Robust animals for grass based production systems

Luc Delaby, F. Buckley, N. Mchugh, Fabienne Blanc

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Delaby L.[1], Buckley F.[2], McHugh N.[2] and Blanc F.[3]
[1]INRA, AgroCampus Ouest, UMR Physiologie, Environnement et Génétique pour l'Animal et les Systèmes d'Elevage, 35590 Saint Gilles, France; [2]Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co, Cork, Ireland; [3]Université Clermont Auvergne, VetAgro Sup, INRA, UMR Herbivores, 63122 Saint-Genès-Champanelle, France

Abstract

A characterisation of dairy, beef and sheep best suited to profitable/sustainable production within the context of European [semi] intensive pasture-based systems will be conducted. To deliver optimal performance, pasture must be managed effectively, but pasture-based systems are less energy intensive and are climate sensitive. This induces challenges and constraints not normally posed to animals in intensive feeding environments and emphasises the importance of animal traits associated with robustness and adaptive abilities. A survey of French dairy farmers concluded that a robust cow is a 'transparent' cow with a long lifetime. The traits required under grazing include: efficient converters of feed to product, such as high milk yield or milk solids (dairy) or meat yield/weaning weight (beef/sheep), good functionality, healthy, reproductively fit and finally, exhibiting longevity. Unique to successful grazing, is a capability to achieve large intakes of forage to meet productive potential and an ability to adapt to fluctuating feed supply. In seasonal systems, grazing ruminants will be expected to conceive and give birth at the appropriate time each year, usually within 365 days. The optimum breed or strain will differ, based on local management constraints and objectives. However, general principles do apply and recommendations will be made based on this review with regard to the traits of interest for pasture-based production.

Keywords: robustness, grass based system, grazing, selection

Introduction

As a consequence of the increasing world food demand associated with the growth of the human population, the future requires promotion of more efficient, sustainable livestock systems, and the use of greater proportions of non-human competitive products to feed farm animals. The ruminant's natural ability to consume forages and sub-products and to produce high quality human food helps to develop and improve forage based systems. Within these systems, grass-based systems using preferential grazing as animal feed, are viewed as economically and environmentally optimum. In temperate areas, well managed grazed grass is the unique forage which is correctly balanced to meet the nutritional requirements of both large and small ruminants.

In the context of this paper, pasture-based systems may be characterised as systems where the primary feed source is grazed grass (typically ≥60% of the diet). The extent and efficiency with which grazed pasture is maximised will vary across Europe. Intensified pasture-based systems such as that practiced in Ireland are characterised by long term permanent pastures, the application of grazing management practices to maximise pasture production and quality in combination with relatively high stocking density to result in high milk solids or carcass production per unit area. Less intensified pasture-based systems, more typical of France, tend to be associated with a greater diversity environment; multispecies pastures (some with clover) or natural grasslands, seasonal climatic extremes, and availability of high quality alternative feeds. Common, however, is a lower cost of production, system resilience and environmental sustainability (O'Donovan and Delaby, 2016). A further advantage is greater societal acceptability as a 'friendly livestock system' (Cardoso *et al.*, 2016). However, all of these advantages of grass-based systems are only effective if the characteristics of the dairy, beef and sheep breeds can match the requirements and limits of such systems.

The objective of this synthesis paper is to highlight such specificities and to outline the key animal characteristics required by robust cattle and sheep in pasture-based systems.

A brief background to grass-based system specificities

Pasture-based systems are generally more constraining, less stable and more uncertain than indoor based systems, whereby, the system is designed to serve the animal. In pasture-based systems, the reverse is true. The system is such that the animal is faced with natural irregularities or antagonisms, e.g. inclement climatic conditions, parasitic agents, etc. As the animal is *de facto* an integrated part of the system, the animal is expected to contribute to its ability to face environmental variability and hazards, known as robustness. Genetically robust dairy cows are less sensitive to sub-optimal circumstances (Veerkamp *et al.*, 2013). In a recent paper Friggens *et al.* (2017) proposed a generic definition of animal robustness as '*The ability, in the face of environmental constraints, to carry on doing the various things that the animal needs to do to favour its future ability to reproduce*'.

In contrast to dairy cattle where only about 10% of the world's milk production is from grazing systems, beef and sheep are primarily managed under grazing. Consequently, in general, different strains of individual beef or sheep breeds have either not evolved from selection in different production environments, or they have not spread outside of their original geographical area (Buckley *et al.*, 2005). Dairy cows that are optimal in a pasture-based system of production share many general characteristics with cows that are appropriate for a non-pasture system. However, the relative importance of traits can differ (Washburn and Mullen, 2014). Nutrient demand intentionally coincides with seasonal forage availability, fertility is emphasised, as generally does selection for high milk fat and protein content. Similar principles apply to beef and sheep where production is also chiefly based on the efficient conversion of grass to meat. As with seasonal pasture-based dairying, efficiency is optimised when beef cows/ewes give birth in spring with increasing herd/flock demand matched by increasing pasture supply.

Ability to adapt to grazing

Maximising grass intake is a key characteristic in grass-based systems (Delagarde *et al.*, 2001). Feeding behaviour is inextricably linked to the nature of the feed on offer and the circumstance by which the feed is presented (Prendiville *et al.*, 2010). Systems based on grazed pasture intrinsically limit nutrient intake compared with indoor total mixed ration (TMR) diets. This is evident from studies conducted in the USA by Kolver and Muller (1998) who suggested a 20% decrease in daily intake with pasture-fed cows. A similar result was observed in Ireland by Kennedy *et al.* (2003) and Horan *et al.* (2006) where Holstein cows highly selected for milk volume were not capable of eating enough to satisfy the demand associated with the milk potential. The study of Prendiville *et al.* (2010) related feeding time of lactating dairy cows in their pasture-based study with comparable feeding times in a TMR-based indoor study (Aikman *et al.*, 2008). Apart from environmental, plant and management factors (Dillon, 2005), milk production from pasture is limited by the ability of the grazing animal to consume sufficient quantities of herbage (Stakelum and Dillon, 2003). Increased grass allowance induces higher levels of grass intake but also higher levels of refusals and decreases pasture utilisation (Delaby and Horan, 2017; Pérez-Prieto and Delagarde, 2013). Therefore, a balance must be achieved between performance on a per animal and per hectare basis (McCarthy *et al.*, 2011). Effective pasture management enforces a limited grass allowance, balancing the dual objectives of generous feeding to achieve performance and high levels of pasture utilisation, thus optimising farm profitability (Penno, 1998).

A study in beef cattle by Goodman *et al.* (2016) on rangeland pastures has observed behavioral adaptation to the decrease in food availability. Across two diverse temperament profiles, beef cows classified as fast eaters when indoors were shown at grazing to spend less time close to the drinker and to explore a larger area of the pasture. They were considered to express a 'go getters' temperament. In contrast, slow eaters cows expressed a 'laid back' temperament. Interestingly, the two contrasting temperament profiles were shown to be positively correlated to animal performance with 'go-getters' showing shorter return to estrous after calving and heavier calf weaning weights than 'laid-back' cows. These findings are in line with Prendiville *et al.* (2010) who showed that cows with higher production efficiency were more aggressive grazers. Pryce *et al.* (2005) observed that dairy animals that are lighter are capable of superior productivity within intensive pasture-based systems because of their lower maintenance requirements and higher production per unit of feed consumed. An ability to achieve large intakes of forage relative to their productivity potential should also confer an increased likelihood of survival, another integral component of optimal financial performance (Lopez-Villalobos *et al.*, 2000).

Ability to cope with variability of grass resources and to rebound

As grazing systems are subjected to the external environment, animals may be exposed to unpredictable disturbances from the external environment (severe climate, predation, diseases; Mirkena *et al.*, 2010). Animals react to such perturbations by initiating adaptive responses that may alter phenotype, physiology and/or behaviour. These adaptive responses rely on underlying adaptive mechanisms that will support the ability of the animal to withstand and/or rebound from perturbation (resilience or indeed robustness). Such adaptive mechanisms were reviewed in several papers (Blanc *et al.*, 2006; Mirkena *et al.*, 2010; Mulliniks *et al.*, 2016) that outlined the key roles of metabolic flexibility, nutrients allocation, body reserves, behavioural strategies and temperament to explain the diversity in the ability to rebound. In grass-based systems, deviations in productive or functional traits are tolerated when animals are experiencing disturbances provided that they can react quickly when conditions become favourable again. For example, as described by Blanc *et al.* (2007), 40% of the ewe lambs that experienced severe under nutrition from three to nine months were still not cycling at nine months of age. But after the introduction of *ad libitum* feeding, they reached puberty within a three week period and could be used for breeding. Such an ability to rebound is also observed for other life functions like growth (compensatory growth in heifers; Hoch *et al.*, 2003) or lactation as observed on the milk yield in a ten day residence time grazing paddock (Roca-Fernandez *et al.*, 2012).

In temperate climates, grass growth is seasonal with maximum growth observed in spring (between mid-April and late May; Northern Hemisphere), a variable decrease in summer and minimum or no growth observed in the winter months. This aspect is well illustrated with the four regional French and Irish grass growth profiles simulated with the 'Moorepark St Gilles' grass growth model (Figure 1a and b; Ruelle *et al.*, 2018). This typical profile has large consequences on the feed resources available to animals, with an excess of grass often observed in spring and a deficit in winter. The summer period is probably the most variable period according to the latitude in Europe and depending on local temperature and rain regularity.

Coupled with the seasonality in grass growth, is the unstable nature of the nutritional value of grass, which changes firstly with the season, the age of regrowth and the phenological stages. Leafy grass or legumes in spring are characterised by a high nutritive value, in terms of energy, protein content and also voluntary intake. Although at this time the grass is highly palatable, the ratio between the grass energy content to the fill unit value, named energy density, can be too low to match a lactating animals energy demand. Matching the animal demands with grass only in the spring months can be a real challenge. With conserved grass, hay or silage not supplemented with concentrate, the feeding situation may be worse and can result in energy deficit periods as shown in Figure 2. This is particularly important for dairy cows

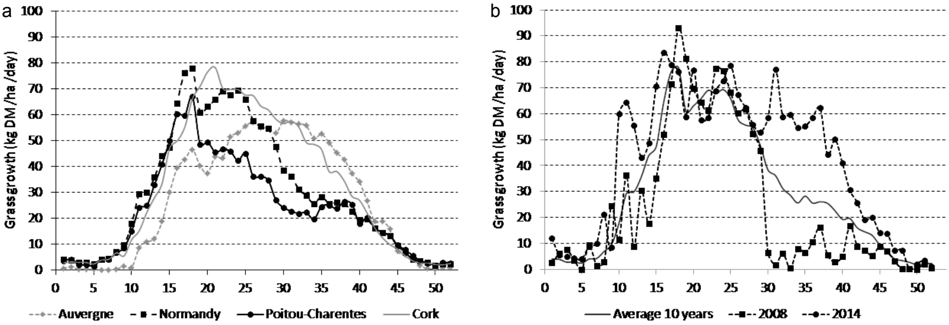

Figure 1. Annual grass growth profile according to the geographic localisation in France and Ireland (a) and the year in Normandy (b). On an average for 10 years (Figure 1a), the grass growth profile of a same type of pasture with the same level of N mineral applied differs because altitude, rain, temperature and light differ. The grass growth starts early in Ireland (Co Cork - Fermoy - 52°08 N / 8°16 W), later in upland (Auvergne - Marcenat - 45°18′ N / 2°49′ E) and is higher in summer than in Normandy - Le Pin (Lowland - 48°44′ N / 0°08′ E) or in Poitou-Charentes - Lusignan (Lowland - 46°26′N / 0°07′ E), region with higher temperatures in summer and mainly less regular rains. Within a region, the average profile is also highly variable between years, week per week, due to the highly variable climatic conditions (Figure1b).

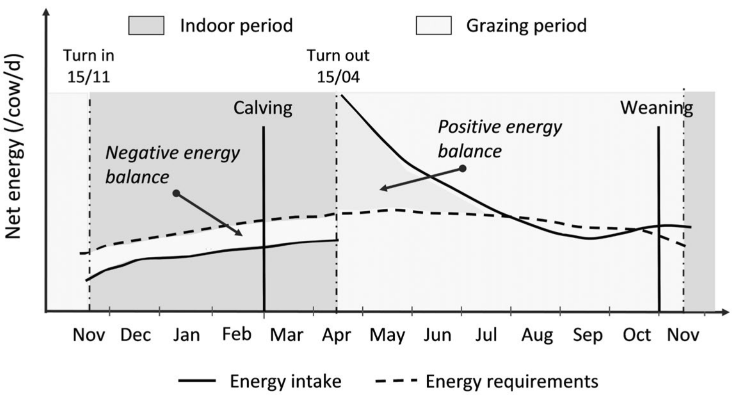

Figure 2. Changes in net energy requirements (dotted line) and energy intake (solid line) of beef cows in a winter calving system in France. Energy balance is negative during all the indoor building period because of low energy density of hay and increasing energy requirement from the end of pregnancy and early lactation. Energy balance becomes positive since cows are turned out and graze (Institut de l'Elevage, 2015)

in early lactation at grazing (Peyraud and Delagarde, 2013) or for suckling cows and ewes at the end of gestation when fed with poor quality forages indoors in winter.

In these conditions, the challenge for the ruminant female is to maximise grass or forage intake and where deficits in energy requirements exist, the ruminant must be able to react and limit the consequences of this imbalance. This imbalance between the grass energy supply and the energy demand of the lactating beef cow rarely occurs due to the relatively low milk production potential of the cow and milk yield demand of the often single suckled calf. However, for ewes rearing high litter sizes and managed at high stocking rates, coupled with the low energy supply of grass can have a knock-on effect on lamb growth rate and the number of days to slaughter for individual lambs (Earle *et al.*, 2017a). Such physiological energy deficits resulting from high requirements concomitant with limited intake capacity have been exacerbated by genetic selection for productive traits such as milk yield in the North American Holstein (Kolver and Muller, 1998) and selection for high prolificacy levels in ewes (Safari *et al.*, 2005). This is well illustrated in the INRA Le Pin experiment where Holstein cows turned out at grazing with only 3 kg of concentrate DM after a nine to 11 weeks early lactation indoor winter feeding period. The Holstein cows with a greater milk yield potential had greater observed milk yields at the peak of lactation in winter and during all the spring grazing period. However, they also expressed a greater decline in the milk yield six and 12 weeks post-turnout (Table 1).

To cope with nutritional challenges resulting from changes in both seasonal grass availability and quality and changes in animal nutritive requirements, animals must be able to store body reserves when feed conditions are favourable and to mobilise them in limiting feeding conditions. Cows that can maintain a higher body condition score may have an advantage in pasture systems because they can draw upon body reserves if feed is limited (Pryce and Harris, 2006). As described by Delaby *et al.* (2010), the body condition score losses, reflecting body tissue mobilisation in early lactation, are higher in Holstein cattle with high genetic merit for milk yield and in low feeding levels compared with Normande low genetic merit for milk yield and high feeding levels. These observations were also reported by Roche *et al.* (2006) comparing North American or New Zealand Holstein cows with or without concentrate supplementation at grazing and by Dillon *et al.* (2006) within Irish experiments comparing different dairy breeds. An on-going sheep study in Ireland (McGovern and McHugh, 2017) has shown that greater body reserve mobilisation in early lactation is observed in ewes of high genetic merit for maternal traits relative to ewes of low genetic merit for maternal traits in a grass-based system. On an annual basis, the animal must be able to limit the consequence of poor condition score (energy balance) on other functions such as fertility, sensitivity to disease, and ultimately, longevity. But in reality, in both cows and high prolificacy ewes early in lactation, control of body reserve mobilisation is very difficult as it is highly associated with genetic merit (Walsh *et al.*, 2008) and the body condition score at calving or lambing.

Ability to reproduce and achieve compact parturition

One of the main objectives of grass-based ruminant producers is to be at least self-sufficient in forages and if possible to be totally feed self-sufficient. At farm level, in grass-based systems, the first factor to determine the level of self-sufficiency is the global stocking rate (i.e. the number of cattle or sheep that can be fed on the farm area). The optimum stocking rate will be highly dependent on the local agro-climatic potential. Secondly, a producer must match herd/flock demand to the seasonality of grass availability (Butler, 2014; Delaby and Horan, 2017; Earle *et al.*, 2017a). In ruminant production, the maximum energy demand usually occurs in the period immediately pre-parturition and during the weeks following parturition when milk production reaches its peak. Consequently, the optimal grass-based system parturition should occur in the weeks prior to high grass availability. Seasonality of reproduction in small ruminant species is a natural adaptation to the annual pattern of grass resources availability; in bovines, reproduction can occur at any time within the year.

Table 1. Effect of milk potential (evaluated with the peak of lactation) on milk and body condition score changes during the spring grazing period (adapted from the INRA Le Pin 2006-2015 experiment).

	Milk yield (kg day^{-1})				Body condition score [0 to 5]		
	Peak of lactation	At grazing turnout (lactation days)	6 weeks after turnout	12 weeks after turnout	At calving	At turnout	12 weeks after turnout
Primiparous							
> 35 kg at peak	39.8	35.9 (74)	30.5	25.3	3.25	2.50	2.10
< 35 kg at peak	30.6	28.4 (78)	25.6	21.9	2.85	2.60	2.40
Multiparous							
> 45 kg at peak	51.0	45.7 (60)	36.1	30.6	2.85	2.25	2.00
< 45 kg at peak	40.4	35.8 (66)	31.5	26.1	2.60	2.40	2.25

Reproduction performance is one of the most important determinants of production efficiency and genetic gain in most dairy production systems (Esslemont and Peeler, 1993). The use of minimal supplementation coupled with seasonal calving requires cows that are reproductively efficient and adapted to obtain most of their nutritional needs from pasture (Washburn and Mullen, 2014). It is generally accepted that Holstein cows highly selected for milk yield are not suited to seasonal pasture-based systems due to reduced body condition score and inferior reproductive performance (Dillon *et al.*, 2006 – Table 2).

Furthermore, in order to maximise reproductive performance and lifetime production efficiency, heifers must conceive at around 15 months and calve by 24 months of age (Heinrichs and Hardgrove, 1987). In seasonal production systems, the relative importance of age at puberty is greater than in confinement and year-round calving systems. To achieve seasonal targets, an early onset of puberty is critical (Archbold *et al.*, 2012). Breed differences do exist suggesting differences in suitability for intensive compared with less intensive pasture-based dairying and indeed, beef production. The findings of Archbold *et al.* (2012) indicate that Jersey × Holstein-Friesian heifers are earlier to mature than Holstein-Friesian heifers, whereas, continental breeds like Normande or Montbeliarde are a little bit later maturing. Larger European beef breeds were shown to grow faster to heavier mature weights, but reach puberty at older ages and have lower reproductive efficiency, especially in less favourable conditions (Morris *et al.*, 1993).

In countries or regions where the rain is evenly distributed across the year (40 to 60 mm monthly) and grass growth occurs in summer, the ideal parturition period is in spring (Figure 3). Spring turnout dates should be adapted according to the start of grass growth and will be later in northern compared with southern Europe, or in uplands compared with lowlands. For cattle, a compact calving period in spring allows peak grass growth to coincide with the lactation period. For sheep, the shorter lactation period (three months) allows for high stocking rates to be achieved during the highest grass growth period in the year. Moreover, during this period (i.e. spring and early summer), the grass nutritive value matches the animal nutritional requirements. An additional benefit of calving in the spring for dairy and beef cows is that the dry off period coincides with winter when grass growth ceases and conserved forages can supply the lower nutritive requirements of the animal. In regions with frequent drought periods in summer, two parturition periods occurring at six monthly intervals may be optimal (Pottier *et al.*, 2007 – Figure 3).

Table 2. Reproductive performance observed in the INRA Le Pin experiment (The cow for the system? - 2006-2015) and in the Teagasc NGH experiment (Next Generation Herd – 2013-2016) in comparison with the objective for grass-based dairy system and compact calving management (12 weeks calving period).

	Target	The cow for the system?[1]				NGH[2]	
Feeding level		**High**		**Low**		**NatAv**	**Elite**
Breed		**Holstein**	**Normande**	**Holstein**	**Normande**		
Milk yield (kg)		8,660	6,000	6,230	4,670	5,610	5,410
BCS at calving (pts [0 to 5])		2.85	3.50	2.65	3.10	2.75	2.90
BCS losses (pts [0 to 5])	0.50	-1.00	-0.60	-1.20	-0.85	-	-
Interval calving - 1st ovulation (days)	25 to 30	41	33	39	30	-	-
Normal cyclicity profile rate (%)	80	48	65	44	77	-	-
First AI in-calf rate (%)	60	33	43	28	38	46	61
6 week in-calf rate (%)	70	41	46	35	51	58	73
13 week in-calf rate (%)	90	60	73	55	68	81	92

[1] High: In winter (100 days), early in lactation, total mixed ration with maize silage, dehydrated alfalfa and concentrate, *ad libitum*. At grazing (180 days), 0.35 ha per cow, 4 kg concentrate and 5 kg maize silage from July. In autumn (85 days), 5 kg maize silage, 4 kg concentrate and grass silage *ad libitum*. Low: In winter (100 days), early in lactation, total mixed ration with grass silage and big bale haylage, *ad libitum*. At grazing (180 days), 0.55 ha per cow. In autumn (85 days), grass silage *ad libitum*. No concentrate.

[2] Two genotypes based on Ireland's dairy selection index, the Economic Breeding Index (EBI): NatAv (n = 45 annually) representing national average based on EBI and Elite (n = 90 annually) representing the top 1%.

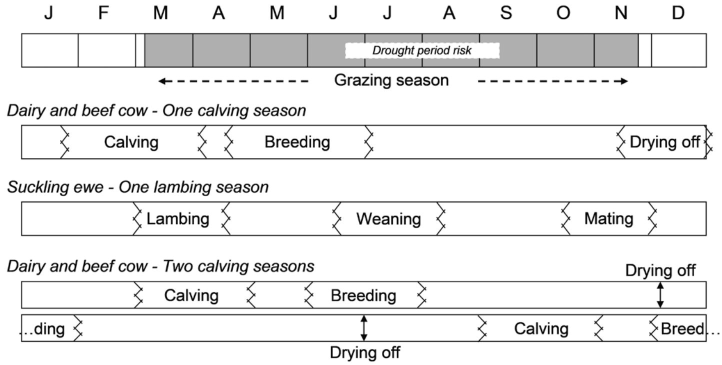

Figure 3. Grass-based system management recommendations for cattle and sheep according to the grazing season length and the risk of drought period in summer (Delaby and Horan, 2017; Earle *et al*, 2017a; Pottier *et al*, 2007).

According to the area of the grazing platform, the herd proportion assigned to calve in one period can be split 50/50 or 66/33, respectively in spring and autumn.

Compact calving or lambing require a strictly managed compact breeding period and excellent fertility performance. This demands a return to cyclicity to coincide with the commencement of the breeding season and to successfully achieve pregnancy within a limited breeding period of 3 months for cattle and 1.5 months for ewes. In one-lambing-per-year sheep farming systems, reproduction occurs in the post-weaning period, whereas in the case of both beef and dairy cows, reproduction occurs during early lactation. Ewes have a greater chance to recover body reserves prior to mating thereby increasing their ability to maximise prolificacy (i.e. litters of multiples). As prolificacy is one of the most important criteria of the lamb production system efficiency (Earle *et al.*, 2017b); maximising litter size or prolificacy is a function of the genetic strain (Dawson and Carson, 2002) and also the body reserves ('flushing') at mating (Coop *et al.*, 1966). In beef cattle, when the breeding season occurs at grazing, the increase in feeding level improves the energy status of the cows, thereby reducing the period to cyclicity, specifically in thin cows (Friggens *et al.*, 2017). The dairy cow situation is more complicated as a consequence of the high nutrients demand for lactation at this period (Friggens *et al.*, 2010) and impacts a cascade of fertility characteristics. To obtain good reproductive performance, the luteal activity has to be restored and regular, the oestrus and heats should be well expressed and easy to detect and after AI, the conception should be effective and the embryo implantation success to re-calve (Bedere *et al.*, 2017a and 2017b). This defines the proprieties of a robust cow according the objective of compact calving.

Ability for maternal care and to stay healthy

During parturition, another important robustness characteristic of dairy, beef and sheep is the ability to deliver a viable offspring. Increased dystocia at parturition (caesarian, vaginal tearing) has a negative impact on subsequent reproductive performance, especially in cattle (Meijering, 1984). Levels of dystocia must also be minimised to reduce labour requirements at parturition and also to provide a favourable perception to consumers of grass-based production systems. Maternal care traits such as mothering ability or progeny suckling ability are also of importance to ensure low levels of calf or lamb mortality in all systems but especially in extensive systems (Macfarlane *et al.*, 2010).

A survey of dairy farmers (Ollion, 2015) where farmers were asked to define a robust cow, 80% of farmers answered a '*cow with no problems, never sick, who doesn't need to see the veterinarian*'. In terms of health, three traits are specifically relevant to grass-based systems. The first key characteristic is the ability of the animal to cope with parasite burdens. Parasite burden is a major issue in grass based systems as, when not controlled it can have negative effects on productivity and when anthelmintic treatments are used questions are raised in relation to its impact on the environment as well as anthelmintic resistance. At the animal level, genetic selection to reduce parasite burdens can be achieved (Moreno-Romieux *et al.,* 2017; McHugh *et al.*, 2014). Animals on grass-based systems are also more susceptible to the effects of inclement weather and grass nutrient imbalance (excess of nitrogen, minerals), and are therefore at greater risk of metabolism or digestive disequilibrium such as bloating, grass tetany and also for ewes, pregnancy toxemia. Such nutritional disorders are often lethal and therefore, non-occurrence is a necessity. The last major problem for grazing systems concerns feet and leg diseases. Dairy cows must walk to the milking parlour two times per day, therefore lameness is a common occurrence. In addition, lameness in sheep, often characterised by scald or footrot is common within grass-based systems (O'Brien *et al.*, 2017). Lameness, in either sheep or dairy cows, has a negative impact on the animal's ability to graze, thereby reducing energy intake and thus, milk or growth performance as well as reproductive performance.

A robust animal must be a multi-functional animal

Robustness is a multi-factorial trait and relies on the ability of the ruminant female to be able to assume the highlighted productive and functional expectations, to cope with constraints and be resilient to disturbances. Recently, Ollion *et al.* (2016) performed multivariate analysis to explore the diversity in the ways cows prioritise between life functions (milk yield, body condition change and reproduction success) in early lactation (time when dairy cows are experiencing an energy deficit). The concept of dairy cow profiles developed in this study helps to describe different types of cows beyond the breed effect. This method has been applied on the INRA Le Pin experiment (Cloet *et al.*, 2015) and four profiles with specific trade-offs have been highlighted (Figure 4). Some cows prioritise milk solids yield without a detrimental effect on reproduction (cluster 1) while others are less efficient with regard to fertility without compensating in milk solids (cluster 2) or are unable to compromise (cluster 4). Clearly, cluster 3 appears to be more in accordance with compact calving grass based systems with priority given to reproduction

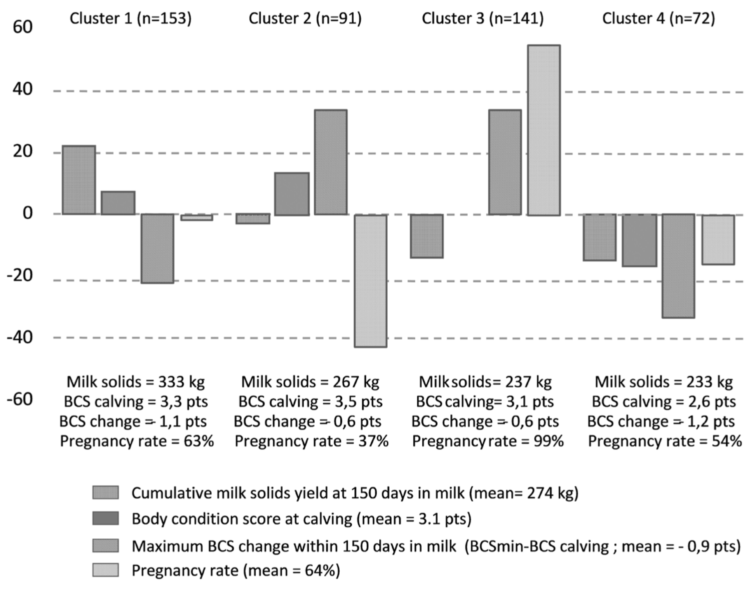

Figure 4. Expression profiles of priorities between milk solids yield, body condition score and pregnancy rate of Holstein and Normande cows. Deviations are expressed in relative proportion (%) of the mean value observed for the 457 lactations clusters of lactation profiles were identified by multivariate analysis followed by clustering analysis. Values between brackets are number of lactations in each cluster.

(pregnancy rate = 99 vs 64% on average) and maintaining body condition without impairing milk solids yield. It is possible to hypothesise that such differences between profiles are associated with a diversity in nutrient acquisition (forage intake capacity) and or in nutrient allocation (Friggens *et al.*, 2017).

Genetic improvement programmes should use a selection index that combines all the economically important traits appropriately for the local conditions and systems (Buckley *et al.*, 2005). An excellent example of success in this regard is the Irish Economic Breeding Index (EBI). Both genetic trends from the national population (Figure 5) and the most recent results from a controlled experiment at Teagasc Moorepark, 'Next Generation Herd' (Table 2) are illustrations of the consequence of a better agreement in the selection criteria and producer goals (Buckley *et al.*, 2017). Experimental evidence from studies in beef and sheep also indicate that selection of females based on their genetic merit for maternal type traits may result in the selection of a more robust female for grass-based systems (McCabe *et al.*, 2016; McGovern and McHugh, 2017). A 'better balance' may also be obtained by crossbreeding (Buckley *et al.*, 2014; Coffey *et al.*, 2016; Dezetter *et al.*, 2015) due to a combination of both breed complementarity and heterosis.

This concept of a well-balanced animal is well expressed by grassland farmers in response to an open multi-answer survey realised by Ollion *et al.* (2015) and presented in Ollion *et al.* (2018). The question was 'What is a robust cow to you?' The first trait (80% of farmers speak about) cited by farmers was good health (never sick, no veterinary need) followed by morphology with 64% (solid legs, able to go grazing, good udder). The third trait quoted (33%) concerned reproductive function with an ideal of one calf every year. Intake capacity, milk yield and temperament closed the list, cited by 18 to 20% of the farmers. Besides quoting functional, productive or behavioural traits, farmers also characterised a robust cow through integrative characteristics or properties. '*Longevity*' was mentioned by 50% of the farmers followed by '*transparency*' (36%) and '*ability to adapt*' (33%). Transparency means that the animal is totally transparent within the system. This last expression (*The better females are those you never hear about*) was also reported by Brochard *et al.* (2016) in a survey concerning all the ruminant females.

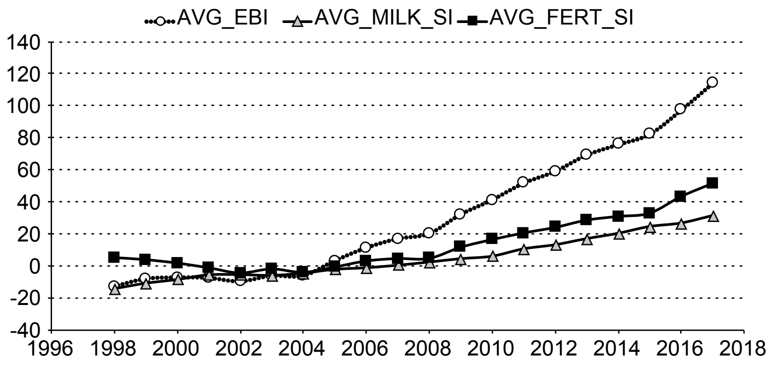

Figure 5. Rate of genetic gain in Economic Breeding Index (EBI), Milk sub-index (MILK_SI), Fertility sub-index (FERT-SI); € per lactation) for dairy females born in Ireland between 1996 and 2017 (source: A. Cromie, Irish Cattle Breeding Federation, personal communication).

Conclusion

For [semi] intensive pasture-based systems, robustness can be defined under three broad characteristics: (1) match high milk or growth performance to high forage intake capacity, (2) ensure high fertility (cattle) and prolificacy (sheep) and the delivery of offspring without assistance, and (3) remain healthy. These three main objectives challenge breeding and genetic research to define and be able to evaluate the best parameters to select future generations of ruminant livestock. Multi-trait selection is definitely more complicated than single trait selection as has been the focus in the past. It must be cognisant of sustainability within future ruminant feeding systems.

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