A Genetic Breeding Program for Racing Pigeons

The following first appeared as a series of four articles in the *Racing Pigeon Digest* from April 1994 through July 1994. It has been reformatted for the web as well as edited slightly to improve the clarity of certain sections. It represents my thoughts on the breeding of racing pigeons and essentially describes the breeding program at Shewmaker Genetics.

In my opinion, the Digest is the premier journal of the sport in the United States. Back issues and subscriptions can be obtained by contacting the *Racing Pigeon Digest* at P.O. Box 3088, Lake Charles, LA 70602. Telephone: (318) 474-1289. FAX: (318) 478-4996. E-mail: RPDMag@aol.com.

Introduction

We compete in a sport of incredible odds. The fact that a bird is even able to complete a race is something that will always amaze me. To some it must appear as nothing more than a lottery where a few thousand birds are released and somebody just happens to win.

To those who carefully observe the sport though, there clearly are factors at work which contribute to the success of the winning bird. We all have known of those rare and exceptional birds that have amassed astonishing records. We have known or read of handlers who can consistently place near the top. We have known or read of breeders who consistently produce top birds. These amazing feats defy an explanation as simple as random luck.

So what are these factors and how can their affects be maximized in the birds that a flyer races and the youngsters that he or she produces? To my way of thinking, there are five factors which contribute to a bird's ability to win a race; it has to have **a body, an attitude, condition, fuel, and a minimum of bad luck**. Each of these factors are in turn made up of several components and the desired composition will vary depending upon the type of race and the race conditions. There have been many wonderful articles over the years describing methods which seek to maximize one or more of these factors, but the complete flyer will realize that they all are important and all must be addressed in the flying **and** breeding programs. The very interesting articles and videos which have recently surfaced on the "young bird darkening system" are aimed at increasing motivation in young birds (attitude) and sustaining form over the young bird season (condition). Carbohydrate loading before a race is an excellent method for maximizing the energy reserves of the bird (fuel). All of these methods are important and if they can significantly improve your existing circumstances then they should have a positive impact on your loft. Some breeders and flyers though seem to focus on a single factor and fail to realize they are needlessly limiting their potential for further improvement.

All but luck are totally shaped and controlled by the genetics and environment of the bird. The genes determine the limits that are attainable; the environment determines to what extent those potentials are expressed. The relative importance of genetics or environment varies with every trait. Some, like color, are almost totally determined by the genetic composition of the bird. Attitude on the other hand, is highly affected by the environment. We don't know the exact quantitative relationship for most traits, but we do know that virtually every trait is affected to some degree by both genetics and environment. Our objective as breeders and handlers is to **manage both to our advantage**.

This series of articles will attempt to provide a good solid foundation for understanding and managing the genetics of our flocks. Genetics is not a trivial topic that can be adequately covered in a single article. This is probably the biggest single reason genetics is so widely misunderstood by animal breeders of all species - too few breeders have had the opportunity to study the subject at anything more than a superficial level. On the other hand, just because the subject is substantial does not mean that it is particularly difficult. There is very little in genetics that is hard to understand; it just takes a a steady effort to get through the necessary basics. **If you are willing to approach the subject with an open mind and a bit of discipline, you should be quite knowledgeable by the end of this series.** I will have to use some jargon, but I will confine it to the terms you are likely to find in other books or articles. I will also try to keep it very practical as it relates to the breeding of racing pigeons and not delve so deeply among the trees that we loose sight of the forest.

Finally, I must make it clear that nothing I say should be viewed as absolute or definitive. New discoveries are constantly being made in genetics. I don't believe there is a week that goes by that I don't learn something new or rethink something I once thought I understood. I will speak with conviction about those things that have worked for me and will, of course, welcome your input at all times. And when those inevitable open questions, issues, and discrepancies arise, we will just have to apply the only true test I know to resolve them - controlled experiments and honest evaluation of the results. Welcome aboard!

Lesson 1: The Role of Selective Pressure

To really understand genetics one needs to be knowledgeable about how it works at several different levels. It is not enough to know how chromosomes segregate or how a dominant gene is able to mask a recessive one. Genetics is an integrated discipline that operates at the molecular, cellular, tissue, organism, and population levels. As pigeon breeders we are ultimately interested in the study of genetics at the population level. In other words, we want to consistently and for a long period of time, breed winners from a loft (population) of birds. While we would all love to have a "golden pair", our real interest should be in having "golden lines" that breed on for endless generations.

In the course of this series we will touch on all of these different levels. We want to start out though from the point of view of the population. It is closest to what you work with and it should orient you for some of the more tedious details that we will necessarily cover in later issues.

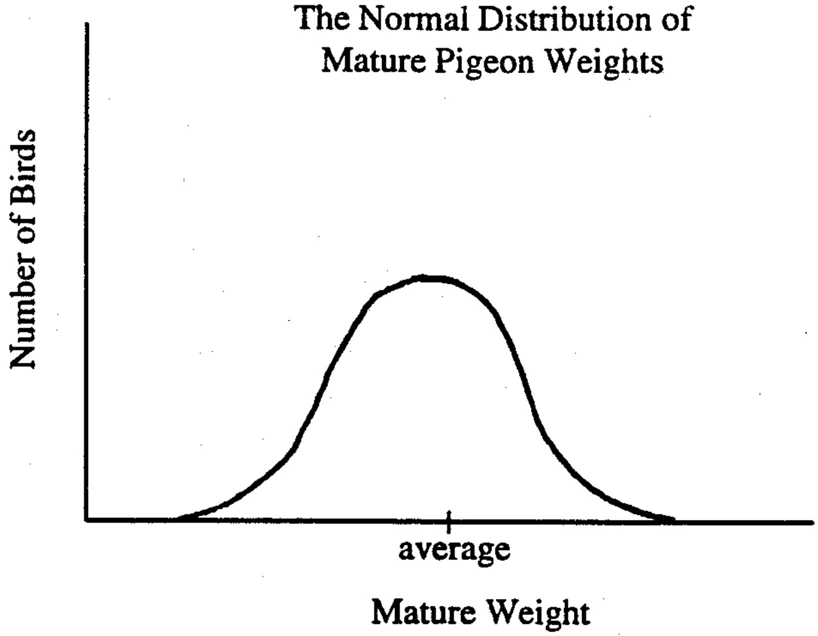
Our first case study will be with a population of bacteria. What? Bacteria? Absolutely! The laws of genetics are amazingly consistent for all species. The vast majority of what you will learn about pigeon breeding applies equally to the breeding of hogs, rabbits, flies, and even bacteria. The advantage that bacteria offer in studying genetics is their extremely short life cycle. I always have great difficulty discussing genetics with horse and cattle breeders because the rather long generation time means that few of these people have a perspective of more than ten generations or so of working with their respective species. Many of the most important lessons of genetics require a perspective of hundreds or even hundreds of thousands of generations. This can be accomplished with bacteria where the generation time is as short as 20 minutes.

The Normal Distribution

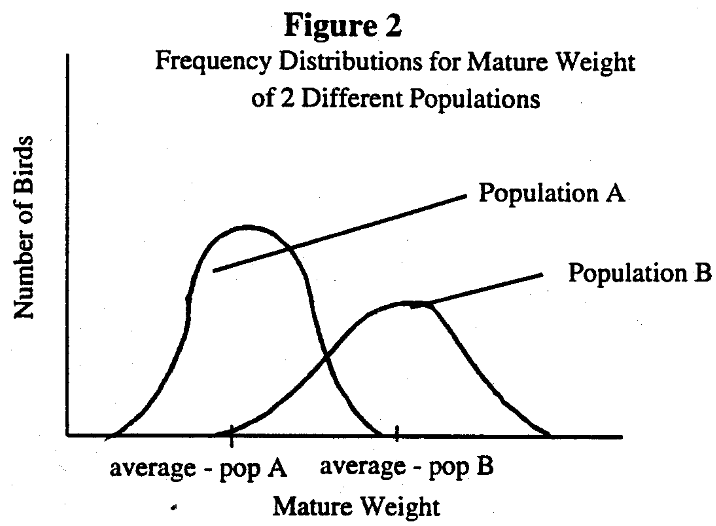
Many important observable traits in organisms are not discrete, but represent a continual gradation between two extremes. An example of this type of trait in pigeons is mature weight. If the mature weight of a large number of birds from a particular population were measured and graphed, the data would approximate what is known as a "normal distribution curve" (Figure 1).

Figure 1

The Normal Distribution of Mature Pigeon Weights



Traits such as speed, endurance, and attitude would have similar graphs though they are much more difficult to measure than mature weight. As you can see from the graph, relatively few animals actually have a weight that is equal to the average weight. Figure 2 shows that the "spread" of the frequency distribution curve can be tight or broad and that two different populations can have a different average mature weight. Note that in both cases, the center of the "bell" curve represents the average for population.



In our case study, we are going to consider the frequency distribution of drug resistance to a particular drug for a particular population of bacteria. Remember that everything that we learn about bacterial resistance to drugs applies to speed, endurance, attitude and many other traits in racing pigeons.

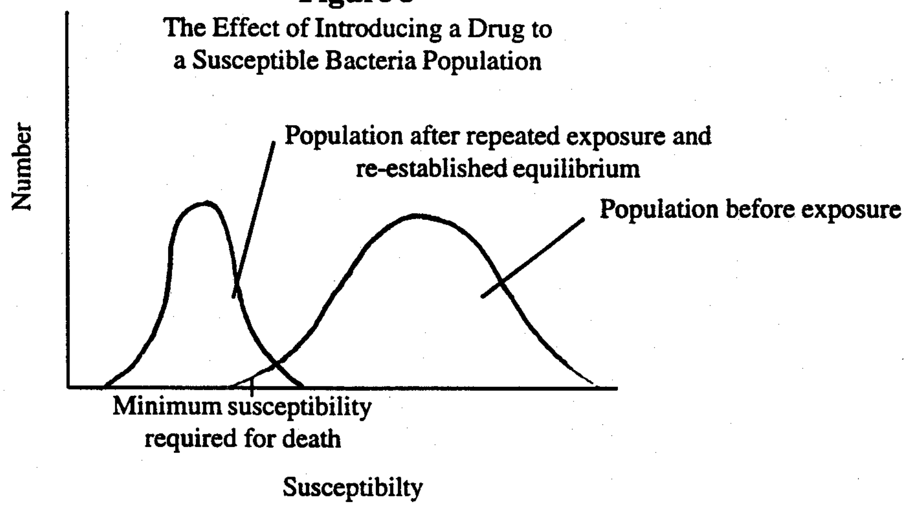
What Happens When We Apply Selective Pressure?

In the wild, animals more or less mate randomly. In a stable environment where changes are not occurring, most populations will reach an equilibrium where the frequency distribution will be the bell curve shown in Figure 1. This equilibrium condition will be characterized by the "average" individuals being the most suitably adapted to the current environment. As long as the environment does not change to favor a different type of animal, the frequency distribution curve will remain unchanged, even though rare animals will occasionally be produced which are significantly above or below the average.

When the environment does change in such a way as to offer a greater advantage to an animal who is not average, the equilibrium is upset. If the environment eventually becomes stabilized under these new conditions, the equilibrium will become re-established with the new average centered around the value that represents the greatest advantage.

In our case study, we are going to change a stable environment by adding a deleterious drug. Some members of the bacteria population will be highly susceptible to the drug, some will be of average susceptibility, and some will be of low susceptibility. When the drug is added to the environment most of the bacteria will probably die, while a few of the variants who were of low susceptibility will survive and breed to produce the next generation. The exact numbers which die will depend in part on the rate and duration with which the drug is administered. This next generation (having been bred from low susceptibility parents) will have a lower average susceptibility to the drug than the previous generation, but they will not all be identical. The average susceptibility will shift lower, but variation will still exist (Figure 3). If the population is repeatedly exposed to the drug, one of two outcomes will eventually occur - the population will die out or it will become resistant to the drug.

Figure 3
The Effect of Introducing a Drug to a Susceptible Bacteria Population



Tip: Avoid continuous or excessive use of anti-bacterial drugs in the loft. Doing so creates an ideal environment for the generation of a drug resistant strain of the bacteria. It is far better to reserve the use of effective drugs for problem situations only. Even then, resistant strains can develop.

What are the Implications In Breeding Pigeons?

Lets consider what this means in our lofts. First, there is a frequency distribution curve for each of the many thousands of different traits which define a pigeon. Fortunately we are only interested in a handful of them. Second, any time we selectively limit which end of the bell curve is allowed to reproduce the next generation, we are shifting the frequency distribution. If we exert a little selective pressure (cull lightly) we will make a little progress (perhaps barely noticeable). **If we exert extreme selective pressure (accurately cull hard and often, using replacement breeders only from one extreme end of the distribution curve) we will dramatically shift the frequency distribution in the direction of our selection.**

It sounds simple enough, but it is surprising how few breeders (in all species) are really doing it. Here are the four most common mistakes that I see being made:

1. **Not having a clear and consistent idea of the traits for which you are selecting.**

   The application of selective pressure will only work if it is actually applied in a focused and sustained manner. Not knowing what you are really selecting for is essentially the same thing as random mating. Remember what happens in a stable environment where random mating occurs? The distribution curve doesn't move. In other words, you won't make any progress. This doesn't mean you won't occasionally produce outstanding animals that come from the top end of the curve. But it does mean your population is not improving.

2. **Attempting to select for too many traits at a time.**

   There really aren't any limits to the number of traits that you can simultaneously select for. However, the more traits for which you simultaneously select, the slower your rate of progress. Your rate will be fastest if you focus on the area in which you want to make the most improvement. In this regard, "selecting by the basket" makes enormous sense.

3. **Applying inaccurate selection criteria.**

   Obviously (at least to me), selecting for large toe nails will do little to improve the genetic basis for endurance in your long distance family. There are many theories out there which place great emphasis on such traits as the eye, the wing, the muscle, and so on. **The breeder must be very careful that what is being selected for is really related to the trait he or she is trying to improve and that an accurate method of measuring that trait is established.** Several years ago there was a tremendous push to select swine which were "wide and well sprung in the body cavity". Unfortunately too many breeders chose to evaluate this trait visually instead of also using ultrasound instruments. The result was the generation of whole herds of wide looking hogs that had the same small body cavity but huge amounts of backfat. As I said earlier, I do believe that for a bird to be a contender, it must have the machinery to do the job. I think it is very appropriate to consider what type of wing or muscle structure best supports a bird for a certain type of race. But, be forewarned! What you think you are doing and what is actually happening may be two different things. The only way to tell if your methods are working is to measure your results and monitor your rate of progress.

4. **Not applying sufficient pressure**

   - This problem can be manifest in one of two ways. Either the breeder is not being restrictive enough in the birds that are used for breeding the next generation, or the breeder is not turning over the generations fast enough. Remember the lessons of the bacteria. You can make great strides, but you only have so many generations to work with in your lifetime. The goal should be to move aggressively forward while retaining just enough of the previous generation to allow recovery from mistakes. Very important note: Not all selection is based upon traits that you can see or measure in an animal (traits like these are collectively referred to as the **phenotype** of an individual). Some selection is done on the basis of an animal's genetic composition (the genetic composition that produces the phenotype is called the

genotype). Selection of the latter type requires techniques such as progeny testing where the genotypes of the parents are evaluated on the basis of the phenotypes (including race performances) of the offspring. We will discuss this point more in a later issue.

Tip: When starting out or starting over, get your animals from an outstanding, established strain or family. Why spend the majority of your breeding career reinventing the wheel when you can instead spend that same time taking the family to the next level. I agree with people who argue that most families almost certainly aren't pure, especially when you are talking about the old lines. However, with a little care, birds can be obtained from these families which represent years of careful breeding and which will start you out with a tight distribution of performance related traits.

Lesson 2: The Significance of the Genotype

Why are some birds great in the races, but just don't seem to breed that greatness on to the next generation? One of the most perplexing aspects of breeding animals, is reconciling the sometimes substantial difference between the results of a particular mating and what we had originally expected. For example, one would expect the breeding of "winner to winner" to be a sure fire combination. I would certainly agree this is often true and we should definitely be selecting breeders only from the very top end of our loft, but such a mating is far from a sure thing! Why is it that some of the best birds just don't seem to pass their excellence on to the next generation? A similar question can be asked for those occasional mediocre animals which produce outstanding racers when paired in a particular combination.

The answer to these questions lies in a single concept - **an animal's phenotype determines its performance potential while it's genotype determines its breeding potential.**

Phenotype is a term that simply means the traits or properties of an organism that can be observed or measured. The phenotype for a given animal will depend entirely on its genotype and the collective influence of its environment.

Genotype is the term used to refer to the genetic constitution of an organism. A very simple example that illustrates the difference between these two terms can be drawn from human eye color.

Let us suppose eye color in humans is determined by a single pair of genes. It isn't actually quite this simple, but it will serve to illustrate my point. Each individual inherits two genes for eye color (one from each parent). If both genes are for "brown" eye color, the individual will be brown eyed. Similarly, if both genes are for "blue" eye color the individual will be blue eyed. If the individual inherits one of each, the gene for "brown" eye color dominates and the individual will be brown eyed. If we represent the "brown" eye color gene as B and the "blue" eye color gene as b, the following table represents all possible phenotypes and genotypes:

Genotype **Phenotype**

BB Brown Eyes

Bb Brown Eyes

bb Blue Eyes

The B gene is said to be **dominant** over the **recessive** b gene. Whenever two genes are paired which code for different phentotypes, it is very common for one to mask the affect of the other. The general convention is to represent the dominant gene with a capital letter and the recessive gene with a lower case letter.

As this example shows, **individual organisms can (and do) carry genes which are not expressed**. In this case, it is possible for a brown eyed individual to carry but not express the "blue" eye color gene.

One can not fully determine the genotype of an animal by looking at its phenotype. If an individual has a phenotype of brown eyes we know it does not have a genotype of "bb", but we do not know if it is "Bb" or "BB".

Examining the offspring can provide additional information about the genotype of a parent, but this too does not always tell the whole story. For example, once a brown eyed parent produces a blue eyed offspring, we know the exact genotype of the brown eyed parent: Bb. On the other hand, if two brown eyed parents had six brown eyed children, we really don't know the exact genotype of either parent. Why not? Lets consider the various possibilities.

Scenario Father Mother

Genotype Genotype

1 BB BB

2 BB Bb

3 Bb BB

4 Bb Bb

Which one of the above four scenarios is occurring if six brown eyed offspring are produced? We don't know! If 100 brown eyed offspring had been produced without a single blue eyed youngster, we would be fairly certain that it was either Scenario 1, 2 or 3. With just six, we really can't rule out Scenario 4 because it is statistically possible (just like it is statistically possible to toss a coin a get six heads in a row. There are however, two approaches we could take to narrow down the possibilities.

The first approach would be to examine the phenotypes that appeared in the pedigrees of each parent. If either parent was the direct offspring of a blue eyed father or mother, we could positively determine its genotype to be Bb. This is because a blue eyed parent can only contribute a b gene to the offspring and an individual can only have brown eyes if they have at least one B gene.

The other approach, that can only be employed in a livestock production environment, is to perform test mating(s). By pairing each of the original brown eyed parents with a blue eyed individual, additional information can be obtained which will allow us to narrow the possibilities. Once a single blue eyed offspring is produced from such a test mating, we know positively that the genotype in question is Bb. If instead, eight brown eyed individuals were produced, we would begin to suspect a genotype of BB. If one hundred brown eyed individuals were produced, we would be very certain the genotype is BB. Of course, we would not know positively that this is the case. It would still be theoretically possible that the genotype is Bb, just as it is unlikely, but theoretically possible, to flip a coin one hundred times and obtain all heads. **Notice that once the first blue eyed offspring is produced the genotype is know, but until that time the test matings never absolutely prove anything.**

The mathematical field of statistics provides us a way to determine the likelihood of a particular genotype. The more brown eyed offspring that are produced, the higher our "confidence" that the genotype is BB. When performing test matings such as these, I generally like to have at least ten offspring produced from a particular mating before I jump to any firm conclusions.

Of course, all of this is a little confusing. It becomes *very confusing* when we go from a consideration of "single gene traits" such as eye color to real breeding situations where we are concerned with the "many gene traits" of speed, endurance, attitude, and physical conformation.

Just to illustrate my point, lets consider the possible phenotypes and their respective genotypes for a "three gene trait". (I don't think anyone knows the exact number of genes that are involved in the phenotype that we call speed, but I would guess it is in the hundreds.)

<u>Genotype</u> <u>Phenotype</u>

XXYYZZ XYZ

XXYYZz XYZ

XXYyZZ XYZ

XxYYZZ XYZ

XXYyZz XYZ

XxYyZZ XYZ

XxYYZz XYZ

XxYyZz XYZ

XXYYzz XYz

XXYyzz XYz

XxYYzz XYz

XxYyzz XYz

XXyyZZ XyZ

XXyyZz XyZ

XxyyZZ XyZ

XxyyZz XyZ

xxYYZZ xYZ

xxYyZZ xYZ

xxYYZz xYZ

xxYyZz xYZ

XXyyzz Xyz

Xxyyzz Xyz

xxYYzz xYz

xxYyzz xYz

xxyyZZ xyZ

xxyyZz xyZ

xxyyzz xyz

As you can see, a "three gene trait" can involve 27 different genotypes that produce 8 different phenotypes. For the trait of "speed" with its (perhaps) hundreds of gene pairs, the number of genetic combinations and their resulting phenotypes is truly staggering.

There are two very important points here that you must remember. First, **most of the traits we are interested in with racing pigeons are determined by many different gene pairs**. These "many gene traits" can produce many different genotypes with a whole range of resulting phenotypes. The phenotypes produced in any particular loft will approximate a bell curve (as discussed last month) that represents a frequency distribution between two extremes.

Second, you must realize that **an animal can display an excellent phenotype and yet still carry a great deal of genetic diversity that is not being expressed**. While the animal may be an excellent performer, it may not be uniform enough in its genotype to produce a high percentage of excellent offspring.

To illustrate this latter point, consider the following two matings. Notice that both matings involve the crossing of animals with identical phenotypes (in other words, physically indistinguishable to the breeder). For the purposes of this discussion, lets stipulate that we are selecting for speed with the following relationship between phenotype and genotype:

<u>Phenotype</u> <u>Genotype</u>

Fast AABB

AsBB

AABb

AaBb

Medium aaBB

aaBb

AAbb

Aabb

Slow aabb

Mating Number 1:

AaBb X AaBb (Fast X Fast)

This mating will result in the following offspring:

<u>Phenotype</u> <u>Genotype</u> <u>Frequency</u>

Fast AABB 1 in 16

AaBB 2 in 16

AABb 2 in 16

AaBb 4 in 16

Medium aaBB 1 in 16

aaBb 2 in 16

AAbb 1 in 16

Aabb 2 in 16

Slow aabb 1 in 16

Notice that 9 out of every 16 offspring will be expected to be "fast".

Mating Number 2:

AABB X AABB (Fast X Fast)

This mating will result in the following offspring:

Phenotype Genotype Frequency

Fast AABB 16 in 16

In this case 100% of the offspring will be "fast".

If this example had assumed three gene pairs determined "speed", then the AaBbCc X AaBbCc mating would produce 24 out of 64 "fast" offspring (37.5%) and the AABBCC X AABBCC mating would again produce 100% "fast" offspring. As the number of gene pairs responsible for a given trait increases, the more dramatic this effect can become.

There is obviously then a distinct advantage in selecting birds for the breeding loft which have the right genotype in addition to the right phenotype. **We want animals for breeding that are homozygous for the desirable genes**.

When both of the genes of a particular pair are the same, the genes are said to be **homozygous**. When they are different, they are **heterozygous**. In our earlier example of human eye color, BB and bb represent homozygous pairs and Bb represents the heterozygous condition.

Our goal as animal breeders must be to produce the outstanding phenotype in a manner that is both predictable and repeatable. To do this we strive to build a breeding loft which is high in homozygosity and low in heterozygosity.

Lesson 3: The Paradox of Heterozygosity

Unfortunately, it is not that simple. There is another factor at work that can act to negate the predictability advantages of a homozygous gene pool. Nature places a tremendous priority on survival. One of the chief mechanisms Nature uses to insure survival of a population is diversity. The more variable and diverse a population is, the more able it will be to respond to changes in its environment.

By promoting variation for all traits, Nature is in effect covering all its bases. Its approach is to allow the most suitable members of the population to flourish, but to insure that the population maintains enough variability so that it will have members who will be viable should different environmental conditions arise.

One of the mechanisms by which Nature promotes variation is heterosis. **Heterosis** is a widely observed phenomenon in which animals with a high degree of heterozygosity display greater vigor in terms of growth, survivability, fertility, and other phenotypic traits. Commercial livestock producers have long taken advantage of heterosis in the production of meat animals by crossing various breeds to produce the market animal. The same approach has been employed by plant breeders in producing hybrid sweet corn.

The opposite effect of heterosis is **inbreeding depression**. The more inbred a population is, the more homogeneous its gene pool, and the more likely that growth, fertility, and disease resistance will be lowered.

Just as the swine producer can cross a Duroc to a Hampshire to produce crossbred market hogs that thrive and grow quickly, the pigeon flyer can cross two unrelated families to produce vigorous birds that race better than either of the parental lines. In other words, we would be strongly advised to breed racers which are high in heterozygosity and low in homozygosity - the exact opposite of what we just said we wanted to produce in our breeders.

On the surface it would appear that we have an unresolvable paradox here. How can we simultaneously promote heterozygosity and homozygosity?

Next: A practical method for solving this paradox.

In the first two articles in this series, we have established a solid foundation from which more practical topics may now be considered. Before going on, lets review the more important points in this foundation.

1. **Virtually all traits of an organism are affected by both genetic and environmental components.**

   The genetic component sets the limits while the environment determines how much of this potential is actually expressed. New methods such as the "Darkening System" generally improve our ability to maximize the environmental component, while mating assignments and selection are the keys to maximizing the genetic component.

2. **Significant genetic progress requires exerting extreme and focused selective pressure over an extended period of time.**

   The best account of this I have read to date in the pigeon world is the series of articles written by Bob Tavares about Maurice Jamal that appeared in the *Racing Pigeon Bulletin* (November 22, November 29, December 6, 1993). One of many noteworthy points made in this series was that Maurice has bred from fewer than 4% of the birds he has raised.

3. **Breeding animals should be high in homozygosity and low in heterozygosity.**

   We want a narrow gene pool of superior genes which allows for the production of a uniform crop of outstanding offspring.

4. **Racing birds should be high in heterozygosity**

   to reverse the effects of inbreeding depression and to maximize the effects of heterosis.

Lesson 4: Strategy for a Breeding Program

We concluded last month with a question; how can we practically promote heterozygosity in the race team and homozygosity in the breeding loft, all within the same flock?

Up to this point, most of what has been suggested in this series is fairly straight forward and represents what I would consider conventional wisdom. What I am going to suggest now is far from conventional and may very well generate considerable controversy. The ideas are not being put forth as the only method for successful livestock improvement, nor do I claim that they originate with me. They are offered because they work and, from my point of view, they work better than any other strategy that I have used or seen in the thirty five years I have been involved in animal breeding. It should be further noted that many racing lofts today are already employing many aspects of this strategy, though perhaps not to the extreme that I would recommend.

Here is the seven step breeding program that solves our paradox. It allows a single loft to produce a uniform and superior racing bird generation after generation, without being hindered by any of the negative effects of inbreeding and without limiting further improvement.

Step 1: Establish a clear idea of what you are trying to produce. True, this is obvious. It is also absolutely essential.

Do you want to breed show birds, dominate the short distances, excel in the long distances, or race a general purpose bird which is competitive in a particular range of distances?

All are legitimate objectives, but each will have somewhat different selection criteria. You must know what you want to produce and your vision must remain focused year after year after year.

Step 2: Establish effective and reliable methods for measuring these qualities. Again, this is obvious, but essential. The measurements are necessary both for aiding in the selection of breeders as well as monitoring the progress of the breeding program from year to year.

I am in agreement with those who argue that the basket is the best way to select breeders. The breeding program I am outlining though, advocates inbreeding of the parental lines and crossing to produce the race team. As such, this approach *absolutely requires* that the basket results be evaluated within like groups. **By evaluating within "contemporary groups", crossed birds are not given an artificial advantage for heterosis nor are inbred birds unfairly penalized for inbreeding depression.** A separate contemporary group should be defined for each parental line.

Parental lines can and should be raced as long as they are competitive. There is certainly no more valuable bird than one that is highly inbred and possessing an outstanding race record against the best birds of the combine.

However, as the gene pool of the parental lines is narrowed around the outstanding genes, significant inbreeding depression will occur. It is expected that a point will eventually be reached where this depression effect is simply too pronounced for the birds to be competitive. Rather than this point marking the end of the usefulness of the parental line, it will more likely mean that the prepotency of the parental line has been established.

By selecting only those birds that race at the top of their contemporary group, we are reasonably well assured that we are narrowing the gene pool around the desirable genes. As we will discuss next month, inbreeding simply narrows the gene pool. It doesn't automatically narrow it around the genes we want.

In extreme cases this may mean conducting our own "loft" races in which parental line breeder candidates are raced among themselves.

Progeny testing is another important consideration in evaluation methods. This is especially true in this system where we are trying to narrow the gene pool of the parental lines. Progeny testing affords us the best data for evaluating parental genotypes. Race data from other relatives can also be used. This topic will be discussed in more detail in a later issue.

Step 3: Obtain or develop a number of outstanding parental lines that represent reasonably narrow (homozygous) gene pools rich in the genes for which you are breeding. You will need at least two lines. For small lofts this is sufficient. The two lines will be crossed to produce the race team.

For larger lofts there are some advantages in having four. In this scenario, the race team is produced by crossing two separate crosses. Parental lines A and B are crossed to produce one parent and lines C and D are crossed to produce the other parent. The resulting race team is then one quarter each A, B, C, and D. This approach provides 100% heterosis in the race team as well as 100% heterosis in each of the parents of the race team. The idea here is to maximize the environmental component of the race team birds by insuring that they are raised by vigorous parents that show no effects of inbreeding depression. Remember that the environmental influences start not at birth, but at least as early as conception and possibly earlier if one considers follicle development in the hen.

The parental lines must be of the highest possible quality. The goal should be to establish parental lines which have narrow gene pools of world class genes.

How is this accomplished? It is basically a two step process: acquire the genes and then concentrate them through inbreeding.

It is important that you understand that you can not select for genes which are not present somewhere in your flock. Imagine trying to breed world class racing pigeons by starting with a pair of fantails. Mutations do occur, but their frequency rate is so low that for all practical purposes, you can discount this possibility.

It is equally important that you understand that inbreeding can only concentrate what is already there. Inbreeding from a pair of mediocre birds will almost certainly produce a line which will uniformly produce mediocre birds. There is absolutely no substitute for quality foundation animals.

Keep the lines straight! Do not allow yourself to periodically cross in other lines and still think of it as the original line. There is a place for outcrossing and it will be discussed later, but it must be by very careful design.

Step 4: While strictly keeping the parental lines straight, perform test crosses to find the golden "pairs".

Not all crosses are successful. It is entirely possible to cross two outstanding individuals of two well bred homogeneous lines and get mediocre offspring.

It is necessary then that we not only have good quality parental lines, but that they also cross well.

The only way that this can be accomplished is to perform a number of test crosses. The task can be made easier by watching the race sheets and seeing what is working for other flyers. Most racing pigeons fanciers are aware of the advantages of racing the crosses.

Breeders should keep in mind how Sweet Corn is produced. Hundreds of highly inbred lines (many with ears that are little more than nubbins) are crossed and evaluated. Of the thousands of crosses that are made, only a few are selected for commercial production. The wonderful ears that we buy in the store are these carefully produced hybrids.

When a great bird is produced by a cross, many flyers make what I consider a mistake by breeding that bird back into one or both of the parental lines. My recommendation would be to instead go back to the two parents of the great bird and linebreed around each of them in their respective lines. The goal would be to produce a subfamily within each line based around the respective parent. If this was successful, the flyer would now have two lines which could be crossed on demand to produce large numbers of birds genetically very similar to the original hit bird.

The goal of this breeding program is to produce quality offspring endlessly from generation to generation. However, the quest for improvement should never cease. Even the most successful breeder should always be experimenting with new lines and crosses.

The "experimental" lines must never be allowed to intermix with the established parental lines except as part of controlled crosses. Further, the breeder must enter these experiments fully expecting to dump the experimental lines and their associated investment when the results are anything less than spectacular.

Step 5: Race the crosses!!! Remember to use contemporary group testing to continue improvement in the parental lines and to use the race results of crosses to evaluate the genetic value of the parents.

Don't give in to the urge to breed the great crosses back into either parental line. If a *truly* great cross bird is produced, breed it to a bird of an unrelated line to produce more race birds. Another option would be to intensely linebreed around the bird to attempt the creation of another line. Be prepared for disappointment though. It takes many generations to create a true line that is able to produce uniform offspring.

Step 6: Maintain compre-hensive records. Make sure your records are detailed and that they are retained for every year of your breeding program.

The breeder today who has true families of quality birds and twenty years of breeding and racing records is truly postured to take his or her loft to the next level. Complex genetic analysis of these records is an almost impossible task if done by hand, but is just another task for many of today's powerful desktop computers. You may not have a computer today, but chances are you will someday. The records you keep today will be almost certainly be the keys to the kingdom tomorrow!

Step 7: Perform carefully controlled outcrosses as needed. There is a major problem with this breeding program if we were to stop at Step 6.

While inbreeding acts to narrow the gene pool by concentrating the genes of outstanding animals, it also tends to reduce variability. So while inbreeding can give you 9 quality birds out of 10, the 9 birds will represent a kind of genetic ceiling that will be almost impossible to exceed.

To resolve this problem, we use carefully controlled outcrosses. The introduction of an outcross animal to a line will almost always have an immediate and drastic impact on the gene pool of the line. It generally results in the gene pool becoming more diverse and consequently a wider range of phenotypes being observed. This means that we will lose (at least for the moment) the uniformity and predictability that we had created with inbreeding, but we will have recovered the ability to produce that rare "freak" that represents the far edges of the bell curve we discussed in the first article. In other words, our genetic "ceiling" will have been removed.

Once the outcross matings have demonstrated an ability to significantly improve the quality of the offspring in at least some matings, the line is again closed to outside crosses and inbreeding resumed. The goal is to now retain the desirable genes from the outcross animal(s) and the line while eliminating the undesirable genes that the outcross introduced. This task is usually easiest if a single outcross animal is used.

Until the results of an outcross have been proven satisfactory, the original gene pool of the line should be carefully preserved.

In general, outcrosses should be done very sparingly.

Lesson 5: What is Inbreeding?

In the last article I put forth a breeding strategy that would allow a single loft to produce a uniform and superior racing bird, generation after generation. The program placed a heavy emphasis on inbreeding within the parental lines, but without being particularly hindered by any of the negative effects of inbreeding and without limiting further improvement.

This month we will conclude the series by taking a closer look at specific inbreeding strategies for developing and maintaining the parental lines.

In simplest terms, inbreeding is nothing more than the mating of related organisms. (Note: Since all members of a species share some common ancestry, the term "related" needs to be qualified. A more robust definition would be that inbreeding is the mating of organisms more closely related than the average of the population.) It can be carried out with plants or animals and is a very effective tool for increasing the uniformity in the offspring.

Many people seem to hold a very negative view of inbreeding. One of the more common misconceptions is that inbreeding causes defects and abnormalities. This is simply not true. What does happen is that as the inbreeding progresses, the frequencies of certain genes within the population increase, potentially exposing undesirable recessive traits (URT). As you will recall from the May 1994 issue, recessive single gene traits are only expressed when both of the inherited genes are recessive. **Inbreeding didn't cause the undesirable trait, it merely exposed the fact that the undesirable genes were present in the**

population.

In the case of humans, some of these URTs represent very serious situations. Sickle Cell Anemia is just one of many genetically based diseases where the homozygous recessive condition is eventually fatal. Obviously, there are very good reasons in the human population to avoid inbreeding.

This is not the case in plant or livestock production, where undesirable individuals can simply be culled. Within the context of livestock improvement, inbreeding should be viewed as a powerful and effective tool when used correctly.

How does inbreeding differ from linebreeding?

Another area of confusion is the relationship between inbreeding and linebreeding. Linebreeding is nothing more than a particular type of inbreeding in which the related animals are paired in such a way as to intensify the contribution of a particular ancestor.

It is often used after the premature death of a key animal or in cases where a key animal is unavailable or too costly for purchase. It can also be used to produce "clone" lines that have an extremely high percentage of genes from a particularly outstanding bird.

For example, lets consider two matings involving a "super cock". Lets imagine a scenario where this "super cock" is owned by another flyer/breeder and the price of obtaining him is simply beyond our budget. However, the breeder does have two outstanding offspring (a cock and a hen) that are available at a price we can afford. As the following example will show, we can potentially obtain the same benefit from both scenarios:

super cock

x < x is 50% the "super cock"

a

super cock

b <

d

y < y is 50% the "super cock"

super cock

c <

e

Bird "y" is said to be linebred around the super cock. Bird "y" is also inbred, since both of its parents are more closely related than the average racing pigeon.

More importantly, both birds "x" and "y" can trace 50% of their genetic contribution as coming from the "super cock". It is as if both birds were sired by the "super cock". (Note: Actually, it isn't quite that simple. The 50% contribution of the "super cock" for bird "y" is definitely a theoretical figure that represents the most likely contribution of the "super cock". Since only one gene of each pair will be passed to "y" from each of its parents, only some will have originated from the "super cock". The actual contribution of the "super cock" to bird "y" will then be somewhere between 0% (if all the genes should just happen to have come from "d" and "e") and 100% (in the equally unlikely event all of the genes happen to come from the "super cock"). The actual percentage will depend upon which egg is fertilized by which particular sperm. In other words, there will be a frequency distribution centered about 50% with theoretical extremes of 0% and 100%. Through selection, we hope to utilize those animals that are 50% or higher.)

While the goal of inbreeding is to increase uniformity, the goal of linebreeding is to increase the contribution of a common ancestor. Considering again our "super cock", linebreeding would allow us to produce animals that have an unusually high percentage of "super cock" genes. In this next example, the theoretical contribution of the "super cock" to pigeon "z" is 7/8ths or 87.5%:

super cock

z <

super cock

a <

super cock

b <

c

(Note: To produce birds with more than 50% "super cock" requires the use of either the "super cock" himself or linebred offspring that are themselves more than 50% "super cock" breeding. In this case, simply buying the two children of the "super cock" as suggested in

Example 1 would not be sufficient. Obviously, if the "super cock" is available, obtaining full breeding rights should be our first choice.)

While "z" is linebred around the "super cock", it is also very inbred and can be expected to exhibit some decline in vigor. As was discussed last month, this can detract from the flying career of "z". However, if the "super cock" is(was) truly super, this inbreeding will enhance the breeding career of "z".

Polygamous or bull breeding systems allow the breeder fortunate enough to own a "super cock" to carry out this breeding strategy without interfering in any way with the more traditional matings. The Jackson Lofts Video # 10 featuring Rick Mardis' Bull System is outstanding and one that all practitioners of extreme linebreeding should see.

In general, I believe all true "super" birds should be successively paired with an outstanding son or daughter for as long as the "super" bird remains fertile. Birds that are say, 15/16ths "super cock", would allow his influence to be carried forward far longer than would be the case with traditional mating strategies.

An even better scenario would be the extreme linebreeding of the cock and hen of a golden pair. The development of a line which was 63/64ths "golden cock" and another line which was 63/64ths "golden hen" would virtually allow the perpetual breeding of the golden "pair" as was discussed last month.

Remember, in selecting the son or daughter to use in building these "clone" lines, select only the most outstanding individuals of the generation.

A final scenario for linebreeding would be when a particular bird in the loft consistently produces winners (particularly when bred to several different mates). Even if this bird has never won a race, its ability to produce multiple winners indicates that it possesses many of the genes for which we are selecting. Once an animal such as this has been identified, I would immediately begin a program of successive matings to outstanding children.

How close is too close?

If the birds are **truly world class**, I don't believe it is possible to breed them too close! If reproduction and disease resistance become too much of a problem, the breeder can always backup by crossing back to more distant members of the family. Remember too that when the inbred birds are mated to a total outcross (as in the production of the racing team) there is **no** inbreeding depression exhibited in the resulting offspring. None!

To be specific, I think it is perfectly all right to breed brother to sister or parent to child. Both of these matings represent the same degree of inbreeding and can safely be carried out for several generations without experiencing an extreme decrease in reproduction or disease resistance. Again, while such matings are acceptable, they should only be carried out with exceptional animals.

When there is not a single outstanding individual around which to fashion the matings, pairings should be constructed with the idea of concentrating the genes for the desirable traits for which we are selecting.

Making it work.

Here are some additional guidelines:

1. **Always select for the weakness of the line.**

   If a bird should pop up that excels in a trait for which your line or family is weak, retain it for breeding even if it is seriously deficient in traits that are strong in the line. The freak bird represents a powerful breeding piece for your particular loft and should not be routinely culled without first being given a chance to pass on its unique genes for the trait that is weak in the rest of your loft. Persist even if the next generation continues to show serious weakness in the traits the line is strong in. These traits are well represented in the gene pool and they will resurface in subsequent generations in a great enough frequency that you will be able to affect improvement in both areas.

2. **Cull more, not less, than you would with normal breeding systems.**

   It simply can not be over stated - inbreeding should only be used with outstanding animals. You are attempting to segregate and concentrate the genes that make these animals outstanding. Selecting anything less than the very top end is counter productive. To put it another way, by selecting from less than the very top end, you are selecting against the very genes you are trying to concentrate!

3. **Selection is a three stage process!**

   I think of selection in terms of three distinct "cuts". The first is based on the bird's **potential**, the second on the bird's **performance**, and the third on the performance or breeding of the bird's **progeny**.

When these specific selection cuts are made will vary from loft to loft. A bird though shouldn't usually be "stocked" until it makes it past the third cut.

In many lofts, the first cut will usually occur at weaning. At this time the number of young birds retained must fit the capacity of the facilities. The selection criterion used at this stage might be based upon pedigree evaluation, performance of previous siblings and relatives, and/or physical evaluation of the squeeker. Crowding must never be permitted. The breeder will clearly retain the top end of the crop based upon his or her perception of their potential. As I have said before, I am not sure we are as good at evaluating this potential as we think we are and so if your facilities and time permit, you should probably settle and train all of the birds you raise.

The "performance cut" or second stage of selection will usually occur at the **end of the young bird racing season and again at the end of the first old bird season**. Our selections at this point are heavily based on the performance of the bird, though some consideration can still be given to pedigree and relatives if the line is late maturing. The need to retain certain animals for planned linebreeding matings can also play into which birds are retained at this stage.

The "progeny cut" or third stage of selection will occur at various points in time, but will represent our assessment as to the ability of this bird to "breed on". I like the recommendation Rick Mardis makes in the "Bull" video that the bottom third of the breeding loft be culled each year and that the middle third be paired with different mates the following year..

Series Summary

I have tried in these four articles to present a solid foundation from which a world class breeding program can be constructed. I don't believe you can embark on such an effort without a clear understanding of the underlying processes. With this foundation, you as breeders can adapt and modify many of the ideas presented here to suit both your goals and your methods.

The material of the last four issues has, at times, been rather technical and may require repeated reading to fully comprehend. You are encouraged to do this. As I said in the introduction to the series, none of this is difficult, it just takes time to absorb. As you master the details, don't lose sight of the overall plan. In closing, let me stress one last time, these important points:

1) Start with superior stock.

2) Develop accurate selection criterion.

3) Test consistently and cull hard.

4) Incorporate progeny testing in your selection.

5) Maintain accurate records.

6) Use inbreeding to develop or maintain multiple parental lines.

7) Race the crosses.

8) Never stop experimenting.