AN INTERNATIONAL COMPARISON OF THE MAIN MEAT SHEEP GENETIC SCHEMES

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Abstract

Meat sheep genetic schemes are compared in Australia, New Zealand, Ireland, United Kingdom and France thanks to interviews of professionals and regarding their organizations, genetic traits, innovations and economic. It appears that tools are rather similar but the cost of genetic control and indexation, selected animals and insemination are significantly diverse. Genomic is implemented all over the studied countries and should be a major change for the genetic improvement, with more efficiency in countries which have a reliable and centralized control system and database.

Keywords: lamb, mutton, selection, organizations, management

1. The world sheep meat context

The sheep meat is a minor sector representing only 3 % of the world meat consumption in 2012, according to IMS, USDA and GIRA data, but can be a significant activity in some regions like Oceania, East Asia, South America, Middle East and Western Europe for instance (Table 1).

However, the sheep and goat meat production increased rapidly during the last decades, especially in developing countries like China (Table 2).

Moreover, as shown in Table 3, sheep production has a low environmental impact compared to the other meat productions like beef, pig and poultry (FAO 2009b).

In the future, sheep meat demand is estimated to increase from 13 million tons in 2012 to 15 million tons in 2019 (Ashworth 2012).

In this fast changing context, our study aims at describing and comparing the organizations and orientations of the sheep genetic improvement systems for some meat sheep countries in the world.

Table 1. Sheep populations over the world (million heads in 2011)

	Asia	Africa	Europe	Oceania	America
Sheep population	464	255	127	104	93

Source: FAOSTAT 2012

Table 2. Compared evolutions of the different meat productions in the world (% variation 1987-2007)

Item	Pig	Poultry	Cattle	Sheep and goat
Developed countries	+6	+62	-14	-14
Developing countries	+186	+283	+92	+116
Of which China	+228	+3266	+1117	+600
TOTAL WORLD	+82	+142	+22	+63

Source: FAO 2009a

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Table 3. Relative contributions of the animal species for the emissions of greenhouse gas along the food chain

	Cattle and buffaloes	Pigs	Poultry	Small Ruminants
LAND use and land use change	+++	+	+	NS
FEED production *	+	++	++	NS
Animal PRODUCTION **	++++	+	+	++
MANURE management	++	+++	NS	NS
PROCESSING and TRANSPORT	+	+	+++	NS

Note: from ++++ highest to + lowest. NS is non-significant
* excluding change in soil and plant carbon stock, ** including enteric methane, buildings and machinery+
Source: Adapted from Steinfeld et al.2006

2. Protocole of the study

We selected Australia, New Zealand, United Kingdom, Ireland and France because of their mature and diverse sheep genetic organizations even though their national flocks are not always important (see Table 4).

Table 4: Sheep population for the studied countries (million heads in 2011)

Country	AUS	NZ	UK	IRL	FR
Flock	73	31	32	5	8

Source: FAOSTAT 2013

For each treated country we will describe the genetic organizations, traits and index calculation, innovations and economics aspects. e did some bibliography researches and completed by a questionnaire to the main actors of the genetic schemes, filled by emails or phoning interviews. In cross-checking the information from the different sources within the same country, we gave ranges of data which have neither representative nor statistical value.

2.1. Australia

Australia is partially converting its wool flock to meat. Even though the merino breed is still dominant with 85% of the flock in 2002 (Barret 2003), the Meat and Livestock Australia (MLA) is forecasting the lamb production to rise from 0.4 million tons in 2011 to 0.5 in 2016 (MLA 2012).

Organizations in Australia

Meat and Livestock Australia (MLA), linked to the industry and the government, is driving Sheep Genetic Australia (SGA) which is genetically recording about 1000 sheep farms and 1 million sheep. This important database is coming from different independent associations like Lambplan (the most important in meat sector), Merinoselect or CSIRO Select for instance. Lambplan database has a significant part (15 to 20%) of the prolific Border Leicester breed in females like males, showing the importance for the meat sector in Australia. Within the main recorded meat breeds, the Poll Dorset represents 41%, the White Suffolk 36% and the Dorper 10%.

The system “Information Nucleus” aims at having a common progeny testing by Artificial Insemination, like presented in Figure 1.

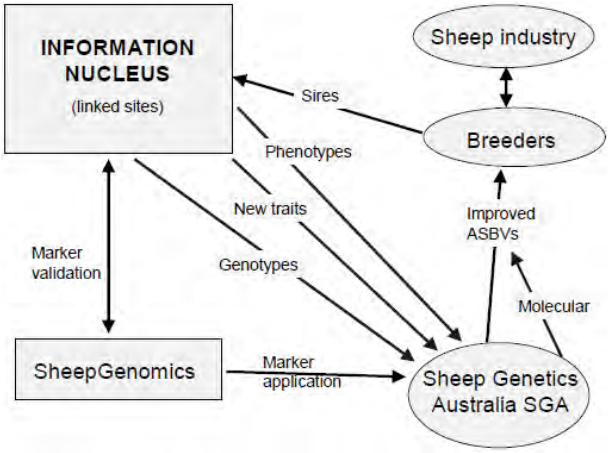


Figure 1. Industry linkage for the Information Nucleus
Source: Fogarty 2007

Traits and indexes in Australia

The estimated traits are: prolificacy, number of weaned lambs, birth weight, growth rate, fat and muscle width and depth (measured by echography), internal parasites resistance (measured by feces eggs counting), and scrotum circumference. Indexes are calculated either as a flock index for non-connected flocks, or as an Australian index for the connected flocks.

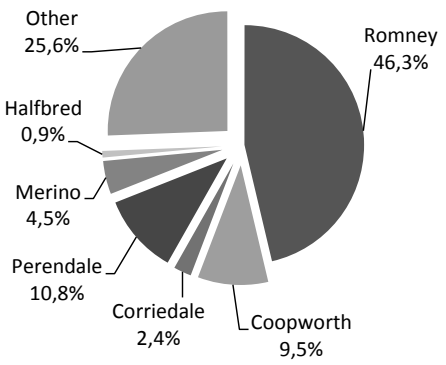
Innovations in Australia

Some new traits are studied: the lean meat yield, the intramuscular fat, the shear force, the lambing ease, the gestation length and the zinc and omega 3 composition of the meat. As for the genomic, a long term program has been set up in 2001 (95 million of Australian dollars) with about 100 rams and progeny which are genotyped with the 54K chip every year. Commercial developments are expected in 2013.

Economics in Australia

The Australian breeders are the main contributors to the implementation of the genetic tools cost, whereas the Government is the main contributor of the fundamental or applied research.

2.2. New Zealand



According to FAO statistics, the New Zealand sheep flock has been divided by two for the last 30 years, from 70 to 35 million heads. The sheep flock curve is clearly the opposite of the dairy herd one. New Zealand is much more meat oriented than his Australian neighbor. As shown in Figure 2, the dominant breed is the Romney with 46% of the national flock (Beef and Lamb NZ 2012).

Figure 2. New Zealand sheep breeds
Source: Beef & lamb NZ Economic Service from sheep & beef farm survey 2009-10

Organizations in New Zealand

The inter-branch organization "Beef & Lamb New Zealand" is dealing with the sheep genetic databases through its unit Sheep Improvement Limited (SIL). The SIL is subcontracting the performance control to independent extension services and progeny tests about 200 rams a year on their wool production, mother ability and muscle yield. We can find numerous sheep breed associations, sometimes a few per breed. Some of them can participate to the performance control. For some genetic schemes, some breeders are setting some "breeding group" to exchange some rams or doing a common flock.

Traits and indexes in New Zealand

The main meat trait is the "Lean Meat Yield" mainly estimated by live echography (95% of the data), but as well by the CT-scan (precise but expensive) or the Via-scan (in the slaughter house). The breeders can also genotype their animal for the double muscle gene MyoMax (found in Texel) or the muscle development gene LoinMax (found in Poll Dorset). The reproduction traits are mainly the prolificacy and weaning rate. To face the helminthic resistance, the animal resistance can be estimated by either a phenotype counting protocol (WormFec, started in 1994) on the feces eggs, or by the blood antibody testing protocol. A similar protocol exists for the facial Eczema by dosing the enzyme. Most of the index are expressed in economic gains from the reference year 2005, meaning that the index are easily positive. Some synthetic index can be calculated for either the "Terminal Sire" index based on growth and meat yield, or the "Dual Purpose" index based on growth, reproduction and wool.

Innovations in New Zealand

An experimental program of genomic has been launched with OvitaLamb (Consortium of Agresearch and Beef & Lamb NZ) and Pfizer. The greenhouse gas emission, the ewe longevity and the lamb survival are also studied.

Economics in New Zealand

The genetic program is funded, approximately fifty percent each, by the taxes paid by the industry to Beef & Lamb NZ (0.4 NZ$/carcass) and by the breeders' payment for the ewes controls. The progeny testing program like the genomic research are co-funded by the Government and the Beef & Lamb NZ.

2.3. United Kingdom

The British sheep flock has stopped his drop of nearly 30% from 2000 to 2009; however from 2009 the national flock is slightly increasing again to about 15 million ewes in 2012 and this rise is forecasted to continue in 2013 thanks to favorable prices and market conditions (EBLEX 2012). According to the level of the "three tiers system", the main breeds are mainly the hardy breeds (Scottish Blackface, Welsh and Swaledale), the Longwool breeds (Bluefaced or Border Leicester) and the terminal breeds (Suffolk, Texel or Charollais).

Organizations in UK

The Meat and Livestock Commission (MLC), mainly funded by meat levies collected by state agencies like EBLEX (English Beef and Lamb Executive) for England, HCC (Hybu Cig Cymru,

or meat promotion Wales) for Wales and QMS (Quality Meat Scotland) for Scotland, is driving the genetic schemes. The Signet Breeding Service, with the collaboration of EGENES (dependent from the Scottish Agricultural College), is in charge of the genetic database and indexation. The performance control is done by different organizations like flock books or private companies.

Traits and indexes in UK

The hardy breeds are mainly selecting the reproduction traits, maternal ability (live lambs 8 weeks after lambing), live weight (weight of the female at the first mating) and mortality. The Longwool breeds focus on prolificacy and the terminal breeds on lean carcass yield or fat content, estimated either by ultrasound echography at 21 weeks or by the more precise computed tomography scanning for 600 terminal sires. Indexes are transmitted as EBV (Estimated Breeding Value) or on a scale out of 100. Some synthetic indexes are made according to the system: Welsh Hill, Maternal, Hill, Longwool or Terminal. Some genetic schemes with progeny testing system have implemented a connexion via artificial insemination, called the "Sire Reference Scheme" (SRS).

Innovations in UK

A scoring of the maternal ability for lambing is developed for the Scottish Blackface. It includes the lambing assistance, the lamb vigor at 5 minutes (difficult to measure) and the suckling assistance. A test for the detection of the double muscle gene is on the market. And the nematode resistance starts to be integrated into some schemes. A footrot resistance gene has been identified by genomic method, but no scheme based on genomic seems to be implemented up to now.

2.4. Ireland

According to the CSO Census of Agriculture in 2010, the total number of sheep in Ireland fell from 6.8 million in 2000 to just 4.7 million in 2010, a decrease of one third. This was mainly due to the low profitable and high labor demanding sheep farms compared to other productions like beef or dairy cattle for instance. As for the United Kingdom, the sheep number is slightly increasing from 2010 to reach 5.1 million head in 2012 (DAFF 2012). The sheep breeds are diverse, but clearly dominated by the Suffolk (Table 5).

Table 5. Sheep breeds in Ireland, in % of heads

Breed	Suffolk	Scottish Blackface	Cheviot	Texel	Charollais	Belclare	Leicester
%	51	14	12	10	4	3	2

NB: excepted for Cheviot and Scottish Blackface, the breed numbers are including crossed animals
Source: Jones 2008

Organizations in Ireland

The "Sheep Ireland" organization is in charge of the meat sheep genetic schemes, it is linked to the Irish Cattle Breeding Federation (ICBF). Sheep Ireland is running three programs:

- Lambplus: recording and indexing the sheep of about 250 farms.
- Maternal Lamb Producers (MALP): progeny testing about 22 sheep farms to assess the rams on their maternal qualities.
- Central Progeny Test (CPT): progeny testing about 4 sheep farms to assess about 32 rams (Suffolk, Rouge de l'Ouest, Charollais, Belclare, Texel and Vendeen) on their meat qualities.

Traits and indexes in Ireland

The Lamplus program is recording: the lambing ease (scored from 1 to 4), the growth (weights at lambing, 40 days and weaning), the mortality and the fat and muscle depth by scanning. The programs of MALP and CPT are adding as well the diarrheas level, the laming rate and the ewe live weight. The CPT is implementing the feces eggs counting. Three types of indexes are calculated: the production index (lamb growth, muscle and fat development), the maternal index (weaned lamb weight, muscle and fat development and lamb survival) and the lambing index (lambing ease and lamb survival). In 2009, those three indexes have been combined in a new synthetic one called the "Overall Sheep Value" that you can find on the "Eurostar Indexes". The genetic indexes are also expressed as an economic value.

Innovations in Ireland

A "health index" including footrot and a gastro-intestinal parasite resistance indexes are under studies.

Economics in Ireland

Sheep Ireland is 100% funded by the DAFF. However, even though the funding has been negotiated for 4 years, it is decreasing from the starting year in 2009.

2.5. France

The French sheep flock is about 4 million meat ewes and 1.5 million dairy ewes. Concerning meat breeds, two main types are used: specialized meat breeds (Ile de France, Mouton Charollais, Texel, etc.) and hardy breeds (Lacaune viande, Blanche du Massif Central, Merinos d'Arles, etc.).

Organizations in France

By gathering all the stakeholders of breeding programs, FGE (France Genetique Elevage) coordinates and manages the national collective system of the ruminant genetic improvement. L'Institut de l'élevage (the French Livestock Institute) is responsible, in collaboration with INRA (French National Institute for Agricultural Research) for the technical coordination, methods and protocols, database management system and breeding values computing. Only licensed operators

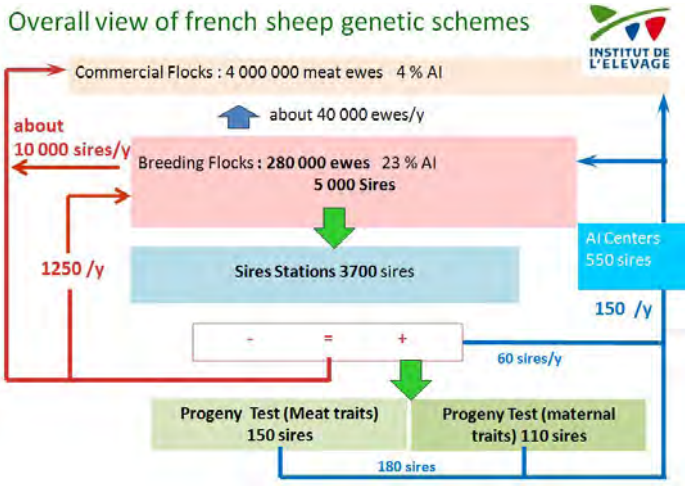


Figure 3. Organization of the French meat sheep genetic schemes
Source: document from Institut de l'Elevage

are authorized to do the recording. This collective system ensures the reliability of data used for genetic evaluations (France Génétique Elevage 2011).

Breeding programs (including breeding objective definition) and flock-book are managed by certified Selection Agencies. Only one can be certified by breed. Almost 280,000 ewes (1200 breeders), are registered for official data recording, and about 3700 rams are evaluated each year in collective ram station.

Traits and indexes in France

Breeders select for both maternal and meat traits. Thus, whatever the breed, improving maternal ability is always important because lamb productivity is a major factor explaining return of meat sheep farms. Equally, improving meat abilities remains a significant objective for specialized meat breeds and some hardy breeds which are commonly used as purebred (Table 6). Data recording is performed on farm and on ram station. For several breeds, a progeny testing is also performed. In station, according to the specific objectives of each breed, a synthesis index is calculated, combining the four basic breeding values related to meat ability. Various breeding values are performed thanks to a progeny testing on meat and/or maternal abilities and, most often, a synthesis index is calculated.

Table 6. Main selected traits for the French meat sheep genetic schemes lambs nt system, ion, methods

TRAITS	Data recording	Comment
Prolificacy	F	litter size
Mothering value	F	indirectly measured by 30-day-weight of lambs
Post-weaning growth	F	based on Average Daily Gain in grams between 30 and 70 days
Growth	S	based on Average Daily Gain in grams during control (8 weeks)
Weight at fixed age	S	between 140 to 170 days old, depending of breed
fat at fixed weight	S	based on fat thickness measured by ultrasound
muscle development at fixed weight	S	based on body score and muscle thickness measured par ultrasound
growth and carcass quality	PT	weight, yield, fatness, etc. measured on at least 30 carcasses
Scrapie resistance	F&S	All rams carrying the sensitive allele VRQ have been culled. All young males used in breeding schemes are resistant to Scrapie (ARR / ARR)

F = Farm, S = ram Station, PT = Progeny Testing
Source: (Tiphine 2011)

Innovations in France

Taking recent results on new traits into account requires a long process before integrating them in the breeding goals. Currently 3 new traits should be quickly available for breeders:

- Parasitism resistance (based on individual worm egg counts after artificial infestation)
- Reactivity to humans (based on challenging tests involving human contact)
- Feed efficiency (based on individual consumption measured by concentrate feeder).

Concerning the genomic implementation, the Scrapie program has constituted a large-scale implementation of gene assisted selection for all sheep breeds. Others types of mutation carried by genes, such as myostatin gene or ovulation genes have already been managed in breeding programs. Nevertheless many questions remain, like their inclusion in genetic evaluation. Others studies are still in progress: for instance, potential benefits of genomic selection and use of molecular markers for parentage assignment.

Economics in France

The genetic program is funded by the Government, by taxes paid by farmers and by the breeders' payment for the recording.

3. Compared genetic costs

The costs of the genetic registration, performance controls, selected animals and insemination are quite diverse according to the studied countries as shown in Table 7.

Table 7. Compared genetic costs for sheep farmers

Cost in euros (*)		AUS	NZ	UK	IRL	FR
Indexation	Registration & Performance control	265/year 80/intervention 1.3/ewe 8/ram	1-2/ registered ewe 1.3-2.6/ controlled ewe	10.5/ controlled ewe	100/ year	4/registred and controlled ewe (from 0,8 to 10)
	Echography		2-3.3/ram 65/for CT scan		3/ animal	15,24/animal (2 measures-only in collective station)
Indexed rams	For breeders	4000-20000	320-3200	1300-4000		300-1000
	For commercial flocks	800-2000	250-600	400-1200/ terminal sire 700/ hardy ram	350-500	200-500
Reproduction	AI (laparoscopy)	28	12-24	140 + 8-19	8-18	10 vaginal AI + semen
	Semen dose	16-50	12-20	25-65	15-70	

(*) currency conversion rates: 1 AUS$ = 0.8 € and 1 NZ$ = 0.65 €
Source: from inquiries done from Autumn 2011 to Spring 2012

4. A benchmark attempt for the meat sheep genetic schemes

4.1. Organization

Some countries have very centralized genetic organization like France who has only one database and indexation unit for all the controlled breeds in the country, some other countries are very decentralized with sometime several indexation schemes within the same breeds like United

Kingdom for instance. The centralized systems can draw profit of an optimum connecting net for progeny testing, especially if the artificial insemination is widely spread. Consequently, the index accuracy is usually high and the genomic tools more efficiently developed in those systems.

4.2. Traits and breeds systems

The traits are quite the same concerning the growth rate and carcass quality (muscle and fat). However, some countries have early integrated some disease or parasite resistance traits like New Zealand or Australia. Some interesting attempts to build an ideal "dual purpose" (meat and maternal) breed can be noticed like the Romane in France (ex-INRA401 from Romanov and Berrichon du Cher), where the breed composition were highly controlled, or the Cambridge in UK or the Belclare in Ireland, where the breed composition were more diverse.

The more complex "combined breeds", like it is practiced in New Zealand, can also be considered as an attempt to build an ideal "dual purpose" breed. The British "three tiers systems", largely used in UK and Ireland is combining hardy, prolific and meat breeds all along the chain but in keeping the pure breeds nucleus and using the hybrid vigor improvement at each generation.

4.3. Economics

The funding of the sheep genetic schemes is coming from either Government, or industry or farmers. The origins are rather divers around the world, but in a nutshell we can make a difference between some countries which have a significant part of the sheep genetic investment coming from the Government (France, or Ireland for the recent years), industry (United Kingdom) or farmers (Australia).

However, even if it is difficult to precisely estimate, it would be interesting to share an analysis of the investments profitability like the SRUC (ex-SAC in Scotland) tried to do in their document "Breeding gains for the sheep sector" (KNOWLEDGESCOTLAND 2011). We can also differentiate two ways to orient the communication on the index.

- "Economic index": like in Ireland, where the indexes are regularly communicated with their conversion in potential economic return.
- "Technical index": like in France where the indexes most often remain in physical units with a clear communication on accuracy levels.

4.4. Innovation

Genomic is obviously the new technology that would deeply transform the sheep breeding schemes. It is progressively integrated in the dairy cow and dairy sheep breeding schemes and some beef cattle ones but still has to be strengthened for a good implementation in the meat sheep schemes.

The double muscle gene has started its commercial development in such countries like New Zealand. The Scrapie resistance gene has already been widespread all over the French schemes. Many studies have been recently done on prolificacy genes identification and the availability of genotyping could significantly transform the actual slow intra-breed selection of this trait, which has a low heritability and a long cycle when we use progeny testing.

But no large program of sheep genetic schemes has been based on genomic yet. This should be affordable in regions or countries that have high average index accuracies thanks to a full and reliable identification and traceability system, a centralized and precise genealogy registration and a powerful connected indexation system.

5. Conclusions

The world context for meat market like the environment pressure could represent an optimistic opportunity to the sheep meat sector. However, the meat sheep genetic schemes are rather diverse among countries and have no significant world governance institutions, international genetic scheme or professional exchanges. This sector could draw an interesting profit from a higher exchange in a benchmarking and win-win attitude.

6. References

Ashworth S., 2012; Global sheep industry, developing trends. Available at www.nationalsheep.org.uk, consulted on February 15th 2013 Ed. Quality Meat Scotland. Diaporama 40 slides.

Barret D., 2003; Australian sheep flock, breeds and age composition. Australian Farm Survey Report. 18 pp.

BEEF and LAMB NZ, 2012; Compendium of New Zealand – Farm facts. Ed. Beef and lamb New Zealand Ltd Economic Service. 28 pp.

DAFF, 2012; Fact sheet on Irish agriculture – December 2012. http://www.agriculture.gov.ie/media/migration/publications/2012/FactSheetIrishAgriculture150113.pdf . 2 pp.

EBLEX, 2012: UK Yearbook 2012 – Sheep. Eblex July 2012. 30 pp.

FAO, 2009a; Rural Income Generating Activities – database available at www.fao.org/es/ESA/riga/english/index_en.htm, consulted on 1st of March 2013.

FAO, 2009b; The state of food and agriculture – Livestock in the balance. Ed. Electronic Publishing Policy and Support Branch, Communication Division.180 pp.

FAOSTAT, 2012 : available at http://faostat.fao.org/site/339/default.aspx, consulted on 1st of March 2013.

Fogarty N.M., Banks R.G., van der Werf J.H.J, Ball A.J., Gibson J.P., 2007: Proc. Assoc. Anim. Breed. Genet. 17:29.

FRANCE GENETIQUE ELEVAGE, 2011. La génétique française pour les filières bovines, ovines et caprines. 8 pp.

Jones H., 2008; Breed composition of the national flock. Ed. TResearch, volume 3, number 3. Autumn 2008.

KNOWLEDGESCOTLAND, 2011; Science Policy Connections Online. Breeding gains for the sheep sector [http://www.knowledgescotland.org/success-stories.php?id=237], published on July 6th 2011.

MLA, 2012: Australian sheep industry projection, mid-season update. Ed. MLA Ltd. January 2012. 26 pp.

Steinfeld H., Gerber P., Wassenaar T., Castel V, Rosales M., de Haan C., 2006. Livestock's long shadow. Environmental issues and options. Rome, FAO

Tiphine L., David I., Raoul J., Guerrier J., Praud J.P., Bodin L., Francois D., Jullien E., Poivey J.P., 2011; Estimation of breeding values for meat sheep in France – EAAP Stavanger September 1st 2011.