Out of Africa: Survival of the Fittest :
And
The Genetics of Profitability

Introduction and Background

It is said that in Africa, only the fittest survive. One could apply this in general terms, but for the sake of this exercise, I'll stick to animal husbandry.

Firstly let me tell you a little about South Africa, my origins and the breed of sheep with which I farm. Thereafter I'll go into animal selection. The country covers some 471,000 sq miles – that is 4 ½ times larger than NZ (and over 6 times smaller than Australia). A whole 6% of S.A. is made up of National Parks.

For those of you who have visited S.A., I am sure you would agree that it's a wonderful and beautiful place ranging from forest to desert and sub-tropical to savannah.

There are 9 provinces with ours, the Eastern Cape being the poorest, mainly due to a lack of mineral wealth and industrial development. Nevertheless, we have the most livestock; roughly a ¼ of SA's 14 million cattle, 30% of the 25m sheep and nearly 40% of the 6 ½ m goats. The E.Cape also produces 30% of SA's wool.

Average farm size in our area is about 5000ha, each carrying about 2500 sheep units. Due to heavy stock losses caused mainly by vermin and theft, many farms have been converted to game-viewing, tourism and hunting enterprises. As is the case in many countries, many of the younger generation are being discouraged from farming and opting for other careers.

The Karoo climate is harsh with summer temperatures reaching highs of 30 to 42 deg C and winter nights are frosty in the high-lying areas dropping to lows of about minus 12 deg C. We also get occasional snow. The average rainfall in the area is 325mm (13inches) and the topography varies from flats covered in dwarf-shrubs (Karoo bush) to rugged mountains, reaching up to 8200ft above sea-level and covered in coarse grass. This harsh climate results in severe nutritional shortages, particularly over winter and during periodic droughts and of course, after fires.

Many farmers suffer huge stock losses due to vermin like the Black-backed Jackal and Lynx. Stock theft can be a problem making small stock farming especially difficult for those farmers adjacent to the towns and cities and old tribal homelands.

Of our approx.50m inhabitants, 77% are Black, 11% White and the balance, Coloured, Asian and African refugees. Income disparities are enormous and there are many poor people with +- 40% of the employable population being unemployed.

My paternal ancestor, a Frenchman serving as a Captain in the Dutch-East India company left Switzerland and settled in the Cape (now known as the Western Cape of S.A.) in 1790. At about this same time, the Commander of the Dutch Forces of the Cape, took charge of four Merino type Ewes and two Rams that had been presented to the Dutch Government by the Spanish King. (Incidentally, the progeny of these same Merinos were also to become the origin of the Australian wool sheep industry). Being interbred with the woolless fat-tailed indigenous African sheep, they did really well in the Cape. By strict selection and only 15 years later, 8000 of the Cape Colony's sheep were wool-bearing.

On my mother's side, the Southeys arrived in SA with the British Settlers of 1820. They were settled on 1000 acres of untamed country in the Eastern Cape that formed a buffer between the Xhosa tribes descending from the North, and the predominantly Dutch Settlers from the South. From there, the Southeys moved to the arid Karoo interior where they purchased a farm and bred sheep and cattle. Some of us are still there, and we love it!

Breeding and Selection

My son Jean and I, farm with Dohne Merino Sheep on our farm "Grassdale". The breed was developed by the S.A. Dept of Agric. and a few breeders in the E.Cape in 1939 by crossing the German Merino meat sheep with the woolled Merino. The Dohne has been most successful and is a good example of a true dual-purpose breed. Not only is it hardy, fertile and fast-growing, but it also carries high-quality fine Merino wool. The Dohne makes up approx. a third of the woolled sheep population in S.A.

Generally well-managed, the Breed's main focus has been on performance figures that are taken at 12 months of age. EBV's (Estimated Breeding Values) for Body Mass, Clean Fleece Mass and Fibre Diameter are recorded and configured by BLUP (Best Linear Unbiased Prediction) into an REV (Relative Economic Value) and ranking. Wool weight has been maintained, fibre diameter reduced, and body weight increased. Graphs are drawn showing genetic trends and Elite Sire Lists are produced.

The question that now begs is:
"Whether our selection method is effective in serving our best interests?"

With the indiscriminate use of BLUP, there has been a chase for high figures and rankings. The figures have, quite expectedly, become a useful "marketing tool". Particularly, high body mass EBV's.

Our Breed Society is now beginning to realize that there has been too much focus on EBV's, and that with the overuse of so-called Elite Sires, (Elite on BLUP) there has been a narrowing of the gene pool and 'genetic-pinnacling'. In an attempt to improve matters, modifications like 100 day body weight EBV's, and later fertility, are to be included in the REV. Our Breed Society Manager has referred to these problems as being "A field strewn with challenges for Scientists and the technical team".

Blup
There is no doubt that advances in computer technology have enabled an array of calculations, adjustments and comparisons to be made. BLUP was, and is still considered by many as being the absolute panacea of selection tools. Unfortunately the indiscriminate use of BLUP has led to many problems. Apart from inappropriate goal-setting and misuse, the accuracy of comparisons made that cut across or eliminate different environments and different years should be examined.

For this exercise, I have divided the talk into three sub-sections:-

- The outcomes of present selection methods based on BLUP
- The science and accuracy of these methods
- The alternatives and solutions available

The Outcomes of Present Methods
It would be remiss of us as breeders, and as an industry, were we not to examine the status quo and way forward in animal breeding and to ask "Are our selection goals still relevant and are our methods really effective in serving our best interests?"

I must unfortunately report that in South Africa, criticism of the present BLUP system is not taken lightly.

S.A. animal scientist, Andre Mentz, PhD, dared speak out in his book entitled "The Holistic Alternative – A Guide to Cattle Farming in SA" – wherein he says that animal science isn't very scientific and that the focus is incorrectly on performance instead of on production. While Dr Mentz has grassroots support, he was marginalised professionally and sued. When settled out of court, it was said "that he was guilty and had backed down".

Instead of being so defensive of their turf, our BLUP mentors would be well-advised to heed what some of the critics are saying!

Johan Zietsman, Cattleman and Consultant, who "lost" his land in Zimbabwe, speaks of inappropriate breeding and management practices saying that they cause farmers to discriminate against those characteristics in their animals that make livestock farming profitable. He believes that BLUP technology that allows EBV's of different cattle breeds to be directly comparable nationally and internationally, to be impossible.

He states "Fertility – the most important trait determining the profitability of beef production – is subject to genotype X environmental interaction. The inherited characteristics that make an animal adapted to one environment (eg. Scotland) are the same that make it unadapted in another eg.Zimbabwe).

Body condition, the vital component of practical cow fertility, is determined by adaptation. A major problem arises in the case of EBV's of criteria e.g. average daily gain and feed conversion ratio being diametrically opposed to veld productivity. In such a case, BLUP, accelerates the achievement of an undesired end point".

He also states "the most desirable bulls, from a veld production perspective, are culled, generally being referred to as 'pony-types' (smaller-framed, stocky, early-maturing animals).

Anecdotally, some years ago, Chris Cummins of Breakout River Meats, Australia put it so aptly: "Sheep have grown bigger but haven't put on meat. What had been a necessary reform years ago, was now producing lambs that couldn't be

effectively finished, with good loin, eye-muscle and hindquarter. These animals don't present well or yield well, so there is less cutting and fewer dollars".

Dr Roger Hunsley, retired U.S. professor and cattle expert said on a recent trip to S.A.: "Most cattle breeds have reduced size over the last few decades, as experience has taught that the 'large and lanky' types are not as efficient as farmers thought". He further suggested that breeders "Reject extremes and select animals that produce and deliver quality carcasses".

To take the point further, an outstanding paper was produced by Dr Beilharz, Agric and Resource Management, Australia). I quote extracts:-
"Quantitative genetics and the breeding for maximums is being applied as though animals are not limited by their natural environment.

Consider that natural selection has been continuously active adapting organisms / animals to their natural environment. When adaptation is complete, (as indicated in fossil records when species have not changed much over long evolutionary periods) organisms are utilising all the resources available to them in the most efficient way. In this state, organisms / animals are limited completely by the resources of their environment.

Many animal breeders have been pushing for genetic maximums rather than optimums. In the case of body mass, by the indiscriminate use of EBV's, many sheep and cattle have become too large. This emphasis on largeness is neither necessary nor desirable and has resulted in negative effects.

These animals not only require more food for maintenance and production, but conversely, fewer animals can be kept on the available food resource. In biologically adapted animals, every increase in a production trait or characteristic (using resources) will reduce biological fitness (as the increased production uses resources that earlier were used to maximise fitness).

What we need to select for is "economic fitness" i.e. that combination of production traits and biological fitness that gives the best commercial return on the resources available in the environment. Should we have to improve the environment (supply more food), we should determine whether the extra returns from higher production are greater than the extra costs incurred.

Animals that, phenotypically, show efficient economic production and satisfactory reproduction in the available environment, must have a good set of genes for the particular environment. Common sense suggests that the best procedure then is to select as breeders these animals with phenotypes expressing the economically best combination of production and fitness over a suitably long productive life on each farm. That is phenotypes (visible characteristics) not EBV's, as it is phenotypes that must express themselves in the environment in which production is taking place.

Farmers should beware of introducing stock which is "genetically better" (on EBV's) from more productive areas. Selecting animals on the genotypic level by for example selecting animals with high body mass EBV's, has led to big responses as environments and feeding has improved, but there are signs that phenotypes in many of these populations are also now limited. More and more unwanted side-effects are appearing. What has happened is that breeding programs based on EBV's have successfully produced animals whose genes demanded more resources than the environment could provide. A result of the inappropriate definition of breeding objectives.

It would be far better if:-

1. Every breeding program was restricted to a specific population in a specified, preferably uniform, environment.

2. The total lifetime pattern of production to be achieved was to be reflected accurately in the breeding objective.

A genetic response to selection is not something which, if achieved once by itself, will last forever.

For example, a response for body mass is not possible unless the environment is improved to sustain it (the response will eventually be defeated by natural selection and return to the equilibrium sustainable in the unimproved environment). Also, selecting young animals for faster progress through rapid turnover of generations brings responses in the traits of young animals. Exaggeration of traits of young animals usually occurs at the cost of lifetime production. One gets what one selects for!

Extremes should be avoided and genetic traits should be in balance with one another AND with the environment. There is no environmental slack available for genetic improvement without some negative consequences.

The genetic goal therefore should surely be to maximise economic fitness i.e. to optimise phenotypic traits given the available resources, rather than genetic improvement per se (breeding for maximums).

Animals are bred for monetary return, which usually comes from phenotypic products. It also makes sense to maximise production per unit of land (pasture/veld), rather than the performance of individual animals. One therefore needs to concentrate on optimal "economic fitness" (effectiveness), within the constraints of the natural environment".

The Science and Accuracy of Selection based on BLUP

Epi-Genetics

Let's now dig a bit deeper and get right in under the skin to the cellular level:-

Dr Irvin Lazlow, who holds 4 Phd's and has twice been nominated for the Nobel Peace Prize, says "The prevailing model of biological evolution, which has given so much emphasis to the centrality of genes, needs to be radically reconsidered. Instead we now need to examine the entire organism (or animal) as a coherent entity in constant and dynamic multi-level interaction with its environment.

The variations and mutations of gene expression are a response to environmental signals mediated by the cellular membranes. The structure of DNA, as a wound double-helix is ideal to act as an antenna to receive and transmit electro-magnetic waves. Resonantly linked via the receptors in cell membranes, it enables a continuous coherence to flow throughout the organism and a selective resonance with its environment.

While the DNA code may be unchanged in some cell types, differences may arise in the way the genes are expressed. These differences are transferred to the cells of offspring – a phenomenon called 'epi-genetic inheritance'.

As put by Agresearch Scientist, Christine Couldrey "Traditionally it was believed that genes determined not only the growth and production potential of animals, but also what they looked like and how they behaved. Subsequently it has been found that genetically identical animals, for example, identical twins, and more notably cloned animals, are not exactly identical in looks or behaviour.

Such observations are part of the increasing evidence suggesting that additional forces are also at work in controlling growth, development and disease. These forces are referred to as epi-genetics and can have lifelong effects on the resulting offspring.

Epi-genetics is a layer of information that lies on top of genetic information, effectively bridging the gap between nature and nurture because the epi-genetic info that cells carry has been built up in response to the environmental conditions that animals have experienced throughout their lifetimes, starting as early as egg and sperm formation.

This information in turn, controls the genome in individual cells that make up the animal. It is now well accepted that in response to the environmental conditions that cells, and hence animals are exposed to:-

There are:

1. chemical additions on certain parts of the DNA
2. changes to the proteins that support the structure of the DNA in each cell
3. small molecules produced in cells that associate with specific regions of the DNA

These epi-genetic processes work together to determine which regions of the genome will be actively used in any cell type at any given time.

The honey bee is an extreme example of where the larvae are fed different diets that changes the chemical additions to the DNA, which then causes the DNA to manifest differently to that predicted by the sequence, and bees with different shape and unique functions develop".

Steven Pinker, Professor at Harvard, said "I believe that geneticists will find that there is a large store of information in the non-coding regions of the genome (the so-called 'junk' DNA), whose size, spacing, and composition could have large effects on how genes are expressed. I also believe that many examples of what we call "the same genes" in different species may differ in tiny ways at the sequence level – ways that have large consequences for how the organism is put together.

Ian Wilmut, Leader of the Department of Gene Function and Development at the Roslin Institute near Edinburgh, whose team produced the first clone, "Dolly" the sheep says "Because all adult cells have the same genetic information, the differences amongst them must have arisen from sequential differences in the function of the genes".
He also says "We have already long been accustomed to the idea that cells are influenced by their external environment, and in the lab, we use specific methods of tissue culture to control their function".

Personally, I would therefore conclude that linear adjustments of performance data of animals across different environments must result in only very approximate figures, as gene expression is not as fixed as was previously believed.

I call BLUP "a rough guide" but unfortunately many still consider it absolute gospel and tend to focus so much on the figures, that they seem to forget about the animal and its structure.

"It's easy to breed sheep with good figures – it's far more difficult to breed good sheep! And it takes time".

The Alternatives and Solutions Available:-
Requirements:

- Restriction of data for a breeding program to a relatively uniform environment, avoids the problem of inefficient data from elsewhere.
- The suggestion is therefore to select the progeny of the animals that themselves demonstrate appropriate phenotypic performance.
- This should occur in the natural environment in which they will be expected to produce and reproduce.
- To select holistically and not for single traits and extremes.

This can be termed the genetics of profitability.

The take-home message is that a balanced, holistic, multi-trait selection approach is required.

Falkirk
I met Ian Walsh in W.A. in late 2004 on the property of Alex and Lyn Leach, Katanning - the pioneers of the Dohne breed in Australia. I was so impressed by the sheer logic of the Falkirk System that I immediately invited Ian to SA. It wasn't long before a solid client base was formed and a South African Falkirk business registered with the office being operated by my wife Linda, in Graaff-Reinet.

Ian has now made about 20 trips to S.A and hand-eyed and scanned thousands of sheep, goats and cattle. I can personally attest to Falkirk's regular clients being highly satisfied with the results they are achieving. It has become evident that the Falkirk Index System in SA has now grown to a point where we need to clone Ian so as to be more readily available at shorter notice. Either more visits from Ian or a permanent scanner is now required.

Something of interest to me is that there are a few first-time Falkirk users that don't return. I imagine that the reason is that their traditional selection choices and Falkirk are at odds. This is hardly surprising when one considers what they've believed and been taught to focus on in the past. It's a pity really as these are the very flocks and herds that stand to benefit the most from Falkirk.

It would be wise to remember: that the real value of education is to learn to NOT accept everything that you are told. The Falkirk Index has certainly helped open up my mind.

Our Normandy Dohne Merino Stud was the pioneer of the F.I.S. in SA, and we are extremely impressed with the results. We only wish that so many others that breed for maximums and extremes could see the folly of their ways. Needless to say, many breeders continue to make very good money out of high BLUP figures, more especially the body masses. There's no doubt in my mind that animals from areas with superior environments and better food resources are unfairly advantaged when it comes to selection based on BLUP.

As a result of applying the Falkirk Index System for the past 7 years, our Normandy sheep now have:

1. sound structure
2. blockier, meatier carcasses

and we also boast outstanding quality wool.

Throughout this paper, I found that I could say *ENTER FALKIRK*, as it kept meeting the criteria being recommended. Indeed, to my knowledge, there is no similar system commercially available in South Africa.

It is interesting to note that the Falkirk Index System in SA, is working its way upwards from the grassroots commercial farm level into the Stud Industry and not the other way round.

As an example of common sense prevailing, many commercial cattle farmers in the Karoo have begun introducing Boran cattle (as they have Nguni and Tuli and other indigenous African breeds).

This development is significant because these are the cattle that man has not "interfered" with much, and the farmers are raving about their productivity. The Boran has been bred by the laws of nature – survival of the fittest!

It developed in the Borana Plateau in Southern Ethiopia, East Africa. This seems to have been the point where the different ancient breeds migrated through to their various destinations in Africa.

Their genetic make-up is 24% European Bos Taurus, 64% Bos Indicus and 12% African Bos Taurus. The Boran is the only breed in the world to have this specific gene combination, and because it has been purebred for some 1300 years it delivers strong hybrid vigour. (The last infusion of "new" genes was in 700AD). Apparently the first Boran import to S.A. took place from Kenya in about 1994. This breed is now also to be found in Aus. and the USA.

They are medium-framed and some of the breed characteristics include

- the ability to withstand periodic food and water shortages
- the ability to walk long distances
- the ability to digest low quality food
- longevity
- resistance to ticks and insects
- the ability to withstand heat and sun

Please note that these are all traits of adaptability.

In our area, an E.Cape Midlands Boran Club has recently been formed with 28 active members and Falkirk will be involved from the outset. WATCH THIS SPACE!

May I now use this opportunity to compliment and congratulate you all here on what you are doing to improve your livestock.

May you, with Falkirk, continue to go from strength to strength with your holistic methodology and investment in soundly based genetics.

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