direct addressing," since the address refers directly to the location of the data. However, if an instruction address (P and/or Q) is an indirect address, it does not refer directly to the data. Rather, it is the location of a second address; this second address is the location of the data to be used by the instruction. A flag in position P_6 and/or Q_{11} indicates that the P and/or Q address of an instruction is indirect. This feature helps to modify storage locations for variable field length operation of the problem.

The instructions that direct the computer are stored in the magnetic core memory of the computer. The high-order digit (0_0) of an instruction must be located in even-numbered core location. An instruction is referenced by the core location of its high-order digit (0_0). Thus, we refer to the instruction at the core location 00012, the instruction we are referencing to is made up of the digits in core location 00012 to 00023, inclusive. Program instructions are executed sequentially. The sequential execution of instructions can be altered by control instructions. It has internal machine indicators to facilitate the decision-making ability.

Addition is accomplished in the computer by literally attaching data digits to a machine generated address of 003XX to form a 5 digit add table address. The add table is stored at location 00300 to 00399. The answer is then "looked-up" in the add table. Subtraction is almost identical with that of addition. However, subtrahend digit is inserted in the look-up address in its tens complement form on the first cycle and its tens complement form thereafter. Multiplication is accomplished by combining the digits to be multiplied into a table address. The base address is chosen to be 00XXX. The multiplicand digit is inserted into the tens position of the base address. The multiplier digit is routed through a special device called the doubler. The doubler is an internal device that doubles a digit. Although a multiplier digit enters the doubler as a single element, it leaves this unit as a 2 digit number. After it exits from the doubler, the tens digit of the number is incremented by 1 and is then routed to the hundreds digit of the base address which is being formed. The unit digit of the doubler effort is routed to the unit digit of the base address, and this completes the construction of the multiplication table "look-up" address. The multiplication table occupies core locations 00100 to 00299.

There is no internal circuitry to prevent entry into this area or destruction thereof, during program operation. Tables can be changed during execution of the program at any time, by internal transmission of records or can be read in through input devices.

Program preparation is simplified by the use of a programming system. Programming of any computer system is essentially a work of "translation." Information which is suitable to the human components, who were the almost exclusive data processor up to the date 1940's, must now be written in a form acceptable by the machine. This process of writing the information in a form acceptable by the machine is generally known as coding. The concept of compilation can be of substantial assistance to the programmer. Experience to the date shown that in general case, through the use of compiling, coding and debugging, costs are reduced. Compiling as a process, provides the programmer with a language relatively easy to learn, when writing in a symbolic language for a subsequent compilation into a source program, which we efficiently write as "source statements." The compilers can examine all the facets of the object language program and after summarizing the information, can compile an efficient machine program. Symbolic programming is used which uses mnemonic or symbolic notations and requires compiler for its conversion into machine language—an object program. The object program contains the information regarding the assignment of locations in core storage for both data and instructions. The compiler used was supplied by IBM Corporation, which is called Symbolic Programming System (SPS).

CHAPTER IV

MATHEMATICAL MODELS

A mathematical model is a simulated representation of a real system under study. The representation may be in the form of a linear or nonlinear relationship. A model can also be viewed as a proposition arising from empirical evidence and one expects the phenomena to follow the same. When one searches for a best fitting model, the model building becomes an iterative process. One derives as good a model as possible then fits to the best observations available, making modifications and improvements of model. If it is clearly incompatable with the observations more variables are introduced and is tested again to fit it to the observations.

This process is continued until a proper model is obtained. Biases can be moderated and reduced by carefully designed experiments and proper application of statistical methods: the altimate test of goodness of any model depends on how it performs in future predictions.

In this study three models have been proposed. The role of each model is to assign allelic relationship to allelic combination at a locus for the purpose of evaluating observed (phenotypic) expression. As for example in additive model if the genotype at a locus are AA Aa and aa then $\alpha + \alpha$, $\alpha + \beta$, $\beta + \beta$ values were assumed respectively whereas the values of same genotype AA AA and aa are $\alpha + \alpha$, $\alpha + \beta$, $\beta + \beta$

respectively when dominance model is assumed. These three models are studied to obtain responses for all possible combinations of selection intensities and linkage conditions for several generations. The three models can be represented in the following manner.

Models	Genotype	Phenotypic value
Additive	1/1	2
	1/0 or 0/1	1
	0/0	0
Dominance	1/1	1
	1/0 or 0/1	1
	0/0	0
Over-dominance	1/1	1
	1/0 or 0/1	2
	0/0	0

Let us consider an example to see how a phenotype is evaluated under each model. Suppose a gentoype has four loci with the following strucutre

1100/1010

In additive model, the first locus 1/1 has phenotypic value 2, the second locus 1/0 has phenotypic value 1, the third locus 0/1 has phenotypic value 1 and the fourth locus 0/0 has phenotypic value 0. The total phenotypic value of the genotype of an individual is 4 according to the additive model. In complete dominance model the first locus 1/1 has phenotypic value 1, the second locus 1/0 has phenotypic value 1, also the third locus has phenotypic value 1, and the last locus has phenotypic value 0. The total phenotypic value of the genotype of an individual is 3. Similarly, in complete dominance model, the genotype of an individual has value 5. One model is considered at a time. All the phenotypic values are added for selected and unselected populations of both sexes. After the termination of a generation, the means and the variances are calculated.

These models are probabilistic models and can be written as

$$\Pr (P \leq p) = F (Q, S, L, p) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad 22$$

Where p represents response

Q represents a column vector with elements which are invariant over class, k of situations of interest.

S represents a column vector of selections which vary over k.

L represents a column vector of linkages which vary over k.

It is conveniently written as:

$$P = \mu_1 (Q; S; L) + E \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad 23$$

Where $(Q, S, L) = \int_{-\infty}^{+\infty} p \; dp \; F (Q, S, L, p) = E(P/Q,S,L)$ 24

and $E = P - \mu(Q, S, L)$

E has an accumulative density function of the form

$$\Pr(E \leq e) = F(Q, S, L, p)$$

$$= F(Q, S, L, e + \quad (Q, S, L)) \quad . \quad . \quad . \quad 25$$

Where $e = p - \mu(Q, S, L)$ and $E(E/Q, S, L) = 0$.

The purpose of these models is to study the behaviour of the population under the genetic pressure, linkage and selection. The result shares what one expects when such a model is adopted by nature. Also it shows, if such results are seen in nature one might reasonably assume the model that the nature might have pursued. Evaluating the phenotypic values according to the models and after the end of the process one faces the problem of analysis. The problem faced by one, who tests a few observations and having no function at his disposal, wants a systematic way of determining a function that fits his observations. Attempt is directed to find a function that fits the observations well and make decision accordingly.

Assume that a function f(x) can be expanded into a Taylor series so that we obtain

$$Y = f(x) = \theta o + \theta_1 x + \theta_2 x^2 + -- + \theta_k x^k \quad . \quad . \quad . \quad 26$$

Where Y is a response and x represents generation. This function f(x) can be written as

$$Y = \alpha o + \alpha_1 x + e_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad 27$$

Where e_1 is the remainder in a Taylor series, which we assume for our purpose is random error. If the fit to a linear equation is not satisfactory a new model is assumed

$$Y = \beta_o + \beta_1 x + \beta_2 x^2 + e_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad 28$$

Where e_2 is a remainder after a quadratic is fitted to the observations. Any degree polynomial can be fitted as desired by increasing degree of polynomial and hence reducing random error. Polynomial of degree n-1 will go through n observations and fit the observation perfectly. However, in most cases, this is not what one wants. A lower degree polynomial that represents the observation is highly desired.

We shall begin to fit a first degree polynomial to sets of n observations. Observations can be represented by equation (29).

$$Y_i = \alpha_o + \alpha_1 x_i + e_{1i} \qquad i = 1, 2, . . . n . \quad . 29$$

After fitting first degree polynomial a test of hypothesis, $\alpha_1 = 0$, is performed. Observations can be conveniently represented in vector form,

$$Y = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix} \qquad X = \begin{bmatrix} 1 & x_1 \\ 1 & x_2 \\ \vdots & \vdots \\ 1 & x_n \end{bmatrix} \qquad \alpha = \begin{bmatrix} \alpha_o \\ \vdots \\ \alpha_1 \end{bmatrix} \qquad e_1 = \begin{bmatrix} e_{1i} \\ e_{12} \\ \vdots \\ e_{1n} \end{bmatrix}$$

$$I = \begin{bmatrix} 1 & \cdots & \cdots & 0 \\ 0 & 1 & 0 \cdots & 0 \\ 0 & \cdots & \cdots & 1 \end{bmatrix} \qquad nxn$$

$$Y = X\alpha + e_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad 30$$

We shall assume that the random vector e_1 has zero for its mean and $\sigma^2 I$ for its variance-covariance matrix, where I is identity matrix. The form of frequency function of e_1 is unspecified, therefore, the principle of maximum likelihood cannot be used to obtain the estimators of the unknowm parameters α. Instead, we shall find the value of α, say $\hat{\alpha}$, such that the sum of squares $\sum_{i=1}^{n} e_{1i}^2$ is a minimum. This gives (superscript 1 should be read as primes)

$$\sum_{i=1}^{n} e_{1i}^2 = e \ e_1 = (Y - X\alpha)^1 \ (Y - X\alpha) \quad . \quad . \qquad 31$$

The value of α that minimizes $e^1 e$ is given by the solution to

$$\frac{\partial}{\partial \alpha} (e^1 e) = 0.$$

By solving we get

$$\frac{\partial}{\partial \alpha} (e^1 e) = 2X^1 Y - 2 \ X^1 X \hat{\alpha} = 0 \quad . \quad . \quad . \qquad 32$$

The least squares estimate of α are, therefore,

$$\hat{\alpha} = (X^1 X)^{-1} X^1 Y \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad 33$$

If, by using the F test, we decide that $\alpha_1 = 0$, we conclude $Y = \alpha_0 + e_1$ fits the observations adequately. If, instead, we decide to reject the hypothesis and conclude

$\alpha_1 \neq 0$ then we fit the second degree polynomial

$$Y_i = \beta_0 + \beta_1 X_i + \beta_2 X_i^2 + e_{2i} \quad i = 1, \ldots n \quad . \quad . \quad 34$$

The least square estimate of β's of second degree polynomial can be written as

$$\hat{\beta} = (X^1X)^{-1} X^1Y \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad 35$$

$$\text{Where } X = \begin{bmatrix} 1 & x_{11} & x_{11}^2 \\ \cdot & & \\ \cdot & & \\ 1 & x_{12} & x_{12}^2 \\ & & \\ 1 & x_{1n} & x_{1n}^2 \end{bmatrix} \quad \text{and} \quad Y = \begin{bmatrix} Y_1 \\ Y_2 \\ Y_n \end{bmatrix}$$

If we decide by using F test that $\beta_2 = 0$, and considering the result of the previous test $\alpha_1 \neq 0$, we can conclude

$$Y = \alpha_0 + \alpha_1 X + e_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad 36$$

fits the observations adequately. If instead we decide $\beta_2 \neq 0$, then third and higher degree polynomial can be tried and fitted adequately.

Whenever we conclude that a certain degree polynomial adequately fits the observations, we can then estimate the coefficients and thus determine the least-square curve. The non-significance of a result does not imply that the observations actually came from any specified degree of polynomial. It is merely a procedural criterion for establishing what polynomial is adequate.

Suppose it is decided that the quadratic polynomial

$$Y = \beta_0 + \beta_1 x + \beta_2 x^2 + e_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad 37$$

is an adequate representation of the observations. When we examined the linear polynomial

$$Y = \alpha_0 + \alpha_1 \quad + e_1 \quad . \ . \ . \ . \ . \ . \ . \ . \qquad 38$$

the term e_1, which we assumed took on the aspect of a random variable, has quadratic trend in it. This may introduce a bias in the error sum of squares for linearity. Similar remarks hold when higher degree polynomial is fitted. A second degree polynomial is used in this study.

CHAPTER V

THE PROGRAM

The IBM 1620 Computer does not work out its own solution to the problem at hand but must be instructed exactly how to make intermediate decisions, as well as how to solve any given problem. A list of planned instructions which guides the computer to perform calculations, is called a program. The program determines the sequence of operations and logical decisions. The program also consists of statements of the problem in terms of arithmetic operations, precision requirements, formal logic and a set of addresses assignment for memory, storage and input-output operations of the problem. The type of operation, which is used repeatedly in the program is called subroutine. It consists of definite set of instructions to carry out the operation required, and can be independently linked or removed from the program whenever necessary. The use of subroutine is an essential feature of high speed computing.

Usually a big sized problem is partitioned into small sized problem-units and each unit can be programmed and checked conveniently because of the small size. The problem is stored as subroutines for their repeated use.

There are six subroutines in the program and they are as follows:

1. Random number generator
2. Initial population
3. Reproduction
4. Evaluation of phenotype
5. Selection
6. Polynomial curve fitting

A brief description of the subroutine is given below.

Random number generator

Almost all random number generator can be obtained as a special case of the following recursive relation.

$$X_{i+1} = \underline{C}X_i + \underline{a} \pmod{m} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad 39$$

$$i = 0, 1, 2, \ldots$$

Non-negative integers X_0, *a*, *c* and m, where m is chosen according to size of the random number desired, in our case m is the number of genes in a genotype of an individual. *a* and *c* are constants, and X_0 is a random number obtained from any available source of random numbers. Then X_1, X_2, ----- to be the non-negative integers generated by the equation (39). It is hoped that the resulting sequence follow a uniform distribution with zero mean and unit variance. Such a sequence is often called "pseudo-random." Each *c* is carefully tested, because the particular value of *c* used will determine not only the apparent randomness of the sequence but also its period. Different values of *c* are used for generating decimal numbers.

It is not difficult to find values of c and a which produces maximum period for a recursive relation. When m is a power of 2, for example, any odd a combined with any c = 1 (Mod 4) affords the maximum period, equal to m. For a = 0, the maximum period is reduced to m/4. Length of the period is one standard that has been used in selection of a and c. Speed of generation is the second that is used. But a great deal of freedom still remains and the question of how to use this freedom is never answered. The most frequent solution has been to make a choice of a and c which appears favorable on intuitive ground and then carefully examine generated sequences by standard statistical tests for serial correlation of various lags and undesirable properties. The random number generator of multiplicative type where a = 0 is used to generate random numbers which required in subsequent routines. This random number generator was tested, by statistical techniques available, an IBM 1620.

Initial population

The genotypes for NM male individuals and NF female individuals are generated by random process such that at each locus the expected frequency of the unfavorable allele is P_1. The allele are represented by one of the two symbols A or a. Each chromosome consists of two sequences of M symbols. These two sequences represent the homologous chromosome pair and the position of the symbols in the sequence specifies the locus. Such numbers of chromosomes constitute a genotype of an individual. The sex of an individual is determined by the sex-chromosome of a genotype. If the genes of all loci of the sex-chromosome have the same symbols then it is identified as a male individual, otherwise female. Let us consider an example with three loci per chromosome and two chromosome per genotype of an individual. This example will show the analogy between genetic representation of a genotype and a computer representation of a genotype.

Male genotype		Female genotype	
Autosome	Sex-chromosome	Autosome	Sex-chromosome
$\frac{AaA}{aAa}$	$\frac{aaa}{aaa}$	$\frac{AAa}{aAa}$	$\frac{aAa}{AAa}$

It is rather hard to work with alphabetic symbols A and a in the computer. The symbols are then represented numerically by 1 and 0, respectively. The computer representation of genotypes given above will be as follows:

Male genotype		Female genotype	
$\frac{1\ 0\ 1}{0\ 1\ 0}$	$\frac{0\ 0\ 0}{0\ 0\ 0}$	$\frac{1\ 1\ 0}{0\ 1\ 0}$	$\frac{0\ 1\ 0}{1\ 1\ 0}$

The genotype of individuals then arranged in linear order, and each individual is stored successively in higher order locations.

Male genotype

Genes	1	0	1	0	0	0	0	1	0	0	0	0
Locations	1	2	3	4	5	6	7	8	9	10	11	12

Female genotype

Genes	1	1	0	0	1	0	0	1	0	1	1	0
Locations	13	14	15	16	17	18	19	20	21	22	23	24

Figure 2. Male and female genotype in computer locations

Where gene at location 1 is allelic to gene at location 7 and gene at location 2 is allelic to gene at location 8 and so on. Similarly gene at location 13 is allelic to gene at location 19 and so on. In this arragement, paternal and maternal genotypes are placed side by side. Let p'=.5 be the probability associated with each locus of the chromosomes of an individual.

Where m is number of loci-chromosome and q is number of chromosomes in a genotype. Replace add table by probability table in the computer and add according to the probability table. Probability table is a table that has the structure as shown in the appendix. Construction of such a table is accomplished by the procedure described hereafter. Two digits say r_1 and r_2 between 0 and 9 are selected. The sum of these two digits, ignoring the resulting carry over digit, is tested against the given number p. The number p is chosen according to the linkage probability required for the generation of initial population. If the result of the test exceeds or equals the given number p, then 0 is placed in the location $003r_1r_2$, otherwise 1 is placed in the same location. This procedure is followed until all 100 cells of the table are filled up. Sex-chromosome for male is generated by duplicating the field of the sex-chromosome. This genotype will be identified as male genotype. The whole procedure is repeated NM and NF number of times to complete the generation of the initial population.

Reproduction

Random mask method (Bohidar, 1960) is used in this section of the program as a part of the reproduction subroutine. A set of random numbers are generated, they are tested against the linkage probability p_1 for the first gene of the locus of a chromosome, and also tested against p_2 for the rest of the genes of loci in a chromosome. The occurance of the test which exceeds p_1 and p_2 are represented by 0 and 1. This procedure repeated for q number of chromosomes in the genotype. The resulting top part of the genotype is called a random mask.

Complement (bottom part of a genotype) of the generated mask can be obtained by table look up operation. Initialize the field besides the generated mask, replace add table according to Figure 3.

Location	0	1
00300	1	0

Figure 3. Addition table for complement

By adding generated mask to zero field, a complement is obtained. This is a bottom part of the genotype. Two such random masks with complements are generated.

Formation of gametes of male and female with m.q number of loci involves identification of its genetic constitution. This is accomplished by performing the two logical operations of two haploid genotypes. Logical operations can be illustrated by the following example.

Let 001 and 011 be regarded as a single diploid genotype with three lcoi. The first locus is homozygous for the 0 allele, the second locus is hetrozygous and the third locus is homozygous for the 1 allele. The logical product of the two haploid components of this genotype is 001, which identifies the loci homozygous for the 1 alleles. Simply it can be shown as follows: 0/0 = 0, 0/1 or 1/0 = 0 and 1/1 = 1. Logical sum of genotype can be expressed as 0/0 = 0, 0/1 or 1/0 = 1.

These operations are performed by changing the add table. For logical product table of Figure 4 is used and for logical sum table of Figure 5 is used.

Random selection of male and female parents are accomplished by following equivalent relation.

$$Z \equiv K \text{ Mod } (NM \text{ or } NF) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (40)$$

Where Z is a random number and $K \leq$ NM or NF. According to the value of K, male or female is transferred to working area by modifying the address of the selected individuals.

	0	1
300	0	0
310	0	1

Figure 4. Addition table for logical multiplication

	0	1
300	0	1
310	1	

Figure 5. Addition table for logical sum

Gametes are formed by logical operations with randomly selected parents and their respective masks accompanied by complements. Two gametes constitute an offspring. This subroutine is repeated $N_1 + N_2$ times to generate required number of offsprings.(see Appendix A for explanation of symbols).

Evaluation of phenotype

The computation of phenotypic value of a specific genotype of an offspring consists of adding all the digits according to a particular model. The top part of the chromosomes in the genotype and the bottom part of the chromosomes in the genotype, both are added by add table. Add table is replaced according to the model employed.

Additive Model

Locations	0	1
00300	0	1
00310	1	2

Complete Dominance

Locations	0	1
00300	0	1
00310	1	1

Over Dominance

Locations	0	1
00300	0	2
00310	2	1

After adding the top and the bottom part of the chromosomes in the genotype, each digit is added locus by locus. This addition is accumulated and stored near the genotype in the computer. Consider the genotype of the following structure.

$$\frac{1\ 0\ 1\quad 1\ 1\ 0}{0\ 0\ 1\quad 1\ 0\ 0}$$

Adding the top and the bottom part according to the additive model, the result of the addition is

1 0 2 2 1 0

Each digit will then be added digit by digit. The resulting phenotype of an individual is 6. In computer genotype and phenotype are stored as follows:

1 0 1 1 1 0 0 0 1 1 0 0 $\bar{5}$ 1 6 0 0 0 0 0 0 0 0 ¥.

Selection

The selection of the offsprings are accomplished by internal sorting. The internal sorting is achieved by comparing pairs of elements, the choice of the next pair of elements to be compared depends upon the outcome of the previous comparisons. However, in the program, the sequence of comparison is fixed. Only the upper truncation method is employed. Individuals with higher phenotypic values were retained in the computer, others were ignored. The logic of internal sorting can be explained by help of the flow chart. Offspring selected are parents for the next generation.

Polynomial curve fitting

Polynomial of the second degree is employed in this study to fit the responses. Let us represent four equations

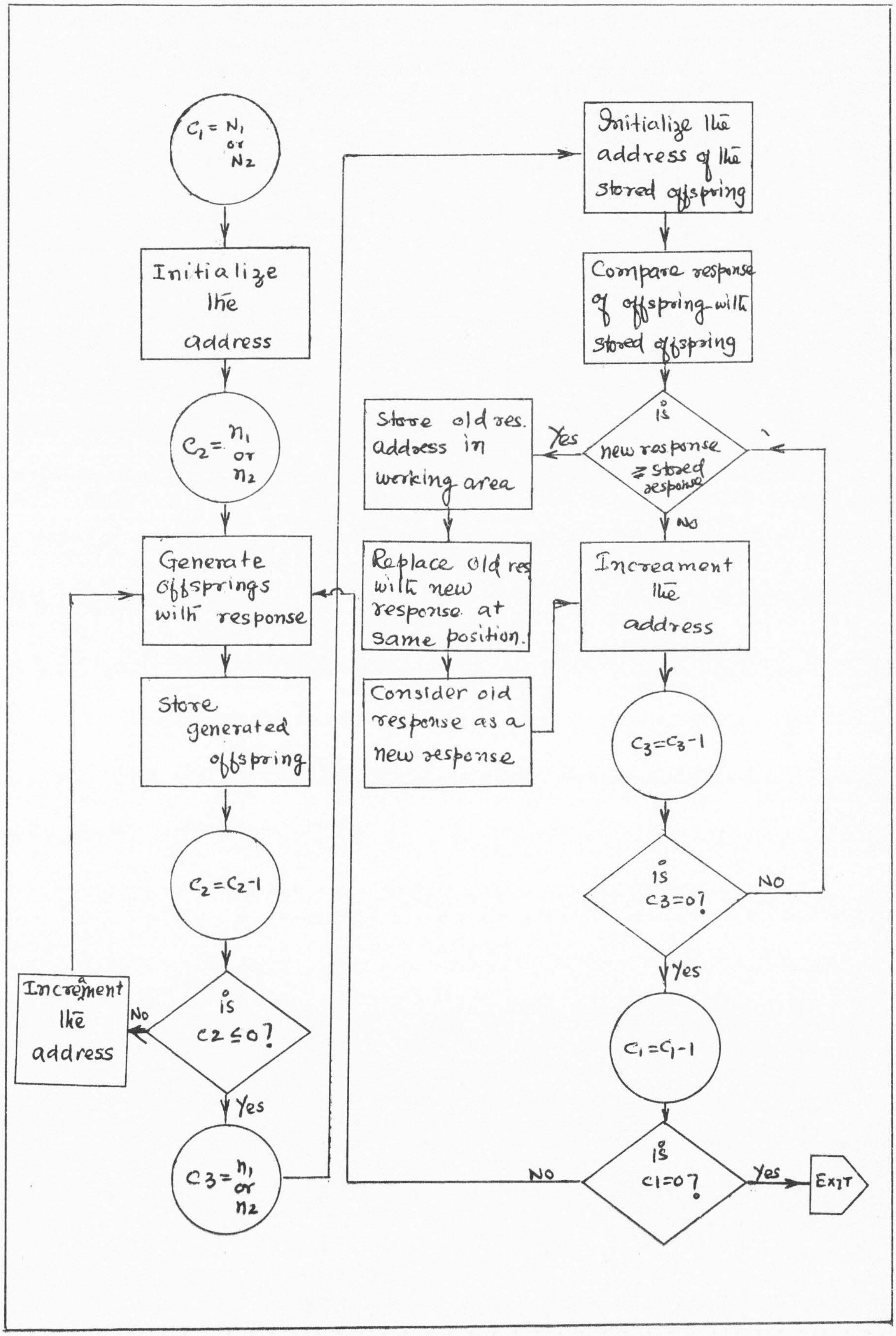


Figure 6. Flow chart for sorting subroutine

as:

$$Y_1 = \beta_{01} + \beta_{11}X_1 + \beta_{21}X_1^2 + e_1 \quad . \quad . \quad . \quad (41)$$

$$Y_2 = \beta_{02} + \beta_{12}X_1 + \beta_{22}X_1^2 + e_2 \quad . \quad . \quad . \quad (42)$$

$$Y_3 = \beta_{03} + \beta_{13}X_1 + \beta_{23}X_1^2 + e_3 \quad . \quad . \quad . \quad (43)$$

$$Y_4 = \beta_{04} + \beta_{14}X_1 + \beta_{24}X_1^2 + e_4 \quad . \quad . \quad . \quad (44)$$

Where

Y_1 represents unselected male mean.

Y_2 represents unselected female mean.

Y_3 represents selected male mean.

Y_4 represents selected female mean.

X_1 represents generation.

$X_2 = X_1^2$ represents square of the generation.

Least square estimation technique is used to estimate doefficients. After completion of generation sum, sum of squares, sum of products are calculated and accumulated. Completing the required number of generations $\hat{\beta}$'s are calculated according to the following formula:

$$\hat{\beta}_{1i} = \frac{\left(\sum_{i=1}^{n} X_{2i}^{2}\right)\left(\sum_{j=1}^{n} X_{1j}Y_{ij}\right) - \left(\sum_{j=1}^{n} X_{1j}X_{2j}\right)\left(\sum_{j=1}^{n} X_{2j}Y_{ij}\right)}{\sum_{j=1}^{n} X_{1j}^{2}\sum_{j=1}^{n} X_{2j}^{2} - \left(\sum_{j=1}^{n} X_{1j}X_{2j}\right)^{2}/n} \quad (45)$$

$$\hat{\beta}_{2i} = \frac{\left(\sum_{j=1}^{n} X_{1j}^{2}\right)\left(\sum_{j=1}^{n} X_{2j} Y_{ij}\right) - \left(\sum_{j=1}^{n} X_{1j} X_{2j}\right)\left(\sum_{j=1}^{n} X_{1j} Y_{ij}\right)}{\sum_{j=1}^{n} X_{1j}^{2} \sum_{j=1}^{n} X_{2j}^{2} - \left(\sum_{j=1}^{n} X_{1j} X_{2j}\right)^{2} / n} \qquad (46)$$

$$\hat{\beta}_{01} = \bar{Y}_{ij} - \hat{\beta}_{1i} \bar{X}_{1} - \hat{\beta}_{2i} \bar{X}_{2} \qquad (47)$$

$$R_{i}^{2} = \frac{\hat{\beta}_{0i} \sum_{j=1}^{n} Y_{ij} - \hat{\beta}_{1i} \sum_{j=1}^{n} X_{1} Y_{ij} - \hat{\beta}_{2i} \sum_{j=1}^{n} X_{2} Y_{ij}}{\sum_{j=1}^{n} Y_{ij}^{2} - \left(\sum_{j=1}^{n} Y_{ij}\right)^{2} / n}$$

$$i = 1, 2, 3, 4$$
$$j = 1, 2, 3 \dots n \qquad (48)$$

Each card contains identification, $\hat{\beta}_0$, $\hat{\beta}_1$, $\hat{\beta}_2$ and R^2 for each population with different combinations of selection and linkages. This subroutine is written to utilize floating point computation procedure to avoid unnecessary housekeeping.

CHAPTER VI

RESULTS AND DISCUSSION

Introduction

Due to the large body of results for interpretation put forth by the computer, the only means of examining them is by tabulation. They are tabulated in the appendix for reference. Each table contains information regarding the means and the variance per generation for unselected male and female and selected male and female for each of the combinations of the levels of the following factors,

(i) Replication
(ii) Model
(iii) Selection intensity
(iv) Linkage probability

When we refer to any case study, we have to specify the levels of the above noted four factors for identification and it will save both time and space to represent the information, with some sort of symbolic representation. We, therefore, propose to symbolize the specifications as follows:

R_1 represents the run number one.

M_1 represents the additive model.

M_2 represents the complete dominance model.

M_3 represents the over dominance model.

S_1 represents the selection intensity 20/40.

S_2 represents the selection intensity 10/40.

S_3 represents the selection intensity 5/40.

L_1 represents the linkage probability .5.

L_2 represents the linkage probability .1.

L_3 represents the linkage probability .01.

L_4 represents the linkage probability .003.

(1) represents selected female population.

(2) represents selected male population.

(3) represents unselected female population.

(4) represents unselected male population.

If, then, a case has the following specification,

$$(R_1)\ (M_1)\ (S_3)\ (L_4)\ (1)$$

then it pertains to selected females of the case studies for the first run with linkage probability .003 and selection intensity 5/40 under additive model. If any of the terms contain more than one category, it means that all of them are considered together.

Results

The following cases were examined and only the salient features of each case will be mentioned. In evaluating the phenotype of male individual, sex-chromosomes are counted twice.

1. $(R_1)\ (M_1)\ (S_1)\ (L_1)\ \left[(1),\ (2),\ (3),\ (4)\right]$. The first-generation means were 34.6, 33.9, 31.825 and 31.175,

respectively for (1), (2), (3) and (4) and their respective variances were 3.74, 7.89, 11.494 and 13.894. The unselected and the selected population attained fixation at generations 20 and 19, respectively with a mean value of 64. The linear rate of genetic progress were 3.0268, 3.2214, 3.1259 and 3.2855, respectively for (1), (2), (3) and (4) and their quadratic rate of genetic progress, respectively were -.07018, -.07883, -.06879 and -.07546 with a respective intercept of 31.7817, 31.0413, 29.0199 and 28.2707. The R^2 values for the β_0, β_1 and β_2 fittings were .99776, .99731, .998 and .99746 for (1), (2), (3) and (4), respectively.

2. (R_1) (M_1) (S_1) (L_2) $[(1), (2), (3), (4)]$. The first-generation means were 35.5, 33.7, 32.625 and 31.025, respectively for (1), (2), (3) and (4) and their respective variances were 2.25, 8.81, 13.534 and 14.024. The unselected and the selected population attained fixation at generations 21 and 20, respectively with a mean value of 62. The linear rate of genetic progress were 2.9449, 3.1333, 3.1204, and 3.3063, respectively for (1), (2), (3) and (4), and their quadratic rate of progress, respectively were -.07432, -.08194, -.07676 and -.08429 with a respective intercept of 32.5633, 31.6928, 29.8027 and 28.9502. The R^2 values for the β_0, β_1 and β_2 fittings were .99603, .99584, .99665 and .9966 for (1), (2), (3) and (4), respectively.

3. (R_1) (M_1) (S_1) (L_3) $[(1), (2), (3), (4)]$. The first-generation means were 35.8, 34.0, 32.775 and 31.575,

respectively for (1), (2), (3) and (4) and their respective variances were 2.66, 5.7, 13.724 and 10.994. The unselected and the selected population attained fixation at generations 26 and 25, respectively with a mean value of 54. The linear rate of genetic progress were 1.0867, 1.566, 1.4222 and 1.4746, respectively for (1), (2), (3) and (4), and their quadratic rate of genetic progress, respectively, were -.01995, -.022, -.02957 and -.03115, with a respective intercept of 37.7513, 37.2134, 34.652 and 34.3107. The R^2 values for the β_0, β_1 and β_2 fittings were .92559, .90791, .92952 and .91974 for (1), (2), (3) and (4), respectively.

4. (R_1) $(M_1$ (S_1) (L_4) [(1), (2), (3), (4)]. The first-generation means were 35.7, 34.0, 32.675 and 31.575, respectively for (1), (2), (3), and (4) and their respective variances were 2.61, 5.7, 13.569 and 10.994. The unselected and the selected population attained fixation at generations 10 and 9, respectively with a mean value 46. The linear rate of genetic progress were 2.6598, 3.1571, 2.999 and 3.4505, respectively for (1), (2), (3) and (4), and their respective quadratic rate of genetic progress were -.14791, -.18427, -.14828 and -.18304 with a respective intercept of 34.7764, 33.2654, 31.3531 and 30.1902. The R^2 values for the β_0, β_1 and β_2 fittings were .94998, .91393, .96889, and .95754 for (1), (2), (3) and (4), respectively.

5. (R_1) (M_1) (S_2) (L_1) [(1), (2), (3), (4)] . The first-generation means were 36.3, 35.4, 31.825 and 31.175,

respectively for (1), (2), (3) and (4) and their respective variances were 1.21, 11.04, 11.494 and 13.894. The unselected and the selected population attained fixation at generations 13 and 12 with a mean value of 64. The linear rate of genetic progress were 4.98, 5.1287, 5.2835 and 5.283, respectively for (1), (2), (3) and (4) and their quadratic rate of genetic progress respectively were -.1923, -.19674, -.18604 and -.18141 with a respective intercept of 32.5582, 31.6373, 27.6436 and 27.0855, respectively. The R^2 values for the β_0, β_1 and β_2 fitting were .99916, .99868, .99868, .99968 and .99958 for (1), (2), (3) and (4), respectively.

6. (R_1) $M_1)$ (S_2) (L_2) [(1), (2), (3), (4)]. The first-generation means were 36.8, 35.8, 32.625 and 31.025, respectively for (1), (2), (3) and (4) and their respective variances were .76, 8.16, 13.534 and 14.024. The unselected and the selected population attained fixation at generations 19 and 18, respectively with a mean value 64. The linear rate of genetic progress were 3.0099, 3.076, 3.4879 and 3.5639, respectively for (1), (2), (3) and (4) and their quadratic rate of genetic progress respectively were .08484, -.08683, .0979 and -.1016 with a respective intercept of 37.2407, 36.1772, 32.427 and 32.1198. The R^2 values for the β_0, β_1 and β_2 fittings were .98354, .97884, .98743 and .97785, respectively for (1), (2), (3) and (4).

7. (R_1) (M_1) (S_2) (L_3) [(1), (2), (3), (4)]. The first-generation means were 37.2, 45.6, 32.775 and 31.575,

respectively for (1), (2), (3) and (4) and their respective variances were 1.16, 6.04, 13.724 and 10.949. The unselected and the selected population attained fixation at generation 14 and 13, respectively with a mean value 56. The linear rate of genetic progress were 2.7252, 3.2763, 3.6558 and 3.9965, respectively for (1), (2), (3) and (4) and the quadratic rate of genetic progress, respectively were -.1043, -.1337, -.1443, and -.1622 with a respective intercept of 37.6773, 36.4055, 32.9423 and 31.5046. The R^2 values for the β_0, β_1 and β_2 fittings were .9417, .95216, .96943 and .9669 for (1), (2), (3) and (4), respectively.

8. (R_1) (M_1) (S_2) (1_4) [(1), (2), (3), (4)]. The first-generation means were 37.1, 35.6, 32.675 and 31.575, respectively for (1), (2), (3), and (4) and their respective variances were .89, 6.04, 13.569 and 10.994. The unselected and the selected population attained fixation at generation 8 and 7, respectively with a mean value of 52. The linear rate of genetic progress were 4.5983, 5.3024, 8.6815 and 5.7179, respectively for (1), (2), (3) and (4) and their quadratic rate of genetic progress, respectively were -.030892, -.35952, -.31517 and -.34285 with a respective intercept of 35.5237, 33.0827, 24.6725 and 28.5068. The R^2 values for the β_0, β_1 and β_2 fittings were .92211, .95374, .97212 and .97044 for (1), (2), (3) and (4), respectively.

9. (R_1) (M_1) (S_3) (L_1) [(1), (2), (3), (4)]. The first-generation means were 37.0, 37.6, 30.85 and 31.75, respectively

for (1), (2), (3) and (4), and their respective variances were 1.6, 1.84, 14.078 and 15.988. The unselected and the selected population attained fixation at generation 11 and 10, respectively with a mean value of 64. The linear rate of genetic progress were 5.377, 5.018, 5.627 and 5.245, respectively for (1), (2), (3), (4) and their respective quadratic rate of genetic progress were -.21537, -.1895, -.19652 and -.16806 with a respective intercept of 31.5527, 32.5927, 32.5927, 26.1252 and 27.1498. The R^2 values for the β_0, β_1 and β_2 fittings were .9971, .9951, .9982 and .9979 for (1), (2), (3) and (4), respectively.

10. (R_1) (M_1) (S_3) (L_2) $[(1), (2), (3), (4)]$. The first-generation means were 37., 38.6, 31.8 and 31.6, respectively for (1), (2), (3), (4) and their respective variances were 2.4, 6.64, 13.31, and 14.84. The unselected and the selected population attained fixation at generation 13 and 12, respectively with a mean value of 64. The linear rate of genetic progress were 3.5135, 3.4381, 4.0131 and 4.0511 respectively for (1), (2), (3), (4) and their respective quadratic rate of genetic progress were -.10888, -.10718, -.11828 and -.12262 with a respective intercept of 35.6042, 36.3483, 30.3472, and 30.5215. The R^2 values for the β_0, β_1 and β_2 fittings were .96659, .97872, .97913 and .97407 for (1), (2), (3) and (4), respectively.

11. (R_1) (M_1) (S_3) (L_3) $[(1), (2), (3), (4)]$. The first-generation means were 31.6, 38.8, 32.35 and 31.975, respectively for (1), (2), (3), (4) and their respective variances were .64, .3.36, 10.878 and 15.874. The unselected and the selected population attained fixation at generation 12 and 11, respectively with a mean value of 52. The linear rate of 4.2402, respectively for (1), (2), (3), (4) and their respective quadratic rate of genetic progress were -.1437, -.1157, -.21923, and -.21622 with a respective intercept of 37.6773, 38.9, 30.6692 and 30.7278. The R^2 values for the β_0, β_1 and β_2 fittings were .89743, .90851, .95305 and .94578 for (1), (2), (3) and (4), respectively.

12. (R_1) (M_1) (S_3) (L_4) $[(1), (2), (3), (4)]$. The first-generation means were 37.6, 38.8, 32.45 and 32.0, respectively for (1), (2), (3), (4) and their respective variances were .64, 2.16, 10.548 and 15.65. The unselected and the selected population attained fixation at generation 6 and 5, respectively with a mean value of 50. The linear rate of genetic progress were 7.37, 6.54, 8.68 and 9.08, respectively for (1), (2), (3), (4) and their quadratic rate of genetic progress were -.728, -.649, -.751 and -.810 with a respective intercept of 31.64, 33.72, 24.67 and 24.22. The R^2 values for the β_0, β_1, and β_2 fittings were .976, .954, .997 and .992 for (1), (2), (3) and (4), respectively.

13. (R_1) (M_2) (S_1) (L_1) [(1), (2), (3), (4)]. The first-generation means were 28.6, 29.45, 30.85 and 31.75, respectively for (1), (2), (3), (4) and their respective variances were 13.04, 11.94, 14., and 15.98. Both the populations did not attain fixation. The linear rate of genetic progress were 2.33, 2.23, 1.56, and 1.46, respectively for (1), (2), (3), (4) and their respective quadratic rate of genetic progress were -.029, -.025, .0013 and .005 with a respective intercept of 25.34, 26.07, 28.06 and 28.54. The R^2 values for the β_0, β_1 and β_2 fittings were .994, .993, .988, and .987 for (1), (2), (3) and (4), respectively.

14. (R_1) (M_2) (S_1) (L_2) [(1), (2), (3), (4)]. The first-generation means were 29.5, 29.0, 31.8 and 31.6, respectively for (1), (2), (3), (4) and their respective variances were 8.55, 16.3, 13.31 and 14.84. The population of both sexes did not attain fixation. The linear rate of genetic progress were 1.89, 1.85, 1.67 and 1.59, respectively for (1), (2), (3), (4) and their respective quadratic rate of genetic progress were -.033, -.031, -.024 and -.022 with respective intercept of 28.69, 28.86, 28.75 and 29.14. The R^2 values for the β_0, β_1 and β_2 fittings were .995, .993, .991 and .992 for (1), (2), (3) and (4), respectively.

15. (R_1) (M_2) (S_1) (L_3) [(1), (2), (3), (4)]. The first-generation means were 29.9, 21.15, 32.35 and 31.98, respectively for (1), (2), (3), (4) and their respective variances were 9.29, 12.83, 10.88 and 15.87. The population

of both sexes did not attain fixation. The linear rate of genetic progress were 1.09, 1.84, 1.02 and 1.0, respectively for (1), (2), (3), (4) and their quadratic rate of progress were -.023, -.031, -.021, and -.021 with respective intercept of 30.2, 28.86, 30.28 and 30.15. The R^2 values for the β_0, β_1 and β_2 fittings were .963, .994, .968 and .976 for (1), (2), (3) and (4), respectively.

16. (R_1) (M_2) (S_1) (L_4) [(1), (2), (3), (4)]. The first-generation means were 30.05, 29.2, 32.45 and 32.0, respectively for (1), (2), (3), (4) and their respective variances were 9.45, 12.66, 10.55 and 15.65. The population of both sexes did not attain fixation. The linear rate of genetic progress were .887, .951, .795 and .773, respectively for (1), (2), (3), (4) and their quadratic rate of genetic progress were -.012, -.014, -.009 and -.084 with respective intercept of 30.39, 29.96, 30.48 and 30.72. The R^2 values for the β_0, β_1 and β_2 fittings were .986, .988, .982 and .988 for (1), (2), (3) and (4), respectively.

17. (R_1) (M_2) (S_2) (L_1) [(1), (2), (3), (4)]. The first-generation means were 31.6, 32.1, 30.85 and 31.75, respectively for (1), (2), (3), (4) and their respective variances were 7.64, 9.29, 14.08 and 15.99. The population of both sexes did not attain fixation. The linear rate of genetic progress were 3.00, 3.06, 3.21, and 3.16, respectively for (1), (2), (3), (4) and their quadratic rate of genetic progress were -.069, -.071, -.072 and -.071 with

respective intercept of 30.30. 29.96, 30.48 and 30.72. The R^2 values for the β_0, β_1 and β_2 fittings were .970, .969, .981 and .979, respectively.

18. (R_1) (M_2) (S_2) (L_2) [(1), (2), (3), (4)]. The first-generation means were 31.9, 32.3, 31.8 and 31.6, respectively for (1), (2), (3), (4) and their respective variances were 4.09, 9.61, 13.31 and 14.84. The unselected and selected population attained fixation at generation 16 and 15, respectively with a mean value of 54. The linear rate of genetic progress were 3.23, 3.26, 3.12 and 3.20, respectively for (1), (2), (3), (4) and their respective quadratic rate of genetic progress were -.107, -.108, -.091 and -.097 with a respective intercept of 30.29, 29.84, 26.97 and 27.44. The R^2 values for the β_0, β_1 and β_2 fittings were .993, .991, .991 and .990 for (1), (2), (3) and (4), respectively.

19. (R_1) (M_2) (S_2) (L_3) [(1), (2), (3), (4)]. The first-generation means were 32.4, 32.2, 32.35 and 31.98, respectively for (1), (2), (3), (4) and their respective variances were 4.04, 6.56, 10.88 and 15.87. The unselected and selected population attained fixation at generation 10 with a mean value of 40. The linear rate of genetic progress were 2.72, 2.62, 2.53 and 2.59, respectively for (1), (2), (3), (4) and their respective quadratic rate of genetic progress were -.169, -.158, -.135, and -.138 with a respective intercept of 29.41, 29.33, 27.42 and 27.32. The R^2 values for the β_0, β_1 and β_2 fittings were .989, .987, .933 and .940 for (1), (2), (3) and (4), respectively.

20. (R_1) (M_2) (S_2) (L_3) [(1), (2), (3), (4)]. The first-generation means were 32.6, 32.2, 32.85 and 32.0, respectively for (1), (2), (3), (4) and their respective variances were 3.64, 6.56, 10.55 and 15.65. The unselected and selected population attained fixation at generations 10 and 9, respectively with mean value of 40. The linear rate of genetic progress were 1.51, 1.59, 1.31, 1.46 for (1), (2), (3), (4) and their respective quadratic rate of progress were -.061, -.066, -.032, and -.040 with a respective intercept of 29.61, 29.65, 28.45 and 28.09. The R^2 values for the β_0, β_1 and β_2, respectively were .995, .984, .955 and .952 for (1), (2), (3) and (4), respectively.

21. (R_1) (M_2) (S_3) (L_1) [(1), (2) (3) (4)]. The first-generation means were 34.0, 34.6, 30.85 and 31.75, respectively for (1), (2), (3), (4) and their respective variances were 3.2, 5.04, 14.08 and 15.99. The population of both the sexes did not attain fixation. The linear rate of genetic progress were 2.94, 2.95, 3.32, and 3.26 for (1), (2), (3) and (4), respectively and their respective quadratic rate of genetic progress were -.074, -.071, -.079, and -.077 with a respective intercept of 31.18, 30.84, 30.21 and 29.63. The R^2 values for the β_0, β_1, and β_2 fitting were .922, .926, .947 and .948 for (1), (2), (3) and (4), respectively.

22. (R_1) (M_2) (S_3) (L_2) [(1), (2), (3), (4)]. The first-generation means were 33.4, 34.4, 31.8 and 31.6, respectively

for (1), (2), (3), (4) and their respective variances were 3.44, 8.24, 13.31 and 14.84. The population of both the sexes did not attain fixation. The linear rate of genetic progress were 3.81, 3.56, 3.89 and 3.95, respectively for (1), (2), (3), (4) and their respective quadratic rate of genetic progress were -.165, -.143, -.153 and -.155 with a respective intercept of 33.45, 33.08, 28.78 and 29.13. The R^2 values for the β_0, β_1 and β_2 fittings were .975 .979, .984 and .982 for (1), (2), (3), and (4), respectively.

23. (R_1) (M_2) (S_3) (L_3) [(1), (2), (3), (4)]. The first-generation means were 33.6, 34.0, 32.35 and 31.98, respectively for (1), (2), (3), (4) and their respective variances were 5.04, 4.9, 10.88 and 15.88. The unselected and selected population attained fixation at generation 6 and 5, respectively with a mean value of 40. The linear rate of genetic progress were 3.00, 2.78, 1.86 and 2.14, respectively for (1), (2), (3), (4) and their respective quadratic rate of genetic progress were -.228, -.199, -.011 and -.047 with a respective intercept of 30.48, 30.84, 29.69 and 29.19.
The R^2 values for the β_0, β_1 and β_2 fittings were .964, .932, .936 and .955 for (1), (2), (3) and (4), respectively.

24. (R_1) (M_2) (S_3) (L_4) [(1), (2), (3), (4)]. The first-generation means were 33.6, 34.0, 32.45 and 32.0, respectively for (1), (2), (3), (4) and their respective variances were 5.04, 4.8, 10.54, 15.65. The unselected and selected population attained fixation at generation 6 and 5, respectively

with a mean value of 38. The linear rate of genetic progress were 2.43, 2.17, 1.96 and 2.40, respectively for (1), (2), (3), (4) and their respective quadratic rate of genetic progress were -.217, -.182, -.092 and -.145 with a respective intercept of 31.34, 31.66, 29.89, and 29.06. The R^2 values for β_0, β_1 and β_2 fittings were .975, .954, .919 for (1), (2), (3) and (4), respectively.

In all cases of Model 3 (over dominance model) the values at which the population attained complete fixation could not be obtained because of the fluctuations and consistant maintenance of genetic variability. The linear rate of genetic progress and quadratic rate of genetic progress were respectively inconsistant from case to case. The R^2 values ranged from .06637 to .98198.

Discussion

The discussion part will mostly consist of locating the optimum combination of linkage value and selection intensity that yields the maximum responses. Here the following responses will be considered.

1. Number of generation consumed to attain maximum fixation.

2. The mean value of the responses at the maximum fixation.

3. The linear rate of change of genetic progress.

4. The quadratic rate of change of genetic progress.

At the end a comparative merits of the different models will be discussed in the light of the above findings.

Additive model. It was of interest to find the number of generations consumed by a population to attain maximum fixation. A three-dimensional graph with

X-axis = levels of linkage

Y-axis = levels of selection

Z-axis = number of generation to maximum fixation.

It can be observed that the combination of .01 as linkage and selection of 20/40 required the highest number of generations to attain maximum fixation.

The lowest number of generations are at linkage .003 and selection 5/40. As the selection becomes more intense, the number of generations to achieve maximum fixation decreased over all linkage conditions. Among the linkage conditions over all selections, comparatively higher number of generations are obtained at linkage condition .1.

The highest fixation values are at linkage .5 over all selections and at linkage .5 and selection 10/40. The lowest value of fixation is at linkage .003 and selection 20/40. The fixation values decreased from linkage conditions .5 to .003 over all selections. Among the selections over all linkage conditions, comparatively higher fixation value in less number of generations is at linkage .5 and selection 10/40.

The highest values of linear rate of progress and quadratic rate of progress, are at linkage .003 and selection 20/40. The lowest values are at linkage .01 and selection 20/40. The higher values of rate of progresses are at linkage .002 over all selection.

Complete dominance model. Fixation values were achieved at a) linkage .01 and selection 10/40; b) linkage .01 and selection 5/40; c) linkage .003 and selection 10/40; d) linkage .003 and selection 5/40. At other combinations of linkage and selections, means of the tenth generation are considered for comparisons. The highest mean is at linkage .5 and selection 5/40. The lowest mean is at linkage .003 and selection 20/40. Means decreased as linkage conditions varied from .5 to .003 over all selections. They increased as selection became more intense over all linkages.

The highest rate of progress is at linkage .1 and selection 5/40. The lowest linear rate of progress is at linkage .003 and selection 20/40. Except in case of linkage .01 and selection 5/40, the linear rate of progress increased as selection became more intense over all linkages.

Over dominance model. The means of twenty generations are considered in this model for all cases. The highest mean is at linkage .5 and selection 5/40 and the lowest mean is at linkage .01 and selection 5/40. Since no definite trend was established in linear and quadratic rate of progresses, it is rather difficult to compare.

In conclusion, the highest fixation value can be achieved at linkage .5 and selection 10/40. If the highest fixation is not the goal, one can select linkage .003 and selection 5/40 to reach fixation with highest linear and quadratic rate of progresses. Additive model shows better results than both of the other models. Complete dominance model is preferred over over-dominance model if definite trend is required.

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APPENDIXES

Appendix A; Parameters

Parameters selected for this study are as follows:

1. m = Number of loci for a single chromosome.
2. q = Number of chromosomes in a genotype of an individual.
3. p_1 = Linkage probability for a genotype.
4. p_2 = Linkage probability for mask.
5. NM = Number of male individuals for initial population.
6. NF = Number of female individuals for initial population.
7. N_1 = Number of male offsprings to be generated.
8. N_2 = Number of female offsprings to be generated.
9. n_1 = Number of male offsprings to be selected.
10. n_2 = Number of female offsprings to be selected.
11. GN = Number of generation of selection study.
12. h^2 = An environmental variance.
13. M = Model under study for selection.
14. R = Number of replications.
15. σ_E^2 = Variance for epistacy.

The values of parameters, may be chosen for a particular case of study have certain range and restrictions. a) $M \geq 1$, $q \geq 1$ and $m.q \geq 100$. b) $0 \geq p_1 \geq 1$, $0 \geq p_2 \geq 1$, $0 \geq h^2 \leq 1$ and $0 \geq {}^{2}_{E} \leq 99.99$. c) $1 \leq$ NM, NF; N_1; N_2; n_1;

n_2; R; GN ≤ 99, $N_1 \geq n_1$ and $N_2 \geq n_2$. d) $M.q(NM + NF + n_1 + n_2 + 42) \leq 13500$.

Appendix B; Parameter card, operating procedure and output format

Parameter card:

Columns	Contents	Digits
1-2	NM	$\bar{x}x$
3-4	NF	$\bar{x}x$
5-6	N_1	$\bar{x}x$
7-8	N_2	$\bar{x}x$
9-10	n_1	$\bar{x}x$
11-12	n_2	$\bar{x}x$
13-15	q	$\bar{x}xx$
16-18	m	$\bar{x}xx$
19-22	p_1	$\bar{x}xxx$
23-26	p_2	$\bar{x}xxx$
27-28	Analysis	$\bar{x}x$
	$\bar{0}0$ = Polynomial curve fitting	
	$\bar{0}1$ = Analysis of variance ≠	
29-30	Model type	$\bar{x}x$
	$\bar{0}0$ = one dimension	
	$\bar{0}1$ = two dimension	
31-32	Models	$\bar{x}x$
	$\bar{0}1$ = Additive model	
	$\bar{0}2$ - Complete dominance	

	$\overline{0}3$ = Over-dominance model	
	$\overline{0}4$ = Additive model (two dimension)	
	$\overline{0}5$ = Complete dominance model (two dimension)	
	$\overline{0}6$ = Over-dominance model (two dimension)	
33-34	Response	$\overline{x}x$
35-36	GN	$\overline{x}x$
37-38	R	$\overline{x}x$
39-43	σ_E^2	$\overline{x}x.xxx$*
44-46	Constant	$\overline{x}xx$
76	H^2	$\overline{x}$
	$\overline{1}$ = 1	
	$\overline{2}$ = .5	
	$\overline{3}$ = .2	
77	R	x
	1 = Rep 2	
	:	
	:	
	9 = Rep 9	
78	M	X
	1 = Additive model	
	2 = Complete dominance	
	3 = Over-dominance model	
	4 = Additive model (two dimension)	
	5.= Complete dominance (two dimension)	
	6.=Over-dominance model (two dimension)	
79	Selection	x
	1 = 20/40	

2 = 10/40

3 = 5/40

80 Linkages x

1 = .5

2 = .1

3 = .01

4 = .003

Each card is punched with flags as indicated over digit x.

Operating procedure:

1. Reset the computer.
2. Load object deck.
3. Read add table, probability table and three random numbers. (These cards are supplied with object deck).
4. Read parameter card.
5. Two cards are punched out after completion of each generation. First card contains the information on actual phynotype. The other card contains the information on count phenotype.
6. After completion of the required number of generation, seven cards will be punched out. First three cards contain the information on sum and sums of squares of the response. Last four cards contain coefficients of the polynomial curve.
7. Batch processing is assumed.

Output format:

Generation Cards:

Card No. 1. This card contains the actual response of the selected and unselected population.

Columns	Contents
1-10	Unselected male mean
11-20	Unselected male variance
21-30	Unselected female mean
31-40	Unselected female variance
41-50	Selected male mean
51-60	Selected male variance
61-70	Selected female mean
71-80	Selected female variance

Card No. 2. This card contains the count response of the selected and unselected population. The format of this card is the same as for card No. 1.

Analysis Cards:

Card No. 1.

Columns	Contents
1-10	Average of responses for unselected male.
11-20	Average of responses for unselected female.
21-30	Average of responses for selected male.
31-40	Average of responses for selected female.
41-50	Sum of squares of responses for unselected male.
51-60	Sum of squares of responses for unselected female.
61-70	Sum of squares of responses for selected male.
71-80	Sum of squares of responses for selected female.

Card No. 2

1-10	Sum of product of responses and generations for unselected male.
11-20	Sum of product of responses and generations for unselected female.
21-30	Sum of product of responses and generations for selected male.
31-40	Sum of product of responses and generations for selected female.
41-50	Sum of product of responses and generation squares for unselected male.
51-60	Sum of product of responses and generation squares for unselected female.
61-70	Sum of product of responses and generation squares for selected male.
71-80	Sum of product of responses and generation squares for selected female.

Card No. 3

1-10	Average of generations
11-20	Average of generation squares
21-30	Sum of squares of generations
31-40	Sum of squares of generation squares
41-50	Sum of product of generations and generation squares

Card No. 4, 5, 6, 7

21-30	b_0 (intercept)
31-40	b_1 (linear rate of progress)
41-50	b_2 (quadratic rate of progress)
51-60	R^2 (R square)

Identification of this coefficient are punched in columns 1 through 6. Column 1 contains the identification for selected and unselected males and females.

Column	Contents
1	1 = Selected female
	2 = Selected male
	3 = Unselected female
	4 = Unselected male

Columns 2 to 6 will be identical to the columns 76-80 of the parameter card. This will completely identify each card.

Appendix C; Checking procedure for a particular example

As an assurance to the programmer and for the satisfaction of the experimenter rigorous checks were made at every possible interval of the program. At earlier stage each step of the program were followed closely. It will be cumbersome to assign addresses to the computed and stored information in the computer. A particular (small) case is considered to show the results at important stages of the program.

Assumptions are made that probability tables are in core storage and addresses of storage for population are computed correctly by the program in computer at every stage of operation.

Parameters are selected as follows: $m = 3$, $q = 2$, $p_1 = .5$, $p_2 = .1$, $NM = 3$, $NF = 3$, $N_1 = 5$, $N_2 = 5$, $n_1 = 2$, $n_2 = 2$, $GN = 4$, $h^2 = 1$, $M = 1$ (one dimension), $R = 1$, ${}^{2}_{E} = 0$. Two random numbers were obtained from a random number table. Random numbers of $2 \times m \times q$ digits are $X_0 = 785192360462$ and $\underline{C} = 150321689014$.

Genotype of initial population is generated first by the following procedure:

Set of six random numbers are generated by reccursive relation.

$$X_i + 1 = \underline{C}\, X_1 \pmod{2Mq}$$

$X_1 = \bar{3}69263596038\ \bar{9}\ 16238207410.$

$X_2 = \bar{1}83466076073\ \bar{8}\ 26983765425.$

$X_3 = \overline{0}91058934886\ \overline{7}\ 82485693102.$

$X_4 = \overline{0}45144079518\ \overline{3}\ 91678307429.$

$X_5 = \overline{2}24207444240\ \overline{1}\ 50610218793.$

$X_6 = \overline{1}11401956297\ \overline{7}\ 23626824150.$

Probability table of p_1 (Appendix D) is transferred at 00300-00399. Two parts of X_i are separated by flag on high order digits of each part. These two parts are added accordingly to the probability table p_1 and carry of each position is ignored at the time of addition. Resulting genotype of the initial population will be stored linearly as shows.

100 101 001 110

010 110 111 100

001 111 010 100

110 011 100 010

101 010 001 011

011 010 001 110

Sex of genotype identified at this stage. Genes of last chromosome of first three individuals are transferred at the end of genotype. Male and female population were represented as below after transferring appropriate fields.

K_1^2 (Nos(assumed in computer)	Male genotype			
0	100	101	001	101
1	010	110	011	110
2	001	111	010	111

K_2 (Nos. assumed in computer)	Female genotype			
0	110	011	100	010
1	101	010	001	011
2	011	010	001	110

Two random masks were generated for segregation of population to produce an individual offspring. Sets of random number were generated. They were tested against probability p_1 and p_2. Following was the order of testing. For first gene of first chromosome was tested with p_1 and rest of the genes were tested against p_2.

Random numbers	.875	.013	.478	.321	.782	.091
Probability for test	.5	.1	.1	.5	.1	.1
Genes	0	1	0	0	0	1

Figure. Generation of mask

Second mask was also generated by same procedure, which can be written as:

100 000.

Complements of masks were obtained by changing the add table according to figure. Masks with complements were stored side by side.

010 001 101 110

100 000 011 111

Gametes of male and female were formed to represent an individual. A male and a female were selected from initial population. Two random numbers generated to accomplish selection of male and female with the help of the following equivalent relation.

$$Z_1 = K_1 \pmod 3$$
$$Z_2 = K_2 \pmod 3$$

$$Z_1 = 271 \quad \text{then} \quad K_1 = 1$$

and

$$Z_2 = 752 \quad \text{then} \quad K_2 = 2.$$

Selected male and female were then transferred to working area for logical operations. Add table is changed according to figure, for logical multiplication. Addition was performed to accomplish logical operation. Resulting genotype of both sexes were then stored.

	Male				Female			
Genotype	101	001	100	001	100	101	110	001
Mask	010	001	101	110	100	000	011	111
	000	001	100	000	100	000	010	001

Add table was again changed for logical sum according to figure 5. Resulting genotype of both sexes were then added with corresponding genes of chromosomes to form gametes.

Male		Female	
000	001	100	000
100	000	010	001
100	001	110	001

Two gametes then constituted a genotype of an offspring. Genotype then stored as

100 001 110 001.

After obtaining genotype of an offspring genotype was evaluated according to the additive model of one dimension. Phenotype of an offspring generated was 5 according to the model mentioned.

Five male offsprings and five female offsprings were generated by repeating above mentioned procedure after initial population. Phenotypic values were computed and stored side by side.

	Genotypes				Phenotypic value
Male offsprings	100	001	110	001	05
	011	010	100	101	06
	100	000	010	000	02
	101	110	000	000	04
	011	111	010	100	07
Female offsprings	100	000	010	100	04
	001	001	100	000	03
	111	010	001	101	07
	010	000	000	000	01
	101	110	010	000	05

Two male offsprings and two female offsprings were selected for successive generation. Mean and variance of selected and unselected population were computed, before selected population replaced the initial population.

Unselected population	Mean	Variance
Male	4.8	2.96
Female	4.0	4.0
Selected population		
Male	6.5	.25
Female	6.0	.2

Data cards were punched out at each generation. This process was repeated 4 times. Second degree polynomial was fitted to the observations. R square value was .9999.

Result of cases: $m = 3$, $q = 5$, $p_1 = .5$, $p_2 = .1$, $NM = 20$, $NF = 20$, $N_1 = 80$, $N_2 = 80$, $n_1 = 20, 10$, $n_2 = 20, 10$, $GN = 15$, $h^2 = 1$, $M = 1,2.$, $R = 1$, $\sigma^2_E = 0$, were checked with the results of Bohidar (1960). Results were quite satisfactory.

Appendix D; Core locations

Core locations	0	1	2	3	4	5	6	7	8	9
300	1	1	1	1	1	0	0	0	0	0
310	1	1	1	1	0	0	0	0	0	1
320	1	1	1	0	0	0	0	0	1	1
330	1	1	0	0	0	0	0	1	1	1
340	1	0	0	0	0	0	1	1	1	1
350	0	0	0	0	0	1	1	1	1	1
360	0	0	0	0	1	1	1	1	1	0
370	0	0	0	1	1	1	1	1	0	0
380	0	0	1	1	1	1	1	0	0	0
390	0	1	1	1	1	1	0	0	0	0

Probability table of p_1 = .5.

Appendix E; Programming

```
*     THE IBM 1620 COMPUTER SOURCE PROGRAM FOR SIMULATION OF GENETIC SYSTEM.
      TAA    DS   101Z                                              02278     00101
      TBB    DS   101Z                                              02379     00101
      CNAA   DS   100Z                                              02479     00100
      CNBB   DS   100Z                                              02579     00100
      CNCC   DS   78Z                                               02657     00078
      CNA    DS   100Z                                              02757     00100
      CNB    DS   100Z                                              02857     00100
      CNC    DS   78Z                                               02935     00078
      CARD   DS   80Z                                               03015     00080
      PMC    DS   80Z                                               03095     00080
      P      DS   ,PMC-79Z                                          03016     00000
      ZA     DS   400Z                                              03495     00400
      WA     DS   200Z                                              03695     00200
      WB     DC   10,N300000000Z                                    03705     00010
                                                                    N300000000Z
      WC     DC   11,N300000000Z                                    03716     00011
                                                                    05300000000Z
      WD     DS   10Z                                               03726     00010
      WF     DC   10,N200000000Z                                    03736     00010
                                                                    N200000000Z
      WG     DS   400Z                                              04136     00400
      MSA    DS   200Z                                              04336     00200
             DS   21Z                                               04357     00021
      MSB    DS   200Z                                              04557     00200
      TT     DS   12Z                                               04569     00012
      SIX    DC   12,060000000000Z                                  04581     00012
                                                                    060000000000Z
      SY     DSB  10,4Z                                             04591     00010 00004
      SSY    DSB  10,4Z                                             04631     00010 00004
      SCY    DSB  10,4Z                                             04671     00010 00004
      SSCY   DSB  10,4Z                                             04711     00010 00004
      SUMY   DSB  10,4Z                                             04751     00010 00004
      SSUMY  DSB  10,4Z                                             04791     00010 00004
      SYX1   DSB  10,4Z                                             04831     00010 00004
      SYX2   DSB  10,4Z                                             04871     00010 00004
```

```
X1     DS   10Z                                               04911     00010
X2     DS   10Z                                               04921     00010
SX1    DS   10Z                                               04931     00010
SX2    DS   10Z                                               04941     00010
SX12   DS   10Z                                               04951     00010
START  TFM  99,480,9Z                                         04952 16 00099 00M80
       TFM  RA+6,TAA-100Z                                     04964 16 04982 02178
RA     RNCD Z                                                 04976 36 00000 00500
       SM   99,80,10Z                                         04988 12 00099 000Q0
       BZ   INZ                                               05000 46 05036 01200
       AM   RA+6,80,10Z                                       05012 11 04982 000Q0
A01    B    RAZ                                               05024 49 04976 00000
IN     TF   CNA,CNAAZ                                         05036 26 02757 02479
       TF   CNB,CNBBZ                                         05048 26 02857 02579
       TF   CNC,CNCCZ                                         05060 26 02935 02657
       RNCDPZ                                                 05072 36 03016 00500
       WNCDPZ                                                 05084 38 03016 00400
A02    SF   ZA-399Z                                           05096 32 03096 00000
       M    P+14,P+17Z                                        05108 23 03030 03033
A03    SF   95Z                                               05120 32 00095 00000
       TF   TL,99Z                                            05132 26 05035 00099
       TF   TG,99Z                                            05144 26 05107 00099
       A    TG,TLZ                                            05156 21 05107 05035
       TFM  A,WGZ                                             05168 16 05131 04136
       S    A,TGZ                                             05180 22 05131 05107
       TF   B,AZ                                              05192 26 05503 05131
       AM   B,1,10Z                                           05204 11 05503 00001
       TF   D,AZ                                              05216 26 05527 05131
       A    D,TLZ                                             05228 21 05527 05035
       TF   E,BZ                                              05240 26 05575 05503
       A    E,TLZ                                             05252 21 05575 05035
       TF   C,EZ                                              05264 26 05515 05575
       S    C,P+17Z                                           05276 22 05515 03033
       TF   F,CZ                                              05288 26 05659 05515
       A    F,TLZ                                             05300 21 05659 05035
       TFM  G,CNA+1Z                                          05312 16 05683 02758
```

```
      TFM  H,CNB+1Z               05324 16 05695 02858
      S    G,TGZ                  05336 22 05683 05107
      S    H,TGZ                  05348 22 05695 05107
      TFM  I,ZA+1Z                05360 16 05755 03496
      S    I,TGZ                  05372 22 05755 05107
      S    I,TGZ                  05384 22 05755 05107
      TF   J,BZ                   05396 26 05779 05503
      S    J,TLZ                  05408 22 05779 05035
      TF   K,AZ                   05420 26 05791 05131
      S    K,TLZ                  05432 22 05791 05035
      TFM  TA,MALE-1Z             05444 16 07747 J4311
      TF   CA,P+1Z                05456 26 08707 03017
      TF   CB,P+3Z                05468 26 08839 03019
      A    CB,CAZ                 05480 21 08839 08707
A04   SF   G,,6Z                  05492 32 0568L 00000
A05   SF   H,,6Z                  05504 32 0569N 00000
A06   SF   I,,6Z                  05516 32 0575N 00000
IA    TF   99,ZAZ                 05528 26 00099 03495
      M    CNA,CNBZ               05540 23 02757 02857
      TF   WG,99Z                 05552 26 04136 00099
A07   SF   B,,6Z                  05564 32 0550L 00000
      TF   CNA,WGZ                05576 26 02757 04136
      TR   300,TBB-100Z           05588 31 00300 02279
      A    WG,A,11Z               05600 21 04136 0513J
      TR   300,TAA-100Z           05612 31 00300 02178
      SM   CA,1,10Z               05624 12 08707 00001
      BN   IBZ                    05636 47 05696 01300
A08   SF   C,,6Z                  05648 32 0551N 00000
      TF   WG,D,11Z               05660 26 04136 0552P
A09   CF   C,,6Z                  05672 33 0551N 00000
A10   CF   F,,6Z                  05684 33 0565R 00000
IB    A    TA,TGZ                 05696 21 07747 05107
      TF   TA,WG,6Z               05708 26 0774P 04136
      SM   CB,1,10Z               05720 12 08839 00001
      BZ   ICZ                    05732 46 05756 01200
A11   B    IAZ                    05744 49 05528 00000
```

```
IC     CF   G,,6Z                                 05756 33 0568L 00000
A12    CF   H,,6Z                                 05768 33 0569N 00000
A13    CF   I,,6Z                                 05780 33 0575N 00000
A14    SF   CNC-10Z                               05792 32 02925 00000
A15    SF   CNC-20Z                               05804 32 02915 00000
ICA    TFM  SAA+11,P+1Z                           05816 16 07111 03017
       TFM  SAB+11,P+1Z                           05828 16 07147 03017
       TFM  SCA+11,P+3Z                           05840 16 07291 03019
       TFM  SCB+11,P+3Z                           05852 16 07303 03019
       TFM  SCA+11,P+3Z                           05864 16 07291 03019
       TFM  SCB+11,P+3Z                           05876 16 07303 03019
       TFM  MA,MSA+1Z                             05888 16 08203 04337
       TFM  MB,MSB+1Z                             05900 16 08299 04558
       TFM  MC,MSA+1Z                             05912 16 09223 04337
       TFM  MD,MSB+1Z                             05924 16 08671 04558
       TFM  I,ZA+1Z                               05936 16 05755 03496
       S    MA,TGZ                                05948 22 08203 05107
       S    MB,TGZ                                05960 22 08299 05107
       S    MC,TLZ                                05972 22 09223 05035
       S    MD,TLZ                                05984 22 08671 05035
       S    I,TLZ                                 05996 22 05755 05035
ICC    TF   R,TAZ                                 06008 26 06739 07747
       AM   R,1,10Z                               06020 11 06739 00001
       TFM  M,WA+1Z                               06032 16 05815 03696
       S    M,TGZ                                 06044 22 05815 05107
       TFM  G,MALE-1Z                             06056 16 05683 J4311
       A    G,TGZ                                 06068 21 05683 05107
       TFM  A166+6,P+1Z                           06080 16 06218 03017
       TFM  ICD+6,SUMYZ                           06092 16 06122 04751
       TFM  CMS,21,10Z                            06104 16 07555 000K1
ICD    TF   SUMY,ZA-390Z                          06116 26 04751 03105
       SM   CMS,1,10Z                             06128 12 07555 00001
       BZ   IDZ                                   06140 46 06176 01200
       AM   ICD+6,10,10Z                          06152 11 06122 000J0
       B    ICDZ                                  06164 49 06116 00000
ID     TF   CJ,P+1Z                               06176 26 09055 03017
```

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A17   SF  I,,6Z                                         06188 32 0575N 00000
      TF  H,GZ                                          06200 26 05695 05683
A166  M   P+1,TGZ                                       06212 23 03017 05107
A16   SF  95Z                                           06224 32 00095 00000
      A   H,99Z                                         06236 21 05695 00099
      TFM IDD+6,SYZ                                     06248 16 06278 04591
      TFM CMS,16,10Z                                    06260 16 07555 000J6
IDD   TF  SY,ZA-390Z                                    06272 26 04591 03105
      SM  CMS,1,10Z                                     06284 12 07555 00001
      BZ  IEZ                                           06296 46 06332 01200
      AM  IDD+6,10,10Z                                  06308 11 06278 000J0
      B   IDDZ                                          06320 49 06272 00000
IE    TF  TD,RZ                                         06332 26 08131 06739
      TF  L,RZ                                          06344 26 05803 06739
      TF  CI,P+3Z                                       06356 26 07315 03019
      TFM EPD+23,SYZ                                    06368 16 08515 04591
      TFM EPE+23,SSYZ                                   06380 16 08587 04631
      TFM EPBA+23,SCYZ                                  06392 16 08395 04671
      TFM EPBB+23,SSCYZ                                 06404 16 08467 04711
      TFM EPF+6,P+9Z                                    06416 16 08774 03025
      TFM SLA+11,P+9Z                                   06428 16 08851 03025
      TFM SLE+11,P+5Z                                   06440 16 09067 03021
      TF  T,HZ                                          06452 26 06871 05695
IFF   TFM SX,2,10Z                                      06464 16 07567 00002
IF    TFM CC,0,10Z                                      06476 16 06967 00000
IG    TF  MSB,ZAZ                                       06488 26 04557 03495
      TF  MSA,ZAZ                                       06500 26 04336 03495
      TFM CMS,2,10Z                                     06512 16 07555 00002
      TF  TA,MAZ                                        06524 26 07747 08203
      TF  TB,MAZ                                        06536 26 07963 08203
      TFM TC,MSAZ                                       06548 16 08047 04336
MKA   TF  CA,TLZ                                        06560 26 08707 05035
MKB   TFM MKE+6,P+21Z                                   06572 16 06638 03037
MKC   TF  CB,P+17Z                                      06584 26 08839 03033
MKD   M   CNC,CNC-11Z                                   06596 23 02935 02924
A18   SF  90Z                                           06608 32 00090 00000
```

```
        TF   CNC,99Z                 06620 26 02935 00099
MKE     C    P+21,93Z                06632 24 03037 00093
        BP   MKFZ                    06644 46 06740 01100
        TDM  TB,1,6Z                 06656 15 0796L 00001
        SM   CA,1,10Z                06668 12 08707 00001
        BZ   MKHZ                    06680 46 06836 01200
        AM   TB,1,10Z                06692 11 07963 00001
        SM   CB,1,10Z                06704 12 08839 00001
        BZ   MKBZ                    06716 46 06572 01200
A19     B    MKGZ                    06728 49 06812 00000
MKF     TDM  TB,0,6Z                 06740 15 0796L 00000
        SM   CA,1,10Z                06752 12 08707 00001
        BZ   MKHZ                    06764 46 06836 01200
        AM   TB,1,10Z                06776 11 07963 00001
        SM   CB,1,10Z                06788 12 08839 00001
        BZ   MKBZ                    06800 46 06572 01200
MKG     TFM  MKE+6,P+25Z             06812 16 06638 03041
A20     B    MKDZ                    06824 49 06596 00000
MKH     TDM  301,0Z                  06836 15 00301 00000
        TDM  300,1Z                  06848 15 00300 00001
A21     SF   TA,,6Z                  06860 32 0774P 00000
        A    TC,TB,611Z              06872 21 0804P 0796L
        TR   300,TAA-100Z            06884 31 00300 02178
        SM   CMS,1,10Z               06896 12 07555 00001
        BZ   MKIZ                    06908 46 06968 01200
        TF   TA,MBZ                  06920 26 07747 08299
        TF   TB,MBZ                  06932 26 07963 08299
        TFM  TC,MSBZ                 06944 16 08047 04557
A22     B    MKAZ                    06956 49 06560 00000
MKI     CF   MC,,6Z                  06968 33 0922L 00000
A23     CF   MD,,6Z                  06980 33 0867J 00000
        CM   P+27,0,10Z              06992 14 03043 00000
        BZ   A24+12Z                 07004 46 07052 01200
        TF   WG,G,11Z                07016 26 04136 0568L
        TF   A,T,611Z                07028 26 0513J 0687J
A24     B    SBZ                     07040 49 07364 00000
```

```
      TFM CMS,2,10Z                                   07052 16 07555 00002
SA    M   CNC,CNC-11Z                                 07064 23 02935 02924
A25   SF  90Z                                         07076 32 00090 00000
      TF  CNC,99Z                                     07088 26 02935 00099
SAA   C   CNC-8,P+1Z                                  07100 24 02927 03017
      BN  SC1Z                                        07112 47 07184 01300
      LD  99,CNC-8Z                                   07124 28 00099 02927
SAB   D   98,P+1Z                                     07136 29 00098 03017
A26   SF  98Z                                         07148 32 00098 00000
      TF  TC,99Z                                      07160 26 08047 00099
      B   SCZ                                         07172 49 07196 00000
SC1   TF  TC,CNC-8Z                                   07184 26 08047 02927
SC    M   TC,TGZ                                      07196 23 08047 05107
A27   SF  95Z                                         07208 32 00095 00000
      TF  TC,99Z                                      07220 26 08047 00099
      SM  CMS,1,10Z                                   07232 12 07555 00001
      BZ  SDZ                                         07244 46 07316 01200
      TF  TA,GZ                                       07256 26 07747 05683
      A   TA,TCZ                                      07268 21 07747 08047
SCA   TFM SAA+11,P+3Z                                 07280 16 07111 03019
SCB   TFM SAB+11,P+3Z                                 07292 16 07147 03019
A28   B   SAZ                                         07304 49 07064 00000
SD    TF  TB,HZ                                       07316 26 07963 05695
      A   TB,TCZ                                      07328 21 07963 08047
      TF  WG,TA,11Z                                   07340 26 04136 0774P
      TF  A,TB,611Z                                   07352 26 0513J 0796L
SB    TDM 300,0Z                                      07364 15 00300 00000
      TDM 301,0Z                                      07376 15 00301 00000
      TDM 310,0Z                                      07388 15 00310 00000
      TDM 311,1Z                                      07400 15 00311 00001
      A   WG,MSAZ                                     07412 21 04136 04336
      A   A,MSB,6Z                                    07424 21 0513J 04557
      TR  300,TAA-100Z                                07436 31 00300 02178
A31   SF  J,,6Z                                       07448 32 0577R 00000
A32   SF  E,,6Z                                       07460 32 0557N 00000
      A   K,A,611Z                                    07472 21 0579J 0513J
```

```
        A    D,WG,6Z                                        07484 21 0552P 04136
        TF   WG,K,11Z                                       07496 26 04136 0579J
A33     CF   E,,6Z                                          07508 33 0557N 00000
        TF   WA,WGZ                                         07520 26 03695 04136
        TF   A,WG,6Z                                        07532 26 0513J 04136
A34     SF   E,,6Z                                          07544 32 0557N 00000
A35     SF   J,,6Z                                          07556 32 0577R 00000
        CM   P+31,1,10Z                                     07568 14 03047 00001
        BZ   MLAZ                                           07580 46 07784 01200
        CM   P+31,2,10Z                                     07592 14 03047 00002
        BZ   MLBZ                                           07604 46 07700 01200
        CM   P+31,3,10Z                                     07616 14 03047 00003
        BZ   MLCZ                                           07628 46 07748 01200
        TDM  300,0Z                                         07640 15 00300 00000
        TDM  310,1Z                                         07652 15 00310 00001
        TDM  301,1Z                                         07664 15 00301 00001
        TDM  311,2Z                                         07676 15 00311 00002
A36     B    MLAZ                                           07688 49 07784 00000
MLB     TDM  301,1Z                                         07700 15 00301 00001
        TDM  310,1Z                                         07712 15 00310 00001
        TDM  311,1Z                                         07724 15 00311 00001
A37     B    MLAZ                                           07736 49 07784 00000
MLC     TDM  301,2Z                                         07748 15 00301 00002
        TDM  310,2Z                                         07760 15 00310 00002
        TDM  311,1Z                                         07772 15 00311 00001
MLA     A    WG,D,11Z                                       07784 21 04136 0552P
        TR   300,TAA-100Z                                   07796 31 00300 02178
        A    A,K,611Z                                       07808 21 0513J 0579J
        TFM  CMS,2,10Z                                      07820 16 07555 00002
MLD     CF   E,,6Z                                          07832 33 0557N 00000
        TFM  TA,WGZ                                         07844 16 07747 04136
        TFM  CE,0,9Z                                        07856 16 07051 00000
        TF   CF,TLZ                                         07868 26 07087 05035
        TFM  CG,0,10Z                                       07880 16 07159 00000
EA      TD   CG,TA,11Z                                      07892 25 07159 0774P
        A    CE,CGZ                                         07904 21 07051 07159
```

```
         SM   TA,1,10Z                                07916 12 07747 00001
         SM   CF,1,10Z                                07928 12 07087 00001
         BZ   EBZ                                     07940 46 07964 01200
A38      B    EAZ                                     07952 49 07892 00000
EB       SM   CMS,1,10Z                               07964 12 07555 00001
         BZ   ECZ                                     07976 46 08048 01200
         TF   WG,A,11Z                                07988 26 04136 0513J
         TF   WB,ZA-392Z                              08000 26 03705 03103
         TF   WC-1,ZA-392Z                            08012 26 03715 03103
         TF   WB-5,CEZ                                08024 26 03700 07051
A39      B    MLDZ                                    08036 49 07832 00000
EC       TF   WC-6,CEZ                                08048 26 03710 07051
         CM   P+29,0,10Z                              08060 14 03045 00000
         BZ   EPBZ                                    08072 46 08276 01200
         TF   TT,ZA-388Z                              08084 26 04569 03107
         TFM  CMS,12,10Z                              08096 16 07555 000J2
EPA      M    CNC,CNC-11Z                             08108 23 02935 02924
A40      SF   90Z                                     08120 32 00090 00000
         TF   CNC,99Z                                 08132 26 02935 00099
         A    TT,99Z                                  08144 21 04569 00099
         SM   CMS,1,10Z                               08156 12 07555 00001
         BNZ  EPAZ                                    08168 47 08108 01200
         S    TT,SIXZ                                 08180 22 04569 04581
A41      SF   TT-10Z                                  08192 32 04559 00000
         MF   TT-5,TTZ                                08204 71 04564 04569
         M    P+42,TT-5Z                              08216 23 03058 04564
         MF   96,99Z                                  08228 71 00096 00099
         A    WB,96Z                                  08240 21 03705 00096
         A    WB-5,P+45Z                              08252 21 03700 03061
         A    WC-6,P+45Z                              08264 21 03710 03061
EPB      CF   WB-7Z                                   08276 33 03698 00000
A42      CF   WC-8Z                                   08288 33 03708 00000
         CM   P+33,0,10Z                              08300 14 03049 00000
         BZ   EPBCZ                                   08312 46 08360 01200
         TF   MSA+10,WC-1Z                            08324 26 04346 03715
         TF   WC-1,WBZ                                08336 26 03715 03705
```

```
        TF   WB,MSA+10Z                                08348 26 03705 04346
EPBC    TF   TT,WC-1Z                                  08360 26 04569 03715
EPBA    FA   SCY,TTZ                                   08372 16 00469 08407
                                                       08384 16 00445 04671
                                                       08396 49 00422 04569
        FM   TT,TTZ                                    08408 16 00469 08443
                                                       08420 26 01260 04569
                                                       08432 49 01262 04569
EPBB    FA   SSCY,99Z                                  08444 16 00469 08479
                                                       08456 16 00445 04711
                                                       08468 49 00422 00099
EPC     TF   TT,WBZ                                    08480 26 04569 03705
EPD     FA   SY,TTZ                                    08492 16 00469 08527
                                                       08504 16 00445 04591
                                                       08516 49 00422 04569
        FM   TT,TTZ                                    08528 16 00469 08563
                                                       08540 26 01260 04569
                                                       08552 49 01262 04569
EPE     FA   SSY,99Z                                   08564 16 00469 08599
                                                       08576 16 00445 04631
                                                       08588 49 00422 00099
        AM   CC,1,10Z                                  08600 11 06967 00001
        C    P+27,0,10Z                                08612 24 03043 00000
        BZ   EPFZ                                      08624 46 08768 01200
        C    CI,P+3Z                                   08636 24 07315 03019
        BZ   SLAAZ                                     08648 46 08672 01200
A44     B    SLAZ                                      08660 49 08840 00000
SLAA    C    CJ,P+1Z                                   08672 24 09055 03017
        BZ   EPFFZ                                     08684 46 08708 01200
A45     B    SLAZ                                      08696 49 08840 00000
EPFF    CM   P+33,0,10Z                                08708 14 03049 00000
        BZ   EPFZ                                      08720 46 08768 01200
        TF   MSA+10,WC-1Z                              08732 26 04346 03715
        TF   WC-1,WBZ                                  08744 26 03715 03705
        TF   WB,MSA+10Z                                08756 26 03705 04346
EPF     C    P+9,CCZ                                   08768 24 03025 06967
```

```
      BN   SLAZ                                  08780 47 08840 01300
      TR   L,M,611Z                              08792 31 0580L 0581N
      A    L,TGZ                                 08804 21 05803 05107
      AM   L,21,10Z                              08816 11 05803 000K1
A46   B    IGZ                                   08828 49 06488 00000
SLA   TF   CD,P+9Z                               08840 26 06991 03025
      TF   N,TDZ                                 08852 26 06235 08131
      TF   O,TDZ                                 08864 26 06199 08131
      A    N,TGZ                                 08876 21 06235 05107
      AM   N,9,10Z                               08888 11 06235 00009
SLB   C    N,WB,6Z                               08900 24 0623N 03705
      BNP  SLDZ                                  08912 47 09008 01100
SLC   A    N,TGZ                                 08924 21 06235 05107
      A    O,TGZ                                 08936 21 06199 05107
      AM   O,21,10Z                              08948 11 06199 000K1
      AM   N,21,10Z                              08960 11 06235 000K1
      SM   CD,1,10Z                              08972 12 06991 00001
      BZ   SLEZ                                  08984 46 09056 01200
      B    SLBZ                                  08996 49 08900 00000
SLD   TR   MA,O,611Z                             09008 31 0820L 0619R
      TR   O,M,611Z                              09020 31 0619R 0581N
      TR   M,MA,611Z                             09032 31 0581N 0820L
A29   B    SLCZ                                  09044 49 08924 00000
SLE   C    CC,P+5Z                               09056 24 06967 03021
      BZ   SLFZ                                  09068 46 09092 01200
A30   B    IGZ                                   09080 49 06488 00000
SLF   SM   SX,1,10Z                              09092 12 07567 00001
      BZ   SLGZ                                  09104 46 09284 01200
      TFM  EPD+23,SY+10Z                         09116 16 08515 04601
      TFM  EPE+23,SSY+10Z                        09128 16 08587 04641
      TFM  EPBA+23,SCY+10Z                       09140 16 08395 04681
      TFM  EPBB+23,SSCY+10Z                      09152 16 08467 04721
      TFM  EPF+6,P+11Z                           09164 16 08774 03027
      TFM  SLA+11,P+11Z                          09176 16 08851 03027
      TFM  SLE+11,P+7Z                           09188 16 09067 03023
      M    P+9,TGZ                               09200 23 03025 05107
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A43     SF   95Z                                                          09212 32 00095 00000
        A    TD,99Z                                                       09224 21 08131 00099
        MM   P+9,21,10Z                                                   09236 13 03025 000K1
        SF   95Z                                                          09248 32 00095 00000
        A    TD,99Z                                                       09260 21 08131 00099
        B    IFZ                                                          09272 49 06476 00000
SLG     CM   P+27,0,10Z                                                   09284 14 03043 00000
        BZ   SLHZ                                                         09296 46 09404 01200
        SM   CI,1,10Z                                                     09308 12 07315 00001
        BZ   SLIZ                                                         09320 46 09356 01200
        A    T,TGZ                                                        09332 21 06871 05107
        B    IFFZ                                                         09344 49 06464 00000
SLI     SM   CJ,1,10Z                                                     09356 12 09055 00001
        BZ   SLIZ                                                         09368 46 09356 01200
        A    G,TGZ                                                        09380 21 05683 05107
        B    IEZ                                                          09392 49 06332 00000
SLH     TFM  SLJ+6,MALEZ                                                  09404 16 09458 J4312
        TF   CMS,P+9Z                                                     09416 26 07555 03025
        A    CMS,P+11Z                                                    09428 21 07555 03027
        TF   L,RZ                                                         09440 26 05803 06739
SLJ     TR   MALE,L,11Z                                                   09452 31 14312 0580L
        A    SLJ+6,TGZ                                                    09464 21 09458 05107
        A    L,TGZ                                                        09476 21 05803 05107
        AM   L,10,10Z                                                     09488 11 05803 000J0
        TF   CB,LZ                                                        09500 26 08839 05803
        SM   CB,1,10Z                                                     09512 12 08839 00001
        AM   L,11,10Z                                                     09524 11 05803 000J1
        TF   CN,LZ                                                        09536 26 07519 05803
        SM   CN,2,10Z                                                     09548 12 07519 00002
        C    P+9,CMSZ                                                     09560 24 03025 07555
        BNL  SLMZ                                                         09572 46 09884 01300
        SF   *+47Z                                                        09584 32 09631 00000
        FA   SY+20,CBZ                                                    09596 16 00469 09631
                                                                          09608 16 00445 04611
                                                                          09620 49 00422 08839
        SF   *+47Z                                                        09632 32 09679 00000
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       FA   SCY+20,CNZ                09644 16 00469 09679
                                      09656 16 00445 04691
                                      09668 49 00422 07519
       SF   *+47Z                     09680 32 09727 00000
       SF   *+47Z                     09692 32 09739 00000
       FM   CB,CBZ                    09704 16 00469 09739
                                      09716 26 01260 08839
                                      09728 49 01262 08839
       FA   SSY+20,99Z                09740 16 00469 09775
                                      09752 16 00445 04651
                                      09764 49 00422 00099
       SF   *+47Z                     09776 32 09823 00000
       SF   *+47Z                     09788 32 09835 00000
       FM   CN,CNZ                    09800 16 00469 09835
                                      09812 26 01260 07519
                                      09824 49 01262 07519
       FA   SSCY+20,99Z               09836 16 00469 09871
                                      09848 16 00445 04731
                                      09860 49 00422 00099
       B    SLNZ                      09872 49 10172 00000
SLM    SF   *+47Z                     09884 32 09931 00000
       FA   SY+30,CBZ                 09896 16 00469 09931
                                      09908 16 00445 04621
                                      09920 49 00422 08839
       SF   *+47Z                     09932 32 09979 00000
       FA   SCY+30,CNZ                09944 16 00469 09979
                                      09956 16 00445 04701
                                      09968 49 00422 07519
       SF   *+47Z                     09980 32 10027 00000
       SF   *+47Z                     09992 32 10039 00000
       FM   CB,CBZ                    10004 16 00469 J0039
                                      10016 26 01260 08839
                                      10028 49 01262 08839
       FA   SSY+30,99Z                10040 16 00469 J0075
                                      10052 16 00445 04661
                                      10064 49 00422 00099
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         SF   *+47Z                        10076 32 10123 00000
         SF   *+47Z                        10088 32 10135 00000
         FM   CN,CNZ                       10100 16 00469 J0135
                                           10112 26 01260 07519
                                           10124 49 01262 07519
         FA   SSCY+30,99Z                  10136 16 00469 J0171
                                           10148 16 00445 04741
                                           10160 49 00422 00099
SLN      SM   CMS,1,10Z                    10172 12 07555 00001
         BZ   SLKZ                         10184 46 10208 01200
         B    SLJZ                         10196 49 09452 00000
SLK      TFM  SAA+11,P+9Z                  10208 16 07111 03025
         TFM  SAB+11,P+9Z                  10220 16 07147 03025
         TFM  SCA+11,P+11Z                 10232 16 07291 03027
         TFM  SCB+11,P+11Z                 10244 16 07303 03027
         AM   GN,1,10Z                     10256 11 07699 00001
         SF   GN-1Z                        10268 32 07698 00000
         TF   WD,WFZ                       10280 26 03726 03736
         TF   WD-6,GNZ                     10292 26 03720 07699
         CF   WD-7Z                        10304 33 03719 00000
         BTM  NOM,,10Z                     10316 17 14192 00000
         FA   X1,WDZ                       10328 16 00469 J0363
                                           10340 16 00445 04911
                                           10352 49 00422 03726
         FM   WD,WDZ                       10364 16 00469 J0399
                                           10376 26 01260 03726
                                           10388 49 01262 03726
         FA   X2,99Z                       10400 16 00469 J0435
                                           10412 16 00445 04921
                                           10424 49 00422 00099
         TF   SX1,99Z                      10436 26 04931 00099
         FM   SX1,SX1Z                     10448 16 00469 J0483
                                           10460 26 01260 04931
                                           10472 49 01262 04931
         FA   SX2,99Z                      10484 16 00469 J0519
                                           10496 16 00445 04941
                                           10508 49 00422 00099
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      FM   SX1,WDZ                          10520 16 00469 J0555
                                            10532 26 01260 04931
                                            10544 49 01262 03726
      FA   SX12,99Z                         10556 16 00469 J0591
                                            10568 16 00445 04951
                                            10580 49 00422 00099
      TFM  YB+23,SYZ                        10592 16 10819 04591
      TFM  YD+23,SUMYZ                      10604 16 10903 04751
      TFM  YF+23,SYX1Z                      10616 16 11239 04831
      TFM  YH+23,SYX2Z                      10628 16 11359 04871
      TFM  YDD+23,SSYZ                      10640 16 11047 04631
      TFM  YBD+35,SYZ                       10652 16 11023 04591
      TFM  YDA+23,SSUMYZ                    10664 16 10975 04791
      TFM  YDE+23,SSYZ                      10676 16 11083 04631
      TFM  CA,2,10Z                         10688 16 08707 00002
YAF   TFM  YBB+6,CARD-70Z                   10700 16 10850 02945
      TFM  YDF+6,CARD-60Z                   10712 16 11102 02955
      TFM  YA+11,P+5Z                       10724 16 10771 03021
      TFM  CMS,4,10Z                        10736 16 07555 00004
YAA   TF   WD,WFZ                           10748 26 03726 03736
YA    TF   WD-6,P+5Z                        10760 26 03720 03021
      CF   WD-7Z                            10772 33 03719 00000
      BTM  NOM,,10Z                         10784 17 14192 00000
YB    FD   SY,WDZ                           10796 16 00469 J0831
                                            10808 26 01260 04591
                                            10820 49 01422 03726
      TF   SX1,99Z                          10832 26 04931 00099
YBB   TF   CARD-70,SX1Z                     10844 26 02945 04931
      CM   CA,1,10Z                         10856 14 08707 00001
      BZ   YBDZ                             10868 46 10988 01200
YD    FA   SUMY,99Z                         10880 16 00469 J0915
                                            10892 16 00445 04751
                                            10904 49 00422 00099
      FM   SX1,SX1Z                         10916 16 00469 J0951
                                            10928 26 01260 04931
                                            10940 49 01262 04931
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YDA     FA   SSUMY,99Z                                 10952 16 00469 J0987
                                                       10964 16 00445 04791
                                                       10976 49 00422 00099
YBD     FM   SX1,SYZ                                   10988 16 00469 J1023
                                                       11000 26 01260 04931
                                                       11012 49 01262 04591
YDD     FS   SSY,99Z                                   11024 16 00469 J1059
                                                       11036 16 00445 04631
                                                       11048 49 00402 00099
YDE     FD   SSY,WDZ                                   11060 16 00469 J1095
                                                       11072 26 01260 04631
                                                       11084 49 01422 03726
YDF     TF   CARD-60,99Z                               11096 26 02955 00099
        CM   CA,1,10Z                                  11108 14 08707 00001
        BZ   YIZ                                       11120 46 11420 01200
        TF   WD,WFZ                                    11132 26 03726 03736
        TF   WD-6,GNZ                                  11144 26 03720 07699
        CF   WD-7Z                                     11156 33 03719 00000
        BTM  NOM,,10Z                                  11168 17 14192 00000
YE      FM   SX1,WDZ                                   11180 16 00469 J1215
                                                       11192 26 01260 04931
                                                       11204 49 01262 03726
YF      FA   SYX1,99Z                                  11216 16 00469 J1251
                                                       11228 16 00445 04831
                                                       11240 49 00422 00099
        FM   WD,WDZ                                    11252 16 00469 J1287
                                                       11264 26 01260 03726
                                                       11276 49 01262 03726
        TF   WD,99Z                                    11288 26 03726 00099
YG      FM   SX1,WDZ                                   11300 16 00469 J1335
                                                       11312 26 01260 04931
                                                       11324 49 01262 03726
YH      FA   SYX2,99Z                                  11336 16 00469 J1371
                                                       11348 16 00445 04871
                                                       11360 49 00422 00099
        AM   YD+23,10,10Z                              11372 11 10903 000J0
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      AM   YF+23,10,10Z                  11384 11 11239 000J0
      AM   YH+23,10,10Z                  11396 11 11359 000J0
      AM   YDA+23,10,10Z                 11408 11 10975 000J0
YI    SM   CMS,1,10Z                     11420 12 07555 00001
      BZ   XFFZ                          11432 46 11540 01200
      AM   YA+11,2,10Z                   11444 11 10771 00002
      AM   YB+23,10,10Z                  11456 11 10819 000J0
      AM   YBB+6,20,10Z                  11468 11 10850 000K0
      AM   YDF+6,20,10Z                  11480 11 11102 000K0
      AM   YBD+35,10,10Z                 11492 11 11023 000J0
      AM   YDD+23,10,10Z                 11504 11 11047 000J0
      AM   YDE+23,10,10Z                 11516 11 11083 000J0
      B    YAAZ                          11528 49 10748 00000
XFF   BC1  XFFFZ                         11540 46 11564 00100
      WNCDCARD-79Z                       11552 38 02936 00400
XFFF  SM   CA,1,10Z                      11564 12 08707 00001
      BZ   XFF1Z                         11576 46 11648 01200
      TFM  YB+23,SCYZ                    11588 16 10819 04671
      TFM  YBD+35,SCYZ                   11600 16 11023 04671
      TFM  YDD+23,SSCYZ                  11612 16 11047 04711
      TFM  YDE+23,SSCYZ                  11624 16 11083 04711
      B    YAFZ                          11636 49 10700 00000
XFF1  C    GN,P+35Z                      11648 24 07699 03051
      BZ   SLLZ                          11660 46 11756 01200
      C    CARD-60,ZA-390Z               11672 24 02955 03105
      BZ   SLL1Z                         11684 46 11708 01200
      B    SLL2Z                         11696 49 11732 00000
SLL1  C    CARD-40,ZA-390Z               11708 24 02975 03105
      BZ   SLLZ                          11720 46 11756 01200
SLL2  TFM  A166+6,P+9Z                   11732 16 06218 03025
      B    IDZ                           11744 49 06176 00000
SLL   TF   WD,WFZ                        11756 26 03726 03736
      TF   WD-6,GNZ                      11768 26 03720 07699
      CF   WD-7Z                         11780 33 03719 00000
      BTM  NOM,,10Z                      11792 17 14192 00000
      TFM  CA,2,10Z                      11804 16 08707 00002
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        TFM XA+35,X1Z                                     11816 16 11899 04911
        TFM XAA+23,SYX1Z                                  11828 16 11971 04831
XD      TFM XA+23,SUMYZ                                   11840 16 11887 04751
        TFM CMS,4,10Z                                     11852 16 07555 00004
XA      FM  SUMY,X1Z                                      11864 16 00469 J1899
                                                          11876 26 01260 04751
                                                          11888 49 01262 04911
        TF  SX1,99Z                                       11900 26 04931 00099
        FD  SX1,WDZ                                       11912 16 00469 J1947
                                                          11924 26 01260 04931
                                                          11936 49 01422 03726
XAA     FS  SYX1,99Z                                      11948 16 00469 J1983
                                                          11960 16 00445 04831
                                                          11972 49 00402 00099
        AM  XA+23,10,10Z                                  11984 11 11887 000J0
        AM  XAA+23,10,10Z                                 11996 11 11971 000J0
        SM  CMS,1,10Z                                     12008 12 07555 00001
        BZ  XBZ                                           12020 46 12044 01200
        B   XAZ                                           12032 49 11864 00000
XB      SM  CA,1,10Z                                      12044 12 08707 00001
        BZ  XCZ                                           12056 46 12092 01200
        TFM XA+35,X2Z                                     12068 16 11899 04921
        B   XDZ                                           12080 49 11840 00000
XC      TF  WD,WFZ                                        12092 26 03726 03736
        TF  WD-6,GNZ                                      12104 26 03720 07699
        CF  WD-7Z                                         12116 33 03719 00000
        BTM NOM,,10Z                                      12128 17 14192 00000
        TFM XE+23,SUMYZ                                   12140 16 12223 04751
        TFM XF+6,SUMYZ                                    12152 16 12326 04751
        TFM XEA+23,SUMYZ                                  12164 16 12271 04751
        TFM XEB+23,SSUMYZ                                 12176 16 12307 04791
        TFM CMS,4,10Z                                     12188 16 07555 00004
XE      FD  SUMY,WDZ                                      12200 16 00469 J2235
                                                          12212 26 01260 04751
                                                          12224 49 01422 03726
        TF  SX1,99Z                                       12236 26 04931 00099
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XEA   FM   SUMY,SX1Z                    12248 16 00469 J2283
                                        12260 26 01260 04751
                                        12272 49 01262 04931
XEB   FS   SSUMY,99Z                    12284 16 00469 J2319
                                        12296 16 00445 04791
                                        12308 49 00402 00099
XF    TF   SUMY,SX1Z                    12320 26 04751 04931
      SM   CMS,1,10Z                    12332 12 07555 00001
      BZ   XCCZ                         12344 46 12416 01200
      AM   XE+23,10,10Z                 12356 11 12223 000J0
      AM   XF+6,10,10Z                  12368 11 12326 000J0
      AM   XEA+23,10,10Z                12380 11 12271 000J0
      AM   XEB+23,10,10Z                12392 11 12307 000J0
      B    XEZ                          12404 49 12200 00000
XCC   FM   X2,X2Z                       12416 16 00469 J2451
                                        12428 26 01260 04921
                                        12440 49 01262 04921
      TF   SX1,99Z                      12452 26 04931 00099
      FD   SX1,WDZ                      12464 16 00469 J2499
                                        12476 26 01260 04931
                                        12488 49 01422 03726
      FS   SX2,99Z                      12500 16 00469 J2535
                                        12512 16 00445 04941
                                        12524 49 00402 00099
      FM   X1,X2Z                       12536 16 00469 J2571
                                        12548 26 01260 04911
                                        12560 49 01262 04921
      TF   SX1,99Z                      12572 26 04931 00099
      FD   SX1,WDZ                      12584 16 00469 J2619
                                        12596 26 01260 04931
                                        12608 49 01422 03726
      FS   SX12,99Z                     12620 16 00469 J2655
                                        12632 16 00445 04951
                                        12644 49 00402 00099
      FM   X1,X1Z                       12656 16 00469 J2691
                                        12668 26 01260 04911
                                        12680 49 01262 04911
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TF   SX1,99Z                  12692 26 04931 00099
FD   SX1,WDZ                  12704 16 00469 J2739
                              12716 26 01260 04931
                              12728 49 01422 03726
TF   SX1,99Z                  12740 26 04931 00099
FS   SX1, X2Z                 12752 16 00469 J2787
                              12764 16 00445 04931
                              12776 49 00402 04921
CF   SX1Z                     12788 33 04931 00000
FD   X1,WDZ                   12800 16 00469 J2835
                              12812 26 01260 04911
                              12824 49 01422 03726
TF   X1,99Z                   12836 26 04911 00099
FD   X2,WDZ                   12848 16 00469 J2883
                              12860 26 01260 04921
                              12872 49 01422 03726
TF   X2,99Z                   12884 26 04921 00099
FM   SX1,SX2Z                 12896 16 00469 J2931
                              12908 26 01260 04931
                              12920 49 01262 04941
TF   WD,99Z                   12932 26 03726 00099
FM   SX12,SX12Z               12944 16 00469 J2979
                              12956 26 01260 04951
                              12968 49 01262 04951
FS   WD,99Z                   12980 16 00469 J3015
                              12992 16 00445 03726
                              13004 49 00402 00099
WNCDSUMY-9Z                   13016 38 04742 00400
WNCDSYX1-9Z                   13028 38 04822 00400
WNCDX1-9Z                     13040 38 04902 00400
TF   CARD,ZA-320Z             13052 26 03015 03175
TFM  B1+23,SX2Z               13064 16 13351 04941
TFM  C2+11,SYX1Z              13076 16 13255 04831
TFM  C3+11,SYX2Z              13088 16 13267 04871
TFM  B57+35,SSUMYZ            13100 16 13915 04791
TFM  B1+35,SYX1Z              13112 16 13363 04831
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      TFM B2+35,SYX2Z               13124 16 13411 04871
      TFM B8+23,SUMYZ               13136 16 13675 04751
      TFM B10+11,SYX2Z              13148 16 13543 04871
      TFM B12+11,SYX1Z              13160 16 13555 04831
      TFM B88+23,SUMYZ              13172 16 13747 04751
      TFM B89+11,SUMYZ              13184 16 13939 04751
      TFM B55+23,SYX1Z              13196 16 13783 04831
      TFM B56+23,SYX2Z              13208 16 13831 04871
      TFM CMS,4,10Z                 13220 16 07555 00004
C1    TFM B1+23,SX2Z                13232 16 13351 04941
C2    TFM B1+35,SYX1Z               13244 16 13363 04831
C3    TFM B2+35,SYX2Z               13256 16 13411 04871
      TFM B11+6,CARD-40Z            13268 16 13370 02975
      TFM B3+23,CARD-40Z            13280 16 13435 02975
      TFM B4+23,CARD-40Z            13292 16 13471 02975
      TFM B5+6,CARD-40Z             13304 16 13490 02975
      TFM CA,2,10Z                  13316 16 08707 00002
B1    FM  SX2,SYX1Z                 13328 16 00469 J3363
                                    13340 26 01260 04941
                                    13352 49 01262 04831
B11   TF  CARD-40,99Z               13364 26 02975 00099
B2    FM  SX12,SYX2Z                13376 16 00469 J3411
                                    13388 26 01260 04951
                                    13400 49 01262 04871
B3    FS  CARD-40,99Z               13412 16 00469 J3447
                                    13424 16 00445 02975
                                    13436 49 00402 00099
B4    FD  CARD-40,WDZ               13448 16 00469 J3483
                                    13460 26 01260 02975
                                    13472 49 01422 03726
B5    TF  CARD-40,99Z               13484 26 02975 00099
      SM  CA,1,10Z                  13496 12 08707 00001
      BZ  B6Z                       13508 46 13616 01200
      TFM B1+23,SX1Z                13520 16 13351 04931
B10   TFM B1+35,SYX2Z               13532 16 13363 04871
B12   TFM B2+35,SYX1Z               13544 16 13411 04831
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        AM    B3+23,10,10Z                                        13556 11 13435 000J0
        AM    B4+23,10,10Z                                        13568 11 13471 000J0
        AM    B5+6,10,10Z                                         13580 11 13490 000J0
        AM    B11+6,10,10Z                                        13592 11 13370 000J0
        B     B1Z                                                 13604 49 13328 00000
B6      FM    X1,CARD-40Z                                         13616 16 00469 J3651
                                                                  13628 26 01260 04911
                                                                  13640 49 01262 02975
B8      FS    SUMY,99Z                                            13652 16 00469 J3687
                                                                  13664 16 00445 04751
                                                                  13676 49 00402 00099
        FM    X2,CARD-30Z                                         13688 16 00469 J3723
                                                                  13700 26 01260 04921
                                                                  13712 49 01262 02985
B88     FS    SUMY,99Z                                            13724 16 00469 J3759
                                                                  13736 16 00445 04751
                                                                  13748 49 00402 00099
B55     FM    SYX1,CARD-40Z                                       13760 16 00469 J3795
                                                                  13772 26 01260 04831
                                                                  13784 49 01262 02975
        TF    CARD-20,99Z                                         13796 26 02995 00099
B56     FM    SYX2,CARD-30Z                                       13808 16 00469 J3843
                                                                  13820 26 01260 04871
                                                                  13832 49 01262 02985
        FA    CARD-20,99Z                                         13844 16 00469 J3879
                                                                  13856 16 00445 02995
                                                                  13868 49 00422 00099
B57     FD    CARD-20,SSUMYZ                                      13880 16 00469 J3915
                                                                  13892 26 01260 02995
                                                                  13904 49 01422 04791
        TF    CARD-20,99Z                                         13916 26 02995 00099
B89     TF    CARD-50,SUMYZ                                       13928 26 02965 04751
        TF    CARD-78,CMSZ                                        13940 26 02937 07555
        CF    CARD-79Z                                            13952 33 02936 00000
        TF    CARD-72,P+79Z                                       13964 26 02943 03095
        CF    CARD-76Z                                            13976 33 02939 00000
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      WNCDCARD-79Z                     13988 38 02936 00400
      SM   CMS,1,10Z                   14000 12 07555 00001
      BZ   INTEZ                       14012 46 14156 01200
      AM   C2 +11,10,10Z               14024 11 13255 000J0
      AM   C3+11,10,10Z                14036 11 13267 000J0
      AM   B8+23,10,10Z                14048 11 13675 000J0
      AM   B10+11,10,10Z               14060 11 13543 000J0
      AM   B12+11,10,10Z               14072 11 13555 000J0
      AM   B88+23,10,10Z               14084 11 13747 000J0
      AM   B89+11,10,10Z               14096 11 13939 000J0
      AM   B55+23,10,10Z               14108 11 13783 000J0
      AM   B56+23,10,10Z               14120 11 13831 000J0
      AM   B57+35,10,10Z               14132 11 13915 000J0
      B    C1Z                         14144 49 13232 00000
INTE  TFM  GN,0Z                       14156 16 07699 00000
      CF   I,,6Z                       14168 33 0575N 00000
      B    INZ                         14180 49 05036 00000
NOM   TD   NOM-1,WD-7Z                 14192 25 14191 03719
      CM   NOM-1,0,10Z                 14204 14 14191 00000
      BZ   NOM1Z                       14216 46 14240 01200
      BB    Z                          14228 42 00000 00000
NOM1  SM   WD-8,1,10Z                  14240 12 03718 00001
      TD   WD,WCZ                      14252 25 03726 03716
      TR   WD-7,WD-6Z                  14264 31 03719 03720
      TDM  WD-1,0Z                     14276 15 03725 00000
      TDM  WD,0Z                       14288 15 03726 00000
      BB    Z                          14300 42 00000 00000
TL    DS   ,A01+11Z                    05035    00000
TG    DS   ,A02+11Z                    05107    00000
A     DS   ,A03+11Z                    05131    00000
B     DS   ,A04+11Z                    05503    00000
C     DS   ,A05+11Z                    05515    00000
D     DS   ,A06+11Z                    05527    00000
E     DS   ,A07+11Z                    05575    00000
F     DS   ,A08+11Z                    05659    00000
G     DS   ,A09+11Z                    05683    00000
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H       DS    ,A10+11Z                                        05695     00000
I       DS    ,A11+11Z                                        05755     00000
J       DS    ,A12+11Z                                        05779     00000
K       DS    ,A13+11Z                                        05791     00000
L       DS    ,A14+11Z                                        05803     00000
M       DS    ,A15+11Z                                        05815     00000
N       DS    ,A16+11Z                                        06235     00000
O       DS    ,A17+11Z                                        06199     00000
Q       DS    ,A18+11Z                                        06619     00000
R       DS    ,A19+11Z                                        06739     00000
S       DS    ,A20+11Z                                        06835     00000
T       DS    ,A21+11Z                                        06871     00000
CC      DS    ,A22+11Z                                        06967     00000
CD      DS    ,A23+11Z                                        06991     00000
CE      DS    ,A24+11Z                                        07051     00000
CF      DS    ,A25+11Z                                        07087     00000
CG      DS    ,A26+11Z                                        07159     00000
CH      DS    ,A27+11Z                                        07219     00000
CI      DS    ,A28+11Z                                        07315     00000
CJ      DS    ,A29+11Z                                        09055     00000
CK      DS    ,A30+11Z                                        09091     00000
CL      DS    ,A31+11Z                                        07459     00000
CM      DS    ,A32+11Z                                        07471     00000
CN      DS    ,A33+11Z                                        07519     00000
CMS     DS    ,A34+11Z                                        07555     00000
SX      DS    ,A35+11Z                                        07567     00000
GN      DS    ,A36+11Z                                        07699     00000
TA      DS    ,A37+11Z                                        07747     00000
TB      DS    ,A38+11Z                                        07963     00000
TC      DS    ,A39+11Z                                        08047     00000
TD      DS    ,A40+11Z                                        08131     00000
MA      DS    ,A41+11Z                                        08203     00000
MB      DS    ,A42+11Z                                        08299     00000
MC      DS    ,A43+11Z                                        09223     00000
MD      DS    ,A44+11Z                                        08671     00000
CA      DS    ,A45+11Z                                        08707     00000
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CB     DS   ,A46+11Z                                              08839      00000
MALE   DS   1Z                                                    14312      00001
       DENDSTARTZ                                                 04952
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TABLE 1. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M1, S1, L1.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.175	13.894	31.825	11.494	33.900	7.890	34.600	3.740
2	1	33.800	12.510	34.950	10.448	36.700	6.010	37.600	5.040
3	1	37.625	8.484	37.350	10.528	40.100	3.090	40.100	3.190
4	1	40.200	5.810	40.725	5.199	42.150	2.528	42.550	2.348
5	1	43.275	10.499	42.375	7.584	45.900	4.090	44.600	2.340
6	1	45.175	11.244	45.875	8.659	47.750	2.588	48.450	1.748
7	1	48.775	6.074	48.275	4.049	50.800	1.160	49.700	1.010
8	1	50.200	5.760	50.675	4.320	52.150	2.328	52.300	2.510
9	1	52.275	4.450	51.725	6.650	53.800	3.460	53.750	2.488
10	1	53.900	5.440	53.250	3.688	55.750	2.488	54.700	.810
11	1	54.800	4.310	54.650	2.678	56.550	1.248	55.850	.928
12	1	55.800	3.060	55.850	3.628	57.250	.788	57.400	1.140
13	1	57.550	3.648	57.500	2.700	59.050	1.848	58.800	1.060
14	1	59.150	2.678	59.200	2.610	60.400	.640	60.450	1.048
15	1	60.275	1.650	60.300	2.560	61.250	.888	61.550	1.248
16	1	61.525	1.750	61.325	1.620	62.650	.528	62.350	.628
17	1	62.275	1.000	62.475	.900	63.100	.190	63.200	.460
18	1	63.150	.678	63.200	.610	63.800	.160	63.850	.128
19	1	63.850	.128	63.850	.128	64.000	.000	64.000	.000
20	1	64.000	.000	64.000	.000	64.000	.000	64.000	.000

TABLE 2. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M1, S1, L2.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.025	14.024	32.625	13.534	33.700	8.810	35.500	2.250
2	1	35.900	7.440	36.100	8.990	37.950	4.548	38.250	2.488
3	1	37.425	8.444	37.000	7.350	39.700	3.010	39.000	3.800
4	1	40.700	7.710	40.925	9.869	42.950	2.448	43.550	2.048
5	1	44.300	7.710	44.375	5.734	46.450	2.548	46.300	2.410
6	1	46.400	5.890	46.875	3.509	48.450	1.648	48.450	.848
7	1	48.800	3.610	48.550	3.098	50.350	1.028	49.850	1.128
8	1	49.950	2.248	49.650	2.778	51.100	1.090	51.000	.700
9	1	51.750	2.488	51.300	4.010	52.950	.648	52.950	1.048
10	1	53.825	2.795	53.200	3.110	55.050	1.048	54.500	1.350
11	1	54.975	2.975	54.650	2.728	56.350	.728	55.850	1.228
12	1	56.375	2.535	56.150	1.978	57.550	1.248	57.300	.510
13	1	57.650	1.028	57.425	1.495	58.400	.340	58.400	.540
14	1	58.475	.750	58.525	1.000	59.200	.160	59.300	.210
15	1	59.275	.650	59.350	.678	59.900	.290	60.000	.300
16	1	59.775	.625	59.625	.335	60.300	.410	60.100	.090
17	1	60.275	.300	60.350	.278	60.600	.340	60.700	.310
18	1	60.625	.585	60.875	.410	61.250	.188	61.300	.210
19	1	61.325	.370	61.250	.388	61.800	.160	61.700	.210
20	1	61.775	.175	61.675	.270	62.000	.000	62.000	.000
21	1	62.000	.000	62.000	.000	62.000	.000	62.000	.000

TABLE 3. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M1, S1, L3.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.575	10.944	32.775	13.724	34.000	5.700	35.800	2.660
2	1	36.850	14.478	37.075	10.219	39.500	11.850	39.700	2.110
3	1	37.175	7.694	36.675	9.619	39.450	3.048	39.100	5.890
4	1	41.125	6.859	41.275	6.849	43.250	1.788	43.450	2.448
5	1	43.550	2.898	43.275	2.199	44.850	1.428	44.500	.950
6	1	43.500	2.000	43.500	1.350	44.700	.710	44.450	.348
7	1	44.050	1.548	43.900	1.740	44.900	.790	44.950	.448
8	1	45.025	1.574	45.300	1.760	46.000	.600	46.400	.540
9	1	46.525	.749	46.275	.699	47.250	.188	46.900	.390
10	1	47.025	.424	47.150	.678	47.450	.248	47.750	.188
11	1	47.800	.210	47.750	.488	48.050	.048	48.200	.160
12	1	48.025	.024	47.875	.159	48.050	.048	48.050	.048
13	1	48.050	.148	48.100	.690	48.200	.160	48.500	.550
14	1	48.275	.399	48.375	.684	48.600	.540	48.850	.828
15	1	48.175	.144	48.125	.209	48.350	.228	48.350	.228
16	1	48.650	.528	48.525	.549	49.300	.210	49.150	.228
17	1	49.525	.549	49.475	.649	50.050	.048	50.100	.090
18	1	49.950	.098	49.975	.024	50.050	.048	50.000	.000
19	1	50.025	.025	50.050	.048	50.050	.048	50.100	.090
20	1	50.100	.190	50.075	.120	50.250	.288	50.200	.160
21	1	50.300	.510	50.225	.275	50.650	.728	50.450	.448
22	1	50.600	.740	50.625	1.035	51.200	.760	51.250	1.288
23	1	50.850	1.028	51.050	1.098	51.700	.610	51.950	.448
24	1	52.275	1.600	52.100	1.590	53.200	.760	53.100	.490
25	1	53.400	.890	53.200	.860	54.000	.000	53.950	.048
26	1	54.000	.000	54.000	.000	54.000	.000	54.000	.000

TABLE 4. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M1, S1, L4.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.575	10.994	32.675	13.569	34.000	5.700	35.700	2.610
2	1	37.250	15.788	37.025	11.024	40.250	10.988	39.800	2.760
3	1	36.900	7.540	37.150	9.078	39.150	3.028	39.550	5.148
4	1	40.600	4.140	41.550	6.598	42.200	1.760	43.550	3.548
5	1	43.250	4.438	41.225	5.374	44.950	.748	43.200	1.060
6	1	42.950	1.998	43.125	2.859	44.100	.490	44.450	1.048
7	1	43.775	1.124	44.075	1.069	44.550	.348	44.900	.290
8	1	44.750	.938	44.675	.969	45.550	.248	45.350	.228
9	1	45.650	.228	45.425	.444	46.000	.000	46.000	.000
10	1	46.000	.000	46.000	.000	46.000	.000	46.000	.000

TABLE 5. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M1, S2, L1.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.175	13.894	31.825	11.494	35.400	11.040	36.300	1.210
2	1	36.300	12.360	36.425	12.194	40.900	4.290	40.900	3.090
3	1	40.575	7.294	41.250	10.188	43.900	1.690	45.200	3.160
4	1	44.150	9.828	44.900	8.790	48.400	4.440	49.100	2.690
5	1	48.250	8.638	48.975	5.224	51.600	.840	51.600	.440
6	1	51.575	5.895	51.500	4.850	54.600	.440	54.400	1.640
7	1	54.375	3.735	54.625	3.535	57.000	1.400	56.800	1.360
8	1	56.575	3.195	57.150	4.178	58.800	.360	59.700	1.010
9	1	58.825	2.245	59.175	2.245	60.700	.610	61.100	.490
10	1	61.025	1.425	60.875	1.510	62.600	.240	62.300	.210
11	1	62.675	.870	62.500	.700	63.900	.090	63.300	.210
12	1	63.725	.200	63.525	.250	64.000	.000	64.000	.000
13	1	64.000	.000	64.000	.000	64.000	.000	64.000	.000

TABLE 6. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M1, S2, L2.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.025	14.024	32.625	13.534	35.800	8.160	36.800	.760
2	1	37.850	7.478	38.050	9.398	41.300	2.410	42.100	3.290
3	1	43.000	7.100	41.400	9.690	46.600	2.240	45.200	2.160
4	1	44.675	3.819	44.750	5.538	47.100	1.890	48.100	1.290
5	1	48.500	3.500	48.150	3.878	50.900	1.090	50.800	.360
6	1	50.450	2.248	50.900	3.090	52.300	.210	53.300	.610
7	1	52.325	1.620	51.800	1.260	53.800	.560	53.400	.440
8	1	53.300	1.160	52.900	1.890	54.600	.240	54.600	.640
9	1	54.950	1.098	55.075	1.420	56.300	.210	56.400	.640
10	1	56.375	1.335	56.500	1.450	58.000	.400	57.900	.490
11	1	57.350	.778	57.725	1.050	58.400	.240	58.900	.290
12	1	58.450	1.098	58.525	.750	59.600	.440	59.600	.240
13	1	59.700	.660	59.550	.648	60.500	.250	60.400	.240
14	1	60.075	.670	60.550	.448	61.100	.090	61.400	.240
15	1	60.925	.520	61.025	.625	61.800	.160	62.100	.090
16	1	61.800	.410	61.850	.128	62.300	.210	62.000	.000
17	1	62.325	.270	62.075	.270	63.000	.000	62.700	.210
18	1	63.200	.460	63.300	.460	64.000	.000	64.000	.000
19	1	64.000	.000	64.000	.000	64.000	.000	64.000	.000

TABLE 7. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M1, S2, L3.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.575	10.944	32.775	13.724	35.600	6.040	37.200	1.160
2	1	38.900	9.790	40.200	15.310	43.200	4.760	45.400	3.040
3	1	43.500	4.150	43.375	5.784	46.200	.560	46.200	1.760
4	1	44.625	2.734	45.050	3.298	47.000	1.200	47.400	1.440
5	1	46.950	2.348	47.200	2.110	48.900	.890	49.200	.560
6	1	49.750	1.338	49.575	1.144	51.200	.160	50.700	.410
7	1	50.775	.825	50.650	.528	51.800	.360	51.400	.240
8	1	51.875	.560	51.725	.500	52.700	.210	52.500	.250
9	1	52.250	.288	52.150	.278	53.000	.000	52.800	.360
10	1	53.225	.425	53.275	.500	54.100	.090	54.100	.090
11	1	54.175	.145	54.200	.210	54.700	.210	54.800	.360
12	1	54.825	.645	54.775	.425	56.000	.000	55.500	.250
13	1	55.725	.200	55.725	.200	56.000	.000	56.000	.000
14	1	56.000	.000	56.000	.000	56.000	.000	56.000	.000

TABLE 8. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M1, S2, L4.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.575	10.994	32.675	13.569	35.600	6.040	37.100	.890
2	1	39.025	9.974	40.225	14.824	43.300	5.610	45.400	3.040
3	1	43.525	4.149	43.375	5.784	46.200	.560	46.200	1.760
4	1	44.550	2.698	45.025	3.424	46.800	1.760	47.400	1.440
5	1	46.600	2.640	46.950	2.398	48.900	1.290	49.000	.600
6	1	48.800	1.760	49.125	1.809	50.600	.240	50.800	.160
7	1	51.075	.570	51.475	.400	52.000	.000	52.000	.000
8	1	52.000	.000	52.000	.000	52.000	.000	52.000	.000

TABLE 9. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M1, S3, L1.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.750	15.988	30.850	14.078	37.600	1.840	37.000	1.600
2	1	37.800	11.110	37.000	8.250	42.800	1.360	41.200	2.160
3	1	41.575	6.194	42.025	6.474	45.000	.400	46.000	.800
4	1	45.175	8.394	45.675	4.869	49.200	.160	49.200	.160
5	1	48.775	4.724	49.275	6.949	52.400	.640	53.400	1.040
6	1	52.450	3.598	52.325	3.270	55.600	.640	55.200	.560
7	1	55.150	4.328	55.425	2.795	58.800	1.360	58.400	1.440
8	1	58.575	2.545	58.425	3.895	61.200	.560	61.400	.240
9	1	61.500	1.400	61.000	1.850	63.200	.160	63.200	.160
10	1	63.025	.575	63.300	.510	64.000	.000	64.000	.000
11	1	64.000	.000	64.000	.000	64.000	.000	64.000	.000

TABLE 10. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M1, S3, L2.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.600	14.840	31.800	13.310	38.600	6.640	37.000	2.400
2	1	40.975	8.624	40.025	8.674	44.800	.560	45.000	2.400
3	1	44.025	5.174	43.875	6.209	47.000	.000	47.200	.960
4	1	44.375	3.084	44.375	1.984	47.200	.160	46.800	.160
5	1	46.775	3.524	46.525	1.649	49.400	.640	48.600	.240
6	1	48.875	2.959	48.525	3.149	52.200	1.360	51.400	.240
7	1	52.025	2.575	51.950	2.848	54.400	.240	54.600	.240
8	1	55.325	2.420	54.975	1.875	57.800	.560	57.000	.000
9	1	57.425	1.295	57.150	1.728	59.600	.240	59.200	.160
10	1	59.275	.800	59.400	.990	60.600	.240	61.000	.000
11	1	60.650	.528	60.500	.450	62.000	.000	61.600	.240
12	1	61.675	.220	61.725	.200	62.000	.000	62.000	.000
13	1	62.000	.000	62.000	.000	62.000	.000	62.000	.000

TABLE 11. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M1, S3, L3.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.975	15.874	32.350	10.878	38.800	3.360	37.600	.640
2	1	39.950	11.348	39.200	9.910	45.400	1.440	44.800	2.560
3	1	42.825	6.294	43.150	5.478	46.400	.240	46.200	.160
4	1	45.525	1.599	45.450	1.648	47.200	.160	47.800	.160
5	1	47.275	.599	47.375	.634	48.200	.160	48.400	.240
6	1	47.900	.340	47.975	.324	49.000	.000	49.000	.000
7	1	49.525	.399	49.625	.284	50.000	.000	50.200	.160
8	1	50.150	.128	50.200	.160	51.000	.000	51.000	.000
9	1	50.025	.025	50.025	.025	50.200	.160	50.200	.160
10	1	50.450	.348	50.375	.235	51.400	.240	51.000	.000
11	1	51.325	.470	51.125	.410	52.000	.000	52.000	.000
12	1	52.000	.000	52.000	.000	52.000	.000	52.000	.000

TABLE 12. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M1, S3, L4.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	32.000	15.650	32.450	10.548	38.800	2.160	37.600	.640
2	1	39.850	11.578	39.075	10.019	45.600	1.040	44.800	3.360
3	1	44.600	5.840	44.450	4.448	47.800	.560	47.000	.400
4	1	47.075	.969	47.150	1.428	48.400	.240	49.000	.000
5	1	48.825	.544	48.850	.628	50.000	.000	50.000	.000
6	1	50.000	.000	50.000	.000	50.000	.000	50.000	.000

TABLE 13. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M2, S1, L1.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.750	15.988	30.850	14.078	29.450	11.948	28.600	13.040
	2	23.900	6.140	23.100	5.590	27.700	43.110	27.400	40.240
2	1	32.200	15.910	32.075	16.219	30.400	6.240	31.200	6.760
	2	24.225	7.974	23.900	7.290	27.650	39.028	24.850	22.828
3	1	33.375	18.634	33.125	17.409	32.800	11.360	31.250	12.488
	2	24.375	6.884	23.950	6.598	25.750	28.988	27.650	39.028
4	1	34.300	11.210	35.100	17.090	35.250	4.388	34.450	8.848
	2	24.475	4.649	24.700	7.160	24.600	2.740	25.650	19.628
5	1	35.225	7.674	34.475	5.399	36.250	2.788	35.600	4.040
	2	24.725	4.399	24.250	2.838	24.600	2.640	24.700	2.210
6	1	35.925	6.869	35.850	4.528	37.150	4.228	37.050	2.348
	2	25.275	3.799	24.900	4.740	25.850	2.928	25.850	2.628
7	1	37.050	9.748	37.100	12.690	39.050	5.148	39.650	6.128
	2	25.500	2.500	25.225	4.124	26.300	1.810	26.350	2.828
8	1	39.675	7.619	39.675	12.119	41.700	2.610	41.600	7.640
	2	25.950	3.098	26.225	3.274	26.650	2.628	26.650	2.128
9	1	41.225	7.924	41.925	6.169	43.150	2.528	43.400	3.340
	2	26.475	2.449	26.850	1.578	27.300	1.310	26.800	.960
10	1	43.125	7.009	43.300	7.810	45.350	1.428	45.500	1.850
	2	27.225	2.324	27.250	2.238	27.850	1.228	28.200	.960
11	1	45.950	5.048	45.525	5.549	47.900	1.090	47.350	1.928
	2	28.050	1.248	27.875	1.709	28.600	.640	28.550	1.348
12	1	47.375	4.834	47.625	6.534	49.100	1.490	49.700	3.010
	2	28.275	.999	28.675	.869	28.550	.848	28.900	.490
13	1	49.600	6.840	49.050	6.848	51.800	2.760	51.050	3.248
	2	28.750	.938	28.850	1.628	29.100	.690	29.600	.440

TABLE 13. (CONTINUED)

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
14	1	50.875	5.460	51.275	4.400	52.750	1.488	52.950	1.748
	2	28.950	.848	29.300	.510	29.300	.510	29.350	.328
15	1	52.825	2.595	53.075	3.020	54.150	.928	54.500	1.150
	2	29.325	.569	29.400	.540	29.650	.228	29.550	.248
16	1	54.650	2.428	54.650	2.428	55.950	1.048	55.850	.828
	2	29.550	.398	29.650	.278	29.900	.090	29.800	.160
17	1	56.125	2.110	55.850	2.178	57.300	.810	57.050	.748
	2	29.825	.144	29.775	.174	29.900	.090	30.000	.000
18	1	57.150	1.728	56.950	2.548	58.200	.760	58.200	.660
	2	29.900	.090	29.775	.324	30.000	.000	29.950	.048
19	1	58.400	1.090	58.400	1.240	59.250	.188	59.300	.410
	2	29.975	.024	29.900	.090	30.000	.000	30.000	.000
20	1	59.225	.525	59.100	.540	59.800	.160	59.600	.240
	2	29.975	.024	30.000	.000	30.000	.000	30.000	.000
21	1	59.700	.210	59.650	.328	60.000	.000	60.000	.000
	2	30.000	.000	30.000	.000	30.000	.000	30.000	.000

TABLE 14. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M2, S1, L2.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.600	14.840	31.800	13.310	29.000	16.300	29.500	8.550
	2	23.300	4.360	23.800	5.410	27.750	45.588	27.600	33.240
2	1	33.750	10.788	33.825	18.294	33.300	7.710	33.600	11.340
	2	24.400	8.390	25.000	5.050	25.100	21.990	25.800	23.260
3	1	34.075	11.069	32.275	11.949	35.400	3.640	33.450	4.748
	2	23.550	7.098	23.250	6.988	23.850	5.528	23.800	6.460
4	1	33.575	7.094	33.500	10.500	35.600	3.040	35.900	6.990
	2	23.025	5.774	23.000	6.050	24.000	4.500	24.000	6.000
5	1	36.000	7.850	36.125	6.259	38.200	2.260	38.100	2.090
	2	24.075	4.119	23.250	3.738	24.400	3.340	23.800	3.060
6	1	37.450	3.098	37.475	3.849	38.850	1.428	38.850	1.428
	2	24.200	3.560	23.825	6.194	24.900	2.290	23.750	3.588
7	1	38.600	3.690	38.725	2.499	40.050	1.448	40.050	.948
	2	24.025	5.374	24.500	4.350	25.200	3.860	24.800	3.660
8	1	39.925	3.169	40.450	3.798	41.450	.548	42.000	1.900
	2	24.675	3.869	25.425	3.644	25.300	2.310	26.050	3.848
9	1	41.875	2.709	42.050	2.898	43.050	1.548	43.450	1.148
	2	25.250	4.388	25.050	2.198	25.500	4.450	25.450	2.748
10	1	42.900	3.090	42.775	2.374	44.250	1.088	44.000	1.300
	2	25.325	3.769	25.750	3.488	26.300	2.510	26.350	2.428
11	1	43.125	2.759	43.900	2.840	44.350	.328	45.150	1.128
	2	25.400	2.090	25.575	1.894	25.700	2.010	25.900	1.690
12	1	44.550	1.798	44.575	3.694	45.650	.728	46.150	1.528
	2	25.825	1.494	25.900	1.940	26.100	1.390	26.250	1.988
13	1	45.925	3.069	46.225	1.724	47.400	.940	47.250	.788
	2	25.700	1.460	26.075	2.119	26.100	.990	26.600	1.640

TABLE 14. (CONTINUED)

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
14	1	46.675	4.569	46.800	2.810	48.350	2.528	48.100	1.590
	2	26.250	1.238	25.875	1.609	26.800	.660	26.350	1.728
15	1	48.075	2.669	48.325	3.619	49.350	1.028	49.850	1.628
	2	26.075	1.219	25.875	1.009	26.700	.610	26.350	.528
16	1	49.600	2.890	50.350	2.228	51.000	.600	51.500	.450
	2	26.250	.638	26.550	.398	26.600	.240	26.850	.228
17	1	50.975	1.475	50.775	1.525	51.950	.548	51.700	.610
	2	26.775	.524	26.675	.319	27.000	.300	26.800	.260
18	1	51.450	1.698	51.050	1.148	52.550	.348	51.800	.560
	2	26.475	.399	26.350	.378	26.850	.128	26.650	.228
19	1	52.425	.745	52.375	.735	53.100	.390	53.100	.090
	2	26.775	.224	26.800	.160	27.000	.100	27.000	.000
20	1	53.025	.575	53.050	.498	53.600	.240	53.550	.248
	2	27.025	.274	27.050	.198	27.200	.160	27.250	.188
21	1	53.300	.560	53.250	.588	53.850	.328	53.850	.228
	2	27.275	.249	27.050	.348	27.400	.240	27.350	.228
22	1	53.825	.345	53.850	.428	54.200	.160	54.250	.188
	2	27.125	.109	27.150	.128	27.200	.160	27.250	.188
23	1	54.250	.238	54.275	.250	54.500	.350	54.550	.348
	2	27.225	.174	27.250	.188	27.450	.248	27.500	.250
24	1	54.450	.398	54.250	.188	54.900	.390	54.500	.250
	2	27.375	.234	27.250	.188	27.750	.188	27.500	.250
25	1	54.725	.450	54.650	.478	55.250	.188	55.250	.188
	2	27.600	.240	27.525	.249	28.000	.000	28.000	.000
26	1	55.525	.400	55.325	.420	56.000	.000	55.850	.128
	2	27.925	.069	27.900	.090	28.000	.000	28.000	.000

TABLE 15. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M2, S1, L3.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.975	15.874	32.350	10.878	29.150	12.828	29.900	9.290
	2	23.675	4.519	24.225	4.874	28.200	48.060	27.850	34.728
2	1	33.150	13.878	32.950	17.648	31.350	5.428	32.800	9.560
	2	23.875	11.059	24.775	7.924	25.350	48.828	25.550	19.648
3	1	32.525	14.949	31.800	11.210	32.500	2.050	32.400	2.540
	2	22.725	11.449	22.950	8.698	22.600	9.540	23.050	9.248
4	1	33.175	2.794	32.425	2.744	34.350	1.428	33.650	1.728
	2	22.225	6.874	21.275	10.199	22.750	8.488	21.750	11.888
5	1	34.275	1.699	34.600	1.590	35.300	.510	35.650	.528
	2	22.925	11.669	21.875	13.459	24.200	12.660	23.300	13.110
6	1	35.425	1.444	35.725	1.399	36.450	.448	36.600	.540
	2	22.800	14.610	24.100	10.990	23.600	14.340	25.050	9.648
7	1	36.200	1.360	35.975	.974	37.100	.690	36.750	.488
	2	23.050	12.048	22.550	13.248	23.750	12.588	23.050	12.348
8	1	37.150	.728	37.500	1.400	37.800	.360	38.400	.340
	2	22.700	12.210	22.750	13.038	22.300	13.310	22.900	13.090
9	1	38.250	.938	37.975	.624	38.950	.548	38.500	.350
	2	22.600	10.940	23.850	12.578	23.150	12.228	23.700	14.710
10	1	38.675	.519	38.925	1.119	39.150	.128	39.700	.710
	2	22.225	9.724	22.450	12.498	21.050	5.148	22.900	11.590
11	1	39.650	.978	39.875	.709	40.400	.340	40.500	.450
	2	22.600	10.640	22.625	10.484	23.100	12.390	23.800	13.860
12	1	40.000	.150	40.075	.169	40.150	.128	40.250	.188
	2	20.675	.269	20.550	.248	20.750	.188	20.750	.188
13	1	40.275	.299	40.125	.159	40.550	.448	40.300	.210
	2	20.750	.388	20.500	.300	20.800	.560	20.600	.340

TABLE 15. (CONTINUED)

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
14	1	40.400	.340	40.525	.299	40.800	.360	41.050	.048
	2	20.825	.344	20.925	.519	21.100	.290	21.450	.248
15	1	41.500	.350	41.425	.294	42.000	.000	41.900	.090
	2	21.275	.299	21.475	.249	21.150	.128	21.350	.228
16	1	41.900	.090	41.850	.128	42.000	.000	42.000	.000
	2	21.350	.228	21.350	.228	21.200	.160	21.250	.188
17	1	42.000	.000	42.000	.000	42.000	.000	42.000	.000
	2	21.275	.199	21.225	.174	21.300	.210	21.200	.160
18	1	42.000	.000	42.000	.000	42.000	.000	42.000	.000
	2	21.225	.174	21.350	.228	21.150	.128	21.300	.210
19	1	42.000	.000	42.025	.024	42.000	.000	42.050	.048
	2	21.225	.174	21.175	.144	21.150	.128	21.200	.160
20	1	42.025	.024	42.025	.024	42.050	.048	42.050	.048
	2	21.125	.109	21.225	.174	21.200	.160	21.250	.188
21	1	42.025	.024	42.025	.024	42.050	.048	42.050	.048
	2	21.025	.024	21.150	.128	21.050	.048	21.050	.048
22	1	42.050	.048	42.125	.109	42.100	.090	42.250	.188
	2	21.050	.048	21.125	.109	21.100	.090	21.250	.188
23	1	42.200	.160	42.150	.128	42.400	.240	42.300	.210
	2	21.200	.160	21.150	.128	21.400	.240	21.300	.210
24	1	42.075	.069	42.075	.069	42.150	.128	42.150	.128
	2	21.075	.069	21.075	.069	21.150	.128	21.150	.128
25	1	42.250	.188	42.425	.294	42.500	.250	42.850	.228
	2	21.250	.188	21.400	.240	21.500	.250	21.800	.160
26	1	42.500	.400	42.800	.510	43.000	.300	43.350	.228
	2	21.425	.244	21.625	.234	21.850	.128	22.000	.000

TABLE 16. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M2, S1, L4.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	32.000	15.650	32.450	10.548	29.200	12.660	30.050	9.448
	2	23.675	4.819	24.250	4.788	28.250	48.288	27.850	34.728
2	1	33.425	11.344	33.125	18.159	31.900	7.590	33.300	9.410
	2	23.950	9.148	24.075	11.169	25.750	35.988	24.250	11.488
3	1	32.450	12.348	31.325	6.069	33.100	2.390	32.150	1.728
	2	22.100	17.140	21.975	11.774	21.800	13.160	23.050	7.248
4	1	32.850	1.628	32.300	3.060	33.850	.528	33.750	.988
	2	21.650	10.378	22.075	11.219	22.450	12.248	23.050	11.048
5	1	33.550	1.698	34.100	1.640	34.600	.540	35.150	.428
	2	20.825	12.694	22.775	12.124	21.700	13.510	24.300	11.810
6	1	34.625	1.634	34.475	.899	35.600	.540	35.250	.388
	2	22.475	15.049	21.925	14.769	23.550	14.848	21.800	14.460
7	1	35.575	.894	35.750	.788	36.300	.210	36.350	.328
	2	23.325	12.219	23.400	11.790	23.500	12.050	23.050	13.148
8	1	36.375	.884	36.050	.698	37.050	.648	36.650	.328
	2	22.850	16.828	22.625	12.484	23.500	17.350	23.150	13.228
9	1	36.600	.640	36.450	.648	37.200	.260	37.100	.290
	2	23.100	13.090	24.050	9.348	23.800	11.060	24.550	12.548
10	1	37.650	1.078	37.450	.848	38.450	.448	38.150	.128
	2	23.600	16.490	23.175	16.744	23.650	17.528	23.250	18.588
11	1	38.450	.698	38.325	.619	39.100	.290	38.950	.248
	2	23.350	16.828	23.450	16.448	23.700	15.310	22.300	14.010
12	1	39.475	.399	39.525	.749	40.050	.048	40.200	.260
	2	21.125	6.909	21.400	7.640	20.550	3.048	20.500	.350
13	1	40.100	.140	40.325	.219	40.250	.188	40.650	.228
	2	21.500	7.400	20.850	1.728	22.100	9.090	21.350	2.728

TABLE 16. (CONTINUED)

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
14	1	40.250	.238	40.150	.128	40.550	.248	40.300	.210
	2	22.925	11.219	22.475	10.649	22.550	8.048	21.900	7.290
15	1	40.325	.319	40.200	.210	40.700	.310	40.400	.340
	2	22.975	11.724	22.850	12.728	22.950	11.248	22.750	12.288
16	1	40.850	.378	40.975	.474	41.250	.188	41.450	.248
	2	25.325	12.269	24.650	12.828	26.500	6.750	25.800	9.060
17	1	41.700	.310	41.725	.199	42.050	.048	42.000	.000
	2	24.175	9.994	24.075	10.469	24.500	10.250	23.000	8.500
18	1	42.025	.024	42.250	.188	42.050	.048	42.500	.250
	2	25.150	11.078	25.075	10.669	24.650	11.328	25.550	9.248
19	1	42.725	.249	42.500	.250	43.050	.048	43.000	.000
	2	24.675	7.619	25.675	8.369	24.050	5.348	25.350	7.128
20	1	42.225	.274	42.250	.188	42.500	.350	42.500	.250
	2	25.350	9.478	24.475	10.599	24.750	8.988	24.100	8.790
21	1	42.700	.410	42.450	.298	43.200	.160	42.900	.190
	2	24.250	8.938	23.175	6.644	25.100	6.990	23.850	4.728
22	1	43.750	.288	43.600	.340	44.100	.090	44.050	.048
	2	25.150	8.228	24.700	7.460	24.800	8.460	24.550	8.148
23	1	43.875	.259	43.975	.174	44.150	.128	44.150	.128
	2	26.050	7.398	24.925	8.619	25.600	8.640	24.250	7.688
24	1	44.300	.210	44.225	.274	44.600	.240	44.500	.350
	2	25.150	8.228	24.675	8.019	25.000	7.500	24.950	7.748
25	1	44.675	.319	44.825	.644	45.050	.048	45.450	.348
	2	25.825	6.944	24.625	6.284	26.500	5.250	23.800	3.160
26	1	45.300	.310	45.300	.560	45.700	.210	45.800	.460
	2	24.600	5.590	25.175	6.044	23.750	3.188	24.150	3.928

TABLE 17. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M2, S2, L1.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.750	15.988	30.850	14.078	32.100	9.290	31.600	7.640
	2	23.900	6.140	23.100	5.590	23.600	4.240	25.300	26.410
2	1	32.875	13.259	32.925	9.219	34.000	2.200	35.900	3.290
	2	23.850	4.878	24.275	5.699	24.700	1.810	26.500	2.450
3	1	34.800	12.260	34.025	11.074	36.900	4.890	36.000	5.400
	2	24.775	4.124	24.475	3.799	25.800	1.360	25.900	2.090
4	1	36.625	9.084	37.100	11.040	38.900	5.690	41.200	1.760
	2	24.775	3.474	25.525	3.599	25.800	1.960	27.100	1.290
5	1	40.375	7.334	40.975	7.824	43.500	1.650	44.100	1.490
	2	26.725	2.899	26.475	3.099	28.400	1.440	27.400	1.440
6	1	44.100	4.940	43.125	3.709	46.900	2.090	45.200	2.360
	2	27.500	2.250	27.175	2.094	28.400	2.040	28.100	1.290
7	1	45.925	3.269	45.400	7.440	47.600	1.240	48.200	3.560
	2	28.325	1.419	28.050	1.648	28.700	1.210	29.100	.490
8	1	47.625	7.184	47.725	6.649	51.200	.560	51.000	2.800
	2	28.250	2.088	28.325	1.419	29.100	1.090	29.200	.560
9	1	51.625	3.035	50.450	2.898	53.500	.850	52.600	.240
	2	29.325	.719	28.725	1.149	29.700	.210	29.100	.690
10	1	52.925	3.620	53.525	3.800	55.100	1.290	55.700	.810
	2	29.550	.548	29.575	1.194	29.800	.160	29.900	.490
11	1	55.400	2.640	55.125	2.210	57.500	.450	56.900	.890
	2	29.625	.484	29.700	.460	30.100	.090	30.000	.200
12	1	57.050	1.898	57.325	1.720	58.700	.810	58.800	.560
	2	30.000	.200	29.850	.228	30.100	.090	30.100	.090
13	1	58.575	1.245	58.625	1.285	59.900	.290	60.000	.000
	2	30.000	.100	30.125	.159	30.100	.090	30.200	.160

TABLE 17. (CONTINUED)

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
14	1	59.875	.260	59.975	.175	60.300	.210	60.200	.160
	2	30.150	.128	30.200	.160	30.300	.210	30.200	.160
15	1	60.175	.145	60.175	.145	60.100	.090	60.300	.210
	2	30.175	.144	30.175	.144	30.100	.090	30.300	.210
16	1	60.175	.195	60.250	.188	60.500	.250	60.300	.210
	2	30.150	.128	30.250	.188	30.500	.250	30.300	.210
17	1	60.500	.400	60.375	.385	60.400	.240	60.300	.210
	2	30.425	.244	30.300	.210	30.400	.240	30.300	.210
18	1	60.225	.175	60.450	.298	60.400	.240	60.800	.160
	2	30.225	.174	30.425	.244	30.400	.240	30.800	.160
19	1	60.775	.575	60.675	.470	60.600	.240	61.000	.000
	2	30.575	.244	30.550	.248	30.600	.240	31.000	.000
20	1	60.775	.325	60.875	.360	61.000	.000	61.000	.000
	2	30.700	.210	30.750	.188	31.000	.000	31.000	.000
21	1	60.925	.520	61.050	.498	61.000	.000	61.000	.000
	2	30.700	.210	30.775	.174	31.000	.000	31.000	.000
22	1	60.950	.448	60.775	.375	61.000	.000	61.000	.000
	2	30.750	.188	30.675	.219	31.000	.000	31.000	.000
23	1	60.950	.548	61.050	.548	61.000	.000	60.900	.090
	2	30.700	.210	30.750	.188	31.000	.000	30.900	.090
24	1	61.000	.350	61.050	.548	61.000	.000	60.800	.160
	2	30.825	.144	30.750	.188	31.000	.000	30.800	.160
25	1	60.750	.438	60.800	.410	61.000	.000	60.900	.090
	2	30.625	.234	30.675	.219	31.000	.000	30.900	.090
26	1	60.900	.490	60.925	.570	60.700	.210	60.700	.210
	2	30.700	.210	30.675	.219	30.700	.210	30.700	.210

TABLE 18. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M2, S2, L2.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.600	14.840	31.800	13.310	32.300	9.610	31.900	4.090
	2	23.300	4.360	23.800	5.410	23.800	3.360	24.000	1.800
2	1	31.850	6.278	32.300	9.010	34.700	2.010	36.200	1.960
	2	22.475	5.699	23.425	3.744	23.900	4.090	24.100	4.290
3	1	36.525	5.499	35.750	4.388	39.600	2.840	38.500	2.050
	2	23.950	5.248	23.725	4.399	24.400	4.440	24.300	4.410
4	1	38.650	2.378	38.150	4.628	40.700	.410	40.800	1.360
	2	24.400	4.240	24.550	4.798	24.400	2.240	25.000	5.200
5	1	40.350	2.728	40.500	3.750	42.400	.440	42.500	.450
	2	24.050	2.948	25.100	3.440	24.400	2.840	24.600	3.240
6	1	42.350	2.778	41.875	2.159	44.700	.610	43.700	.610
	2	23.775	2.074	24.100	3.140	24.800	1.760	25.500	3.850
7	1	44.250	2.088	44.075	3.919	46.000	1.400	46.800	.760
	2	25.225	1.824	25.050	2.898	25.300	.810	26.800	1.760
8	1	47.200	4.510	47.275	3.299	49.900	.690	49.600	.440
	2	25.950	1.948	26.025	1.274	26.500	1.050	25.700	1.410
9	1	49.550	.348	49.300	.960	50.100	.090	50.400	.240
	2	25.600	.890	26.200	1.360	25.300	.410	26.200	1.760
10	1	50.500	.400	50.225	.525	51.100	.090	51.200	.160
	2	26.100	.740	25.825	.944	26.500	.250	26.400	.440
11	1	50.625	.735	50.700	.860	51.800	.560	51.700	.610
	2	25.575	.394	25.825	.394	26.300	.210	26.300	.210
12	1	51.600	.940	51.475	.700	52.800	.160	52.400	.240
	2	26.275	.499	26.100	.340	27.000	.000	26.800	.160
13	1	51.800	.660	51.800	.860	52.800	.160	53.000	.000
	2	26.200	.260	26.275	.349	26.800	.160	27.000	.000

TABLE 18. (CONTINUED)

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
14	1	52.775	.575	52.875	.460	53.800	.160	53.700	.210
	2	26.650	.228	26.750	.188	27.000	.000	27.000	.000
15	1	53.525	.300	53.600	.390	54.000	.000	54.000	.000
	2	26.975	.024	26.950	.048	27.000	.000	27.000	.000
16	1	54.000	.000	54.000	.000	54.000	.000	54.000	.000
	2	27.000	.000	27.000	.000	27.000	.000	27.000	.000

TABLE 19. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M2, S2, L3.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.975	15.874	32.350	10.878	32.200	6.560	32.400	4.040
	2	23.675	4.519	24.225	4.874	23.600	5.440	24.400	1.240
2	1	30.725	5.399	30.925	5.069	34.000	1.000	33.800	1.160
	2	21.550	10.248	22.025	10.574	23.400	8.240	22.800	6.560
3	1	34.600	1.490	34.800	1.560	36.100	.890	36.400	.240
	2	21.625	10.384	23.550	9.098	21.400	7.440	25.000	5.600
4	1	36.500	1.600	36.375	1.584	38.000	.800	38.000	.200
	2	21.925	6.769	21.650	8.628	20.600	3.440	20.800	5.560
5	1	37.350	.678	37.625	.984	38.200	.160	38.800	.160
	2	21.100	5.740	21.175	5.344	20.300	3.610	20.700	2.810
6	1	39.175	.494	39.300	.410	40.000	.000	40.100	.090
	2	19.875	.109	20.025	.174	20.000	.000	20.300	.210
7	1	39.925	.269	40.050	.148	40.400	.240	40.400	.240
	2	20.100	.090	20.100	.090	20.400	.240	20.400	.240
8	1	40.000	.000	40.025	.024	40.000	.000	40.100	.090
	2	20.000	.000	20.025	.024	20.000	.000	20.100	.090
9	1	40.150	.128	40.075	.069	40.600	.240	40.300	.210
	2	20.150	.128	20.075	.069	20.600	.240	20.300	.210
10	1	40.000	.000	40.000	.000	40.000	.000	40.000	.000
	2	20.000	.000	20.000	.000	20.000	.000	20.000	.000

TABLE 20. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M2, S2, L4.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	32.000	15.650	32.450	10.548	32.200	6.560	32.600	3.640
	2	23.675	4.819	24.250	4.788	25.100	23.890	24.400	1.240
2	1	30.650	6.028	31.100	5.340	33.600	.840	33.600	1.240
	2	21.625	8.684	22.400	6.340	21.300	9.410	22.100	4.690
3	1	34.225	1.624	34.175	1.044	35.700	.210	35.400	.240
	2	21.225	9.874	22.000	11.250	21.400	11.040	23.300	12.410
4	1	35.050	.998	35.100	.890	36.300	.210	36.200	.160
	2	22.200	10.810	21.550	8.298	23.100	7.290	22.600	7.640
5	1	35.900	.490	36.000	.550	36.700	.210	37.000	.000
	2	22.275	9.749	22.100	8.190	22.800	10.160	23.000	4.000
6	1	36.925	.569	37.050	.548	37.900	.290	38.000	.000
	2	21.750	6.988	21.325	7.019	20.100	3.890	19.500	2.250
7	1	37.975	.224	37.900	.440	38.400	.240	38.500	.250
	2	19.725	2.699	19.700	2.810	19.400	.240	19.500	.250
8	1	38.825	.494	38.800	.310	39.700	.210	39.300	.210
	2	19.650	.228	19.725	.199	20.000	.000	20.000	.000
9	1	39.725	.199	39.475	.449	40.000	.000	40.000	.000
	2	20.000	.000	19.900	.090	20.000	.000	20.000	.000
10	1	40.000	.000	40.000	.000	40.000	.000	40.000	.000
	2	20.000	.000	20.000	.000	20.000	.000	20.000	.000

TABLE 21. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M2, S3, L1.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.750	15.988	30.850	14.078	34.600	5.040	34.000	3.200
	2	23.900	6.140	23.100	5.590	24.800	2.960	25.200	6.160
2	1	34.600	10.340	33.600	9.390	34.800	1.760	36.000	.800
	2	24.900	4.990	24.550	4.698	25.600	1.840	25.800	3.760
3	1	35.475	7.499	34.925	8.219	39.800	2.160	38.000	2.400
	2	24.150	4.428	24.025	3.224	26.200	2.960	24.400	3.840
4	1	38.125	6.859	38.725	6.449	41.800	1.760	42.800	2.160
	2	24.550	3.648	24.750	3.288	25.400	1.840	26.800	2.560
5	1	42.075	5.369	42.150	5.428	45.200	.160	46.400	1.440
	2	26.100	2.840	26.550	3.148	27.200	.960	27.200	1.360
6	1	45.200	4.510	46.875	5.059	49.000	1.600	50.400	.240
	2	27.150	2.528	27.400	2.690	28.600	2.640	28.800	2.160
7	1	49.425	3.344	49.625	3.534	52.400	.240	52.600	.240
	2	28.575	1.644	29.000	1.250	29.200	.960	29.600	1.040
8	1	52.575	4.245	52.550	2.548	55.800	.960	55.000	.000
	2	29.325	.869	29.450	.598	30.200	.160	30.000	.000
9	1	55.475	1.800	55.250	2.138	57.000	.000	57.600	.640
	2	29.925	.369	29.600	.790	30.000	.000	30.600	.240
10	1	57.100	1.290	57.250	1.538	58.800	.960	59.400	.240
	2	30.075	.219	30.200	.310	30.200	.160	30.800	.160
11	1	59.075	1.570	59.050	1.098	60.600	.240	60.400	.240
	2	30.250	.388	30.425	.244	30.800	.160	30.600	.240
12	1	60.525	.500	60.525	.700	61.000	.000	61.000	.000
	2	30.600	.240	30.600	.240	31.000	.000	31.000	.000
13	1	61.000	.500	61.050	.398	61.000	.000	61.000	.000
	2	30.750	.188	30.825	.144	31.000	.000	31.000	.000

TABLE 21. (CONTINUED)

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
14	1	60.750	.488	61.100	.540	61.000	.000	61.000	.000
	2	30.600	.240	30.775	.174	31.000	.000	31.000	.000
15	1	61.075	.620	60.875	.460	61.000	.000	61.000	.000
	2	30.725	.199	30.700	.210	31.000	.000	31.000	.000
16	1	60.850	.528	60.975	.525	61.000	.000	61.000	.000
	2	30.650	.228	30.725	.199	31.000	.000	31.000	.000
17	1	61.075	.470	61.125	.410	61.000	.000	61.000	.000
	2	30.800	.160	30.850	.128	31.000	.000	31.000	.000
18	1	60.925	.520	61.125	.510	61.000	.000	61.000	.000
	2	30.700	.210	30.800	.160	31.000	.000	31.000	.000
19	1	61.125	.510	60.975	.525	61.000	.000	61.000	.000
	2	30.800	.160	30.725	.199	31.000	.000	31.000	.000
20	1	60.975	.375	61.050	.498	61.000	.000	61.000	.000
	2	30.800	.160	30.775	.174	31.000	.000	31.000	.000
21	1	60.925	.520	61.050	.498	61.000	.000	61.000	.000
	2	30.700	.210	30.775	.174	31.000	.000	31.000	.000
22	1	60.950	.448	60.775	.375	61.000	.000	61.000	.000
	2	30.750	.188	30.675	.219	31.000	.000	31.000	.000
23	1	60.950	.548	61.050	.548	61.000	.000	61.000	.000
	2	30.700	.210	30.750	.188	31.000	.000	31.000	.000
24	1	61.000	.350	61.175	.595	61.000	.000	61.000	.000
	2	30.825	.144	30.775	.174	31.000	.000	31.000	.000
25	1	60.850	.478	60.875	.410	61.000	.000	61.000	.000
	2	30.675	.219	30.725	.199	31.000	.000	31.000	.000
26	1	60.975	.475	61.000	.650	61.000	.000	61.000	.000
	2	30.750	.188	30.675	.219	31.000	.000	31.000	.000

TABLE 22. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M2, S3, L2.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.600	14.840	31.800	13.310	34.400	8.240	33.400	3.440
	2	23.300	4.360	23.800	5.410	24.800	4.160	24.200	2.560
2	1	33.425	4.844	33.875	6.259	36.800	2.160	38.000	.400
	2	23.825	6.394	23.500	7.000	25.800	1.360	23.800	5.360
3	1	38.600	4.190	38.450	3.698	41.800	.160	41.600	.240
	2	22.225	3.974	22.375	4.934	22.800	.560	24.000	3.600
4	1	41.725	1.949	41.550	2.348	44.000	.800	44.000	.400
	2	22.825	1.444	22.975	1.524	24.000	.800	24.400	1.040
5	1	43.350	1.678	44.100	1.790	45.600	.640	46.600	1.040
	2	23.000	.850	23.625	1.134	24.600	1.040	25.200	1.360
6	1	47.125	1.709	46.750	2.288	49.000	.000	49.200	.160
	2	24.700	.810	24.525	.899	25.400	.240	25.400	.240
7	1	48.275	.199	48.525	.399	49.000	.000	49.600	.240
	2	24.550	.348	24.900	.440	25.000	.000	25.400	.240
8	1	48.550	.348	48.525	.349	49.400	.240	49.400	.240
	2	24.550	.348	24.525	.349	25.400	.240	25.400	.240
9	1	49.350	.578	49.400	.690	50.600	.240	50.600	.240
	2	25.175	.394	25.300	.610	25.800	.560	26.200	.560
10	1	50.375	.735	50.250	.538	52.200	.160	51.400	.240
	2	25.425	.494	25.375	.334	27.000	.000	26.400	.240
11	1	52.450	.648	52.350	.678	53.800	.160	53.600	.240
	2	26.575	.244	26.475	.249	27.000	.000	27.000	.000
12	1	53.775	.175	53.850	.128	54.000	.000	54.000	.000
	2	27.000	.000	27.000	.000	27.000	.000	27.000	.000

TABLE 23. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M2, S3, L3.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.975	15.874	32.350	10.878	34.000	4.800	33.600	5.040
	2	23.675	4.519	24.225	4.874	25.400	1.440	24.800	.160
2	1	32.050	3.148	32.000	4.200	34.800	.560	35.200	.160
	2	22.525	4.199	21.500	10.500	22.400	11.840	19.200	5.760
3	1	35.125	1.159	34.925	1.369	36.800	.560	36.800	.560
	2	22.325	8.269	21.075	9.769	23.400	7.440	22.200	11.760
4	1	37.750	1.588	37.900	1.040	39.800	.160	39.600	.240
	2	22.200	8.660	22.775	6.924	21.200	3.760	21.000	4.000
5	1	38.950	1.398	39.075	.819	40.000	.000	40.000	.000
	2	21.775	6.424	21.750	5.688	20.000	.000	20.000	.000
6	1	40.000	.000	40.000	.000	40.000	.000	40.000	.000
	2	20.000	.000	20.000	.000	20.000	.000	20.000	.000

TABLE 24. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M2, S3, L4.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	32.000	15.650	32.450	10.548	34.000	4.800	33.600	5.040
	2	23.675	4.819	24.250	4.788	25.400	1.440	25.000	.400
2	1	31.850	2.828	32.150	4.378	34.600	.240	35.400	.240
	2	22.425	5.344	21.825	8.444	20.400	8.640	19.200	5.760
3	1	35.475	.499	35.100	.690	36.600	.240	36.200	.160
	2	21.125	8.909	20.050	7.948	22.800	5.760	20.600	7.840
4	1	36.700	.410	36.800	.760	37.800	.160	38.000	.000
	2	20.700	7.410	20.525	6.399	20.000	4.000	20.000	4.000
5	1	37.600	.290	37.675	.319	38.000	.000	38.000	.000
	2	20.850	5.978	20.075	4.519	19.000	.000	19.000	.000
6	1	38.000	.000	38.000	.000	38.000	.000	38.000	.000
	2	19.000	.000	19.000	.000	19.000	.000	19.000	.000

TABLE 25. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M3, S1, L1.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.750	15.988	30.850	14.078	43.200	9.660	40.750	9.288
	2	39.950	25.048	38.450	21.248	33.300	11.310	31.550	14.148
2	1	33.025	18.624	31.225	14.974	43.300	9.810	41.900	11.090
	2	40.550	28.748	39.200	22.360	35.450	13.148	32.050	9.148
3	1	34.000	15.250	33.975	13.374	43.600	3.040	43.150	7.928
	2	40.625	18.034	40.200	18.360	34.850	12.228	35.600	11.340
4	1	35.350	16.878	35.525	12.049	42.400	5.740	43.750	9.888
	2	39.500	12.850	40.750	17.088	36.800	18.160	36.500	8.950
5	1	36.875	16.759	36.550	17.698	44.400	5.540	43.550	6.448
	2	41.575	14.944	40.400	18.140	38.400	8.540	38.200	12.860
6	1	39.250	17.488	39.200	19.660	45.250	8.188	43.550	4.348
	2	41.375	24.134	41.275	15.199	40.400	10.640	40.150	17.728
7	1	39.700	17.810	40.550	16.848	44.700	4.110	43.850	5.728
	2	41.525	17.699	40.750	14.238	40.650	10.928	40.900	16.190
8	1	40.000	12.100	40.675	13.569	43.900	6.490	43.050	2.548
	2	41.450	14.598	39.950	14.348	41.150	14.928	41.400	11.840
9	1	41.275	10.749	41.300	15.910	44.450	3.348	44.500	3.750
	2	41.900	10.440	41.350	16.278	41.800	12.160	41.450	13.748
10	1	41.050	15.898	41.650	21.678	43.500	4.150	44.200	6.960
	2	40.850	12.178	41.150	14.628	41.850	12.528	41.300	22.710
11	1	42.275	18.049	40.625	18.234	44.650	5.828	42.500	4.550
	2	41.725	12.199	40.075	15.669	42.650	11.228	40.900	11.390
12	1	42.325	7.369	42.575	16.994	43.500	3.950	44.400	3.340
	2	40.850	17.928	41.725	14.849	42.000	6.800	44.100	13.090
13	1	42.625	10.084	43.700	11.660	44.450	2.148	44.300	5.610
	2	41.750	10.938	41.050	12.298	43.600	8.440	43.600	11.340

TABLE 25. (CONTINUED)

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
14	1	43.575	10.594	44.025	9.874	44.000	6.100	43.900	1.490
	2	39.825	13.144	40.800	13.810	41.500	22.450	42.650	15.628
15	1	44.250	8.538	43.725	12.249	44.850	4.428	43.850	3.428
	2	41.775	15.274	40.575	13.794	43.500	8.950	43.600	12.540
16	1	44.400	17.590	43.950	12.698	43.550	3.648	44.150	3.328
	2	40.800	11.710	40.875	16.509	43.750	18.888	43.750	13.288
17	1	44.750	12.638	43.725	11.299	43.350	3.028	44.800	2.260
	2	40.825	7.194	42.225	8.974	43.500	14.750	44.000	11.800
18	1	44.650	10.978	44.800	12.960	45.500	1.650	43.100	2.890
	2	41.075	18.719	41.225	5.874	44.350	10.328	45.850	11.028
19	1	46.500	10.650	46.525	7.399	45.250	5.188	44.600	2.740
	2	41.700	14.460	41.225	15.274	45.800	9.560	45.250	9.888
20	1	46.950	7.698	46.950	6.948	43.700	1.810	43.850	3.928
	2	41.250	7.938	40.875	7.909	45.700	10.810	46.150	18.328
21	1	46.650	14.178	46.975	8.874	44.000	4.400	44.400	3.640
	2	41.100	12.640	41.600	12.240	46.150	17.728	46.050	12.648
22	1	46.175	9.894	45.550	9.348	45.050	6.248	45.250	2.388
	2	41.725	10.899	41.825	10.594	45.550	12.548	44.900	12.490
23	1	46.550	10.198	45.850	10.228	45.650	10.628	43.450	7.148
	2	41.350	10.378	40.250	9.988	44.650	16.028	45.200	6.660
24	1	46.775	8.774	47.125	14.059	47.250	3.488	46.450	5.048
	2	42.100	13.490	41.225	11.824	42.900	14.190	43.700	23.010
25	1	47.500	6.950	47.400	10.740	46.800	6.560	46.350	6.228
	2	40.475	12.149	40.425	9.294	42.900	20.090	42.750	18.588
26	1	47.850	8.778	48.150	6.828	48.300	4.610	46.650	5.628
	2	40.200	11.710	40.650	9.078	39.000	13.100	41.850	22.128

TABLE 26. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M3, S1, L2.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.600	14.840	31.800	13.310	40.600	8.640	41.850	7.528
	2	38.300	18.710	39.600	22.490	32.300	18.510	33.150	9.928
2	1	34.750	26.338	34.225	21.524	43.050	2.648	45.200	11.660
	2	39.950	23.398	42.050	26.248	36.000	17.400	34.300	16.910
3	1	36.950	20.648	34.325	13.769	44.000	11.100	44.950	4.048
	2	39.625	35.934	40.825	23.744	36.850	17.228	36.500	7.250
4	1	36.550	11.048	36.075	12.819	45.100	10.490	42.900	12.590
	2	40.700	38.010	38.475	37.749	37.550	15.448	37.200	9.560
5	1	36.225	15.474	37.475	12.749	44.050	11.048	44.700	12.810
	2	38.850	37.778	39.625	44.684	37.250	5.888	39.000	8.100
6	1	38.650	6.878	39.500	8.150	45.800	8.460	43.550	6.848
	2	40.925	39.819	40.450	18.148	39.700	6.510	40.300	6.510
7	1	40.100	11.290	38.975	15.574	45.650	5.228	43.450	5.948
	2	41.275	27.199	38.725	37.249	40.300	5.310	39.200	15.060
8	1	39.575	14.194	39.650	14.078	44.150	5.128	44.500	11.550
	2	40.375	33.034	40.075	32.169	40.300	11.210	39.500	12.450
9	1	40.425	11.394	40.900	9.690	44.350	5.128	42.450	10.148
	2	38.850	46.778	37.925	31.719	41.600	10.040	41.400	11.340
10	1	40.900	11.590	41.325	8.419	42.550	7.448	44.100	6.290
	2	38.150	28.728	40.500	24.550	42.350	6.428	41.550	10.048
11	1	41.200	9.660	41.175	7.644	42.050	4.848	41.350	6.928
	2	38.375	21.384	37.500	21.450	41.500	6.550	41.300	7.610
12	1	41.625	11.634	41.225	11.124	43.650	7.328	43.450	5.448
	2	39.525	27.549	39.325	23.469	42.300	15.210	41.450	8.448
13	1	42.600	9.390	42.400	9.840	42.550	3.548	43.950	6.748
	2	38.850	20.528	40.250	22.088	42.650	15.728	42.750	11.488

TABLE 26. (CONTINUED)

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
14	1	44.875	9.759	44.975	12.724	43.600	3.140	42.400	4.940
	2	40.475	16.599	38.950	20.448	44.900	9.890	45.950	10.648
15	1	46.175	11.444	44.975	6.674	43.450	3.148	44.000	4.400
	2	39.550	18.898	39.475	20.999	44.450	17.548	43.900	16.190
16	1	44.375	8.284	44.475	7.349	43.200	4.360	44.200	4.060
	2	39.400	14.740	39.375	19.784	42.600	9.040	41.900	18.190
17	1	43.875	6.759	43.650	6.678	43.800	4.760	42.400	4.940
	2	36.225	27.774	35.400	30.040	37.800	33.860	36.950	53.848
18	1	42.500	4.850	42.700	3.210	44.100	1.190	43.150	1.428
	2	33.925	32.969	33.650	27.278	34.650	28.828	34.100	18.790
19	1	43.175	6.444	43.000	3.850	44.700	1.910	44.000	1.500
	2	32.800	14.910	31.925	22.069	32.550	14.848	30.550	18.548
20	1	43.550	3.098	43.775	2.724	44.900	1.490	44.900	.590
	2	30.400	14.190	30.325	12.519	31.450	13.348	29.950	17.248
21	1	45.350	3.528	44.900	2.340	46.900	.590	46.100	.790
	2	30.475	8.449	31.150	14.228	30.500	8.450	31.600	12.940
22	1	46.325	2.219	46.400	1.790	47.500	.450	47.550	.448
	2	32.050	10.198	30.550	10.948	31.550	13.748	30.450	7.648
23	1	47.350	2.178	47.750	.988	48.550	.648	48.550	.248
	2	30.575	13.294	30.775	11.774	30.950	18.648	30.050	8.948
24	1	48.775	1.774	48.250	2.388	49.850	.728	49.450	.748
	2	30.725	15.499	30.725	12.649	32.800	11.760	31.400	8.540
25	1	49.925	1.569	49.925	2.569	50.900	.790	51.150	1.028
	2	31.150	12.578	30.850	8.628	31.900	12.490	31.200	7.260
26	1	50.625	2.885	50.750	2.438	51.950	.748	52.000	.900
	2	31.575	6.094	31.150	8.378	31.300	6.410	31.100	8.190

TABLE 27. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M3, S1, L3.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.975	15.874	32.350	10.878	41.400	8.940	43.000	7.900
	2	39.050	21.048	40.325	21.169	33.000	19.200	33.800	6.760
2	1	36.550	14.048	34.300	12.960	44.400	5.940	43.750	6.388
	2	41.450	20.948	38.450	48.998	37.050	15.548	35.000	16.100
3	1	35.275	12.799	34.400	12.290	47.100	3.290	44.250	6.588
	2	42.875	32.659	39.025	62.624	36.300	5.210	34.200	7.660
4	1	37.475	12.899	37.000	13.150	44.800	5.760	46.750	6.988
	2	39.100	63.290	42.275	46.549	37.100	9.990	36.950	11.248
5	1	38.350	12.128	37.225	19.624	46.550	4.048	44.250	24.888
	2	41.300	59.160	35.075	127.369	37.600	4.940	37.200	10.960
6	1	38.275	15.199	38.500	16.550	47.900	6.290	44.650	10.328
	2	41.225	75.874	37.700	76.610	37.300	4.310	36.950	9.848
7	1	35.950	16.248	35.550	14.148	44.900	10.790	45.400	7.840
	2	36.650	104.628	38.700	77.560	36.250	6.988	36.650	5.328
8	1	35.675	11.019	36.575	11.094	38.200	100.660	47.850	3.528
	2	29.650	124.628	38.350	126.128	37.400	12.340	37.500	4.450
9	1	36.300	22.960	37.400	26.540	46.750	4.488	45.600	8.740
	2	38.850	97.578	36.175	110.744	36.950	6.648	37.200	10.060
10	1	37.250	13.138	36.225	15.174	47.350	2.228	46.850	6.628
	2	39.100	104.990	37.350	115.628	37.100	4.890	37.600	4.340
11	1	35.025	18.324	35.125	19.059	45.450	5.848	44.600	10.940
	2	37.050	112.598	37.700	71.310	36.300	5.210	35.950	9.448
12	1	36.300	20.110	37.600	17.590	46.200	2.960	45.650	2.128
	2	38.625	99.184	38.150	78.078	37.050	10.348	37.600	5.540
13	1	34.875	8.159	35.525	12.049	41.900	12.290	39.950	20.248
	2	32.775	95.924	32.275	80.149	34.900	7.790	35.650	20.728

TABLE 27. (CONTINUED)

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
14	1	35.650	19.528	36.350	12.728	45.150	4.528	44.600	2.540
	2	36.650	98.428	34.975	123.924	35.700	6.410	35.950	3.148
15	1	33.175	11.794	32.600	10.190	41.200	16.760	42.550	5.548
	2	30.875	131.059	32.125	128.309	34.100	21.890	35.000	4.700
16	1	32.250	5.638	33.775	11.024	39.600	5.540	43.000	6.300
	2	31.050	116.398	34.400	123.140	34.200	7.460	35.300	6.510
17	1	35.625	5.834	35.000	8.300	45.800	3.060	43.850	3.128
	2	38.325	104.069	36.700	93.110	35.800	3.360	35.800	3.360
18	1	33.200	6.860	32.325	4.819	36.400	32.840	40.600	3.640
	2	28.300	83.510	33.075	90.319	33.050	4.348	32.900	3.190
19	1	34.850	3.978	34.450	4.248	35.000	55.700	38.950	20.748
	2	27.400	86.890	29.750	96.438	34.600	5.540	34.100	6.490
20	1	32.750	7.938	32.175	7.394	39.500	6.450	39.850	9.128
	2	31.600	84.940	31.575	86.894	33.550	5.048	33.350	3.428
21	1	35.300	8.860	35.275	7.299	41.600	26.340	43.850	6.428
	2	31.075	125.269	34.775	114.924	34.750	14.588	36.400	9.240
22	1	36.525	9.449	36.225	9.174	46.150	2.428	45.850	2.128
	2	38.400	99.890	37.650	110.378	37.700	1.310	36.800	5.660
23	1	35.450	4.998	36.100	4.890	35.700	33.610	38.650	60.228
	2	28.150	74.928	29.975	105.924	34.500	5.950	36.350	4.128
24	1	38.075	4.519	37.250	3.788	45.350	1.128	44.200	2.660
	2	37.375	112.684	35.875	98.859	38.800	1.360	38.300	2.510
25	1	36.825	3.544	36.475	3.899	36.450	54.848	31.950	66.848
	2	29.325	79.819	26.600	63.590	36.750	4.688	36.450	4.448
26	1	36.800	6.860	36.650	4.828	42.500	8.550	38.400	31.140
	2	34.900	75.140	30.850	76.228	38.050	7.748	36.750	5.588

TABLE 28. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M3, S1, L4.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	32.000	15.650	32.450	10.548	41.450	9.048	43.000	7.900
	2	39.025	21.824	40.300	20.560	33.100	18.490	33.800	6.760
2	1	36.500	12.400	34.350	12.178	44.250	6.688	43.850	8.828
	2	41.125	24.859	38.475	51.449	36.600	14.540	35.050	14.648
3	1	34.150	18.778	34.425	16.094	43.450	7.048	44.350	5.328
	2	38.075	65.069	38.475	70.799	34.100	8.990	35.000	9.100
4	1	34.550	10.848	34.200	4.910	45.000	8.500	44.900	5.890
	2	38.875	63.709	38.700	66.710	35.400	7.540	34.750	3.888
5	1	33.675	8.869	34.175	6.794	44.050	6.148	44.800	4.760
	2	33.900	132.190	36.625	119.534	33.350	9.028	34.550	5.548
6	1	34.700	6.110	34.050	9.298	44.850	6.028	43.750	7.988
	2	36.850	106.528	35.550	106.798	34.950	5.248	34.250	6.488
7	1	34.975	11.874	34.850	10.078	43.950	6.548	44.050	6.248
	2	36.800	85.560	39.175	53.744	34.950	6.848	34.700	6.210
8	1	35.375	7.884	36.025	10.874	44.100	7.490	43.600	8.340
	2	37.750	79.688	37.400	73.190	35.550	3.748	35.000	9.600
9	1	34.675	5.969	34.375	6.484	42.950	7.548	45.100	6.590
	2	34.700	110.510	38.525	94.549	34.450	5.448	34.850	7.228
10	1	35.175	4.844	33.950	5.098	45.950	1.848	45.150	1.928
	2	39.300	100.760	38.200	102.560	35.050	3.648	33.750	3.788
11	1	33.025	4.374	32.800	3.910	42.550	6.448	42.850	9.528
	2	32.825	119.094	33.800	124.360	33.050	2.248	33.800	2.260
12	1	33.925	5.469	33.175	4.044	44.400	5.940	42.850	6.028
	2	35.150	136.028	33.425	127.344	34.350	3.728	33.500	2.450
13	1	34.800	4.610	34.075	3.519	44.400	6.740	44.050	4.248
	2	37.125	104.459	34.625	123.084	35.100	4.190	34.100	2.890

TABLE 28. (CONTINUED)

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
14	1	34.850	2.428	35.400	3.590	45.050	2.048	45.050	1.748
	2	37.000	123.950	39.525	82.949	35.050	2.348	35.650	3.128
15	1	34.350	2.328	33.750	3.188	41.150	39.828	44.000	1.700
	2	30.075	143.569	35.625	121.284	34.150	2.928	34.150	3.628
16	1	34.025	1.924	34.525	2.549	44.250	.988	44.600	1.940
	2	35.500	119.650	37.325	111.269	34.200	1.460	34.450	1.648
17	1	33.350	4.228	33.900	3.240	44.700	2.510	45.050	1.348
	2	38.350	91.828	39.375	81.384	34.350	2.428	34.150	2.428
18	1	33.650	4.028	34.625	4.584	44.350	1.728	44.800	1.560
	2	35.425	118.044	36.025	122.874	33.800	3.160	34.850	2.228
19	1	33.550	3.248	33.300	3.660	43.900	1.990	43.650	4.628
	2	34.400	125.190	32.925	136.419	33.950	2.448	33.750	1.988
20	1	33.025	2.824	32.725	2.549	43.800	4.660	44.100	1.290
	2	32.750	136.638	34.175	136.694	33.450	1.548	33.150	2.228
21	1	33.925	3.519	34.550	3.248	44.200	.860	43.400	3.240
	2	35.825	111.744	34.150	119.078	33.200	2.360	34.450	2.348
22	1	33.950	3.548	35.125	3.309	44.050	1.448	44.050	1.848
	2	37.825	95.244	35.375	119.484	34.850	1.928	35.300	3.010
23	1	34.675	2.819	34.425	4.194	43.200	3.260	40.250	50.888
	2	31.850	131.878	30.525	120.699	34.350	2.428	34.300	3.810
24	1	33.525	3.849	33.975	4.474	43.950	1.448	43.300	1.510
	2	35.175	127.944	33.375	127.684	33.300	2.010	33.650	2.328
25	1	32.375	2.384	33.175	3.644	44.450	1.348	44.050	1.148
	2	35.875	137.009	35.525	126.749	33.100	1.790	33.350	1.928
26	1	32.750	2.488	32.850	5.428	43.350	3.128	44.200	2.860
	2	31.675	139.169	31.875	154.859	33.000	1.500	33.200	1.660

TABLE 29. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M3, S2, L1.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.750	15.988	30.850	14.078	45.700	5.610	43.200	4.160
	2	39.950	25.048	38.450	21.248	32.900	9.690	32.700	14.210
2	1	32.925	17.619	31.875	13.409	44.400	2.040	44.000	5.800
	2	40.350	14.678	40.350	20.728	36.600	8.640	32.800	10.360
3	1	34.225	13.924	34.450	11.998	46.600	6.440	46.500	3.250
	2	40.250	28.338	41.750	18.388	33.800	10.760	35.700	9.610
4	1	34.350	13.678	34.325	13.369	44.600	4.640	46.000	1.800
	2	39.450	18.148	40.225	17.074	37.300	7.610	35.900	10.290
5	1	37.225	9.374	35.650	15.128	48.000	3.200	46.000	3.000
	2	42.350	20.128	40.775	14.874	38.400	11.840	37.100	6.090
6	1	37.525	10.249	37.050	14.248	45.500	2.250	46.000	2.000
	2	40.400	14.590	41.025	17.774	39.700	2.610	36.800	12.560
7	1	38.150	17.078	38.550	8.798	46.800	3.560	46.700	1.010
	2	41.725	18.999	42.300	15.960	37.500	6.650	38.200	8.360
8	1	37.400	17.040	37.525	13.149	46.000	2.600	47.800	2.360
	2	41.950	13.598	40.925	31.119	38.600	25.640	38.600	22.640
9	1	39.350	15.128	38.450	25.398	45.500	2.850	46.300	3.610
	2	41.725	12.849	41.350	19.428	40.600	16.440	39.800	14.560
10	1	39.225	20.524	40.725	13.049	45.600	1.440	47.800	.960
	2	42.600	7.690	42.900	16.940	40.800	15.960	41.300	8.010
11	1	40.875	19.509	41.550	11.848	47.100	4.490	46.900	1.090
	2	41.850	16.778	42.000	15.200	42.600	13.640	41.000	11.800
12	1	42.125	12.159	42.025	15.724	47.600	6.240	47.500	1.850
	2	42.100	16.440	42.200	18.610	42.400	8.040	40.100	8.090
13	1	41.500	16.200	41.500	13.900	47.000	3.000	45.300	.810
	2	41.900	17.190	41.075	10.369	40.600	8.640	43.800	10.560

TABLE 29. (CONTINUED)

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
14	1	42.025	14.874	42.475	14.099	46.000	2.800	45.900	.890
	2	40.325	19.119	41.975	10.424	42.200	6.160	42.900	5.090
15	1	42.400	10.590	42.225	8.174	46.700	3.610	46.300	4.610
	2	41.375	17.334	41.625	15.134	42.100	7.690	41.300	5.210
16	1	41.750	9.838	41.325	10.419	45.800	4.760	44.400	1.240
	2	40.450	14.998	40.200	13.410	41.800	9.560	41.400	4.240
17	1	41.500	9.650	41.600	8.090	47.100	3.290	46.200	4.560
	2	41.075	19.019	41.425	16.094	42.900	8.090	42.300	5.010
18	1	42.025	11.374	42.225	12.774	45.200	.560	46.100	1.090
	2	40.625	15.484	42.000	11.700	43.900	9.890	43.600	9.640
19	1	43.750	9.838	43.825	10.694	45.900	1.090	45.600	7.440
	2	41.225	15.674	40.400	20.090	42.600	9.040	43.800	6.960
20	1	42.475	12.049	42.900	10.640	46.800	4.760	48.500	2.850
	2	41.000	19.450	42.375	21.884	43.500	9.050	44.500	7.650
21	1	44.075	12.519	43.450	8.498	46.300	1.010	45.700	1.610
	2	41.350	13.478	41.675	12.369	42.200	13.160	42.500	11.450
22	1	43.025	10.524	43.150	12.778	47.700	3.410	45.600	2.640
	2	41.650	23.528	41.000	14.150	43.200	9.560	44.400	11.040
23	1	44.025	12.224	43.825	14.344	46.200	2.960	46.500	5.650
	2	42.000	13.550	41.525	15.049	44.100	5.690	43.800	9.760
24	1	44.100	14.040	43.750	12.038	45.600	1.440	44.800	.960
	2	41.625	11.484	40.850	10.328	42.900	18.090	44.000	4.200
25	1	43.425	14.944	42.725	10.599	46.200	3.760	45.400	2.240
	2	42.300	11.710	41.425	9.144	42.000	12.400	40.400	4.040
26	1	40.775	11.924	40.500	13.100	44.300	2.010	44.300	2.010
	2	40.075	14.069	40.875	8.609	41.200	6.960	41.500	13.050

TABLE 30. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M3, S2, L2.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.600	14.840	31.800	13.310	42.800	6.160	44.100	2.890
	2	38.300	18.710	39.600	22.490	32.800	33.160	33.600	7.240
2	1	35.650	22.128	34.650	12.778	46.700	4.210	46.700	10.010
	2	41.075	24.619	40.200	23.360	39.100	8.890	35.500	8.450
3	1	36.000	11.950	37.325	8.819	46.100	3.690	45.800	4.560
	2	40.575	29.194	40.375	35.084	37.000	9.600	36.100	5.490
4	1	40.325	5.669	40.400	6.040	46.100	3.090	46.100	4.090
	2	37.825	45.944	38.200	38.410	39.400	3.840	40.600	5.440
5	1	40.875	6.809	40.675	8.369	43.600	4.440	41.600	1.640
	2	37.575	28.394	34.700	29.360	41.600	3.240	40.000	7.400
6	1	41.450	5.948	41.925	6.069	43.300	1.610	43.600	2.440
	2	38.800	14.760	38.775	17.424	41.300	4.610	41.600	3.040
7	1	42.050	9.198	41.775	8.624	44.000	2.000	44.100	6.290
	2	35.875	36.709	37.500	26.000	41.500	7.850	40.500	6.650
8	1	40.700	12.210	41.325	10.819	43.400	1.440	45.500	2.650
	2	36.025	39.924	36.600	57.940	41.500	20.850	42.100	14.290
9	1	42.600	15.540	42.200	16.710	43.700	4.410	42.900	2.490
	2	36.300	33.960	36.400	28.140	41.800	6.960	42.000	6.000
10	1	42.800	14.560	43.075	14.019	42.000	1.400	42.100	.890
	2	35.875	26.959	37.400	14.040	42.600	5.240	41.900	6.290
11	1	42.625	13.284	42.500	8.450	42.100	4.490	40.900	2.890
	2	35.600	27.090	34.825	21.944	44.000	12.800	42.200	12.760
12	1	43.100	9.040	43.525	10.699	41.200	1.960	41.900	4.090
	2	35.950	20.148	36.350	23.478	44.900	2.890	43.600	4.240
13	1	44.725	8.649	44.450	11.548	42.800	1.360	41.300	1.810
	2	37.850	14.978	36.250	19.438	44.200	8.560	46.000	2.200

TABLE 30. (CONTINUED)

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
14	1	45.425	4.394	45.000	5.800	41.800	2.560	41.300	4.010
	2	36.250	21.538	36.000	20.950	46.400	1.840	45.700	4.610
15	1	45.850	8.228	45.500	10.100	40.500	1.250	40.700	.810
	2	35.300	16.860	36.175	13.694	45.900	5.690	46.600	4.440
16	1	47.800	6.810	47.150	7.578	40.600	1.840	42.200	5.160
	2	34.925	18.369	37.075	18.769	46.700	4.810	45.100	3.690
17	1	47.850	6.628	47.575	7.794	39.600	10.240	41.600	2.840
	2	34.275	17.249	36.500	16.800	46.800	1.960	46.900	6.890
18	1	48.250	5.988	47.825	5.744	41.500	3.650	41.300	2.210
	2	35.900	18.940	36.325	14.969	47.900	3.290	47.500	3.050
19	1	48.900	4.590	48.975	4.024	39.500	5.250	38.500	5.050
	2	34.425	15.894	34.050	12.498	48.100	6.090	48.800	2.560
20	1	47.525	6.549	48.250	5.938	41.100	1.490	41.100	1.290
	2	36.700	14.760	37.250	14.038	47.400	4.040	47.700	1.410
21	1	47.350	6.828	46.700	7.610	41.700	2.010	42.300	4.810
	2	35.525	27.949	35.500	29.900	48.300	6.210	48.000	4.600
22	1	47.400	13.840	47.850	16.678	41.500	2.450	41.400	1.040
	2	36.225	18.274	35.550	25.348	48.200	2.360	49.800	4.760
23	1	49.150	13.428	49.325	8.419	41.200	1.160	40.000	2.000
	2	36.725	13.999	35.875	10.459	49.100	6.890	50.000	9.800
24	1	49.900	17.840	49.225	19.074	37.400	.440	39.600	1.840
	2	33.725	9.899	34.625	17.934	48.100	6.890	47.700	5.410
25	1	49.075	8.419	48.275	5.549	38.400	1.240	38.700	1.210
	2	34.325	10.069	34.750	9.538	48.600	4.240	47.700	3.010
26	1	50.150	4.028	50.425	3.395	36.200	1.560	37.600	2.240
	2	32.725	7.899	33.425	11.494	49.600	2.640	50.000	1.400

TABLE 31. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M3, S2, L3.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.975	15.874	32.350	10.878	44.100	1.690	44.900	6.690
	2	39.050	21.048	40.325	21.169	31.200	17.560	33.100	4.890
2	1	34.575	12.444	33.650	9.028	44.000	1.200	44.400	2.840
	2	38.850	27.878	38.500	36.200	33.700	4.410	33.600	7.640
3	1	30.550	12.098	31.000	9.050	45.000	5.400	43.800	.960
	2	36.725	91.749	35.150	88.228	33.900	13.890	32.700	6.210
4	1	31.300	8.860	31.900	8.490	44.400	.840	44.500	.650
	2	32.900	125.140	35.150	105.428	32.400	4.440	32.300	2.810
5	1	31.925	8.719	33.000	7.950	45.200	1.160	45.500	1.050
	2	32.575	146.194	30.975	150.024	32.800	1.160	31.600	.840
6	1	31.300	7.810	31.850	6.278	44.500	.850	45.000	.800
	2	29.150	158.178	32.725	147.999	31.700	2.410	32.400	1.640
7	1	34.175	3.894	34.850	2.578	43.900	1.690	29.800	99.960
	2	26.800	101.010	23.050	41.548	32.000	1.600	35.000	1.200
8	1	34.000	5.350	34.075	5.069	45.100	1.090	46.500	1.050
	2	34.175	111.994	36.800	110.960	32.900	1.690	33.600	.840
9	1	29.650	1.528	29.475	1.799	20.700	.810	20.200	.760
	2	18.275	3.749	18.075	2.519	29.700	2.010	29.300	1.210
10	1	29.525	1.999	30.325	1.369	22.500	.850	21.900	2.090
	2	19.375	6.334	19.250	4.188	30.000	2.200	30.600	1.040
11	1	29.700	2.010	29.475	1.849	22.200	.960	21.800	.560
	2	19.650	4.328	19.200	4.360	29.700	.810	30.100	2.690
12	1	29.525	1.799	29.425	2.444	22.600	.440	23.700	.810
	2	19.600	5.240	20.000	7.700	29.900	1.490	29.400	.840
13	1	28.650	1.928	28.575	2.194	20.800	1.760	20.600	.840
	2	17.925	4.719	18.375	2.584	29.000	.800	29.200	1.560

TABLE 31. (CONTINUED)

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
14	1	28.975	1.974	29.075	2.269	22.200	.760	22.300	1.210
	2	19.775	3.774	19.825	3.994	29.100	1.690	29.900	1.690
15	1	29.850	3.328	29.150	3.128	22.800	.760	23.500	.850
	2	19.725	5.699	19.600	10.140	30.300	1.210	29.900	1.090
16	1	29.975	2.474	29.900	3.040	23.000	.800	23.200	.960
	2	19.900	6.290	19.525	8.299	30.400	1.640	29.900	.690
17	1	29.850	1.428	29.900	2.390	23.600	.240	22.800	.360
	2	20.775	5.824	19.900	6.440	30.400	.240	30.000	1.200
18	1	29.825	1.744	29.650	1.728	24.000	.400	23.300	1.010
	2	19.600	11.740	19.625	8.734	30.000	.400	30.100	1.490
19	1	30.125	2.409	29.800	3.310	23.100	.690	22.600	.640
	2	19.375	8.034	19.325	5.869	30.000	.600	30.800	1.360
20	1	30.150	1.978	29.675	2.669	23.900	.490	23.100	1.090
	2	19.950	9.298	19.375	6.884	30.100	.490	30.900	1.090
21	1	30.575	2.094	30.300	2.260	23.100	.290	23.400	.440
	2	19.975	6.474	20.475	6.049	30.600	.440	30.600	.440
22	1	30.150	2.428	29.700	1.360	22.300	1.210	22.700	.810
	2	18.975	6.074	18.975	5.974	31.100	1.090	30.100	1.290
23	1	30.825	1.244	30.800	1.860	23.100	.090	23.000	.600
	2	20.550	6.448	20.575	4.944	30.900	.090	30.700	1.410
24	1	30.450	2.348	30.525	1.999	22.800	.760	22.800	.360
	2	19.425	6.144	19.800	6.310	31.200	.760	30.600	1.440
25	1	31.925	1.119	31.825	2.144	21.600	1.640	21.800	.760
	2	19.150	3.128	19.250	3.388	31.200	.560	30.700	1.210
26	1	31.275	1.449	31.725	1.199	22.300	.610	22.200	.760
	2	19.425	4.194	19.275	4.949	31.100	1.090	31.800	.760

TABLE 32. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M3, S2, L4.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	32.000	15.650	32.450	10.548	44.100	2.090	44.900	6.690
	2	39.025	21.824	40.300	20.560	31.500	18.650	33.100	4.890
2	1	34.775	12.324	33.700	10.410	43.900	.890	44.700	1.810
	2	39.100	27.090	38.675	38.919	33.800	4.760	33.000	4.000
3	1	30.075	9.069	30.750	9.188	43.100	1.090	43.500	1.050
	2	35.025	89.724	35.700	85.710	32.200	12.760	31.800	9.360
4	1	32.400	8.540	31.800	7.260	44.700	2.810	44.000	.400
	2	32.400	110.840	34.725	95.349	31.200	5.960	31.600	2.440
5	1	30.975	8.624	32.350	6.178	44.500	.450	45.500	.450
	2	31.125	156.959	33.725	152.249	32.600	2.040	32.200	.960
6	1	34.375	3.784	34.700	3.210	44.600	1.040	40.500	68.850
	2	26.975	117.274	25.600	93.090	32.200	1.160	33.300	2.610
7	1	32.975	7.024	32.600	5.740	45.300	.810	45.700	.410
	2	32.350	149.478	33.775	160.324	32.100	1.290	32.300	.410
8	1	32.000	5.250	32.900	6.240	45.000	.400	45.300	.610
	2	33.625	150.834	30.925	163.269	32.100	1.690	32.400	1.240
9	1	34.800	4.110	34.050	3.498	39.800	63.760	44.500	.850
	2	25.125	88.959	29.325	130.969	34.000	1.600	33.200	1.360
10	1	32.675	3.369	31.625	2.984	44.900	.490	45.800	.360
	2	31.825	170.994	29.725	191.249	33.100	.490	32.200	.360
11	1	33.450	4.948	33.700	5.060	45.200	1.160	45.100	.890
	2	32.175	145.544	32.150	144.628	32.800	1.160	32.300	1.610
12	1	32.625	7.234	32.100	9.290	45.500	.450	44.900	.690
	2	31.425	170.794	28.650	160.978	32.500	.450	32.800	.960
13	1	33.025	6.674	33.600	9.990	45.300	1.610	45.200	.760
	2	29.600	157.190	27.225	135.774	32.100	.890	32.200	1.360

TABLE 32. (CONTINUED)

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
14	1	33.075	5.069	33.575	5.844	44.900	.490	44.600	.640
	2	28.125	141.509	28.825	137.994	32.200	1.360	32.500	2.050
15	1	31.400	5.290	30.675	4.169	46.200	.360	45.200	1.560
	2	32.425	184.744	28.275	153.749	31.800	.360	31.600	.840
16	1	32.450	6.548	33.125	5.559	44.900	.290	45.100	.490
	2	30.550	151.898	28.600	138.540	32.200	1.760	32.300	1.210
17	1	30.950	6.448	31.475	5.849	45.000	.400	45.000	.600
	2	30.250	174.388	28.225	160.724	31.800	1.960	32.400	.840
18	1	31.000	7.450	31.575	6.294	44.900	.490	45.100	.090
	2	32.825	164.794	32.475	169.899	31.900	1.690	32.600	.840
19	1	30.850	5.178	31.475	5.949	45.200	1.560	45.200	.960
	2	30.275	171.649	29.950	167.648	31.600	1.440	32.800	.960
20	1	33.375	3.534	33.325	4.369	45.100	.890	45.400	1.040
	2	33.825	139.644	33.575	138.394	32.600	1.040	32.300	1.010

TABLE 33. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M3, S3, L1.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.750	15.988	30.850	14.078	47.400	4.640	44.800	1.760
	2	39.950	25.048	38.450	21.248	33.000	6.800	33.200	17.360
2	1	32.525	20.649	32.875	10.859	46.200	2.560	48.400	2.240
	2	39.400	21.090	40.625	21.134	36.000	2.800	35.600	5.840
3	1	36.050	13.148	35.400	11.190	47.600	8.640	49.400	.640
	2	40.150	18.878	41.250	20.288	36.400	7.440	35.200	8.560
4	1	34.175	9.794	36.425	16.894	47.000	.400	47.400	1.840
	2	40.300	19.160	40.600	21.490	34.600	13.840	34.200	20.560
5	1	33.875	15.859	35.425	21.794	46.200	.960	46.000	.800
	2	39.625	24.934	40.700	16.760	36.000	13.200	36.800	2.960
6	1	37.925	8.569	37.350	12.478	46.000	.400	48.400	.640
	2	39.700	19.210	40.500	23.750	39.800	2.560	39.800	15.760
7	1	39.175	15.994	39.075	13.719	47.600	.640	46.000	1.600
	2	40.025	18.874	40.425	12.294	43.000	11.200	40.400	6.640
8	1	41.200	17.160	41.850	9.878	45.400	1.840	46.800	.560
	2	40.625	11.034	40.950	16.148	41.600	11.440	43.800	4.160
9	1	43.675	12.369	43.150	7.878	46.800	2.160	47.000	1.600
	2	40.850	12.128	41.525	12.049	44.400	5.040	44.200	3.760
10	1	44.525	6.399	43.475	10.349	45.400	.640	47.600	1.840
	2	41.650	8.378	40.975	14.174	44.600	12.640	43.000	1.600
11	1	44.025	9.624	44.850	15.478	48.200	8.560	46.800	.560
	2	40.800	19.410	40.500	17.600	40.000	14.800	44.400	7.040
12	1	45.075	9.069	44.475	10.499	47.400	.640	46.200	.560
	2	40.650	10.928	40.350	9.328	39.600	6.640	43.200	5.360
13	1	44.250	11.338	42.975	4.624	49.200	2.160	48.800	2.560
	2	41.625	13.184	42.525	15.349	41.400	3.840	42.400	6.640

TABLE 33. (CONTINUED)

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
14	1	42.600	13.490	44.100	9.090	46.600	1.440	47.000	1.200
	2	42.300	14.210	41.850	12.728	41.000	10.800	43.000	10.800
15	1	43.425	23.244	42.450	21.048	50.800	5.360	48.400	12.640
	2	40.500	8.550	40.800	6.760	39.800	7.760	41.000	16.000
16	1	48.500	12.600	48.525	9.249	53.600	.640	52.800	.560
	2	39.550	12.248	38.475	10.299	39.400	10.240	37.200	12.560
17	1	53.850	5.228	53.125	5.060	55.200	.160	55.200	.160
	2	36.750	7.088	37.100	8.590	36.000	7.600	37.800	8.560
18	1	55.225	3.275	55.150	3.078	57.800	.560	57.400	.640
	2	34.400	7.240	34.475	7.099	33.400	3.440	34.400	13.840
19	1	57.700	1.760	57.750	2.038	58.600	.240	58.800	.560
	2	34.025	4.274	34.500	6.200	33.200	2.160	34.200	7.760
20	1	58.475	.900	58.850	1.728	59.000	.000	60.200	.160
	2	32.575	3.794	32.950	4.098	32.200	2.160	33.400	1.840

TABLE 34. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M3, S3, L2.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.600	14.840	31.800	13.310	44.600	5.040	45.600	1.040
	2	38.300	18.710	39.600	22.490	29.200	12.960	33.600	13.040
2	1	32.800	11.660	33.875	10.909	46.800	1.360	48.800	3.360
	2	41.900	14.240	41.275	21.049	34.200	20.560	35.800	6.960
3	1	30.200	15.510	30.525	15.499	43.800	2.960	45.600	5.840
	2	35.050	56.948	36.225	49.024	30.600	3.440	31.800	4.160
4	1	32.775	12.274	33.250	8.738	43.200	5.760	43.200	.560
	2	30.825	55.744	32.600	57.690	39.000	6.000	37.800	2.960
5	1	34.450	6.498	33.250	5.488	36.600	3.840	33.000	1.600
	2	29.300	18.910	26.675	13.619	36.600	6.240	34.200	12.160
6	1	37.275	7.299	37.550	6.048	37.600	2.240	38.600	1.840
	2	32.250	12.338	33.325	12.619	38.000	2.000	37.000	.400
7	1	39.875	5.209	40.175	3.444	40.200	2.560	39.800	8.560
	2	30.925	26.569	30.850	29.978	38.400	1.840	38.200	1.360
8	1	40.875	6.209	41.450	4.848	37.000	2.800	37.800	2.960
	2	31.500	13.550	32.275	13.849	39.800	6.160	40.800	2.960
9	1	40.775	5.774	40.625	5.834	39.000	2.000	37.200	.160
	2	32.950	14.098	31.825	10.694	39.600	3.440	41.400	5.440
10	1	40.625	4.834	41.000	5.500	38.000	.800	38.800	.560
	2	31.750	22.638	32.425	24.094	41.200	2.960	39.800	1.760
11	1	39.600	4.240	39.200	3.610	35.200	.160	35.800	2.560
	2	27.825	18.394	28.150	16.128	41.000	1.600	40.400	1.840
12	1	40.850	4.528	40.400	4.590	35.000	.400	36.000	.400
	2	28.900	20.090	28.525	21.699	42.400	.640	40.200	2.560
13	1	42.575	3.794	42.450	6.498	36.800	.560	36.000	.000
	2	30.475	15.749	30.000	12.550	40.600	1.040	40.200	2.160

TABLE 34. (CONTINUED)

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
14	1	43.300	3.110	43.250	5.788	32.200	.560	32.400	1.840
	2	28.925	3.869	28.450	5.698	42.200	2.960	43.200	6.160
15	1	41.925	3.669	42.425	7.194	32.200	.960	32.000	1.600
	2	28.350	5.528	28.600	5.040	42.200	3.360	41.800	3.760
16	1	42.000	5.550	42.275	3.549	33.200	1.360	33.400	1.040
	2	28.950	7.598	28.675	8.769	42.400	6.640	42.200	1.760
17	1	43.100	4.490	43.200	4.810	33.200	.160	33.400	1.440
	2	28.900	8.840	28.500	7.450	41.800	3.760	42.800	3.360
18	1	42.925	4.819	42.225	4.124	30.600	.640	30.600	.640
	2	26.600	5.440	26.325	5.519	45.600	1.840	44.400	4.240
19	1	43.975	3.924	44.050	3.598	30.200	.160	31.600	2.240
	2	26.900	3.840	27.200	5.360	43.600	1.840	44.000	2.000
20	1	45.025	3.674	45.475	2.699	31.200	.560	31.400	.240
	2	27.950	4.948	28.325	7.019	45.600	2.240	45.400	1.440

TABLE 35. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M3, S3, L3.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	31.975	15.874	32.350	10.878	45.000	1.200	46.800	6.160
	2	39.050	21.048	40.325	21.169	32.400	18.240	33.600	4.240
2	1	34.725	3.799	34.600	5.390	46.000	1.200	47.200	.160
	2	39.750	14.538	39.800	19.460	32.600	.240	32.600	1.840
3	1	27.600	1.990	27.550	1.748	21.000	3.200	21.400	.640
	2	17.925	3.619	17.750	4.538	28.200	.560	29.000	1.600
4	1	28.175	1.144	28.500	1.700	22.200	.560	21.800	.160
	2	18.775	4.474	19.350	3.178	28.800	1.760	29.200	.160
5	1	28.150	2.528	28.625	2.934	21.200	.160	21.600	.240
	2	18.800	2.910	18.625	3.834	27.400	.640	28.200	.960
6	1	25.700	.810	25.625	2.234	18.800	.160	18.800	.160
	2	16.075	2.919	15.925	3.719	26.200	.160	27.400	1.840
7	1	26.000	2.700	26.175	3.044	19.000	.000	19.600	.240
	2	16.375	3.684	16.425	3.944	26.600	1.440	27.200	.960
8	1	26.500	2.000	26.325	1.669	19.200	.560	18.000	.000
	2	16.325	2.669	16.050	1.698	27.000	.800	27.000	.000
9	1	26.825	1.794	26.775	.974	18.400	.240	18.200	.160
	2	16.300	2.310	16.500	2.000	26.600	.240	26.800	.160
10	1	26.350	1.578	26.700	1.660	18.600	.240	18.400	.240
	2	16.100	2.740	15.900	2.590	26.400	.240	26.600	.240
11	1	26.300	2.410	26.500	1.700	18.800	.160	18.600	.240
	2	15.850	2.928	16.175	1.994	26.200	.160	26.400	.240
12	1	26.225	2.274	26.275	2.499	19.000	.000	18.400	.240
	2	16.075	4.269	15.875	2.259	26.000	.000	26.600	.240
13	1	26.050	1.998	26.750	1.738	18.800	.160	18.400	.240
	2	16.175	2.944	16.300	1.760	26.200	.160	26.600	.240

TABLE 35. (CONTINUED)

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
14	1	26.600	2.440	26.075	1.819	19.000	.000	18.200	.160
	2	16.375	3.184	15.925	2.569	26.000	.000	26.800	.160
15	1	26.550	1.298	26.550	1.948	18.800	.160	18.200	.160
	2	16.650	2.078	16.200	1.760	26.200	.160	26.800	.160
16	1	26.525	1.849	26.225	1.624	18.400	.240	18.400	.240
	2	16.300	2.560	16.075	1.969	26.600	.240	26.600	.240
17	1	26.475	2.199	26.850	1.778	18.000	.400	18.000	.000
	2	16.200	1.860	16.200	1.860	26.400	.640	27.000	.000
18	1	26.625	2.034	26.575	1.994	18.600	.240	18.000	.400
	2	16.500	2.550	15.800	1.760	26.400	.240	27.000	.400
19	1	26.925	1.569	26.825	2.194	18.400	.240	18.600	.240
	2	16.425	1.944	16.300	2.860	26.600	.240	26.400	.240
20	1	26.675	1.969	26.900	1.490	18.000	.000	18.600	.240
	2	15.925	2.269	16.225	2.774	27.000	.000	26.400	.240

TABLE 36. THE PROGRESSIVE MEANS AND VARIANCES OF RESPONSE AND COUNT FROM GENERATION TO GENERATION UNDER SELECTION FOR R1, M3, S3, L4.

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
1	1	32.000	15.650	32.450	10.548	45.200	1.360	46.800	6.160
	2	39.025	21.824	40.300	20.560	32.800	20.560	33.600	4.240
2	1	34.775	3.374	34.400	4.490	46.800	2.160	47.000	.400
	2	40.075	13.169	39.325	18.719	33.000	1.200	32.800	1.360
3	1	27.875	1.559	28.100	1.540	19.600	.240	19.600	.240
	2	16.675	3.269	17.275	2.149	28.400	.240	28.400	.240
4	1	28.200	1.310	28.250	1.688	20.400	.240	20.200	.160
	2	17.775	2.924	18.100	2.040	27.600	.240	27.800	.160
5	1	28.225	1.774	28.050	1.948	19.600	.240	19.600	.240
	2	17.225	2.224	16.875	2.459	28.400	.240	28.400	.240
6	1	28.400	1.640	27.900	1.890	19.800	.160	20.000	.000
	2	17.200	3.260	17.550	2.348	28.200	.160	28.000	.000
7	1	28.300	1.960	28.225	1.974	19.000	.000	19.400	.240
	2	17.075	2.119	17.075	2.619	29.000	.000	28.600	.240
8	1	28.850	1.528	28.825	1.794	19.400	.240	19.000	.000
	2	17.125	2.459	17.150	1.628	28.600	.240	29.000	.000
9	1	29.225	1.974	28.875	1.759	19.400	.240	19.400	.240
	2	16.900	2.190	17.100	1.990	28.600	.240	28.600	.240
10	1	28.500	1.450	28.350	1.578	19.600	.240	18.800	.560
	2	17.100	2.590	16.875	2.359	28.400	.240	28.600	1.040
11	1	28.525	1.249	28.175	1.694	19.400	.240	19.200	.160
	2	17.000	2.350	16.825	2.444	28.600	.240	28.800	.160
12	1	28.375	1.584	28.800	1.410	19.600	.240	19.000	.000
	2	17.075	2.469	17.175	1.944	28.400	.240	29.000	.000
13	1	28.600	1.840	28.850	2.028	19.000	.000	19.600	.240
	2	17.075	1.969	17.350	2.028	29.000	.000	28.400	.240

TABLE 36. (CONTINUED)

GEN	ID	MALE UNSEL AVG.	MALE UNSEL VAR.	FEMALE UNSEL AVG.	FEMALE UNSEL VAR.	MALE SEL AVG.	MALE SEL VAR.	FEMALE SEL AVG.	FEMALE SEL VAR.
14	1	28.675	1.719	28.650	1.928	19.600	.240	19.400	.240
	2	17.375	2.484	17.175	2.694	28.400	.240	28.600	[illegible]
15	1	28.725	1.749	28.550	1.148	19.800	.160	19.400	.240
	2	17.325	2.469	17.350	2.678	28.200	.160	28.600	.240
16	1	28.200	2.360	28.450	1.248	19.400	.240	19.200	.160
	2	16.950	2.248	17.450	1.548	28.600	.240	28.800	.160
17	1	28.375	1.834	28.725	1.299	19.600	.240	19.200	.160
	2	17.225	1.924	17.250	2.438	28.400	.240	28.800	.160
18	1	29.025	1.824	28.300	1.860	18.800	.560	19.600	.240
	2	17.175	1.494	17.075	2.769	29.200	.560	28.400	.240
19	1	28.600	2.440	28.550	2.298	19.200	.160	19.200	.160
	2	16.700	2.560	17.125	1.909	28.800	.160	28.800	.160
20	1	28.825	1.294	28.700	2.360	19.800	.160	19.200	.160
	2	17.600	1.990	17.275	1.499	28.200	.160	28.800	.160

TABLE 37. INTERCEPTS, RATE OF CHANGES, QUDRATIC COEFFICIENTS AND R SQUARES FOR ADDITIVE MODEL.

POPULATION	SELECTION	LINKAGE	BO	B1	B2	R SQUARE
1	1	1	31.7817	3.0268	-.07018	.99776
1	1	2	32.5633	2.9449	-.07432	.99603
1	1	3	37.7513	1.0867	-.01995	.92559
1	1	4	34.7664	2.6598	-.14791	.94998
1	2	1	32.5582	4.9890	-.19230	.99916
1	2	2	37.2407	3.0099	-.08484	.98354
1	2	3	38.6275	2.7252	-.10425	.94170
1	2	4	35.5237	4.5983	-.30892	.92211
1	3	1	31.5527	5.3773	-.21537	.99709
1	3	2	35.6042	3.5135	-.10888	.96659
1	3	3	37.6773	2.8395	-.14370	.89743
1	3	4	31.6400	7.3743	-.72856	.97606
2	1	1	31.0413	3.2214	-.07883	.99731
2	1	2	31.6928	3.1333	-.08194	.99584
2	1	3	37.2134	1.1566	-.02200	.90791
2	1	4	33.2564	3.1571	-.18427	.91393
2	2	1	31.6373	5.1287	-.19674	.99868
2	2	2	36.7172	3.0760	-.08683	.97844
2	2	3	36.4055	3.2763	-.13337	.95216
2	2	4	33.0827	5.3024	-.35952	.95376
2	3	1	32.5927	5.0178	-.18950	.99510
2	3	2	36.3483	3.4381	-.10718	.97872
2	3	3	38.9000	2.4516	-.11757	.90851
2	3	4	33.7200	6.5443	-.64999	.95417

TABLE 37. (CONTINUED)

POPULATION	SELECTION	LINKAGE	BO	B1	B2	R SQUARE
3	1	1	29.0199	3.1259	-.06879	.99800
3	1	2	29.8027	3.1204	-.07676	.99665
3	1	3	34.6520	1.4222	-.02957	.92952
3	1	4	31.3531	2.9999	-.14828	.96889
3	2	1	27.6436	5.2835	-.18604	.99968
3	2	2	32.4247	3.4879	-.09791	.98743
3	2	3	32.9423	3.6558	-.14429	.96943
3	2	4	29.9416	5.3450	-.31517	.97212
3	3	1	26.1252	5.6268	-.19652	.99820
3	3	2	30.3472	4.0131	-.11828	.97913
3	3	3	30.6693	4.2734	-.21923	.95305
3	3	4	24.6725	8.6815	-.75133	.99734
4	1	1	28.2707	3.2855	-.07546	.99746
4	1	2	28.9502	3.3063	-.08429	.99660
4	1	3	34.3107	1.4746	-.03115	.91974
4	1	4	30.1902	3.4505	-.18304	.95754
4	2	1	27.0855	5.2830	-.18141	.99958
4	2	2	32.1198	3.5639	-.10160	.97785
4	2	3	31.5046	3.9965	-.16220	.96694
4	2	4	28.5068	5.7179	-.34285	.97044
4	3	1	27.1498	5.2450	-.16806	.99798
4	3	2	30.5215	4.0511	-.12262	.97407
4	3	3	30.7278	4.2402	-.21622	.94578
4	3	4	24.2225	9.0833	-.81026	.99264

TABLE 38. INTERCEPTS, RATE OF CHANGES, QUDRATIC COEFFICIENTS AND R SQUARES FOR DOMINANCE MODEL.

POPULATION	SELECTION	LINKAGE	BO	B1	B2	R SQUARE
1	1	1	25.3432	2.3398	-.02985	.99494
1	1	2	28.6973	1.8904	-.03291	.99568
1	1	3	30.2011	1.0968	-.02326	.96253
1	1	4	30.3923	.8873	-.01200	.98564
1	2	1	30.2956	3.0050	-.06937	.97013
1	2	2	29.4100	3.2331	-.10685	.99328
1	2	3	29.6083	2.7164	-.16931	.98996
1	2	4	31.1000	1.5079	-.06060	.99498
1	3	1	33.3485	2.9373	-.07135	.92246
1	3	2	30.9318	3.8127	-.16487	.97483
1	3	3	30.4800	3.0057	-.22856	.96405
1	3	4	31.3400	2.4279	-.21785	.97469
2	1	1	26.0778	2.2295	-.02593	.99399
2	1	2	28.8618	1.8485	-.03128	.99396
2	1	3	29.6134	1.1754	-.02572	.96460
2	1	4	29.9657	.9508	-.01391	.98769
2	2	1	29.8398	3.0614	-.07089	.96851
2	2	2	29.3266	3.2615	-.10834	.99162
2	2	3	29.6450	2.6157	-.15794	.98731
2	2	4	30.8417	1.5928	-.06628	.98381
2	3	1	33.0852	2.9485	-.07136	.92634
2	3	2	31.3409	3.5564	-.14290	.97997
2	3	3	30.8400	2.7886	-.19999	.93232
2	3	4	31.6600	2.1721	-.18213	.95415

TABLE 38. (CONTINUED)

POPULATION	SELECTION	LINKAGE	BO	B1	B2	R SQUARE
3	1	1	28.0607	1.5620	.00137	.98860
3	1	2	28.7547	1.6664	-.02429	.99129
3	1	3	30.2802	1.0227	-.02075	.96783
3	1	4	30.4771	.7952	-.00890	.98188
3	2	1	26.9709	3.2101	-.07219	.98060
3	2	2	27.4172	3.1150	-.09131	.99134
3	2	3	28.4534	2.5282	-.13522	.93311
3	2	4	30.2063	1.3114	-.03152	.95453
3	3	1	28.7762	3.3231	-.07921	.94732
3	3	2	27.9142	3.8946	-.15279	.98404
3	3	3	29.6925	1.8624	-.01115	.93593
3	3	4	29.8975	1.9619	-.09240	.91992
4	1	1	28.5447	1.4647	.00542	.98755
4	1	2	29.1375	1.5879	-.02156	.99233
4	1	3	30.4190	1.0080	-.02052	.97666
4	1	4	30.7210	.7725	-.00835	.98874
4	2	1	27.4388	3.1601	-.07101	.97937
4	2	2	27.3166	3.1961	-.09664	.99032
4	2	3	28.0988	2.5902	-.13777	.94044
4	2	4	29.6271	1.4649	-.04042	.95156
4	3	1	29.1276	3.2620	-.07739	.94765
4	3	2	27.6239	3.9475	-.15506	.98215
4	3	3	29.1925	2.1410	-.04686	.95467
4	3	4	29.0650	2.4037	-.14552	.91974

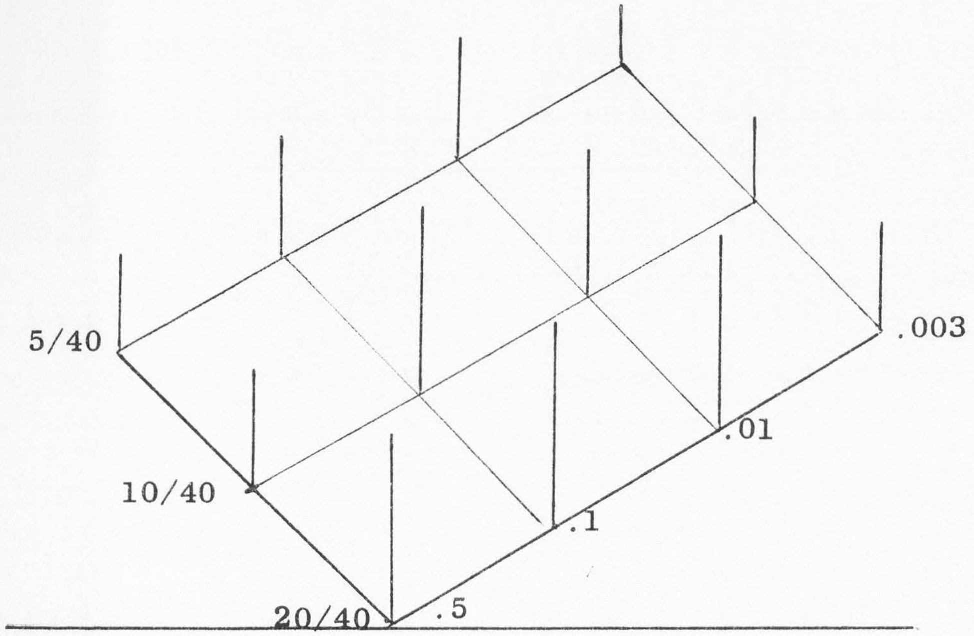
TABLE 39. INTERCEPTS, RATE OF CHANGES, QUDRATIC COEFFICIENTS AND R SQUARES FOR COMPLETE DOMINANCE MODEL.

POPULATION	SELECTION	LINKAGE	BO	B1	B2	R SQUARE
1	1	1	42.8779	-.0201	.00624	.75855
1	1	2	45.7138	-.6415	.03284	.92223
1	1	3	45.4166	-.0749	-.00493	.28724
1	1	4	43.6536	.1218	-.00567	.22230
1	2	1	44.6656	.2672	-.00937	.29127
1	2	2	45.4461	-.2307	-.00142	.79532
1	2	3	51.6133	-2.9098	.06833	.76000
1	2	4	44.0663	.0698	-.00026	.11077
1	3	1	49.8861	-1.1510	.08272	.86496
1	3	2	47.9114	-1.5090	.03473	.79842
1	3	3	43.3881	-4.2590	.16093	.67155
1	3	4	41.8842	-3.9588	.15208	.58293
2	1	1	44.2483	-.1639	.01064	.78003
2	1	2	45.1871	-.5185	.02888	.89634
2	1	3	46.5405	-.3790	.00651	.17484
2	1	4	42.9654	.2133	-.00846	.21704
2	2	1	45.1372	.2038	-.00716	.27701
2	2	2	45.4743	-.2406	-.00143	.81249
2	2	3	52.4136	-2.8827	.06568	.77047
2	2	4	43.7264	.0898	-.00044	.13415
2	3	1	49.1579	-1.0451	.07956	.92805
2	3	2	46.5830	-1.2269	.02182	.87901
2	3	3	41.6568	-3.8799	.14525	.64945
2	3	4	41.0089	-3.7787	.14508	.57275

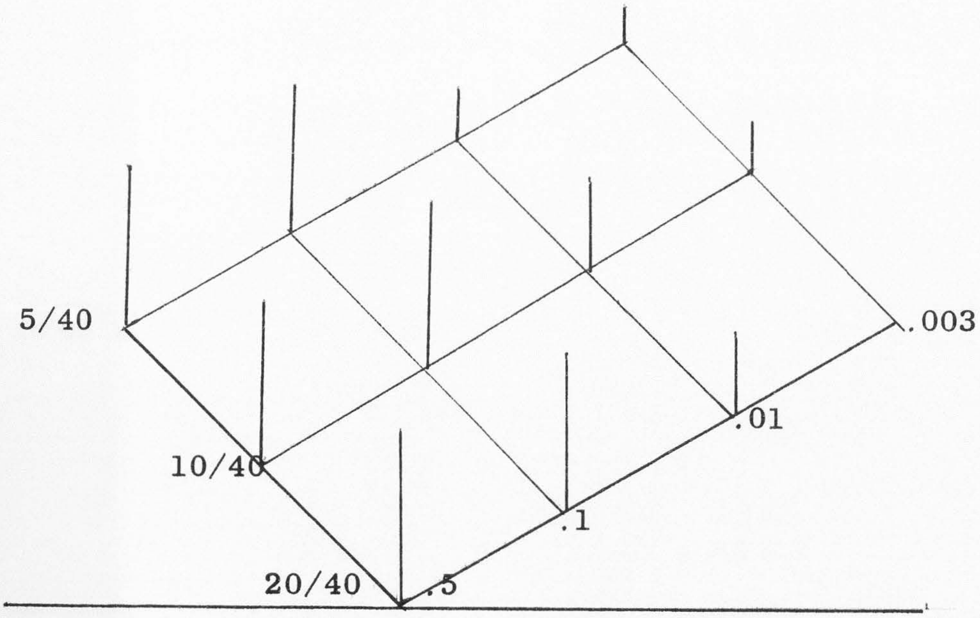
TABLE 39. (CONTINUED)

POPULATION	SELECTION	LINKAGE	BO	B1	B2	R SQUARE
3	1	1	30.7832	1.2569	-.02368	.96041
3	1	2	33.9502	.5666	.00284	.93513
3	1	3	36.5657	-.2708	.01140	.25127
3	1	4	33.5335	.1450	-.00615	.35200
3	2	1	29.9899	1.3141	-.03259	.95413
3	2	2	34.2953	.9982	-.01485	.93491
3	2	3	33.9374	-.4642	.01314	.43072
3	2	4	32.2164	.1464	-.00819	.06637
3	3	1	32.4883	.5894	.03296	.91779
3	3	2	29.4860	1.4421	-.03626	.87425
3	3	3	32.9852	-1.1063	.04230	.67335
3	3	4	32.0720	-.6408	.02520	.40675
4	1	1	31.3957	1.1775	-.02139	.98198
4	1	2	34.3214	.5464	.00287	.93141
4	1	3	37.4849	-.4098	.01581	.36093
4	1	4	34.1137	.0882	-.00523	.45473
4	2	1	30.6409	1.2382	-.03068	.94632
4	2	2	34.0159	1.0456	-.01617	.93755
4	2	3	33.4041	-.4001	.01157	.35980
4	2	4	32.0289	.1968	-.01137	.10219
4	3	1	32.1379	.6439	.03137	.91708
4	3	2	28.8961	1.5460	-.04043	.90874
4	3	3	32.7947	-1.0930	.04202	.66072
4	3	4	32.0369	-.6222	.02447	.38040

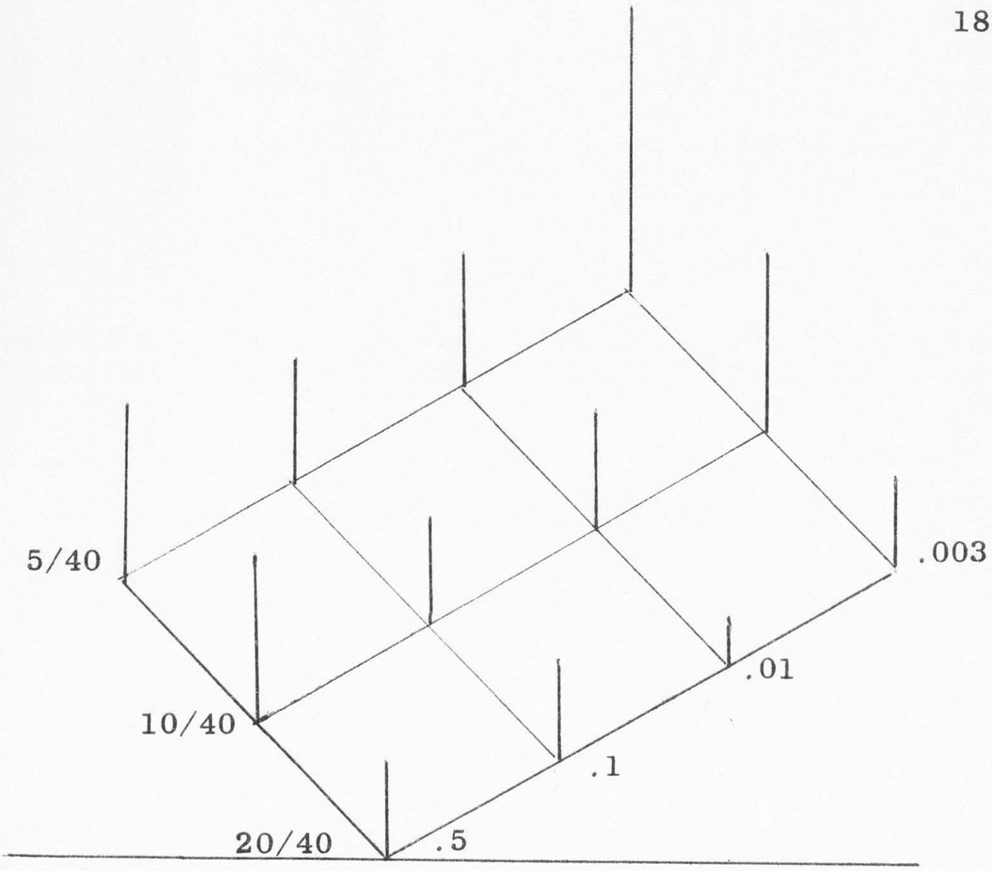
Appendix G; Figures of results



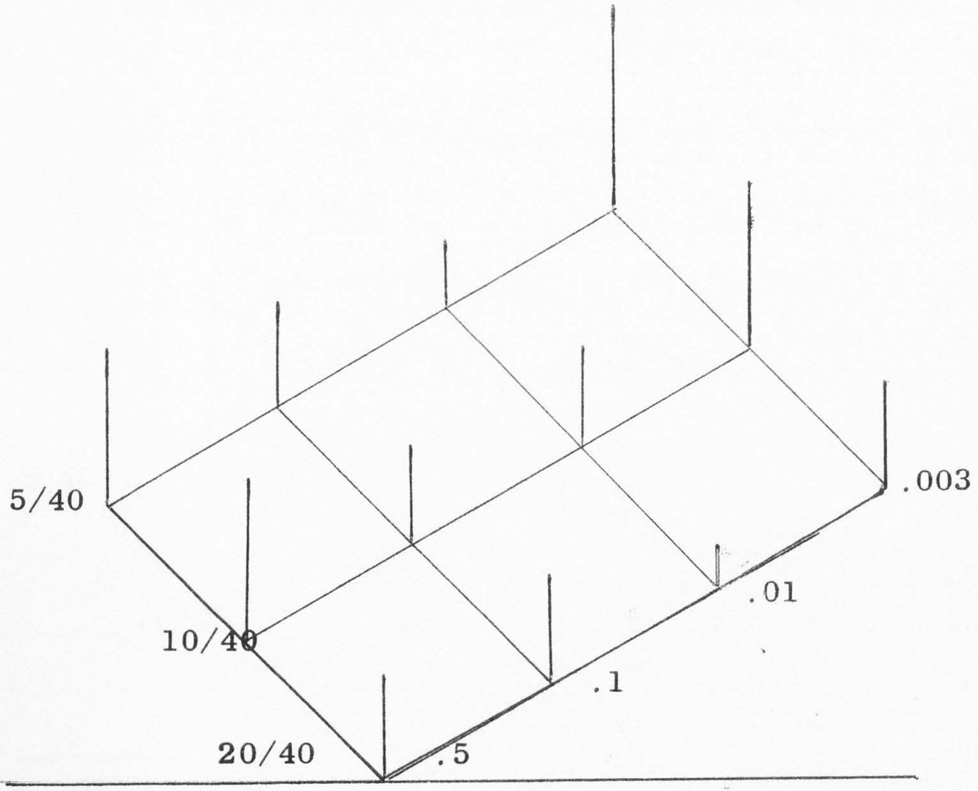
Graph 1. A. Additive model: Number of generations as a response in unselected population



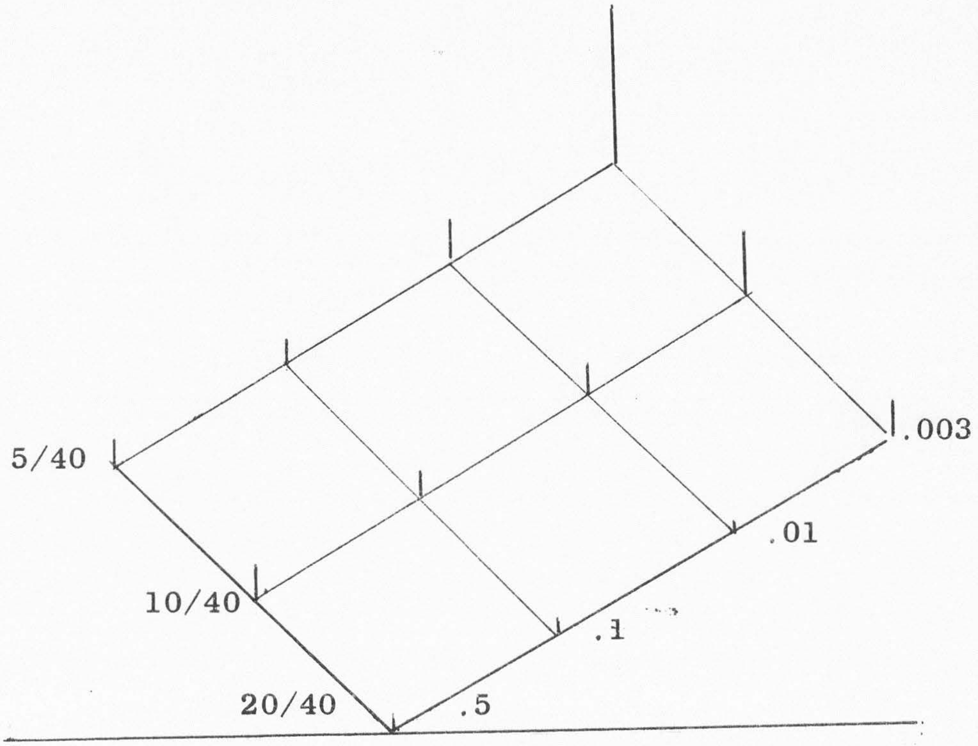
Graph 1. B. Additive Model: Maximum fixation values as a response in unselected population



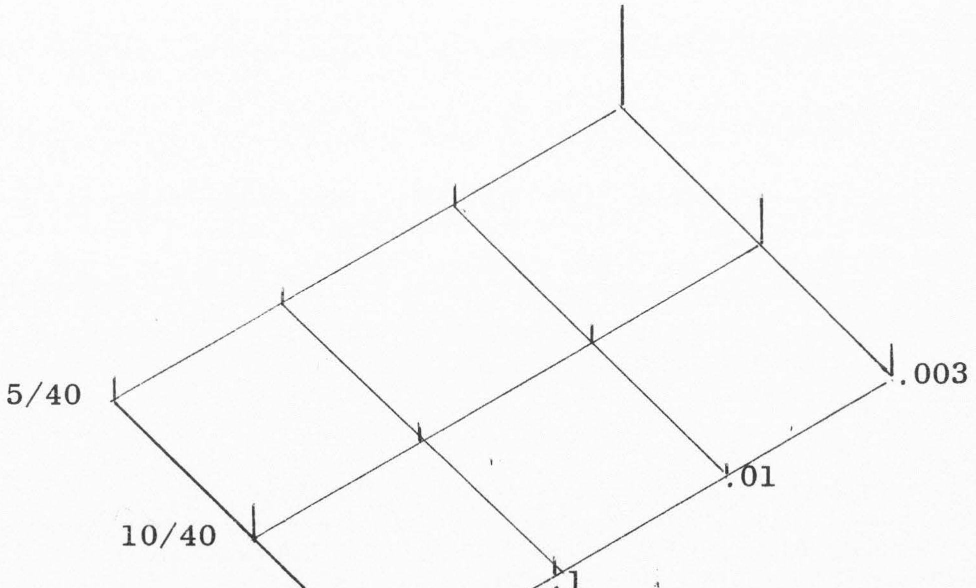
Graph 2. A. Additive model: Linear rate of genetic progress in unselected male population



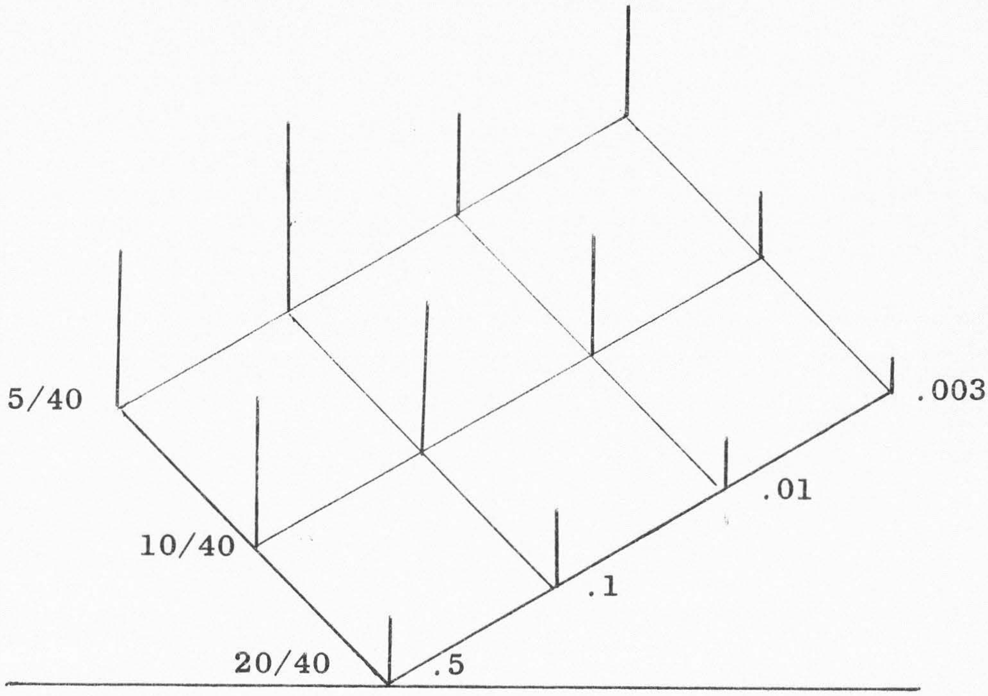
Graph 2. B. Additive model: Linear rate of genetic progress in selected male population



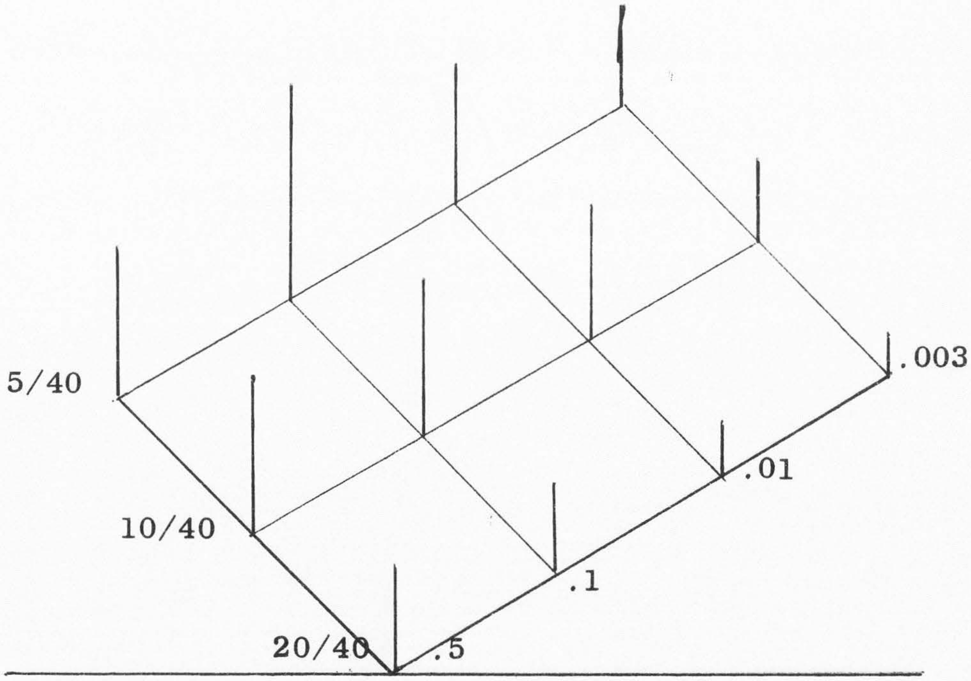
Graph 3. A. Additive model: Quadratic rate of genetic progress in unselected male population



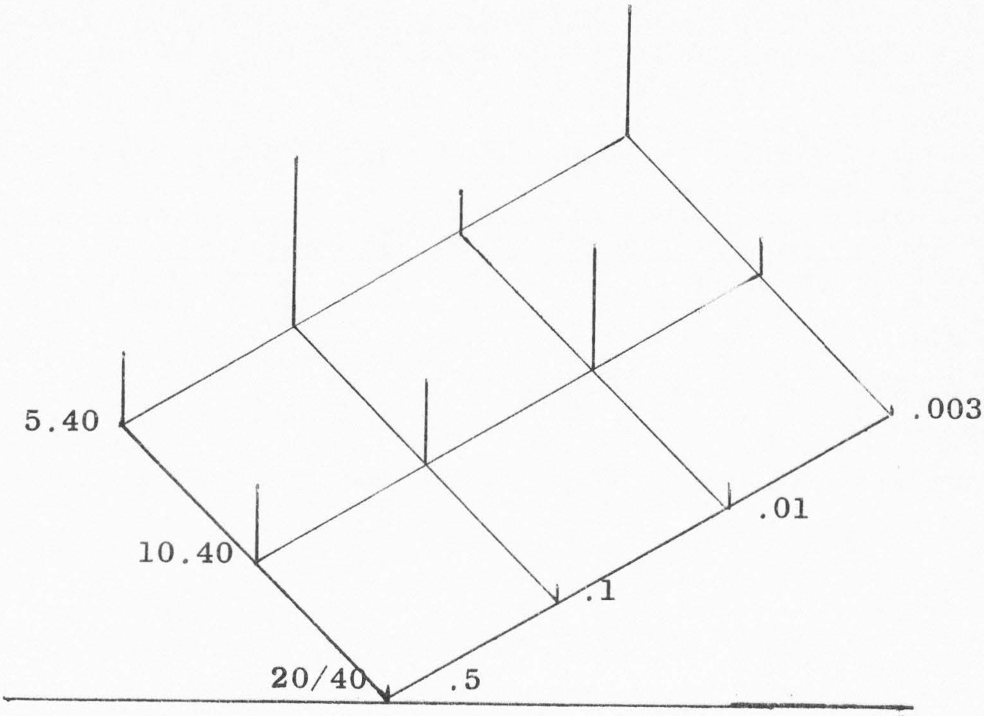
Graph 3. B. Additive model: Quadratic rate of genetic progress in selected male population



Graph 4. A. Complete dominance model: Linear rate of genetic progress in unselected population

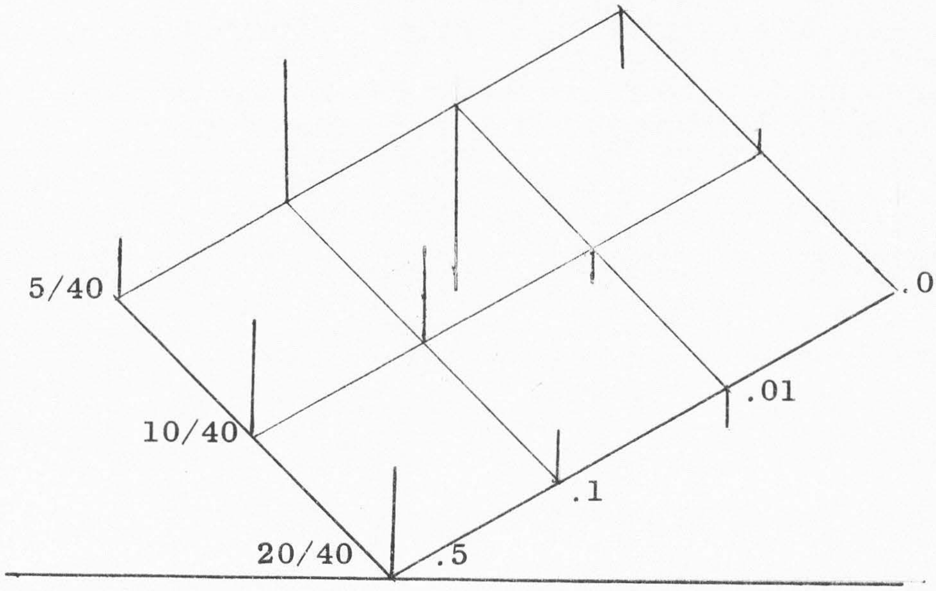


Graph 4. B. Complete dominance model: Linear rate of genetic progress in selected population

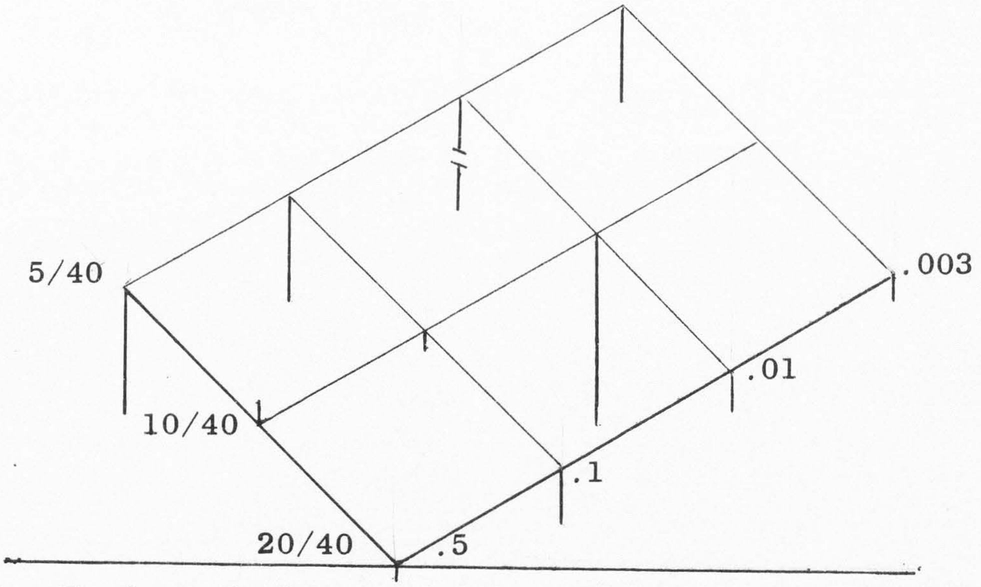


Graph 5. A. Complete dominance model: Quadratic rate of genetic progress in unselected population

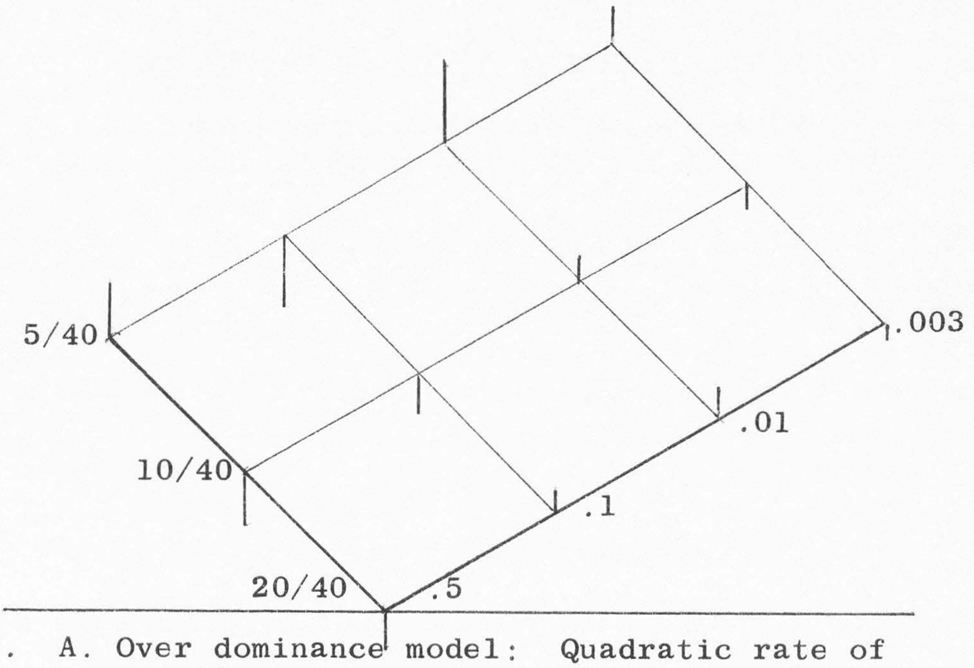
Graph 5. B. Complete dominance model: Quadratic rate of genetic progress in selected population



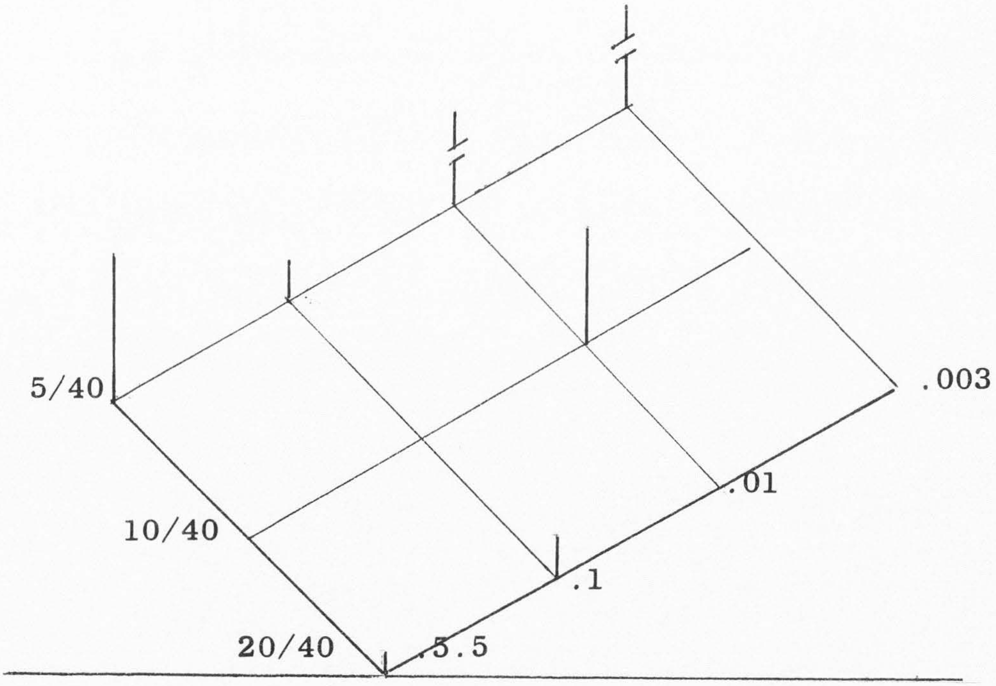
Graph 6. A. Over dominance model: Linear rate of genetic progress in unselected population



Graph 6. B. Over dominance model: Linear rate of genetic progress in selected population



Graph 7. A. Over dominance model: Quadratic rate of genetic progress in unselected population



Graph 7. B. Over dominance model: Quadratic rate of genetic progress in selected population