# Intensification, diversification, and specialization to improve the competitiveness of sheep production systems under pastoral conditions: Uruguay's case

**Fabio Montossi, Ignacio De Barbieri, Gabriel Ciappesoni, Andrés Ganzábal, Georgget Banchero, Santiago Luzardo, and Roberto San Julián**

Programa Nacional de Carne y Lana, Instituto Nacional de Investigación Agropecuaria (INIA), Ruta 5, km 386, PO Box 45000, Tacuarembó, Uruguay

## Implications

- Significant changes have occurred in global sheep production, lamb meat, and wool markets. Product demand is mainly oriented towards fine and superfine wool and lamb meat.
- Sheep production intensification, efficiency, differentiation by adding value to products and processes and minimizing the environmental impact are the main factors driving industry competitiveness.
- More profitable and environmentally friendly sheep production systems are linked with producing more highquality products with less sheep.
- Alignment among researchers, producers, and market demand is the key to being successful at sustaining the sheep industry and its contribution to global food security. As an example, Uruguay´s case is developed in this article.

**Key words:** fine and superfine wools, innovation, lamb meat, sustainability

## Introduction

In the last two decades, major changes in the international market for wool and sheep meat have been observed, resulting from changes in meat and textile consumption patterns. These changes have influenced the way that sheep and sheep products are produced, industrialized and commercialized, particularly in those countries that historically exported the majority of their production to the international market. Improvement in productivity, efficiency, and competitiveness of alternative industries (e.g., synthetic fabrics, cotton, pork, and poultry), business scale, international trade agreements, negative international policies for the wool industry (e.g., regulations on Australia´s wool stock), changes caused by the application of new quality assurance guidelines, product and process certification, branding and promotion, environmental protection policies, animal health and welfare regulations, product issues (e.g., food safety and security, consistency, supply, and culinary attributes), modern dressing styles (e.g., weight, strength, versatility, natural product, softness, appearance, comfort, easy care, all-season, and fashion), availability of skilled labor, and social responsibility for all members of the industry are all factors that have influenced the wool and sheep meat industry.

Despite the overall growth seen in the world population and improved purchasing power in many regions, the aforementioned trends and other related factors have resulted in: a) global wool consumption remaining generally stable between 1.5 to 2.0 million tons/year, while cotton and synthetic fabric consumption continue to rise, recently reaching 22.8 and 42.0 million tons, respectively; and b) the global sheep and goat meat consumption growing less than poultry and pork meat consumption. Wool market studies have shown that general trends favor the production of finer wools (Montossi et al., 2011b). In the case of sheep meat, future world production will be less than that required by the market, which will result in strong demand and firm prices (OECD-FAO, 2012). Using positive scenarios for world economic growth, without major crises, high-value markets will be favorable for sheep meat consumption (particularly for lamb meat) and for fine and superfine wools.

Associated with these market trends, significant reductions have been observed in sheep populations in the major global sheep meat and wool-producing areas (Table 1). These reductions range between 34.3 and 56.0%, being lower for Uruguay compared with Australia and New Zealand. Forecasted projections (next five years) estimate that sheep stocks

**Table 1. Sheep numbers between 1990 and 2009 in Australia, New Zealand, and Uruguay.**

| Country/ year | 1990 | 2000 | 2009 | Change, % 1990 vs. 2009 |
|---|---|---|---|---|
| Australia | 170.3 | 118.6 | 72.7 | -42.7 |
| New Zealand | 57.9 | 42.3 | 32.4 | -56.0 |
| Uruguay | 25.2 | 13.2 | 8.7 | -34.3 |


doi:10.2527/af.2013-0021

**Table 2. Evolution of wool commercialization (clean base; tons) in Australia based on fiber diameter (FD; μm) ranges comparing the periods of 1991 to 1992 vs. 2009 to 2010.**

| Fiber diameter, μm | 1991 to 1992, tons | 2009 to 2010, tons | 1991 to 1992 vs. 2009 to 2010, % |
|---|---|---|---|
| Ultrafine, < 15.6 μm | 26 | 1,270 | 4,885 |
| Superfine, 15.6 to 18.5 μm | 32,340 | 75,599 | 233 |
| Fine, 18.6 to 19.5 μm | 64,958 | 62,376 | –4 |
| Other, > 19.5 μm | 720,130 | 224,849 | –69 |
| **Total, tons** | **817,454** | **364,094** | **–44.5** |

(AWTA, 2013)

will be maintained or increased in those countries accompanied by increases in productivity and efficiency.

Taking Australia and New Zealand as key examples, some questions and doubts can be raised. For example, can the sheep reduction observed in these countries be partially or totally offset by changes in productivity and/or technological modifications to enhance product quantity and quality? In Australia, the decrease in wool production was not similar for the different ranges of fiber diameter. In fact, the greatest decrease was observed in wools with fiber diameters greater than 19.5 μm. Instead, the trend was clearly towards the production of superfine and ultrafine wools, where the production of these wools increased substantially (Table 2). The same trend was observed for the production in favor of fine and superfine wools in New Zealand (New Zealand Merino, 2003). Moreover, in terms of meat production, there were also interesting changes (Table 3). Although the number of sheep deceased, meat production and meat exports increased from 2001 to 2010. The case of New Zealand is presented in Table 4, where the trends observed in sheep meat production are shown for an extended period of time (1986 to 2012).

Beyond the productive, cultural, climate, market, product, technology, and economic differences found between New Zealand and Australia, it is important to highlight the common elements and trends that are influencing productivity, efficiency, and competitiveness of the sheep industries in the primary sector. This information is summarized in Table 5.

Information suggests that there have been significant changes in sheep production systems in both Australia and New Zealand, which had important influences on:

- Improvement in production efficiency, particularly in reproductive rates, carcass weight, and product quality;
- Incorporation and adoption of new technological innovations, principally increases in pasture productivity, more intensive use of supplements, more efficient genetics, and the progressive automation of production management practices; and
- Growth of alliances among the sheep industry members favored by the payment of premiums based on product quality and differentiation, product and process certification, as well as adding value among segments of the sheep industry.

**Table 3. Evolution of sheep meat production indices in Australia for the period 2001 to 2010.**

| Sheep meat production indices | 2001 | 2010 | Change, % |
|---|---|---|---|
| Sheep, million head | 111.0 | 68.0 | –39.0 |
| Lambs slaughtered, millions | 18.0 | 18.6 | 3.3 |
| Carcass weight, kg | 19.7 | 21.6 | 9.6 |
| Meat production, thousand tons | 353.0 | 402.0 | 13.9 |
| Meat exported, thousand tons | 125.0 | 186.0 | 48.8 |

(MLA, 2013)

This article describes the production and technological proposals generated by the National Institute of Agriculture Research (**INIA**) and other research organizations that have resulted in new technology innovations and contributed to the increasing sheep industry competitiveness in Uruguay. The information presented in this article is mainly focused on the Uruguayan sheep industry´s experience, which could be applied to situations in other developing countries.

## Alignment among Research, Production Systems, and Market Demand

In November 2004 (Montossi, 2004a), the INIA of Uruguay presented a strategic plan and actions to improve the competitiveness of the nation's sheep industry. This conceptual proposal aligned research initiatives, sheep production systems, and market orientations (Table 6). The research proposed for the Uruguayan sheep industry was generated during a market period characterized by low wool prices and increased competitiveness of beef, cropping and forestry sectors. The negative effect of low wool prices was particularly observed for the medium to coarse micron fiber diameter range (26 to 32 mm). This was especially relevant to Uruguayan´s conditions given the predominance of the Corriedale breed within the national flock, ranging between 65 to 75%, accompanied by competitive prices of alternative fibers like synthetics and cotton in the market place.

This scenario influenced sheep numbers in Uruguay, where the national flock decreased substantially from 25.2 to 13.2 to 8.3 million total sheep for the years 1990, 2000, and 2010, respectively. As a consequence, most of the sheep population was concentrated mainly in northern and eastern regions of Uruguay, where extensive and semi-extensive production systems are predominant and marked by the prevalence of marginal areas for intensive agriculture production. This fact is a key issue to be considered when new technologies and sheep production scenarios are proposed and developed, as wool production and price differentiation is relevant under such circumstances.

**Table 4. Evolution of sheep production indices in New Zealand for the period 1986 to 2012.**

| Sheep meat production indices | 1986 | 2003 | 2012 | Change, % 1986 vs. 2012 |
|---|---|---|---|---|
| Sheep, millions | 67.0 | 40.0 | 35.0 | –60 |
| Lambing, % | 98.0 | 124.0 | 130.0 | 33 |
| Lambs slaughtered, millions | 32.0 | 26.0 | 27.0 | –16 |
| Carcass weight, kg | 13.0 | 16.9 | 17.3 | 33 |
| Meat production, carcass weight eq., thousand tons | 418.0 | 434.0 | 468.0 | 12 |

(Beef and Lamb New Zealand, 2012)

**Table 5. Consolidated trends observed in sheep production systems in Australia and New Zealand during the last decades.**

| Consolidated trends in Australia and New Zealand sheep production systems |
|---|
| • High value wool |
| • Production of high quality meat |
| • Higher price of land and inputs |
| • Measurement of processes and products |
| • Differentiation and added value |
| • Higher farm scale |
| • Loss of farmers |
| • Lack of qualified human resources |
| • More contracting services |
| • Greater society sensitivity for environmental sustainability and animal welfare |
| • Traceability of process |
| • More products and process certification |
| • Highly efficient genotypes |
| • Strategic alliances along the wool-textile and meat industries |
| • Healthy and safe food production |
| • More professional farmers |
| *Productivity and efficiency key factors:* |
| • Productive pasture and forage species |
| • Food nutritive value |
| • Fertilization |
| • Subdivisions/electric fencing |
| • Pregnancy test |
| • Genetic improvement |
| • Supplementation (Australia) |
| • Automation |

The approach described in Table 6 does not deny that several production systems could be developed within the same ecological region or even between different regions of the country. The specialization and intensification of sheep production systems will continue, but will have a different system or ratio of systems in each region. With these systems, breed orientation and genetic improvement will play a very important role in achieving the maximum production potential in each ecological region. Animal husbandry and feeding systems must be adjusted to each condition, where high-value wool will be produced primarily on soils with low biomass and production potential, and intensive lamb production will be concentrated predominantly on soils with high forage production potential using prolific breeds crossed by terminal sires. The latter promotes high lamb growth rates and heavy, lean carcass weight. In semi-extensive productive conditions, lamb production combines fine or even superfine wool breeds as well as lamb production. Automation and supplement use is being applied for all production system options. As this specialization continues, it will be necessary to match technology with production system and marketing opportunities.

## Innovation, Production, and Economic Impacts Achieved by Research Proposals on Different Production Systems

### *Extensive sheep production*

The economic impact of reducing fiber diameter under different reproductive scenarios on extensive wool production systems was simulated and evaluated on the basis of an area of a 1,000-ha farm. This was developed primarily for shallow soils, where the implementation of improved pastures does not exceed 10% of the total area and a common stocking rate of 0.72 animal units/ha is used. Different weaning percentages (60, 70, and 80%) and different wool fiber diameters (22, 20, and 18 µm; Figure 1) were evaluated.

Reducing fiber diameter in an extensive system increased the sheep producer´s net income as fiber diameter decreased from 22 vs. 18 µm. Regardless of the different wool orientation scenarios studied, most of the producer´s income would come from wool production (60 to 70%) rather than from sheep meat (mainly from cull ewes and lambs). This information is contextualized to a wool system that sells lambs (22 to 25 kg) at weaning, but other producers may sell their males later as two-year-olds on their second fleece. This option would increase income in favor of systems that produce finer wool. The increase in weaning rate percentages augmented the producer´s income, but its contribution is greater in the coarse-fiber diameter range.

It is noteworthy that the process of reducing fiber diameter within the Merino breed does not require a change of breed or even drastic changes in the orientation of the production system. However, it does require the use of genetics with merits to achieve this goal. Uruguay has made ge-

**Table 6. Conceptual model proposed by INIA to develop a more competitive sheep industry in Uruguay.**

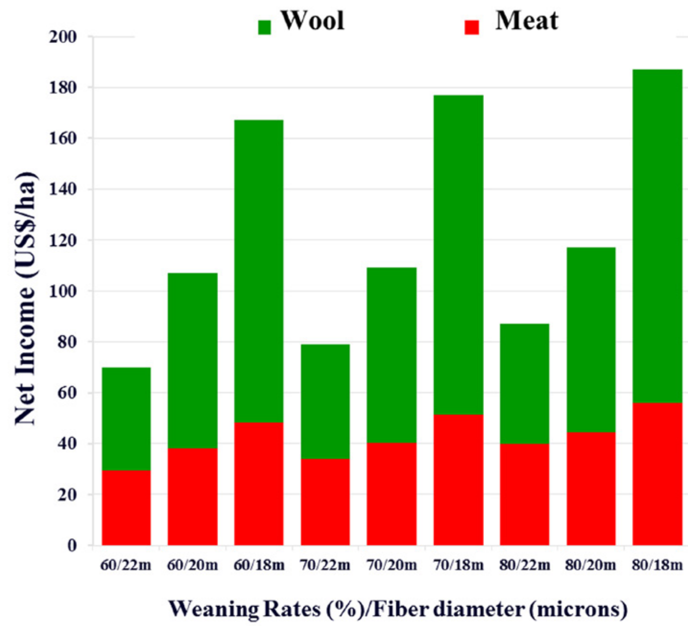
| Facts | Extensive systems | Semi-extensive systems | Intensive |
|---|---|---|---|
| Production orientation | Mainly breeding operations | Breeding operations with or without the use of terminal sires for lamb flattening | Specialized breeding operations with the use of terminal sires for lamb flattening |
| Type of soil | Shallow | Shallow-Medium | Medium-Deep |
| Main products generated by the production systems | Fine and superfine wool + sheep meat as sub-product | Fine wool + lamb meat | Lamb meat + wool as sub-product |
| Predominant breed orientation | Merino | Modern double purpose | Prolific sheep (maternal) + high lamb growth and heavy carcass weight (terminal) |

(Montossi, 2004a)

netic information available to commercial farmers and farm consultants through the use of breeding values provided by the across-flock genetic evaluations of the Merino breed, carried out by the Uruguayan Wool Secretariat (**SUL**) and INIA. The breeding values are available for most all the economically important production traits as well as selection indices, which have resulted in positive genetic trends towards increased profit for Merino sheep farmers (INIA, SUL, and ARU, 2013). These are mainly concentrated in the most extensive regions of Uruguay (e.g., Basaltic region). During the last 14 years, the reduction in fiber diameter in the Uruguayan Merino has been driven by three major projects: a) The Uruguayan Fine Merino Project (Montossi et al., 2007; Montossi et al., 2011b), b) Fine Merino Club (Montossi et al., 2007), and c) The Regional Consortium of Innovation for Uruguayan Ultrafine Wool (CRILU, 2013).

It should be highlighted that the process to produce finer wools has been accelerated at the producer level by better use of genetic resources with objective information, artificial insemination, and health, feeding, and husbandry practices. This has been favored by premium incentives and contracts developed between farmers and milling companies. In 1998, the production of wool under 20 µm was lower than 40,000 kg. Today, the production of this type of wool in Uruguay is greater than 2,000,000 kg (Pedro Otegui, personal communication).

**Figure 1.** Evaluation of the economic impact (US$/ha) of the combination of different weaning rates (60, 70, or 80%) and fiber diameters (22, 20, or 18 µm) applied for an extensive production system. *Note: The values of 22, 20, and 18* µm *fleece wools are assumed to be 8.88, 9.59, and 14.54 US$/kg clean, respectively. Prices 2008 to 2012.*




## *Semi-extensive sheep production systems*

A model of a 1,000-ha farm base carrying 0.72 animal units/ha was used to assess the economic impact of increasing the reproductive efficiency and including the production of heavy lambs (35 to 38 kg) in a semi-extensive production system. This simulation was developed on the basis of the use of a double-purpose system (lamb meat + wool) with sheep that produce wool of 28 µm and the combination of different percentages of weaning (65, 75, and 85%) and the production of two different types of lambs [light lambs weaned at 25 kg (**Cr System**) vs. heavy lambs fed to 35 or 38 kg (**CC System**; Figure 2)].

For the production of heavy lambs and increased reproductive performance, strategic supplementation has been implemented and used in feeding ewes during two key periods of production: pre-mating and pre-lambing (preferentially for feeding ewes in low body condition and/or carrying twins). The dual-purpose system positively influences weaning percentages, which improves farmer income per hectare in the range of 25 to 68% in relation to the traditional production system (65% weaning rate).

As part of the dual-purpose production system evaluated (with wool of 28 µm), sheep meat represents between 55 and 65% of total income. There are further opportunities to increase the revenue of sheep farmers by the production of 26-µm wool within the Corriedale breed and particularly by crossing this breed with other double-purpose, finer-wool type breeds (e.g., Dohne Merino). However, these options are not discussed here.

Beyond the weaning percentage, the inclusion of lamb fattening in the semi-extensive production system increased producer income by 100%. However, the impact of lamb fattening on farmer´s income in the CC system could be limited by decreased reproductive efficiency. This is explained by the competition for forage resources among ewes and lambs, particularly during the winter period when the growth of native and improved forages is lower compared with other seasons and the heavy lambs are normally finished between 10 or 12 months of age. Increasing reproductive efficiency and the inclusion of lamb fattening in this production system would allow for an increase of up to 170% in producer income compared with the more traditional system (weaning rate of 65% and Cr system-producing light lambs). This information highlights the relevant production and economic importance of the development of the finishing lamb innovation for the Uruguayan sheep industry, which was generated

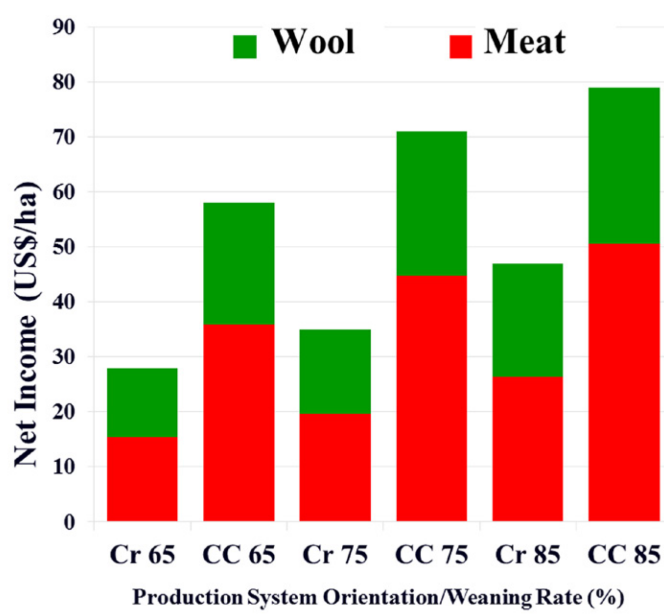



**Figure 2.** Evaluation of the economic impact of the combination of different weaning rates (65, 75, and 85%) and production system orientation (Cr or CC) applied to semi-extensive production systems. *Note: Heavy lambs sold with 38 kg liveweight (LW) at 2.64 US$/kg LW or light lambs sold with 25 kg LW at 2.40 US$/kg LW; 28 µm wool price at US$ 4.5/kg clean). Prices 2008 to 2012.*

**Table 7. The effect of crossbreeding Corriedale (C) with Dohne Merino (MD) on growth and carcass characteristics.**

| Biotype* | 100 C | 50 MD x 25C | 75 MD x 25C | P-Biotype‡ |
|---|---|---|---|---|
| LW, kg | 34.0 a | 38.1 b | 39.0 c | <0.0001 |
| REA, $cm^2$ | 9.8 a | 10.9 b | 10.9 b | <0.0001 |
| REA $^{LWS}$, $cm^2$† | 10.4 a | 10.8 b | 10.7 ab | 0.046 |
| FAT, mm | 3.46 | 3.59 | 3.49 | ns§ |
| FAT $^{PVS}$, mm† | 3.75 a | 3.55 ab | 3.40 b | 0.0415 |
| FLW, kg | 42.1 a | 45.9 b | 47.1 b | <0.0001 |
| CW, kg | 18.0 a | 20.1 b | 20.5 b | <0.0001 |
| GR, mm | 7.6 a | 8.8 b | 8.2 ab | 0.0033 |
| GR $^{PCC}$, mm† | 9.2 a | 8.3 b | 7.3 c | <0.0001 |

* LW = liveweight at first shearing adjusted at 365 days; REA = ribeye area; LWS = liveweight at shearing adjusted at 365 days; FAT = subcutaneous fat thickness on the REA; FLW = final liveweight before to slaughter; CW = hot carcass weight; GR = thickness of subcutaneous tissue measured on the 12th rib at 11 cm from the midline of the carcass.

† Traits adjusted by covariate factors.

‡ P-Biotype = Statistical significance.

§ ns = not significant.

Corriedale sheep (*top*) and Dohne Merino sheep (*bottom*; photo credit: Wikipedia commons).

in 1996 by SUL (Azzarini, 1996). Further research information favored the growth of this technology and business option in the main sheep productive regions of Uruguay (Montossi et al., 2004b,c).

Furthermore, since 2003, INIA has evaluated the effects of crossing Corriedale (**C**) ewes with Dohne Merino (**MD**) sires on production and economic traits, where the research information obtained showed a positive response by the introduction of MD. This research promoted the rapid growth in the use of this new breed in the country (Montossi et al., 2011b). The increase in the proportion of MD in the composite breed up to levels of 0.75 MD results in positive effects in producing finer wool of higher quality, faster lamb growth rates producing heavier and leaner carcasses and yield of more valuable cuts. On the negative side, it should be noted that there were lower fleece weights from MD crossbreds compared with the pure C bred; however, the positive traits with MD crossbreeding alternatives evaluated far outweigh the lower value due to lower fleece weights (Tables 7 and 8).

This research developed by INIA was complemented by similar results observed by SUL. Based on economic simulations, INIA has also demonstrated the positive economic impacts of the inclusion of the MD breed in traditional C semi-extensive farming systems, producing finer wool and faster growing, leaner lambs (Montossi et al., 2013).

This model integrated the production, economic, and social dimensions and used the concept of family income (**FI**) per hectare, which incorporates the economical compensation that goes to pay the "salary" of such a farmer (Table 9). This is a relevant issue to the sustainability of family farms with small-scale and reduced financial and economic support.

With the Corriedale´s (ewe and ram) option, it is possible to produce between 35 and 40 kg of wool/ha and about 190 kg liveweight/ha, generating a FI in the range of 380 to 390 US$/ha. For this comparison, the increase of the maternal weight of the Corriedale ewe from 45 to 69 kg has a minor positive economic impact because the increase in the weaning rate associated with a heavy ewe is almost offset by the reduction in the stocking rate of the production system modeled, with no economical response observed. The use of terminal sires on Corriedale ewes has a very interesting positive effect on production and FI, mainly through better lamb

**Table 8. The effect of crossbreeding of Corriedale (C) with Dohne Merino (MD) on wool characteristics.**

| Biotype* | 100 C | 50 MD x 25C | 75 MD x 25C | P-Biotype‡ |
|---|---|---|---|---|
| FW greasy, kg | 2.62 a | 2.48 b | 2.38 b | <0.0001 |
| FW clean, kg | 2.04 a | 1.86 b | 1.77 c | <0.0001 |
| Yield, % | 77.5 a | 74.2 b | 74.1 b | <0.0001 |
| FD, µm | 24.8 a | 21.5 b | 20.2 c | <0.0001 |
| SS, cm | 12.5 a | 11.0 b | 10.0 c | <0.0001 |
| Y | 63.5 b | 64.5 a | 64.5 a | <0.0001 |
| Y-Z | 2.6 a | 1.9 b | 1.7 b | <0.0001 |

* FW = greasy or clean fleece weight; FD = fiber diameter; SS = staple strength; Y = wool brightness; and Y-Z = wool yellowing.

† P-Biotype = Statistical significance.

## *Intensive sheep production systems*

The case of intensive sheep meat production systems is promoted on highly productive soils. The system was evaluated on the basis of a 100-ha farm model, where 90% of the total area was used for highly productive pastures and fattening lambs sold at 10 or 6 to 8 months of age for pure Corriedales and prolific and meat crossbred biotypes, respectively.

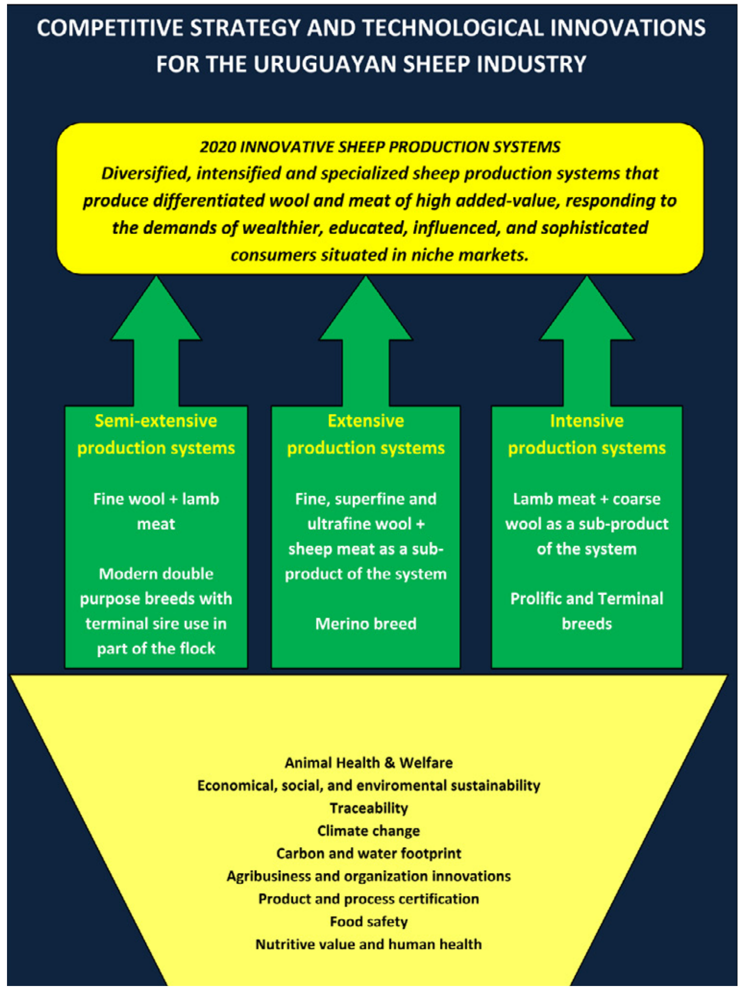
growth rates reducing the age to slaughter and augmenting forage to feed more sheep in the system. This has added effects on increasing stocking rate per hectare and lamb meat production per hectare.

By using prolific breeds and terminal sires, it is possible to achieve weaning rates of 150%, produce heavy lambs weighing between 35 and 38 kg, and have a slaughter age of six to eight months. The stocking rate of this very intensive system could range between 9 to 10 ewes/ha, generating production of lamb meat and wool production in the range of 236 to 370 kg/ha and 50 to 51 kg/ha, respectively.

Under these intensive production conditions, the production and economic impacts of using terminal crossbreeding and highly prolific ewes with moderate adult size generated FI in the range of 500 to 840 US$/ha. This is an interesting production and economic option for a large group of small family farm operations, which are of great social significance for the country. This technology initiative can also be extended to medium- to large-scale farms through the intensification and diversification of sheep meat production at least as a part of the total farm area, complemented with other production options (e.g., beef and/or cropping). The same results have been observed by the Agronomy Faculty of Agriculture, University of the Republic (Bianchi, 2007).

## Conclusions

In this paper, we have presented evidence of the significant changes that have occurred in global sheep production systems, sheep meat, and wool markets. Although these changes have occurred, new opportunities and challenges have been addressed, which has led to increased productivity and efficiency in countries like New Zealand and Australia. Increased marketing opportunities appear to be linked specially with the production, processing, and marketing of fine, superfine, and ultrafine wools and high quality lamb meat. The information presented shows that it is possible to be more profitable through producing more products with less sheep and value-added products. Uruguay is not the exception to this new reality. This approach likely has additional benefits such as reducing greenhouse gas emissions and coping with new scenarios of lower and less-qualified labor available to work on sheep farms.




Research and innovation organizations of Uruguay, INIA, and other institutions have generated new technology proposals for producers that have considered the particularities of the different productions systems and market orientation and demand. These have had a positive and consistent effect on farm productivity and income in Uruguay.

Technology adoption is very complex. It involves a series of technological and non-technological factors, where the latter requires producers to significantly change their production systems, market orientation, and subsequent productivity. To make it happen, the process requires a reasonable period of technology adjustment, maturation, and adaptation, accompanied by keeping market signals positive through an extended period of time. The end result can be more confident farmers that are proactive to making a change. The process is accelerated when members of the sheep industry share a common vision and strategy and make these changes occur. Some successful examples were highlighted here, particularly for the production of fine and superfine wools and heavy lambs in Uruguay.

**Table 9. Evaluation of the economic impacts of the combination of different maternal biotypes (e.g., pure C breed or prolific Frisona Milchschaf and Finnsheep composite ewes) and the potential use or not of terminal sires (e.g., Texel and Poll Dorset) to produce fast-growing lambs in intensive sheep production systems.**

| Dam biotype | Corriedale | Corriedale | Corriedale | Prolific |
|---|---|---|---|---|
| Ram biotype | Corriedale | Corriedale | Terminal | Terminal |
| Ewe weight, kg | 45.0 | 69.0 | 45.0 | 55.0 |
| Ewes/ha | 8.0 | 6.6 | 10.0 | 29.0 |
| Ewe weaning, %* | 90.0 | 112.0 | 90.0 | 155.0 |
| Lamb weaning, %† | 0.0 | 0.0 | 0.0 | 78.0 |
| Wool production, kg/ha | 39.7 | 35.0 | 50.2 | 51.3 |
| Meat production, kg/ha | 187.0 | 190.0 | 236.0 | 370.0 |
| Family income, US$/ha | 382.0 | 390.0 | 500.0 | 841.0 |

* Includes ewes and two teeth hoggets.

† Includes lamb hoggets mated at seven months old.

According to our experience, to adopt new innovations progressively and successfully by an important number of sheep farmers in Uruguay, several factors and procedures had to be considered. This innovation process has common key elements, which can be summarized by: a) demand orientation, b) a common industry vision, c) joint alliances between private and public sectors, d) new proposals developed under crisis situations, e) organizational strengths and cooperation, f) "learning by doing together," g) parties establishing alliances based on contracts, h) teamwork and strong leadership, and i) highly educated, trained, and motivated people. With a continuous improvement process and strategic analysis, technological innovation can and must play a key role in improving the competitiveness of the Uruguayan sheep meat and wool production. The most recent approach and conceptual model generated by INIA to develop a highly competitive sheep industry is presented in Figure 3.

## Literature Cited


AWTA. 2013. Fine wool (<19.5 microns). Australian Wool Testing Authority, Melbourne.

Azzarini, M. 1996. Producción de carne ovina. Centro Médico Veterinario de Paysandú. Paysandú, Uruguay. Proceedings XXIV Jornadas Uruguayas de Buiatría, c.1.1-c.1.7.

Beef and Lamb New Zealand. 2012. Domestic trends and measuring progress against the Red Meat Sector Strategy. http://beeflambnz.com/Documents/Information/Red%20meat%20sector%20conference.pdf. (Accessed 5 May 2013.)

Bianchi, G. 2007. Identificación y cuantificación de factores que afectan la calidad de carne ovina. G. Bianchi, editor. En: Alternativas Tecnológicas para la Producción de Carne Ovina de Calidad en Sistemas Pastoriles. Editorial Hemisferio Sur. Montevideo, Uruguay.

CRILU. 2013. Consorcio Regional de Innovación de Lanas Ultrafinas del Uruguay. http://www.crilu.org.uy/. (Accessed 3 May 2013.)

INIA, SUL, and ARU. 2013. Tendencias Genéticas. Merino. Instituto Nacional de Investigación Agropecuaria, Secretariado Uruguayo de la Lana, and Asociación Rural del Uruguay. http://www.geneticaovina.com.uy/tendenciasxraza.php?razacod=8. (Accessed 5 May 2013.)

MLA. 2013. MLA Australian sheep industry projections 2013. Meat Livestock Australia, North Sydney, NSW, Australia. http://www.mla.com.au/Prices-and-markets/Trends-and-analysis/Sheepmeat-and-lamb/Forecasts/MLA-sheep-industry-projections-2013. (Accessed 5 May 2013.)

Montossi, F. 2004a. Oportunidades y desafíos para la Carne Ovina. http://www.delcampoalplato.org/congreso2004.htm. (Accessed 5 May 2013.)

Montossi, F., I. De Barbieri, M. Nolla, A. Dighiero, R. San Julián, G. Brito, and S. Luzardo. 2004b. Aspectos tecnológicos relevantes de manejo y alimentación para la producción de carne ovina de calidad en el Uruguay. Centro Médico Veterinario de Paysandú. Paysandú, Uruguay. Proceedings XXXII Jornadas Uruguayas de Buiatría, 114-126.

Montossi, F., A. Dighiero, I. De Barbieri, M. Nolla, R. San Julián, G. Brito, A. Mederos, S. Luzardo, L. Castro, and R. Robaina. 2004c. Producción de carne ovina de calidad del Uruguay: Una apuesta rentable y una apuesta para el futuro. Seminario Producción Ovina: Propuestas para el Negocio Ovino, 63–84.

Montossi, F., I. De Barbieri, G. Ciappesoni, D. De Mattos, A. Mederos, S. Luzardo, J. Soares de Lima, G. de los Campos, M. Nolla, R. San Julián, M. Grattarola, J. Pérez Jones, F. Donagaray, and A. Fros. 2007. Los productos logrados en los primeros 8 años (1998 - 2006) de existencia del Proyecto Merino Fino del Uruguay: Una visión con perspectiva histórica. Montossi y De Barbieri (Eds.). En: Productos obtenidos en el Proyecto Merino Fino 1998–2006. Tacuarembó, Uruguay. INIA. Boletín de Divulgación N° 90, 17-36.

Montossi, F., De Barbieri, I., Ciappesoni, G., Ganzabal, A., Banchero, G., Soares de Lima, J. M., Brito, G., Luzardo, S., San Julián, R., Silveira, C., y Vázquez, A. 2011a. ¿Es posible con menos ovejas producir más y con mayor valor agregado?: Análisis y aportes del INIA para una ovinocultura uruguaya más innovadora y competitiva. Suplemento El País Agropecuario. Diciembre 2011, 30-24.

Montossi, F., I. De Barbieri, G. Ciappesoni, J. Soares de Lima, S. Luzardo, G. Brito, C. Viñoles, R. San Julian, C. Silveira, and A. Mederos. 2011b. Merino Superfino y Merino Dohne: Innovaciones tecnológicas para mejorar la competitividad del rubro ovino en sistemas ganaderos extensivos mixtos del Uruguay. Médico Veterinario de Paysandú. Paysandú, Uruguay. Proceedings XXIX Jornadas Uruguayas de Buiatría, p. 164–175.

New Zealand Merino. 2003. Review of the New Zealand Merino Industry. A report to Merino New Zealand (Inc.). http://www.merinoinc.co.nz/Reports/ReviewIndustry.pdf. (Accessed 5 May 2013.)

OECD-FAO. 2012. Chapter 7: Meat. In: Agricultural outlook 2012–2021. p. 163–170.

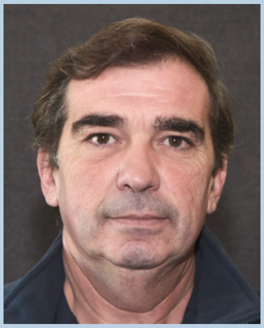

## About the Authors

Fabio Montossi graduated from the Agronomy Faculty of Uruguay in 1989. He obtained his Ph.D. at Massey University, New Zealand. Since 1990, Montossi has been working for INIA Uruguay. Between 1996 and 2006, he took the position of the Head of the Sheep and Goat Research Program at INIA. Since 2006 to present, as a senior researcher, Montossi became the Director of the Meat and Wool National Research Program at INIA. His work is mainly focused on the effects of nutrition and production systems on meat, carcass, and wool quality. He is also interested on the effect of red meat on human health and developing organizational innovations between the shareholders of livestock industries.

**Correspondence:** fmontossi@tb.inia.org.uy

Ignacio De Barbieri graduated from the Agronomy Faculty of Uruguay in 1989. Currently, as assistance researcher, he is pursuing his Ph.D. in animal nutrition at The University of New England, Australia. Since 2000, De Barbieri has been working for INIA Uruguay. His research and technology transfer is principally concentrated on sheep husbandry and feeding management in different production systems.

Gabriel Ciappesoni is a senior research scientist for INIA Uruguay working in animal breeding. He received his M.S. degree in animal production from the Institute of Tropics and Subtropics (Czech University of Life Sciences, Prague) in 2000 and his Ph.D. in animal breeding from the same faculty in 2003. Ciappesoni leads various research projects relates to sheep breeding including genetic evaluations, crossbreeding, and genetic resistance to gastrointestinal parasites and genomics.



Andrés Ganzábal graduated from the Faculty of Agronomy of Uruguay in 1983. Between 1982 and 1990, he worked for the Ministry of Livestock, Agriculture and Fishery. Since 1990, this researcher has been working for INIA Uruguay. He is a senior researcher at INIA, and his research is mainly concentrated on feeding, management, and crossbreeding in sheep for milk, meat, and wool production under grazing conditions.

Santiago Luzardo is an assistant at INIA Uruguay. His work has been focused on beef cattle and lamb fattening stage under grazing systems with and without supplementation, and the influence of those systems on carcass traits and meat quality. Currently, he is pursuing his Ph.D. in the Center for Meat Safety and Quality at Colorado State University. His area of interest is meat quality and particularly meat packaging systems.

Since 1992, Dr. Georgget Banchero is a senior researcher at INIA Uruguay. She got her Ph.D. in the University of Western Australia in 2003. Her main work is reproduction in sheep focused on lamb survival in wool type sheep and recently in meat and prolific sheep. Georgget has focused her research on the effect of nutrition on lamb survival, especially in twin lambs, considering the effect of nutrition on maternal behavior, lamb vigor, and colostrum production.

M.S. Roberto San Julián is a research scientist working for INIA Uruguay. He received his M.S. from Oklahoma State University in 1992 and almost finished his studies to get a Ph.D. degree at Zaragoza University. San Julián was mainly involved in research related to meat and wool production, sheep nutrition and management, meat quality, and most recently, meat sensory and consumer analysis.