SIZING UP BREEDING DATA

GENE TALK

Mark Young

My last column considered the impacts of adult size on animal performance in terms of the rate animals do things and the length of events in an animal's life. This time the focus is on how genetic size scaling theory helps interpret data from animal breeding programmes onfarm or in a research environment.

First, we need to characterise growth in the typical terrestrial mammal in terms of the three main body tissues: bone, muscle and fat (adipose). We express immature body weights (W) in terms of the proportion (U) they are of adult size (A). So U=W/A (multiply U by 100 to get a percentage). If a particular breed of animal is 60kg as an adult, when it is 30kg liveweight we say it is 50% mature (U=0.50).

Young animals are born with lower proportions of fat and higher proportions of bone than adult animals have, so growth after birth is characterised by decreasing proportions of bone and increasing proportions of fat. Interestingly, muscle proportion shows relatively little change compared to fat and bone.

Diagram 1 shows how the proportions of bone, muscle and fat change in the carcase as an animal grows from birth to maturity. From this it can be determined that fat percentage and muscle-to-bone ratio (M:B) both increase from birth to maturity.

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Because larger animals achieve lifetime milestones later, at any given age, genetically larger animals will be less mature but bigger. Also, genetically larger animals will reach the same level of maturity at a later age and an even larger size than they had at the same age as the genetically smaller animal – see **Table 1** for a summary of these and other effects.

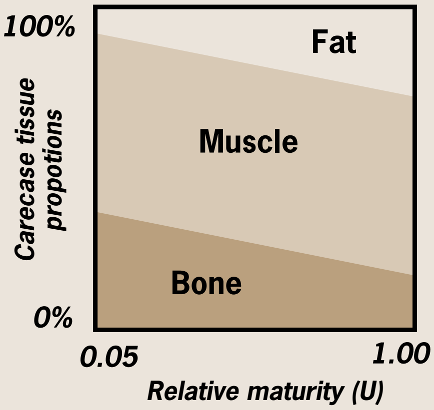
These patterns of growth provide a good model from which to predict growth and examine how particular animals deviate from prediction.

This helps us find interesting genetics that may be because of animals living in a particular environment or adaptation to that environment.

Results of selection experiments with farm animals can often be explained largely, if not entirely, in terms of this model of growth and body (or carcase) composition as a function of adult size. If we select the fastest-growing animals, at a fixed age or using an age-adjusted liveweight, we will favour animals that are genetically larger at maturity. Therefore they will grow faster – for example, be bigger at a given age – but they will be less mature because larger animals mature later. So not only will faster growing animals be larger at the same age, they are expected to have lower fatness and a lower M:B ratio.

Obviously, levels of nutrition and other non-genetic effects like weather and disease affect growth and body

Diagram 1:



composition. But since most animals in a mob are subject to the same effects this theory is pretty robust and has proven useful in explaining the results of selection on growth and body composition.

Results of many selection experiments and breeding programmes where growth rate has increased can be explained largely in this way. We get faster growing animals that are larger as adults but relatively less mature at the time of selection.

Results of selection systems to change body or carcase composition by reducing fatness can be explained in terms of animals becoming less mature at the time of selection (U or W/A) and bigger in size (both W at time of selection and A at adulthood).

We have to be clever to try to work against these strong biological relationships because the intrinsic genetic effect of adult size is hard to change.

Some selection experiments have shown different results and using genetic size scaling theory to interpret them has highlighted the differences. Dr Stephen Bishop, a New Zealand geneticist based in Scotland, reviewed many selection experiments and concluded that in some, selection had favoured animals that ate significantly more than they needed for maintenance – what he termed their "intake ratio".

This can be thought of as appetite whereby some animals eat a lot more than they need while others have a more modest drive for food for their size.

Not surprisingly Bishop's work concluded that animals with a high appetite grew faster but were fatter throughout growth and at maturity. So there are clearly other genetic effects besides those related to adult size. However, the real significance of these other effects can be seen only by using genetic size scaling theory to interpret observed differences.

Overall, adult size is a dominant genetic effect but other genetic effects can be exploited if selection programmes are designed to favour them. In my next column I will look at how genetic size scaling rules demonstrate some other interesting quirks about animal biology.

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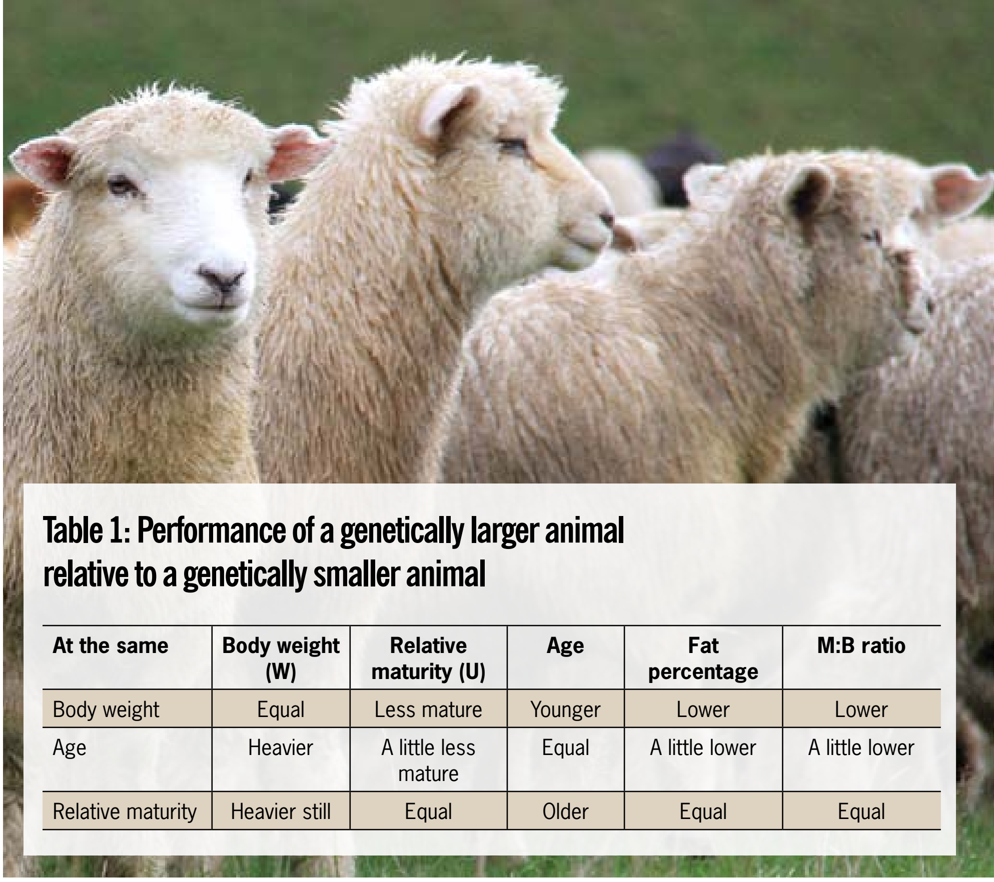

Table 1: Performance of a genetically larger animal relative to a genetically smaller animal

At the same	Body weight (W)	Relative maturity (U)	Age	Fat percentage	M:B ratio
Body weight	Equal	Less mature	Younger	Lower	Lower
Age	Heavier	A little less mature	Equal	A little lower	A little lower
Relative maturity	Heavier still	Equal	Older	Equal	Equal