Data recording and profitability in livestock breeding: Lessons from poultry breeding

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Abstract

The goal of any livestock breeding programme is to earn a return on investment and help their clients be more profitable. Success depends on efficiency of the breeding programme and its ability to supply genetically superior stock on a continuous basis to customers. To make this work availability of accurate information for making timely breeding decisions is key. Data collection and analysis is thus central to the profitability of commercial livestock breeding programmes. The difference between poultry and cattle breeding is primarily due to the structure of the programmes as occasioned by the size and unit value of the animals, reproductive rate, generation interval and the socio-political role of the industry in the (inter)national economy. Genetic improvement in poultry is undertaken at the apex of the breeding pyramid with a one way gene flow from the nucleus to the commercial producer. The commercial producer is entwined in the genetic improvement process in cattle breeding.

Data capture in poultry breeding is in-house and sophisticated because of the need for a broad breeding objective. It is a primary objective for the rearing of animals in the genetically diverse breeding nucleus. The breeding programme is designed to be efficient taking account of the need for genetic improvement, health and welfare of stock. The social responsibility of ensuring safe supply of healthy stock gives bio-security precedence over genetic improvement. Multiple production environments are simulated for data capture to overcome the risk of genotype by environmental interaction. This makes poultry breeding programmes more expensive to run compared with cattle breeding programmes where performance information is recorded in the commercial production environment.

Turning data into information requires huge investment in information technology, infrastructure and personnel. Shared use of resources reduces unit cost and could make cattle breeding organisations more resilient than limited liability companies. For example, the gains possible from incorporating genomic information in livestock improvement are immense. But the level of investment required is huge because it is an extension rather than a replacement for existing infrastructure. In poultry breeding, this huge cost has to be borne by individual companies while the burden can be shared in cattle breeding.

Keywords: data recording, poultry, cattle, breeding programme, profitability

Introduction

Livestock breeding refers, generally, to the art of identifying, selecting, and mating parents of the next generation. It is practiced by every livestock farmer who keeps male and female animals and decides on how to pair them to produce replacements. When there is a desire to improve performance in the next generation, selection is more intense and identification of the parents of the next generation is based on a more detailed evaluation of the available candidates. When breeding is used as a vehicle for genetic improvement, the art of identifying, selecting and mating parents of the next generation takes on a new dimension, involving much more than the primary livestock producer. It involves the setting up of a breeding programme (Olori, *et al.* 2005), where data recording is structured and available data is managed and analysed to predict the genetic value of every selection candidate.

The primary goal of any commercial livestock breeding programme is to make a profitable return on investment in a sustainable way. Sustainable profitability of the breeding programme as a business is reliant on the ability to manage the cost of inputs and maintain a broad based genetic resource in the process of producing highly valuable breeding stock. It also depends on the ability to enhance the genetic superiority and health of supplied stock so as to maintain a competitive edge in a global market place. Because the end product of the breeding programme is a live animal that is expected to thrive and perform in the clients' farm, profitability of your clients depends, amongst other things, on the efficiency of your breeding programme and its ability to supply the client with the best animals for his current and future production requirements.

Information and profitability

The ability to deliver genetically superior stock for profitable commercial production depends on the accuracy of selection decisions in the breeding nucleus. It has a high impact on customer satisfaction and fidelity, volume of sales and hence income and profitability. One essential element in the ability to make timely key decisions in a breeding programme is the availability of accurate information. This includes information on the individual livestock units, the performance environment including micro variations in supplied input, market requirements and product quality. There is also a need to understand regulations affecting your practice and concerns that consumer and other interest groups might have either on your practice or the quality of your product. To this end the need for data collection and analysis to obtain information is common across all livestock species. What data is available, when it is available in the life cycle of the animal, the ease and cost of recording it, how it is stored and maintained and how it is used may however vary between livestock species and hence between their respective breeding programmes.

Structural differences livestock breeding programmes

The major difference between the breeding programme of different livestock species and especially between poultry and cattle breeding programmes is the way they are structured. The structural difference (see FA0, 2007; Simm, 1998) can be attributed to;

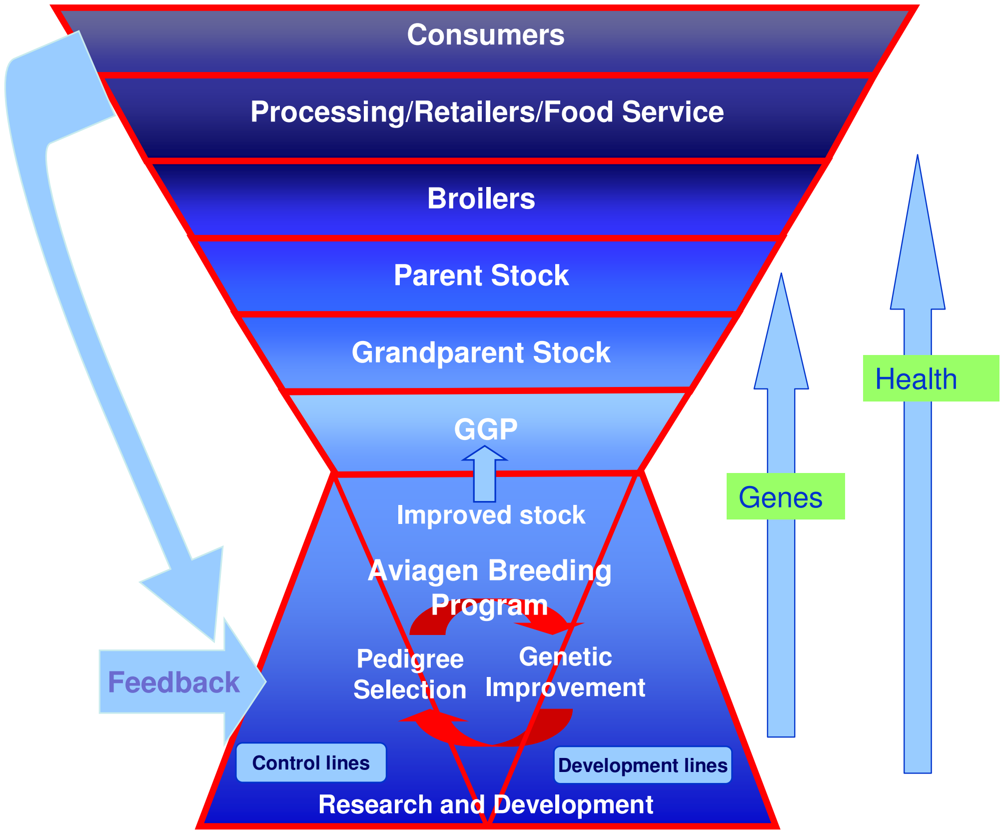
a) The size of the animals which affects the physical space required.
b) Reproductive efficiency (prolificacy and fecundity) which affects the size of the required population and the relative selection intensities possible.
c) Generation interval which affects turnover and rate of progress possible and

d) The socio- political role of the primary industry in the (inter)national economy and sometimes policies which affect the kind and of support and interest the programme gets from the government agencies and the public purse.

The most obvious difference is that between poultry and pig breeding on the one hand and cattle and other small ruminant breeding on the other. In the latter case these are larger animals with higher individual value , lower reproduction efficiency, larger generation interval, and in many countries availability of government support. The design and structure of the breeding programme affects the ability and cost of data collection.

Poultry breeding has evolved over the years through the need to develop complimentary lines which provide hybrid crosses at the commercial level. The increasing complexity required for balanced genetic improvement has resulted in the focussing of this activity in the hands of few companies with the resources (Laughlin 2007) to maintain a diverse population with large genetic variation, select with a broad breeding objective and access to a large market which allows the investment cost to be shared over a sufficiently high number of animals. Whereas the structure is generally thought of as a pyramid with unidirectional gene flow from the nucleus at the apex to the commercial producer at the base, Laughlin (2007) has argued that this concept is a false description of the modern poultry breeding programme because it understates the current roles whereby the nucleus support the entire production process of the industry rather than merely sitting on top of it and passing down improved stock. He suggested that the true structure of the modern poultry breeding program as shown in Figure 1.

In cattle and sheep breeding, commercial farms serve as breeding and recording units and hence are an integral part of the typical open nucleus breeding programme. A schematic representation of this structure is presented in figure 2. The breeding programme therefore comprise of stakeholder organisations responsible for animals registration and pedigree recording, performance /progeny testing, milk recording and other data collection, data storage, management and analysis to provide information on genetic merit. Ownership is loosely defined and is sometimes identified by an association of the stakeholder institutions such as the Canadian Dairy Network (www.cdn.ca/) and the Irish Cattle Breeding Federation (www.icbf.com). This structural difference between cattle and poultry breeding organisations has an impact on the sources and availability of data. It also significantly affect the scope and cost of data recording and hence the efficiency of their breeding programmes.



Laughlin, 2007

Figure 1 Structure of a modern poultry breeding programme

Animal Identification

Identification of individual animals is the most basic and important information in genetic evaluation because of the need for accurate pedigree in defining all relationships. It is also key to linking performance records to individuals and hence to families and production environments. This information is essential in the prediction of the genetic merit from observed performance using quantitative methods based on linear models (Mrode, 2005). This technique relies on estimation of population genetic parameters mostly by Restricted Maximum Likelihood (REML) methods (Gilmour et al., 1995;
Thompson, *et al.,* 2005) and subsequent estimation of breeding values by Best Linear Unbiased Prediction (BLUP) (Henderson, 1975).

Apart from the importance of identification for genetic evaluation purposes, it is also an essential requirement for traceability of animals in cattle and small ruminant farming in most countries (Wissmans, 1999; Stanford et al; 2001; Bowling et al, 2008). In Europe, mandatory animal identification is prescribed by EU regulations (EU, 2000). This means animals used in commercial production can be traced to their parents and hence any data recorded can be used in genetic evaluation in these overlapping breeding programmes with varying ownership structures. This has facilitated data recording in many commercial farms within and across national borders facilitated by standards for animal recording by the International Committee on Animal Recording (ICAR, 2011).

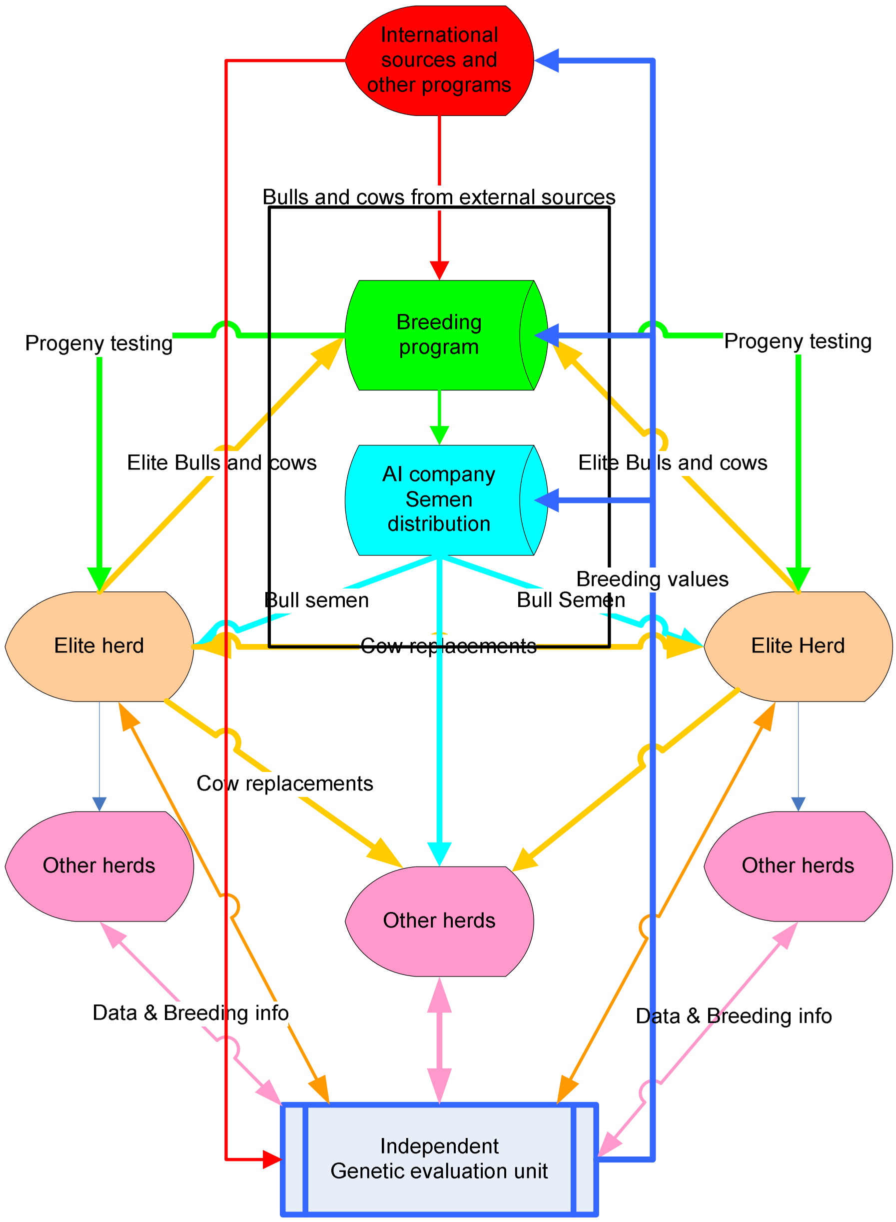


Figure 2. Schematic representation of the structure of a typical cattle breeding programme

These developments has made it possible for the involvement of the commercial producer in breeding and the genetic improvement process in the ruminant animal. Animal identification plays a similar role in poultry breeding. In this case the overwhelming need to maintain accurate pedigree which is central to the ability to make genetic improvement of traits is the biggest motivation. Because of the need to record fitness and reproductive information such as fertility and hatchability, identification of a chick starts on the day the egg is laid. Identification of the hen that laid the egg and her mate is essential in determining the genetic merit of each bird in the fertility of the egg. Whereas factors such as the quality of the shell and its content can be considered direct traits of the hen, egg fertility, embryo survival and hatchability are influence jointly by both the hen and her mate (Wolc et al, 2011). Genetic analysis of these traits thus require accurate identification of the hen that laid the egg (with trap nesting) and her mate. This is achieved either by writing directly on the egg on collection or using egg bar coding to increase accuracy.

The most cost effective way to identify individual animals is to attach a unique identifier on each animal in the breeding unit from birth till the animal is culled. For livestock like dairy cattle with international genetic evaluations, it is a requirement for ids to be unique across countries and ICAR (2011) has helped in this regards to lay down the principles. For traits like carcass weight, and meat yield, this unique identifier stays with the animal until it gets to the processing plant. Unique identifiers come in various forms ranging from ear tags in ruminants to wing or leg bands in poultry. Electronic tags and transponders are used in poultry breeding to record individual performance of birds housed together in group.

Data storage and maintenance

The managements of identification and data recording systems requires the maintenance of a scalable database. Where this is mandatory by law, government has an obligation and has indeed supported the development of huge centralised databases for the storage of animal information in many countries (Wickham, 2004). Absence of government intervention and lack of an animal identification and recording service has been an impediment to the institution of breeding programmes in many developing countries for low input ruminant production systems (Njemali 2005) . Direct support for infrastructural development is another key difference between poultry and cattle breeding programmes. In poultry breeding, the requirement for data storage and maintenance is huge considering the high prolificacy and short generation interval of poultry species as well as the large number of lines and animals maintained in the breeding programme. Investment in computing infrastructure is therefore continuous to accommodate increase in data volume and take advantage of new technologies that allow faster and more efficient data processing.

To have the full benefit from data recording, information from all aspects of production, health and environmental conditions need to be integrated in a single or linked databases with full and easy access for data upload and extraction. New data capture devices (DCDs), the internet and security protocols like Internet Protocol security (IPsec) VPN, fast broadband connections and mobile telephony data connectivity now make remote data recording and transmission feasible with significant impact on accessibility and cost of recording. This has encouraged the development of centralised storage systems with sufficient capacity to accommodate all aspects of production and health recording. The development of a centralised database is also a necessity in poultry breeding because bio-security limits personnel movement and necessitates the dispersal of facilities such as the hatchery, grow, rear and lay farms, processing plants and the veterinary laboratory facilities.

Intellectual property protection

The different ownership structures and (im)possibilities to protect intellectual property (IP) are principally different between ruminants and poultry. In cattle breeding, the value of a unit breeding animal such as a proven bull is extremely high, and the breeding or AI organisation which owns such an elite bull has control over the return of investment via the selling of semen through a manageable, controllable and regulated system of data recording, identification etc. Such organisations only share whatever data is required via agreed independent interfaces such as the national and International genetic evaluation units to allow international comparability (and trade) of their bulls without any possible loss of IP. In poultry breeding, however, the saleable item is the chicks or hatchable eggs. The IP of the hybrid PS or GPS can only be protected by owning the contributing lines or detailed customer contracts. Data from the pure lines (and the in house diversity and power they represent) are the major asset of the poultry breeding companies and the only way to protect their investments is to own and protect the IP on the pure lines.

Performance recording and data capture

Performance recording is common to both ruminant and poultry breeding programmes. However what data and how they are captured vary mostly because of the variation or differences in traits recorded. In cattle breeding, traits of interest include indicators of fertility, calving difficulty, various weights of the animal from calving to slaughter, milk production and components yield, udder health and body conformation traits. Standard methods of recording these have also been prescribed (ICAR 2011). Perhaps the biggest misconception about the poultry breeding industry is the belief that broiler companies only improve body weight and growth while the focus of layer companies is for egg production and quality. This misconception may derive from the history of the evolution of poultry breeding which indicate that chickens used in commercial poultry production today were derived from indigenous breeds, through intensive selection for either laying performance or growth. Crossbreeding and experiments to create specialised breeds started around 1950 in the US and Europe and was followed by the emergence of private structured breeding companies (Hunton, 2005). Yet, poultry breeding companies started broadening their breeding objective to include health reproductive fitness, health and welfare traits in the 1970s, much earlier that any other livestock species. The activities of these breeding companies have resulted in the modern day broiler and layer strains used in commercial poultry industry (Laughlin, 2007).

Profitability of the layer and broiler industries depends on egg production and chick output. All physiological pathways involved in the growth of any animal or birds require a functional body metabolism. This means all support systems of the bird must evolve in synchronisation with, for example, the evolution in rate of tissue development. This is why the ethos of modern poultry breeding is 'balanced genetic improvement'. Those who failed to adopt this earlier have fallen by the way side.

The need for a balanced genetic improvement leading to the evolution of a robust chicken is also informed by the fact that poultry breeding companies supply stock to be used in farming in a very wide variation of macro and micro environments, within and across countries. Because it takes about 4 years or longer (Laughlin, 2007) for improvements made in the nucleus breeding population to be reflected in the commercial population, poultry birds need to be elastic in their response to micro-changes in the production environment. Failure to achieve this quality would result in huge loss in market share and hence profitability. With this in mind, poultry breeding companies commit huge resources to maintain a diverse population of pure lines and perform selection with a broad breeding objective based on the recording of a very wide variety of traits at every stage of the production cycle. Figure 3 shows some of the traits included in the breeding objective of a typical broiler breeding company (Laughlin, 2007).

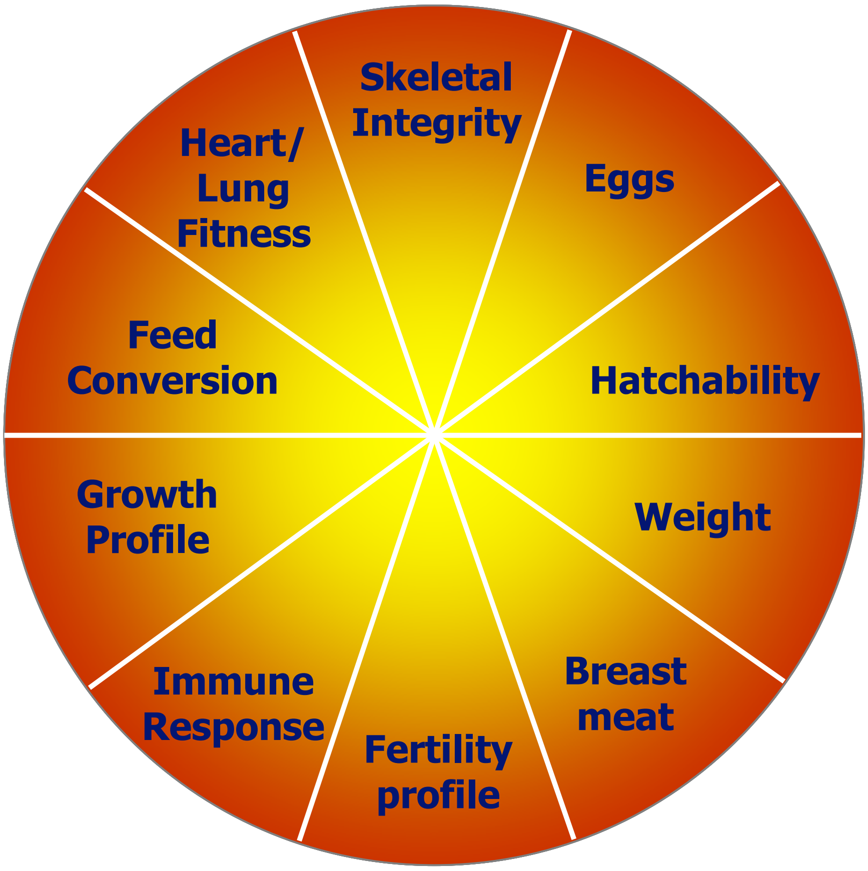


Figure 3. Traits in the breeding objective of a typical broiler breeding programme (Adapted from Lauglin, 2007)

Data recording in poultry breeding takes place mostly within the pedigreed breeding population in dispersed facilities which makes up the breeding nucleus. This allows rapid development and deployment of any suitable verifiable methodology and equipment for data capture. Sophisticated data recording techniques and equipments are required because of the need to record a wide array of traits necessary for a broad breeding objective. In this regard hand held terminals play a key role in the initial data capture from source be it at the hatchery, grow, rear or lay farm or in the processing plant. Each terminal must be customizable to receive and supply data files compatible with the storage database and to be able to inter-phase with the recording equipment which range from simple equipment like weighing scales to more complex ones like the oximeter for recording oxygen saturation of the blood. Integrated systems are used for continuous data capture such as feed intake and feeding pattern during feed efficiency/feeding behaviour tests.

Sources of data

A poultry breeding programme is designed to be efficient taking account of the need for genetic improvement, health and welfare of stock. Data recording is a primary objective for the rearing of livestock in the nucleus. This allows implementation of designs to maximize accuracy of genetic evaluation. The pay off is in profitability arising from increased market share and volume of sales and sustainability. Data recording in cattle and sheep breeding is by and large, a bi-product of commercial production. It is a service provided to the farmers for which they pay a levy one way or another. In cattle and sheep breeding, outright ownership and control of all performance and progeny testing herds, processing plants, milk recording and AI organisation, and genetic evaluation units by one single entity is not likely. However contractual agreement might make it possible for an organisation to control all herds where it test its bulls. In theory, this will allow cattle breeding organisation to determine how many bulls to be tested, how many progeny testing farms there should be, and the distribution of old and young bulls across herds. In reality however, the cost will be overwhelming if the breeding organisation have to also decide which cows to stock, when to milk the cows and for how long. In the mean time, cattle breeding have to rely on the level of uptake of cattle breeding services in terms of herds willing to register and participate in the various data recording services provided.

Environment, health and welfare monitoring

In broiler breeding, typically one male and 10 female birds selected and retained in the apex breeding nucleus could produce about 50 million broilers or about 70,000 metric tonnes of broiler meat (Laughlin, 2007). The social responsibility of ensuring safe supply of healthy stock gives bio-security precedence over genetic improvement. Routine health monitoring is therefore a must hence birds and equipment in the production facilities are regularly tested for a number of defined diseases. Data from this monitoring exercise is an invaluable resource in improving management and welfare of the birds.

Because of the short generation interval, assessment of predicted genetic trends with realised genetic progress is fast hence poultry breeders are very quickly held accountable for what they predict. There is very fast feedback from industry which may necessitate quick adjustment of breeding goals and hence incorporation of novel recording technology. In order to avoid the risk of genotype by environment interaction, performance is tested in contrasting production environments created to mimic practices of different spectra of commercial producers. A broad range of indicator traits for animal welfare health and robustness are routinely recorded to monitor bird well being condition. The need for health testing, extensive bio-security measures and full consideration for welfare in housing and transportation conditions makes poultry breeding programmes expensive to run compared with cattle breeding programmes where some of these costs are borne by the commercial farmers.

The genomic era

The availability of both the cattle (Liu *et al.,* 2009) and the chicken (Hillier *et al.,* 2004) genome maps have launched both species into the era of genomics. This methodology has the potential to increase the accuracy of selection as has been shown for layer chickens (Preisinger, 2012; Wolc *et al.,* 2011). The increase in accuracy however comes at an additional cost which may be up to €5,000,000 per 4 lines as shown in Table 1 (Preisinger,2012). In addition to the cost of genotyping, breeding companies willing to apply genomic selection (Meuwissen, *et al,* 2001; Goddard and Hayes, 2007) must continue to capture performance records in order to generate sufficient training data set for the identified Single Nucleotide Polymorphisms (SNPs). They also need to invest in a new or expand existing database to store genomic data. The storage space require for genomic data increases in exponential terms with increasing SNP density. For example, whereas current phenotypic data takes about 0.5KB space per bird, genomic information stored in the simplest file format takes up about 0.5MB space per animal.

*Table 1. Cost of Genomic selection in Poultry**

Genotyping	Cost per bird	Type of Chip	Cost/line	Total cost per programme
Training data of 4000 birds	€ 200	High Density	800,000	3,200,000
Aplication Selection candidates; 10,000 birds	€ 25	Low Density	250,000	1,000,000
Selected Parents 1000 birds	€ 200	High Density	200,000	800,000
Total cost			1,250,000	5,000,000

* Adapted from Preisinger, R. (2012) Table 1

Conclusion

Data recording is essential in a sustainable breeding programme to generate information required for genetic selection as well as other key decisions. The accuracy of these decisions affects the efficiency of the breeding programme as well as the quality of stock supplied to clients. These combine to determine the sustainable profitability of the breeding programme as well as the satisfaction of its clients. This requirement is common across all breeding programmes. Poultry breeding differs from cattle breeding because of the difference in the breeding structure due to the generation interval and reproductive efficiency of the unit animals. Each structure has its advantages and challenges and its evolution has been shaped by several factors that are unique to poultry and ruminant production respectively

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