Breeding, Gene Dynamics and DNA

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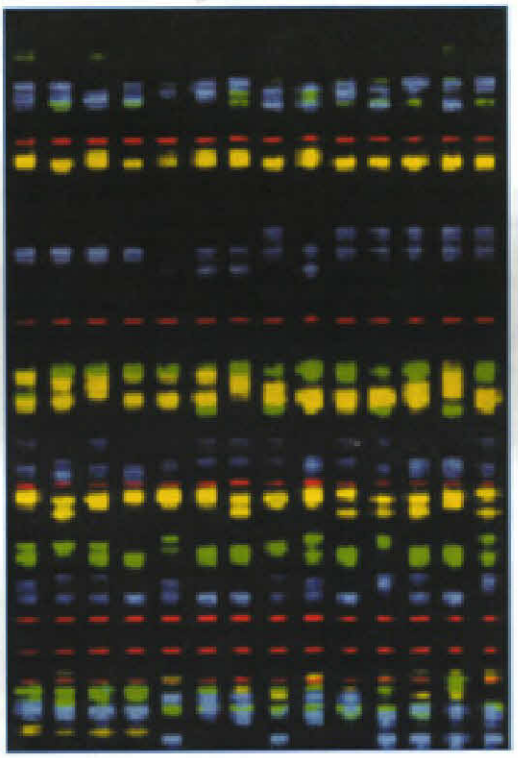
Frequently, when observing a top class sportsperson, it is obvious that he or she is something special. Built to succeed. A natural. They have the gift to seemingly effortlessly excel in their chosen arena. The aura is confident and they appear almost invincible. Their power and stature is communicated not only physically, but also telepathically. In summary, they are the finished articles and seem to have inherited every useful gene version in the book.

Whilst, as humans, we can all readily recognise and appreciate their attributes, it is also apparent that some horses are blessed with the same qualities. Their breeders may recognise it, the agent who purchases them may recognise it and the public may come to recognise it. When it becomes obvious that something special has arrived on the scene, one cannot but help wonder about the mechanisms which arranged all the right genetic combinations within the perfect equine packet.



A similar state of wonderment can be applied to an examination of the negative genetic factors that consign a once promising and apparently athletic colt, to gelding and obscurity. Or those which contrive to produce a similarly disappointing filly which will join the 'also rans' of breeding ranks. Picking out the decent looking animal is one thing, successfully breeding it, or breeding from it, is another.

Where horses differ from most humans is that they are artificially selected and can be bred to emulate the achievements of their notable predecessors. Breeders at the top end of the market have the luxury of realistically attempting to reproduce similar genetic entities, others hope to get somewhere near it. Many others, still, have the modest objective of producing improved progeny from less gifted mares. All things are relative and one man's failure at the top end may be the stuff of dreams for somebody further down the ladder. Whatever the level, many do not fulfil their expectations, realistic or otherwise.

The inevitable impact of commerciality and environmental factors such as training, feeding and prepping can make it difficult to assess the genetic contribution to certain trends. However, commercial aspects apart, environmental factors will not affect the genetic status or potential of a horse and production of the successful racehorse is made easier if the raw genetic material is present at the outset.

Breeding strategies and trends combined with a perception of a horse's ability, or potential, determine the shape of things to come. If there are as many successful fillies on the track as there are colts and given that there are probably less than 5 per cent of colts and over 60 per cent of mares going back into breeding, it would seem natural to assume that the industry is either missing out on a number of useful male animals or breeding from a preponderance of mediocre to useless mares.

Whilst the former might be true to a lesser extent, support for the latter assumption might be a good deal stronger. There is an obvious imbalance and choosing the right mating combinations is precarious.

The fact that this imbalance exists indicates that the selection of colts for breeding is based on success, whereas the selection of mares is often based on hope. This is not restricted to smaller breeders as many of the mares of the larger organisations, rather than being selected based on performance, are chosen on the basis of the presence of black type further back in the pedigree. This would suggest that, for most breeders, the more reliable source of genetic potential comes from the sire. However, the ability of a sire to translate his racing performance into breeding potential is not always guaranteed.

Varying stamina and maturation objectives ensure that there are many genetic mechanisms that may influence success.

Single, major genes known as monogenes undoubtedly affect certain desirable physical and physiological characteristics that contribute to performance. Different variants, or alleles of these carried by different horses probably contribute to variation in performance levels. On the whole, they are relatively easy to select for because the characteristics they control are likely to have obvious effects. However, getting the right combinations of favourable alleles for a number of major genes in the same horse is not so easy. Groups of genes, known as polygenes, also work in an additive manner to affect a trait. These are less predictable in their inheritance as groups of genes are not generally inherited en masse. They are sometimes referred to as Quantitative Trait Loci (QTLs). They affect imprecise traits such as growth, height and stamina. They are likely to be modified by environmental factors such as nutrition and training regime.

Further variation and interaction between genes is also likely to contribute to precocity of young horses. Genes that are activated or repressed as a response to accumulation of chemicals within the horse's body may affect the maturation rates.

Whilst both parents of a foal contribute equally to genes that are carried on chromosomes, the dam also unilaterally contributes DNA via structures called the mitochondria. This can mean that the dam can contribute up to 52 per cent of total DNA and the sire only 48 per cent. As it is passed on only down the female line, the mtDNA as it is known, is present in different allelic formats in different female families. When one considers that mtDNA plays a role in respiration, a molecular basis for Bruce›

Lowe's family classification is provided.

Consider all of these types of genetic interaction and add the fact that some alleles may be 'switched on' or 'turned off' depending on which parent the foal receives it from, and a rough explanation for variability in performance is provided.

It is likely to be a rare occasion when absolutely all of these factors work in harmony to achieve the ultimate objective. To get at least some of them in synchronization would be a useful achievement. They not only affect a horse's performance, but the manner in which they are inherited determines subsequent breeding potential and optimal choice of mating. Ultimately, achieving the optimum mating is dependent on the correct gene dynamics between the stallion and mare.

All horses carry two copies of each regular gene, one from the sire and one from the dam. In the ideal situation, a horse that has received a high number of duplicated alleles for beneficial traits, whilst avoiding duplications of bad ones, is the best racing/breeding proposition. Ideally, it would all be made easier if stallions were extremely genetically homogenous. It would also be desirable if his alleles were dominant over those carried by the mare. This would ensure that the stallion was prepotent. Realistically, this is unlikely to happen. In recent times one might envisage that only Northern Dancer may have been the closest to falling into this category.

The very strategies that ensure the relative genetic health of the breed and the success of many individuals probably dictate that most successful animals are relatively genetically variable or heterogeneous. This makes it more difficult to predict the outcome of matings.

The cyclical choices of matings that recognize the importance of outcrossing are likely to give rise to genetic variability in progeny. Similarly, the use of pedigree theories based on 'nicks' also based on an outbreeding theory would result in genetic heterogeneity in the foals.

Genes involved in producing sprinters may be different from those influencing staying ability. The common policy of crossing speed orientated stallions with mares influencing stamina is likely to produce foals carrying a balance of genetic factors influencing both of these extremes. They are also likely to be variable because of this.

In essence, these policies would give rise to 'hybrids'. It is probable, therefore, that a number of successful animals benefit from the hybrid vigour generated by these strategies. This might help to explain why numerous successful individuals on the track are unable to consistently stamp their progeny.

The most prepotent stallions are unlikely to be very genetically homogeneous because this would have arisen through repetitive inbreeding which is also likely to have produced animals subject to all of the undesirable disadvantages of this procedure. They would be less likely to be genetically healthy. They would at least, however, have a greater degree of genetic consistency than those with less successful stud careers.

In many instances when the mare has performed poorly or has limited potential, a prepotent stallion is a useful choice. However, because every horse is genetically different, the genetic solution in mating one particular stallion or mare may not be the same for the next one.

In some instances it is possible that a mare may be more prepotent than a potential stallion. In the case of a successful track mare with a high number of duplications, one might be better off covering her with a stallion that is less prepotent. This would allow the mare's own genes to dominate and not be cancelled out or over-duplicated. It is not necessarily always a good strategy to cross the best with the best and hope for the best.

These two scenarios, where either the stallion or the mare is the dominant genetic party, help to explain two potential mechanisms for success (or failure). The third mechanism would be where they contribute equally to the genetic equation and there is a certain degree of genetic complementation, a situation that some people may refer to as a 'nick'.

Genetic trends are not always apparent until a number of matings have been made. The number of potential genetic scenarios for each different animal is enormous. It is not always possible to predict the genetic requirements for each animal from paper information alone. If it were, then there would be no failures. If techniques are available which can give a better indication of the genetic status of horses they can only clarify and improve the accuracy of knowledge of pedigrees and breeding theories.

Through use of DNA analyses we are accumulating information that is allowing us to look at the genetic patterns that result from breeding policies.

Bands in a pattern, like the ones shown in the photograph, represent fragments of DNA carrying a gene or genes spread over chromosomes, sex chromosomes and mitochondrial DNA. The position of bands is dependent on the alleles present in a particular horse. As a band represents an allele, it is described as a genetic marker. Examination of the genetic constitution of individual horses, modes of DNA inheritance and identification of beneficial genetic types can be achieved through an examination of 'genetic profiles' of horses created using a wide selection of genetic markers.

Using broad range tests it is becoming possible to examine the basis of such phenomena as 'nicks' and damsire trends. In later articles we hope to refer to specific applications of this work in greater depth. □