An elephants' resting heart rate is 14 beats a minute.

SHAPING UP

GENE TALK

Mark Young

An understanding of the consequences of body size helps explain why animals differ in performance. Studies by mammalian biologists, nutritionists, physiologists and geneticists have found simple relationships that go a long way to explaining why land mammals differ as they do. One key factor is adult body weight (A) of a species. Genetic Size Scaling rules, based on adult size, help predict animal performance and responses to genetic selection.

Generally, bigger animals live longer and eat more per day. But an animal that is 10 times larger does not live 10 times longer and it does not eat 10 times more per day. Detailed studies of feed energy requirements have shown these are proportional to adult weight raised to the power of 0.73 ($A^{0.73}$). Also duration of events in their lives are proportional to adult weight raised to the power of 0.27 ($A^{0.27}$). **Table 1** shows relationships between these different quantities for animals differing in size by 10 times.

An animal that is 10 times larger needs just over five times the feed per day, and lives just under two times longer.

Bear in mind these averages for species and individuals may perform at slightly different rates. However, the relationships are remarkably robust over the range of size in land mammals. Incidentally, if we compare one of the smallest, a shrew at 10g, with the largest, the African elephant at three tonnes, we predict the resting heart rate of the shrew is more than 400 beats per minute (bpm) compared to 14 bpm for the elephant. And their lifespans are 1.5 years and 48 years, respectively. Actual figures are close to these.

A consequence is that a small animal uses more energy per gram of tissue per day than a large animal. However, because large animals live longer both small and large animals use about the same amount of energy per gram of tissue in their lifetime, other things being equal. This is borne out by differences in their cells where small animals have more mitochondria, key cell organelles in energy metabolism.

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How is this useful? Animals can't change dramatically from these biological relationships but deviations that occur are more interesting because of that. The relationships also place constraints on productivity. Let's look at that to explain why a beef cow is under more pressure than a breeding ewe to fit a 365 day production cycle.

Mammalian averages for length of pregnancy and length of lactation are each 50 times $A^{0.27}$. That equates to 520 days for both in a 450kg beef cow compared to 309 days in a 65kg ewe. That exceeds our 365 day "Earth" year for the cow but the ewe has almost two months after weaning to get in shape for mating. Studies of wild cows report that they often calve every second year, consistent with such a difference. The theory also predicts that larger-sized animals go through puberty later and at heavier weights.

Onfarm, lactations are shorter than this for both sheep and beef cattle because farmers can manage feed quality and quantity to maximise production earlier. This enables a sheep farmer to favour growth of weaned lambs later in the season while a beef farmer will have an eye on getting the pregnant cow into desirable condition for calving by the end of winter.

However, a 365-day production cycle still requires a typical beef cow to be pregnant, lactating, or both. She doesn't have the luxury afforded the ewe of a dry period for "recovery" between weaning and mating. And cows must get pregnant near the time of maximum milk production. It is no wonder cow reproduction is a trait beef farmers are strongly focused on.

In the next column I will look at how Genetic Size Scaling rules influence the study of growth and carcase composition, and how that informs us as animal breeders.

You can give B + LNZ Genetics or SIL your thoughts on this topic by email to silhelp@sil.co.nz or by leaving a message on 0800 silhelp (0800 745 435).

- *Dr Mark Young is the senior geneticist with B+LNZ Genetics and SIL.*

Table 1: Size relationships based on adult size (A)

	Adult size (kg)	Metabolic rates scale to:	Time scales to:
	A	$A^{0.73}$	$A^{0.27}$
X	55	18.6	2.95
Y	550	100.1	5.49
Ratio (Y/X)	10.0	**5.37**	**1.86**