NOT AGE, BUT GROWTH
DETERMINES HEIFER DEVELOPMENT

Key milestones in heifer rearing are often expressed in ages. Frequently used benchmarks include weaning age, age of first insemination, and age at first calving. Gauging maturation in terms of age is not wrong when it is based on growth and development. Research carried out over the past decade has confirmed that it is growth though, and not age alone, that determines heifer development. If you accelerate growth rate, development time from calf to production cow can be reduced. However, it is essential to increase the growth rate safely and in a responsible, sustainable, and profitable way. This can be achieved through nutrition

In the late 1950s and early 1960s, studies by Reid et al. (1957)[1], and Swanson and Hinton (1964)[2] reported a reduction in milk production when heifers were fed below their nutritional requirements, and an increase in milk production when they were fed above requirements.

Earlier studies had already shown the impact of nutrition before conception on development and onset of puberty in dairy heifers[3], Later studies have narrowed this down to the influence of early calf growth before weaning on heifer development and increased milk yield later in life[4], giving rise to increased use of accelerated milk feeding programmes.

Good nutrition can switch on the right genes

Recent research has provided evidence that several factors which influence the development of the calf and its subsequent milk production as a heifer are interrelated[5]. This interrelationship is explained by epigenetics – the study of how behaviour and environment affect genetic expression. Various factors can influence the expression of the genome of a calf through multiple epigenetic pathways. What happens is the gene is effectively turned 'on' (activating the gene) or 'off' (silencing the gene), without altering the DNA of the calf's genome.

Examples of such factors include in utero nutrient supply, colostrum intake, quality of nutrition early in life (through milk or CMR feeding), and non-nutritional nur-

turing early in life. These factors affect the development of tissues, including mammary tissues, which play an important role later in life (Soberon 2012)[6]; Sobernon and Van Amburgh)[7]. Due to this, adapted feeding practices can enable full exploitation of the calf's genetic potential.

Accelerated growth increases milk production

Intensive feeding programs encourage a significant increase in milk production. Numerous studies have reported an increase in milk production of 450 kg to 1300 kg in the first lactation, compared to calves with restricted pre-weaning (Foldager and Krohn, 1994)[8]; (Bar-Peled et al., 1997)[9]; (Shamay et al., 2005)[10]; (Terré et al., 2009)[11]; (Moallem et al., 2010)[12]; and (Sobernon 2012)[13].

Increase in milk production of 450 kg to 1300 kg in the first lactation

This higher milk production is related to an improved pre-weaning average daily gain (ADG). On average, 100g of extra pre-weaning ADG results in an increase of 500 kg milk yield in the first lactation. More recent research also shows the effect of age of first calving on lifetime daily milk production (Eastham et al., 2017)[14].

Multiple studies show that the critical window for imprinting of mammary gland capacity for milk production is during the first eight -10 weeks of life (Brown et al., 2005)[15]; (Bach, 2011)[16], (Geiger et al., 2016)[17]. Increased growth rates, due to intensive milk feeding, are related to increased numbers of milk producing cells. (Sobernon et al. 2017)[18], also saw an increase in organ- and whole mammary gland weight.

Accelerated growth reduces the age to breeding

One of the advantages of intensive milk feeding programmes is a direct positive effect on young calves' health, growth and development. Long-term consequences of these programmes have also been found (Drackley, 2008)[19].

Firstly, accelerated growth programmes assist in reducing the age to breeding (Raeth-Knight, 2009)[20] and the age of first calving to 22–24 months. For the farmer, this is of course very interesting economically, as in most countries, the average calving age today is still between 26–30 months, with increased cost per kg of gain above 315 days of age.

Within this perspective, we can consider optimizing calf and heifer development within the window from birth to first conception - The first 400 days of life. This is related to an optimal calving age of 22-24 months. Alongside studies that show optimal development and increased milk production are related to age of first calving, other studies determine this to be the most economically beneficial age of calving.

Table 1: Growth rate

	AGE	% MATURE WEIGHT	WEIGHT (kg)	ADG (kg)
BIRTH	0 DAYS	5.5%	40	Average week 0-10: 0.860
WEANING	10 WKS	14%	100	
	12 WKS	17%	120	1.430
	22 WKS	30%	210	1.285
INSEMINATION	14 MONTHS	55%	385	0.640
1ST LACTATION HEIFER	24 MONTHS	82%	575	0.690
2ND LACTATION		95%	665	
3RD LACTATION		100%	700	

For example, the work of Anna Boulton (Boulton et al., 2015)[21]; Boulton, 201722) has shown that differences in payback time of heifer rearing cost between farms can be largely explained by differences in age of first calving. Prilo et al. (1997)[23] concluded that 23-24 months was the most profitable age of first calving, and no less than 22 months with respect to milk yield and longevity.

Focus on nutrition from the moment of birth onwards

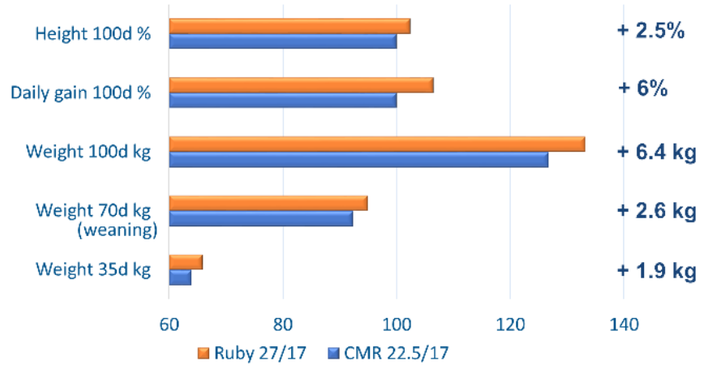
So, If growth matters, which targets to reach?

To realize the optimal age of calving of 22- 24 months towards increasing milk production, what are the goals in terms of growth and development? And how can these targets be reached with nutrition? In the review of Le Cozler et al. (2008)[24], which was based on work of Wattiax et al., (1997)[25] as well as others, growth targets are related to mature bodyweight (see Table 1). As explained within the review, sexual maturity is based on body development but is also dependent on breed. Breeds with high and lean growth reach puberty earlier than breeds with moderate and greater carcass growth. Expressed in rate of mature live weight, Holstein heifers will reach puberty at 43% of their mature weight and are ready to be inseminated around 55% of mature weight (385kg, 14-15 months of age), to be able to reach a body weight of 85% (550kg) of the mature body weight at the beginning of the first lactation. Full mature body weight is not achieved earlier than the third lactation.

So, the target is to achieve a weight gain of 345kg in 400 days, or an average daily gain of 800g/day from birth until insemination. Daily gains are not even from birth to insemination age. Growth rate potentials are higher in the first 180 days, with the highest growth rates reached after weaning.

Feed efficiency is highest before weaning on a milk-fed diet. Feed intake is higher after weaning, along with a relatively high feed efficiency. Due to the high feed efficiency and high growth rates in the initial period of life, the cost per kg of gain in the period is economically beneficial (Bach et al.year)[26].

Research by McCane in 1962[27] in rats has already shown that growth rate and, hence, the animals' growth curve is set within the first weeks of life. We have seen the same occur in calves within a farm trial in Poland (see graph below).



Result from a trial in Poland in 2018, where the high protein Nukamel Ruby was tested against a low protein product, show the effect of elevated protein levels.

With this in mind, the growth target could be growth from birth onwards to reach 385kg weight at insemination. Calves are born at around 5.5% of this weight (40kg) and grow to 14% of it (100kg) in 10 weeks, 17% (120kg) at 12 weeks, and 30% (210kg) at 22 weeks (five months) of age. These growth rates can only be achieved with the right nutrition applied at various levels. This includes feeding of the dam near to calving and when the calf receives colostrum, feeding the calf CMR, introducing feed to the calf at the transitionary stage of weaning, and ensuring that the calf gets high-quality protein starter feed. Therefore, taking growth measurements from calves at different ages is recommended to assess if the desired growth targets are achieved.

How to realize a optimal growth curve?

To reach the growth targets identified, optimal nutrition of the calf should be a top priority from the moment of birth onwards. High level of colostrum feeding, for instance, has already been related to increased growth rate, increased milk production, and improved health (Faber et al., 2005)[28].

Calves are born as pseudo-monogastric animals, and depend upon nutrients from milk or milk replacer for growth during the first weeks of life. The digestibility, and subsequent feed efficiency of colostrum, milk, and milk replacers is very high, enabling fast growth early in life.

An accelerated growth rate can be obtained with an intensified milk feeding schedule, with an intake of ≥1kg dry matter a day, in combination with high protein (24-28%), dairy-based, milk replacers. Milk

replacers with increased protein level will increase average daily gain, hip width and hip height (Hill et al. 2008)[29], Nukamel Research, 2014[30] resulting in lean and tall calf growth. With increased milk powder intake, it is important to balance the protein to energy ratio because either or both can act as a limiting factor in growth. An optimal balance can be obtained by choosing a high protein milk replacer combined with a high plane of feeding.

What is the optimal combination of feeding schedule and milk replacer?

There are two main types of feeding schedule:

- Conventional feeding schedules (up to 750g milk powder per day - or 6L milk) which are focused on early starter intake and rumen development. Within a conventional feeding program, a classical milk composition of around 21-22% protein and 17-18% fat will optimize calf growth and development.
- Accelerated feeding schedules (900g to ≥1200g milk powder per day) which are focused on early calf growth and development, with a more gradual rumen development.

Desired increased growth rates before weaning can be obtained by combining a high protein milk replacer with a high plane of nutrition. As shown In the graph below and in Graph 1, good balanced nutrition really makes a difference.

If you would like to learn more, please contact Jan Druyts (CEO Nukamel): +31 (0)495 541 165 or jan@nukamel.com)

Growth rates will really make the difference

Fig. 2: Growth Goal based on balance and availability of protein and energy