Aspects of Feed Efficiency and Feeding Behaviour in Turkeys

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Introduction

Feed costs equate to around 60-70% of the total costs associated with commercial turkey growing, and thus improvement in feed efficiency is of large direct economical importance to the turkey industry. An improvement of 5 points of Feed Conversion Ratio (FCR) could mean an annual reduction in feed cost of up to £17k (25k Euro) for a turkey producer growing 100,000 turkeys per year (17p or 25 Euro cents per turkey).

Today's breeding companies are developing turkeys for the global industry and the challenge is to supply the market with birds that perform well in a variety of environments. Thus there is increased importance for breeders to minimize effects of Genotype by Environment interactions (GxE) in order to be able to deliver realized year-on-year progress in key traits to their customers.

The key strategy for the breeders in order to maximize progress and minimize GxE would be:

1) Use of multi-factorial schemes performing testing at several different ages, nutritional environments and management regimes in order to reflect a multitude of commercial management practices
2) Make best use of new technology in measurement of key traits and implementation of appropriate statistical methods (e.g. BLUP) to improve accuracy of selection and commercial relevance
3) Use of Genomics (i.e. Marker Assisted Selection) in order to benefit from selection on traits that cannot be improved efficiently under normal breeding programme parameters (e.g. disease challenge)
4) Optimize the breeding programme design in order to relay the progress made at elite breeding programme to the commercial tiers.

This paper will focus on the first two parts, how breeding companies can make best use of new technology, particularly with regards to feed efficiency and thus make quicker improvements and reduce costs for their customers. Furthermore, the aspects of feeding behaviour and its impact on recording and selection for feed efficiency will be illustrated.

Historic Improvement in Growth and Efficiency

Large increases in growth rate have been achieved in the poultry industry over the last decades, with commercial average live weights increases per year of 2.3% for turkeys and 2.7% for chickens.

Havenstein *et al* (2004) compared a modern strain of turkeys with a control strain of turkeys unselected since 1966 and found that body weight had almost doubled during this period (average progress 195g/year). Growing a male turkey to 20lbs then this would take 96 days with an FCR of 2.05 for the modern turkey whereas it would take 153 days and an FCR of 3.43 for the unimproved strain.

It is important to note that despite this substantial progress there is still very significant variation both within-strains and among strains, for growth and feed conversion in turkey lines used commercially (Table 1), as well as in pure lines of turkey selection programmes (Table 2). Thus there is substantial scope for further gain to be achieved for feed efficiency improvements in commercial breeding programmes. Conserving genetic variation is crucial for the sustainability of selection programmes and thus it is in the interest of the primary breeders to maintain a large number of lines displaying different, unique characteristics.

Table 1. Comparison of growth and FCR data on commercially grown Heavy Strain Turkeys

Trait	Worst	Average	Best	Range
Body weight (140d)	17.46	18.23	18.95	**1.50**
FCR	**2.78**	**2.64**	**2.56**	**0.22**

Table 2. Heritability and phenotypic variation in FCR for 6 turkey selection lines

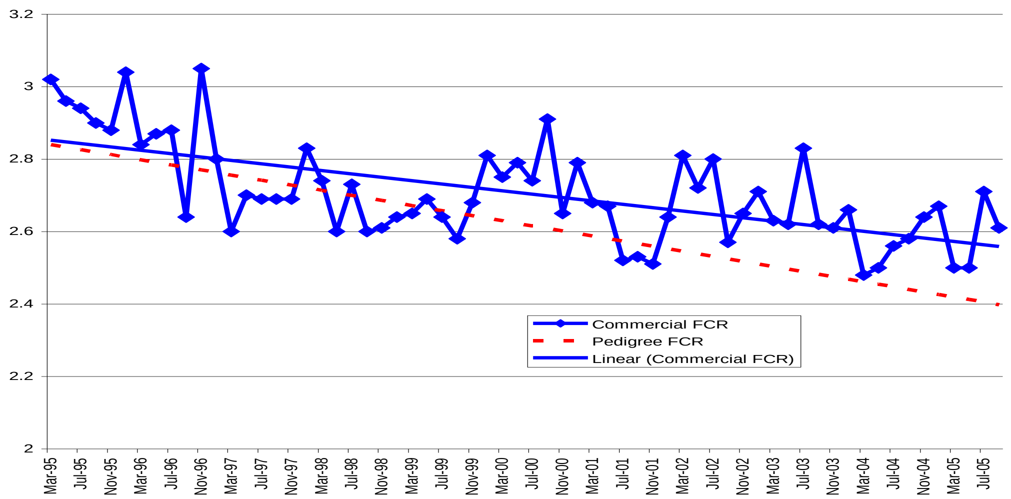
Line	Heritability	CV%
A	0.15	**23.2**
B	0.24	**19.4**
C	0.13	**18.1**
D	0.20	**19.4**
E	0.18	**18.1**
F	**0.14**	**17.5**

Historically in poultry breeding mass-selection has been applied for growth traits, with the benefit of having large contemporary groups to select within. Further efficiency improvements were achieved in poultry breeding as a consequence of implementation of index methodology. During the 1990's the use of Best Linear Unbiased Prediction (BLUP) methodology such as VCE and PEST (Groeneveld, 1990) and DMU packages (Jensen & Madsen, 1993) which takes all available information on relatives into account, has vastly increased efficiency of selection for low heritability traits such as FCR.

Traditionally in poultry breeding a series of sequential selection stages at a juvenile age have been applied prior to FCR testing. For chickens juvenile selection would be applied at 4-5 weeks of age and for turkeys between 14 and 18 weeks of age prior to FCR testing. The FCR testing periods that have been applied in commercial breeding programmes constitute a relatively short period in relation to the lifespan of the bird, in the range of 2-3 weeks for chickens and 3-4 weeks for turkeys. Furthermore, the data generated by such tests are measured in an aggregate form giving a total feed intake and weight gain over a set period. Recording a trait in a composite form where a large number of individual observations make up the trait in the selection goal is associated with a higher accuracy, as each individual observation has a smaller impact on the total selection trait.

Although significant progress has been made in FCR using these methods, the progress in realized commercial FCR as given by field data is less than that achieved in elite birds in high quality pedigree environments. Over the last 10 years improvement in FCR in the field has been in the range of 2 points per year, however, the progress that could be achievable on pedigree level in the same period was substantially higher, at 5.5 points per year. This could be interpreted as evidence of a genotype by environment interaction of recording environment reducing realized field progress.

Figure 1. Comparison of field data for FCR improvement with possible selection response when testing in individual pens in a pedigree environment



Taking a New Approach for Improving Feed Efficiency in Poultry

One of the largest improvements in the ability of improving the response in commercial realized FCR has come from developments of new technology in electronic measurement of individual feed intake in groups of animals. Testing in a group environment is associated with the following benefits (compared to testing in individual pens):

1. The environment is closer to that applied commercially and is thus a more relevant trait to the poultry industry
2. Allows for social interactions between animals affecting feeding behaviour
3. It provides a better welfare for the animals
4. Daily feed intake curves and efficiencies can be calculated
5. A substantially higher proportion of animals can be tested which has a direct positive impact on genetic gain
6. Test periods can be extended to cover a larger part of the birds life, optimizing the coverage of periods of highest importance for each product category
7. It gives a wealth of information on feeding behaviour

This type of technology has been commercially available to use for recording of feed intake in large animals such as pigs (e.g. FIRE- feeder system developed by Osborne Industries) and dairy cattle. However, developing a system for recording individual feed intake in poultry presents a substantially higher degree of complexity and challenge from a technological standpoint due to:

1. *Vast change in body size* over the recording period. A broiler weighing 470g at 14 days will grow to reach 2700g at 35 days, an increase of 570%. Similarly a male line stag increases its body weight by 300% in the period between 10 and 20 weeks of age. This can be compared to pigs, which would show an increase in body weight by around 35% over a 4 week test period.

2. *A more rapid movement* in and out of the feed places than that of larger species and the difficulty in restricting access to the feed places to one bird eating at any point in time.

3. *The small meal size,* with an average of approximately 10g for a male line broiler, recording each meal accurately requires high resolution weighing technology which must be functional in a poultry house with high air speeds created by either cross or tunnel ventilation.

The system developed by and unique to Aviagen for group FCR testing of chickens and turkeys consists of pens with 8 feed places which house between 100-140 birds (depending on strain). The birds are identified using transponder technology and each individual meal is captured throughout the testing period using high resolution scales. For each meal the size, time of day and duration is recorded to the bird identity number.

Selection Strategies for FCR Testing

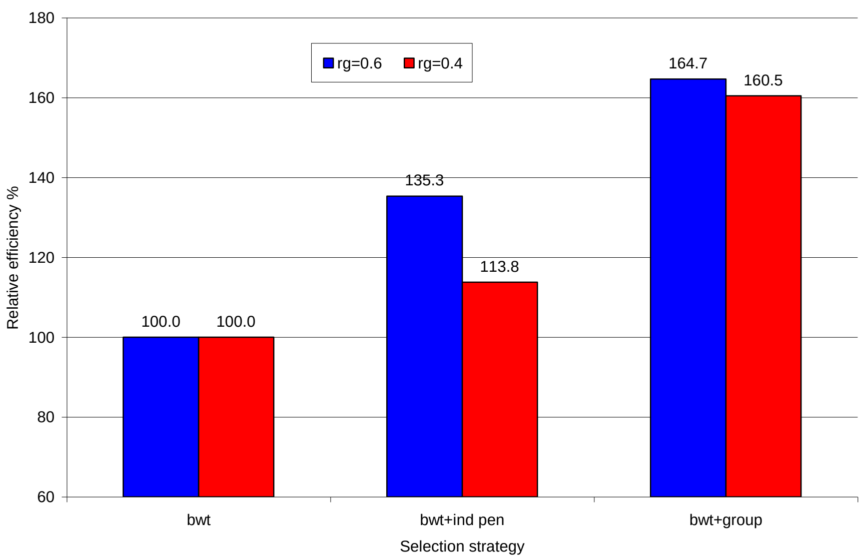
In order to study the relative efficiency of different testing methods on genetic improvement in true 'commercial' FCR for turkeys three strategies were compared using the SelAction software by Bijma & Rutten (2000). The three strategies were:

1. Selection on growth giving a correlated response in FCR
2. Selection on growth and FCR test in individual pens
3. Selection on growth and Group FCR test

Testing FCR in an individual pen environment (I-FCR) gave 35.4% higher genetic progress in true commercial FCR (T-FCR) than selection on body weight alone, when the correlation between C-FCR and T-FCR was 0.6. If the correlation was reduced to 0.4, which could be more in line with the field results reported above, the extra gain was 13.4%. The largest increase in gain was made by including data on birds tested in groups (G-FCR), giving an additional 29.4% (rg=0.4) to 46.7% (rg=0.6) increase in genetic gain compared to testing in individual pens. These increases were achieved through a combination of:

1) Larger full-sib and half-sib groups and 2) Stronger (rg=0.8) relationship between G-FCR and T-FCR than that between I-FCR and T-FCR.

Figure 2. Relative response in true commercial FCR (T-FCR) in Turkeys using three different selection strategies.

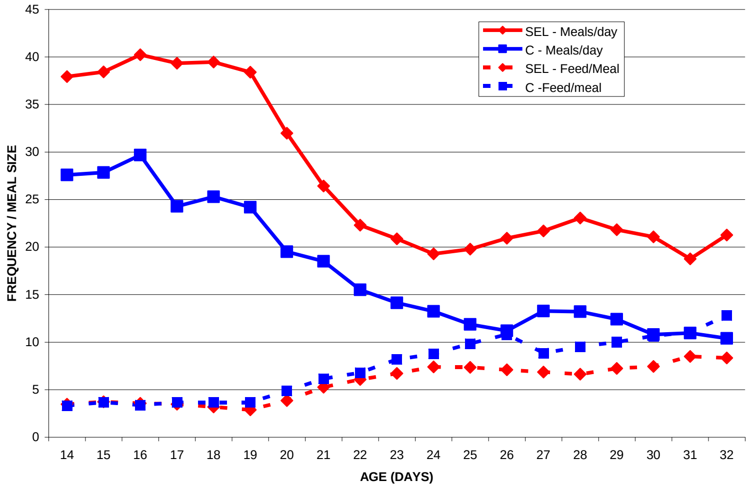


Effects of Selection on Feeding Behaviour

Feeding behaviour may have great impact on future opportunities for selection for feed efficiency. The impact of selection on feeding behaviour has been largely unknown for poultry, however new methodology in definition of meals and short versus long-term feeding behaviour has successfully been implemented for other species, particularly pigs and cattle (Tolkamp *et al*, 2002) giving opportunities for implementation in poultry.

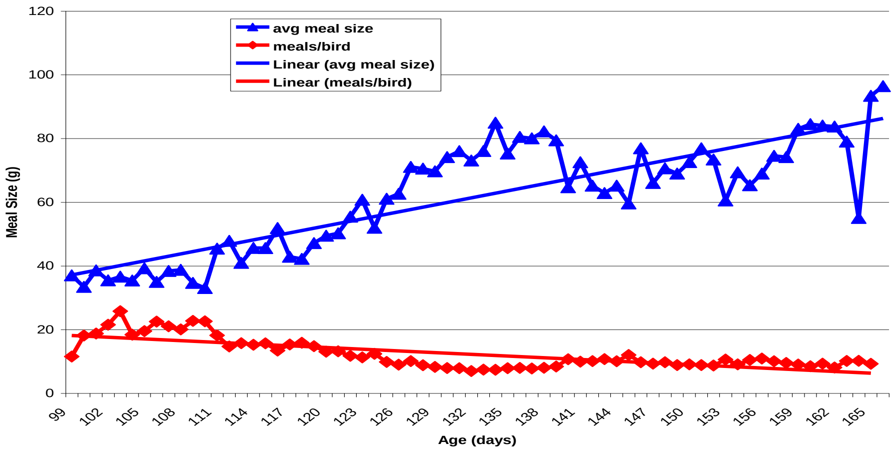
The comparison of a chicken male line selected for growth, efficiency and yield (line S) with a version of the same line but kept as a random bred control line since 1996 (line C) showed large differences with regards to growth and feed efficiency, with the selected line showing an advantage in body weight of 62g (+14%) at 14 days of age and 381g (+21%) at 34 days of age (Figure 3). The advantage in feed efficiency for the selected line was 4 points of FCR. There were substantial differences in the expression of feeding behaviour between the two lines, with the selected line showing a higher feeding frequency than the control line, but with lower average meal sizes than the control line. Thus, a higher proportion of time was spent feeding by the selected line, and these results also indicate that the strive for higher efficiency could be associated with snack-eating behaviour. These findings are consistent with studies by Boa-Amponsem et al (1991) who found significantly higher number of feeding bouts per bird in a fast growing broiler strain compared to a slow growing counterpart. The higher feeding rate in commercial broiler chickens gives a higher gut-fill and thus faster feed passage which can be associated with a high feed efficiency (Cherry & Siegel, 1978).

Figure 3. Average meal size and frequency of feeding for a selected chicken male line versus a line random-bred since 1996.



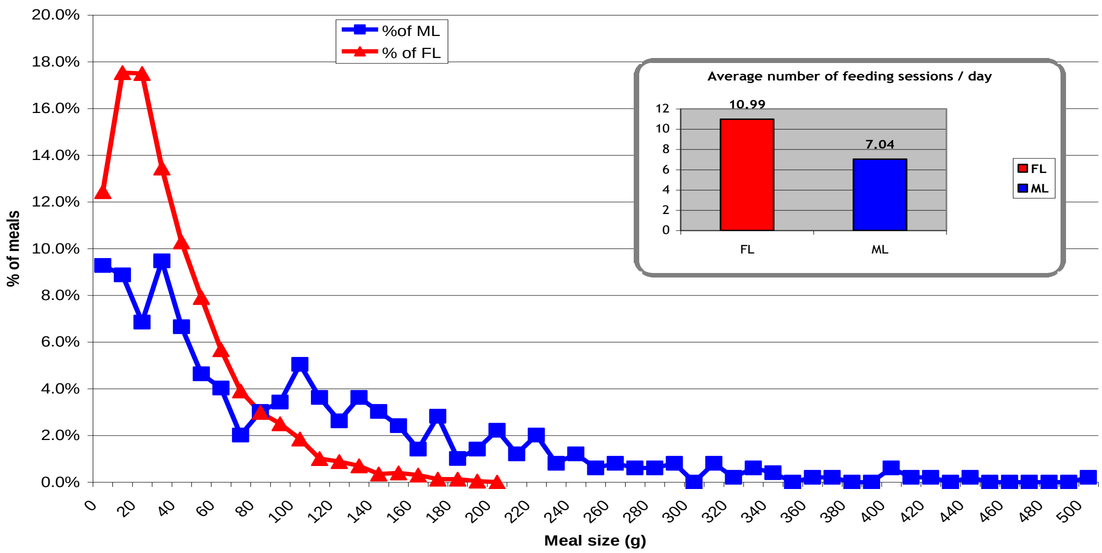
The change in feeding behaviour with age shows a similar pattern for both chickens (Figure 4) and turkeys (Figure 4). The turkeys, grown in the FCR test environment from 14 to 24 weeks showed twice as high feed intake per meal at the end of test compared to beginning of the test period. This was accompanied with a reduction in the number of meals consumed per day, and thus an increase in the time spent per feeding session.

Figure 4. Average meal size and frequency of feeding for a male line of turkeys 14 to 24 weeks of age



When male turkeys from a male and female line were compared the average number of meals per day was significantly larger for a female line compared to a male line (10.99 vs. 7.04 sessions per day). The female line males consumed significantly lower amounts of feed per meal than the male line, the male line turkeys consuming up to 450g of feed in one session compared to 170g in the female line turkeys (Figure 5). Consequently, the male line birds spent a higher proportion of its time budget expressing feeding behaviour.

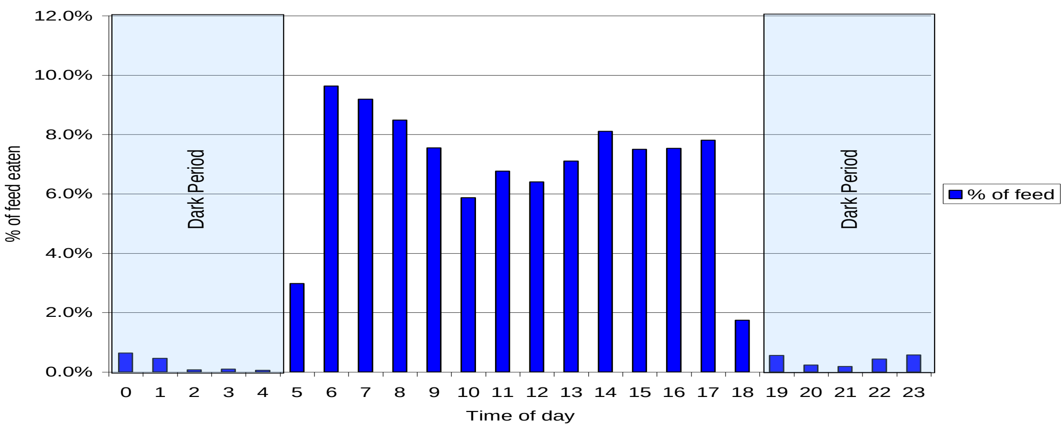
Figure 5. Distribution of meal size and average number of meals for a heavy Male Line (ML) and a light Female Line (FL) of turkeys



Feeding Preferences of Turkeys

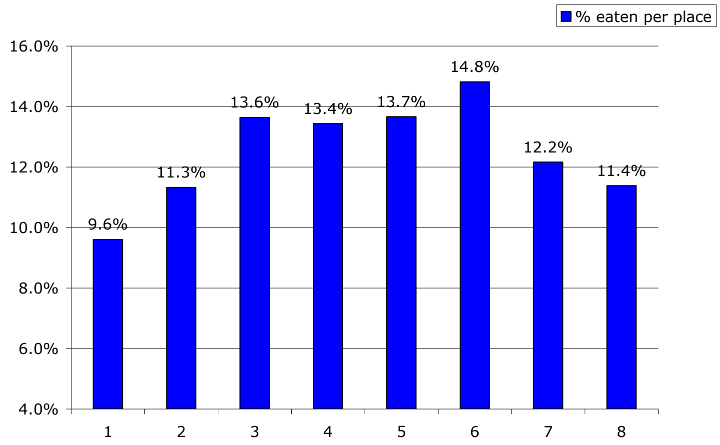
When studying the diurnal variation in feed intake in male line turkeys kept on 14 hours light and 10 hours dark period it was shown that, as could be expected, the highest activity was in the period after the lights had come on after the dark period. However, there was a delay of approximately 1 hour before the peak was reached. Feeding activity was reduced at the time before mid-day (1000-1200hrs), with the birds settling down and displaying resting behaviour. Feed intake increased in the period between 1400-1700hrs, followed by a reduction in activity in the last hour prior to the lights being extinguished. These results indicate that turkeys have a clear sense of the day length and can anticipate when the day draws to a close and respond in their feeding behaviour accordingly.

Figure 6. Diurnal variation in feed intake for a male line of turkeys



In the Aviagen testing scheme a total of eight feed places are offered as a choice of feeding in each group of turkeys. There are distinct feed place preferences both for the group (as shown in figure 8) and for individual turkeys. The preference of the turkeys to feed from the centre located feed places and less from the outer located feed places is most clear. The preference of the middle section could be associated with a higher degree of 'safety' for the birds, as the outer sections would either join onto another pen of birds or to an aisle section representing a higher degree of 'risk' to the birds.

Figure 7. Feeding preferences of a male line of turkeys



Impact of Feed Form/Quality on Feeding Behaviour

Commercial poultry strains are grown in a large number of different nutritional environments and management types. Figure 9 and 10 show results from a trial where feed intake and behaviour in broilers were compared when grown using pellet or crumb feed. Using the pellet feed resulted in significantly higher feed intake per day. Using a crumb feed was associated with a large increase in time spent feeding. Thus the amount of energy spent per unit of feed was higher when using a crumbed feed type, which was also reflected in poorer feed conversion ratios on crumbed feed.

Figure 8. Daily feed intake for a male line of chickens on two different feed forms (Pellet or Crumb)

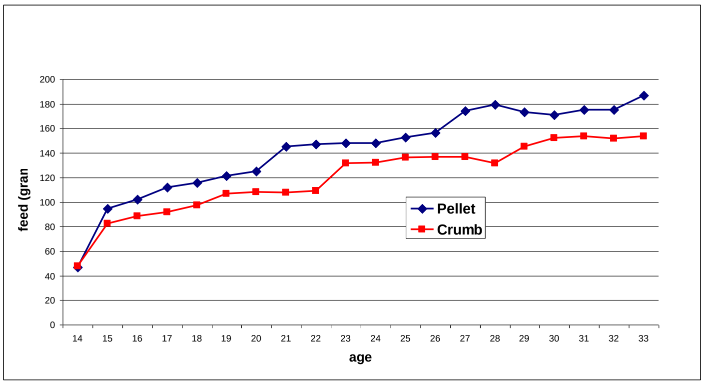
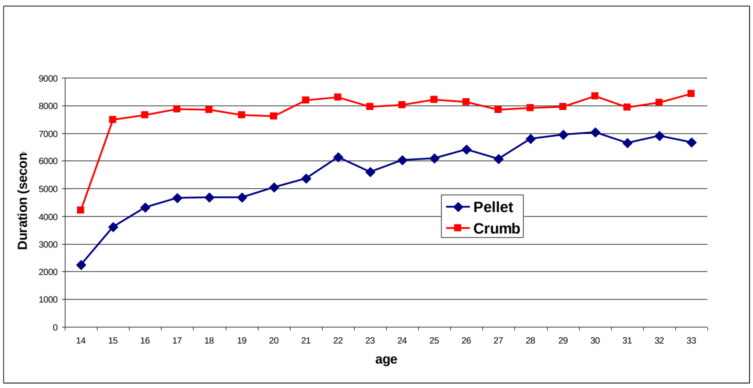


Figure 9. Average meal duration for a male line of chickens on two different feed forms (Pellet or Crumb)



The Way Forward

The supply of poultry breeding stock for a wide variety of markets and environmental conditions has been a driver for the evolution of balanced breeding goals. Selection is consequently applied on a broader range of traits including 1) fitness and welfare traits such as skeletal integrity, cardiovascular fitness and liveability 2) reproductive performance (e.g, egg production, fertility, hatchability) 3) disease resistance (e.g. immune response) 4) efficiency (e.g. yield and feed conversion) and 5) quality traits (e.g. meat quality, feathering).

An essential part of balanced breeding goals and the increase in efficiency of relaying genetic progress to the commercial level is the inclusion of multi-factorial testing schemes, where testing is applied in a variety of management conditions, nutritional regimes and ages.

The implementation of novel data analysis techniques such as random regression models brings increased opportunities to efficiently analyse longitudinal traits such as feed intake patterns and to maximize benefits of high early feed intakes when efficiency is high (Huisman *et al*, 2002).

Focus on the environmental impact of agriculture will also have an impact on the selection for more detailed aspects of metabolic and nutrient utilization efficiency.

With regards to the relationship between feed efficiency measures and feeding behaviour then further research is required in order to distinguish feeding patterns in more detail, define meals and aspects of satiety and feed regulation of the modern turkey, and its impact on performance.

Through investment in genomics (i.e. Marker Assisted Selection) future breeding programmes will offer greatly increased opportunities for selection on traits with relatively low accuracy of selection from limited recording for instance expressed only under extreme conditions such as disease challenge.

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