Angora rabbits

A potential new industry for Australia

A report for the Rural Industries Research and Development Corporation

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Foreword

Australia has a long established reputation for the production of natural fibres, from both animal and plant sources. Until the 1930's Australia had a small Angora rabbit fibre industry and although this industry disappeared from Australia, it has continued in Europe, Asia and South America. Angora fibre is the third largest animal fibre industry by weight after wool and mohair.

This study assesses the potential for the re-establishment of an Angora rabbit fibre industry in Australia. The report is based on a study of the industries in France and China, and recent Australian experiences. This study also draws on published sources of information from the Angora industry and related fibre industries.

The gradual changing of State legislation to allow rabbit farming since the 1980s offered the opportunity for Australia to re-enter the Angora fibre production and marketing industries. The potential for this "new" industry is discussed and the likely constraints of the current low international market prices for raw Angora fibre on this "new" industry for Australia are highlighted. Australia in recent history has entered the animal fibre industries of mohair, cashmere and alpaca. Thus the potential development of an Angora industry in Australia is a continuation of this trend. The Angora industry offers some potential for development in Australia but careful consideration needs to be made about the means of disposal of the resultant fibre onto a depressed international market for Angora fibre. The potential industry needs to draw on the experiences of the other "new" animal fibre industries in Australia.

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This report, a new addition to RIRDC's diverse range of over 900 research publications, forms part of our rare natural (animal) fibres R&D program, which aims to accelerate the development of viable new animal industries.

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Abbreviations

AUD	*Australian dollars.*

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Executive Summary

Declining terms of trade for rural commodities in Australia generates a requirement for increased farm productivity. Risk spreading strategies such as diversification of income streams in mixed farming enterprises may assist rural economics by increasing the utilization of existing farm resources.

Angora fibre production is the third largest animal fibre industry in the world after wool and mohair. Australia plays a significant role in wool production as well as producing alpaca, mohair and cashmere for the international fibre trade. Australia is currently absent from the international Angora fibre trade and as such, provides an obvious path of diversification for the Australian animal fibre industries.

Australia had a small Angora industry until the 1930's and there have been recent attempts to revive the industry in the 1980s and in the early 2000s. These developments have been facilitated by the changes to some State government laws since the mid 1980s that now allow for commercial rabbit farming in Australia. The Angora rabbit industry is an intensive animal industry and as such is subjected to the planning regulations of intensive animal industries. Being an intensive animal industry, Angora fibre production is significantly different to other fibre industries in Australia in that they cannot draw on the expertise of Australian livestock operators in the grazing sheep and cattle industries. However, Australia does have internationally competitive intensive animal industries that could provide some expertise for the development of an intensive fibre industry. Australia also has an intensively housed sheep industry for the production of super fine wool that could provide some expertise in intensive fibre production and marketing.

China dominates the world Angora fibre trade, producing approximately 90% of the world Angora fibre. China has taken over the position in the world market traditionally held by France as the main source of Angora fibre. World Angora fibre production has declined since the early 1990s after import prices of Angora fibre into France peaked in 1985 at AUD$89.32 per kg of raw fibre. The current (2001) import price into France is AUD$23.44 per kg. At this price for raw fibre France has been unable to profitably sell raw fibre on the international market but still maintains a viable Angora rabbit industry. The Angora rabbit growers through their cooperative now retain ownership of the fibre until at least the yarn stage of manufacture. These low world prices have seen a number of European and South American Angora fibre produces disappear from the world Angora fibre markets.

There are no significant animal husbandry difficulties for Australia to be successful in farming Angora rabbits for fibre production. In many aspects Angora rabbit production is likely to be less demanding than meat rabbit production as fibre is predominately produced from adult rabbits. Meat rabbit production places a high demand on reproduction and growth rates to ensure a high

production per doe of meat. There are currently limited numbers of French Angora rabbits in Australia and are no large scale commercial producers of German Angora rabbits in Australia. Australian quarantine protocols have been developed for the importation of Angora rabbits from France, and although this is an expensive way of acquiring rabbits, limited numbers will only need to be imported to start an industry in Australia. Australia has skills in the housing, feeding and management of intensively housed livestock that should not inhibit the development of a domestic Angora industry.

Unfortunately the Australian industry will be severely handicapped by the current world prices for Angora fibre. To be successful an Australian Angora industry will have to replicate the Angora industry models developed by France and Finland. These countries are unable to compete with China on the world market but have maintained an industry in the case of France and building an industry in Finland by retaining ownership of the raw fibre through the processing chain to at least the yarn stage of manufacture. These countries are also attempting to convert the majority of the yarn into garments for sale with the traditional fluffy Angora finish. Although there is likely to be small domestic market for this type of garment, the Australian industry would need to look at larger, high value markets to become a viable Australian animal industry. China is the major producer and manufacture of fluffy Angora garments for the international market and thus Australia would be unlikely to successfully to compete in this traditional international Angora garment market.

The Australian industry would need to look at value adding to the raw fibre and to place the product into a high value market outside of the traditional fluffy Angora fabric markets. The fibre diameter profile of Angora down without the bristle component could provide such market opportunity. Australia has a long standing reputation in the production of super fine micron wool and the Angora industry would need to look to this end of the market for product development. The fibre requirements could be met by breeding specific lines of rabbits to produce bristle free fleece or develop processing technologies to remove bristle from fleece wool during processing. If this could be achieved then the Australian Angora industry could enter the next to skin wear market that the traditional Angora textile industry does not currently address. There is a small market for Angora based fabrics for next to skin wear health products market that is based on the light weight and warmth of Angora containing fabrics. The potential growth of this market is likely to be small but provides a basis to develop processing technologies to produce high value light weight fabrics for every day wear.

1. Introduction

This feasibility study aims to assess the potential for Angora rabbit production in Australia.

The Angora rabbit (*Oryctolagus cuniculus*) is a species of the order Lagomorpha and is descended from European wild rabbit. Angora fibre production is the result of a pair of autosomal and recessive genes causing an extension of the active phase in the hair follicle from the normal 5 to 7 weeks in fur rabbits to 12 to 16 weeks in Angora rabbits. Angora fibre production is the third largest animal fibre industry in the world (Table 1) (Leader *et al* 1998).

Table 1. World production of animal fibres (from Leeder *et al* 1998)

Animal Source	World Production (tons)
Sheep fine wool	100,000
Goat mohair	25,000
Rabbit angora	8,500
Goat cashmere	5,200
Alpaca	4,000

There was a small Angora rabbit industry in Australia until the mid 1930s. A combination of rapid rise in synthetic fibres, the depression and pressure from farmer groups oversaw the closure of the industry. Angora fibre production continued in Europe and expanded into Asia and South America.

China is now the dominant Angora fibre producer with the Fine Fibre Network in Europe during the 1990s recording France and Finland as the only European countries remaining with commercial Angora production. There is currently some Angora production in Chile and India. India is a significant Angora producer but does not enter the international Angora fibre market; it is a producer, processor and consumer of Angora fibre. The main retail markets are in Japan, Hong Kong, North America and Western Europe.

Australia has a very small population of Angora rabbits, mainly confined to rabbit fanciers. The first attempts at re-introduction of Angora fibre production in Australia was in the mid 1980s, based in Western Australia, after the laws were changed to allow commercial rabbit farming. This industry was to be based on German Angora rabbits imported from New Zealand or the UK. These initial attempts did not persist long, mainly due to financial constraints. In 2001 there was a new importation of French Angora rabbits for Angora fibre production into NSW by Angora City (Rabbits) Pty Ltd (Guyra Shire Council news, 2002). Australia's skill in raw fibre production makes the Angora industry a natural alternative to the wool, mohair, cashmere and alpaca industries that already exist in Australia. However, there is one major difference; the existing industries are grazing based industries whereas Angora fibre production is an intensive animal production industry.

2. The Angora Rabbit Industry

2.1 History

The Angora rabbit is a very old breed of rabbit, believed to have originated in Turkey in the town of Angora. The Romans kept Angora rabbits and the modern Angora rabbit industry dates from the 1700s. The Angora rabbit was introduced to France from England in 1723 and use of Angora fibre in garments was recorded in 1870. The modern phase of the industry started in the 1930s with simple genetic selection until the establishment of a herd book, the "Angora Rabbit Book of France". German Angoras also underwent similar intensive selection for fibre production based on small holders supplying animals to a central testing station to evaluate animal performance. Until 1965 France was the leading producer, with the world market now being dominated by Chinese produced fibre. China now provides in excess of 90% of the trade Angora fibre (see Figure 1). The other producers are France (see Figure 2), Chile, Argentina, Hungary (see Figure 3), Germany, Finland, and India.

There are two main commercial white, Angora rabbit types (de Rochambeau and Thebault 1990):

- French Angora is bristly with a double coat and is plucked with the aid of Lagodendron.
- German Angora is woolly and the wool removed by shearing. The foundation stock of the German Angora was English Angora and is the result of over 60 years of intensive selection for wool production.

China, central Europe and South America use fibre producing rabbits based on crosses containing 70 to 90% German and 5 to 10% French Angora types. The modern Chinese Angora, or Chinese coarse wool Angora was developed by crossing the German Angora with French Angora and the New Zealand White (meat rabbit breed) rabbits (Thebault 1993; Wang 1993). The Chinese Angora weighs 4.1 to 4.4 kg at 11 months of age and the fleece consists of approximately 15% bristle fibre (Research group of Chinese coarse-wool rabbits breeding, 1995). The bristle content of the Chinese coarse wool Angora is significantly higher than the 0.2 to 1.8% recorded for the French Angora rabbit (Allain and Thebault 2000).

3. World Angora Fibre Market

Angora production is truly an international industry. Angora producing countries tend not to be those with their own processing industries. The latter are not usually significant consumers of finished articles. For example, France is not a large consumer of Angora wool, and for a long time, French Angora production was developed mainly for the export market. The situation has continued to this day with the majority of fibre from producer countries such as China and Chile exporting the raw fibre to processors based in Europe, Japan, and Korea. The main retails markets are in North America, Western Europe and Japan. China is slowly increasing its Angora manufacturing capacity. India is an exception in the Angora industry, being is a producer, processor and consumer of Angora fibre.

There are no specific international records maintained for Angora fibre trading. It is categorized as other fine animal fibre under the international trade code 5102.19: Fine or coarse animal hair, not carded or combed: fine animal hair—other. However, the European Union does have a specified category for Angora fibre reflecting Europe's long association with Angora rabbits.

France dominated the world market for Angora fibre prior to the 1950s. Ossard *et al*. (1995) summarized world production and analyzed the economic returns for Angora rabbit production from 1950 to 1995 (Figure 1). Until 1970 world production was stable at around 1,000 tons per year. There were regular fluctuations in demand, and prices reflected this demand fluctuation (Figure 2). As prices rose and Angora fibre in storage was sold, there was a rise in price followed by a collapse in trade due to a lack of supply. Farmers were unable to increase production during this period due to financial constraints for investment and uncertainty about future prices. However, from 1976 to 1988 there was a sharp increase in demand and the increase in demand was at a higher level than the previous increases in demand. However, supply only increased slowly at first as production could not increase rapidly even with sustained demand. France (Figure 3), Germany and China (Figure 1) increased production. This period also saw Argentina, Chile and Hungary (Figure 4) become significant producers of Angora fibre. During this period New Zealand and Australia made attempts to enter the Angora fibre market by re-starting their Angora fibre industries.

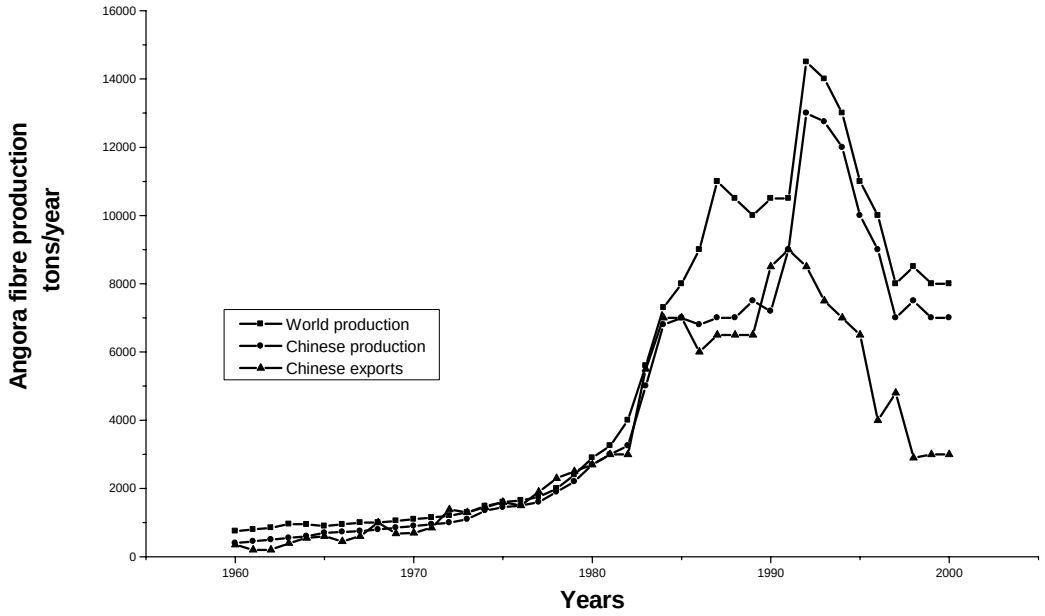

Figure 1. World Angora fibre production, Angora fibre production in China and the amount of Chinese Angora fibre being traded in the international fibre market in tons/year (Source: INRA 2002)

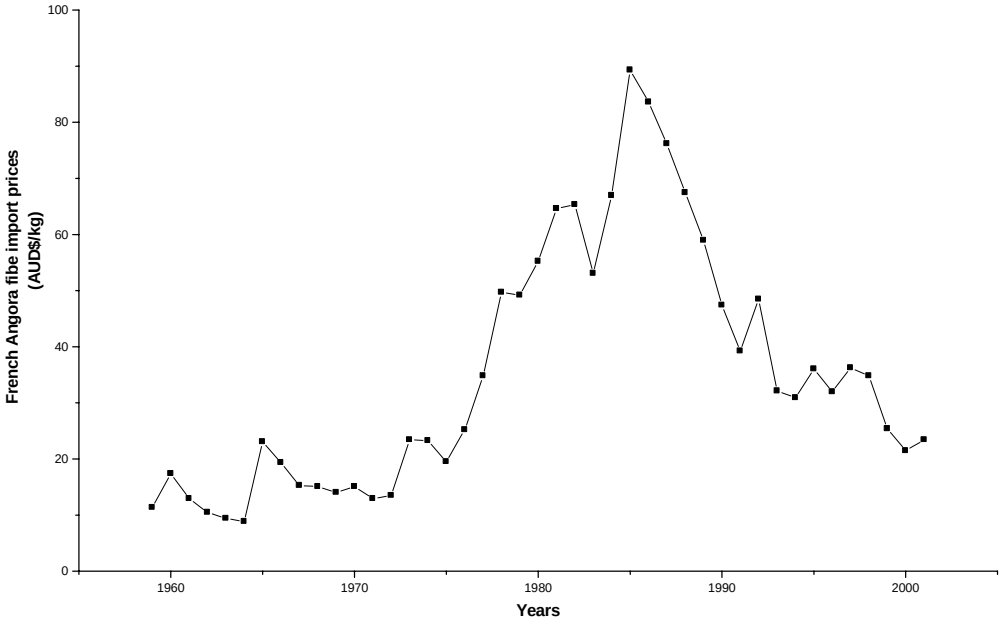

Figure 2. Price paid for Angora fibre import into France from 1959 to 2001 in Australian dollars (Source: INRA)

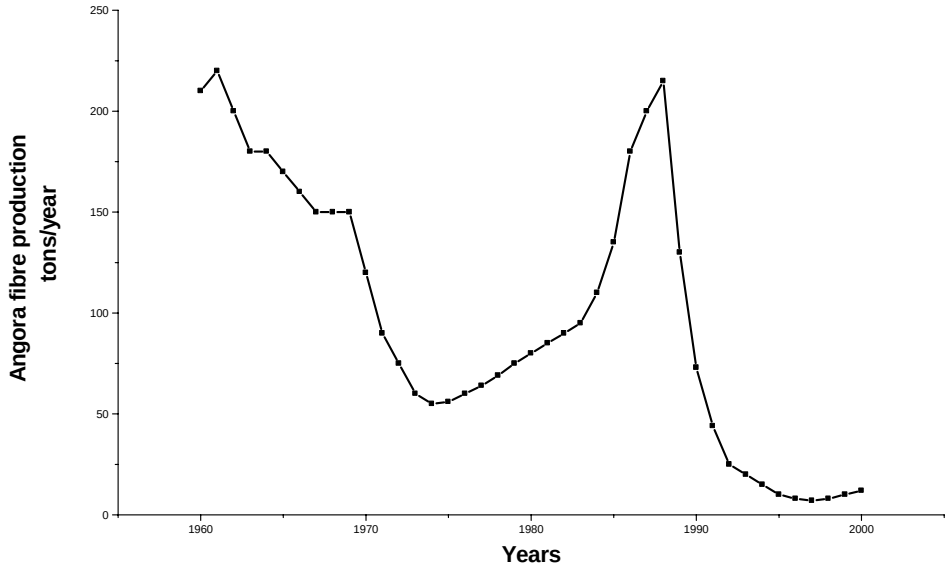

Figure 3. Angora fibre production in France (Source: INRA 2002)

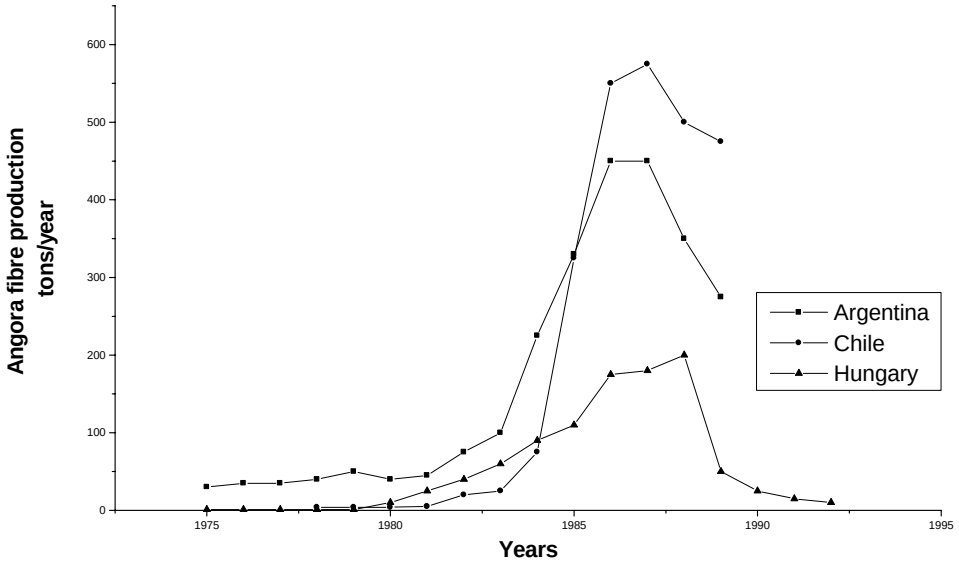

Figure 4. Angora fibre production in Argentina, Chile and Hungary (Ossaed *et al*. 1995)

From 1988 to 1995, the final period covered by Ossard *et al*. (1995), demand remained constant, but supply continued to increase, as producers responded to meet the new demand. At first price once more returned to previous levels, but with more and more Angora fibre being supplied and a stable demand, prices fell below the traditional levels. These prices have not risen since 1995 forcing many of the new entrants from the market, and leading France and Finland to no longer sell raw fibre onto the international market. China now effectively dominates the international Angora fibre market. There are about 50 million Angora rabbits in China producing about 10,000 tons rabbit fibre per year, with 50% of the fibre being exported onto the international market (Tang 2002). With the current low prices there is a capacity within China to rapidly build numbers should the international prices for Angora fibre increase.

3.1 Australian Market

Couchman (1992) reported that Australia imported AUD$7 million of Angora fibre for blending with wool and generated an add-on-value totaling AUD$80 to 85 million. At the quoted prices this was equivalent to 100 tons of Angora fibre. Recent Australian Bureau of Statistic data for the year 2001 (5102.10 import code for China) for Australia imports indicated that there was unlikely to be any importation of Angora fibre into Australia, although this listing is not specific for Angora fibre and relied on country of origin to differentiate between fibre types. There is importation of Angora fibre in finished garment products that are available for sale by the retail trade during the winter months. Australia started a number of Angora rabbit farms in the Western Australia in the 1980s but with the down turn in world prices these new entrants to the Angora industry did not continue to operate. French Angora rabbits were imported into Australia in late 2001 and this operator is still in the development phase.

Thus there is currently no market for Angora fleece in Australia beyond the craft industries as there has never been a large quantity of fleece available on the local market to establish a viable textile

industry based on Angora fibre. Margaret Peel's Fibre Supplies does process raw Angora fibre on request using a woolen process for the craft knitting trade (Margaret Peel 2002).

3.2 Current Market Situation

China is the major world source of Angora fibre and thus sets the world price. Chinese Angora producers currently receive the equivalent of AUD$16.84 per kg for un-classed fleece. The export price is about AUD$19.40 during the first three months of 2002, reduced from AUD$35.96 in 1997. China can supply over 8,000 tons per year of raw fibre (Figure 1). Chinese Angora fibre processing capacity has also increased with the ability to produce more than 4,000 tons of raw fibre into processed products per year according to market requirements. Processing technology has also improved to overcome the problems of shrinkage, felting and pilling in the fabrics (Tang 2002).

France maintains records for the import prices of Angora fibre and in 2001 the price paid for Angora fibre imported into France was AUD$23.44. French Angora fibre is currently priced at approximately at AUD$36 but no raw fibre enters domestic or the international raw fibre markets. The Union of French Angora Breeder handles all the raw fibre and wool is processed to either yarn or garment before being released onto the market. It is estimated that this doubles the value of the fibre to the farmers and has allowed the French Angora industry to continue to operate. It is estimated that the annual production is approximately 12 tons per year (Figure 2) with considerable quantity in storage, although this stock pile has been reduced.

Chile is an exporter of Angora fibre to Europe with an estimated purchase price at European top making mills ranging from AUD$18.80 (Grade 5) to $22.9 (Grade 1) per kg. Chile also has a hand spinning industry with yarn selling for AUD$645 per kg of hand spun yarn on the United States of America market.

Angora fibre is available for hand spinning from local growers in many Western countries and craft markets in most countries have a demand for the Angora fibre. This market is by and large met from rabbit fancier sources and these supplies do not play a role in the commercial supply of Angora fibre.

Eastern Europe, including Germany, and Argentina has ceased production of raw fibre for the international market. India still does not enter the international Angora fibre market and uses all Angora fibre produced internally (Gupta *et al* 2000). Finland is a small producer of Angora fibre and is using the French model of retaining the ownership of raw fibre through to the production of yarn or finished product.

New Zealand, after the rapid developments in the 1980s, has now only one commercial Angora rabbit farm. This operates as a tourist attraction called 'The Shearing Shed' (The Shearing Shed 2002). Demonstrations of rabbit shearing occur daily and they have a shop selling Angora product from the farm.

3.3 Angora Fibre and its Uses

Angora fibre differs from wool in several respects. Angora is a medullated fibre, which makes it light and soft. Angora is a heterotype fleece and contains some coarse hairs called bristle. The bristle content varies with rabbit type and is usually considered to be desirable, as bristles prevent felting on the rabbit and imparts the characteristic fluffiness to the yarn. The down fibre is very fine, with an average fibre diameter of about 11 to 12 microns, however, most of the commercial breeds have some guard hairs that increase the average fibre diameter of the fleece (Rougeot and Thebault 1989; Hermann *et al* 1996). Angora fibre has a low density of about 1.15 to 1.18 gm/cm^3 compared to 1.33 gm/cm^3 for wool and 1.50 gm/cm^3 for cotton. This gives the Angora garments a feeling of being very light but warm.

Angora fibre can be used in several ways:
1). Knitted clothes usually with a moderate fluffing effect, such as pullovers, woollen hats, socks, gloves, etc.
2). Woven material for suiting fabric and next to skin thermal underwear.

Knitted product is the common fabric type produced, as the bristle content of most Angora fleeces makes it unsuitable for the production of next to skin wear or high quality suiting material.

Much of the health wear products are knitted but light weight fabrics. The warm nature of Angora fabrics resulted in Angora fabrics being used in health products for the benefit of arthritis patients and for thermal underwear in cold climates. This is a non-fluffy material currently being sold as blends of wool, Angora and synthetic to produce a durable fabric. Angora fibre blends with synthetics or cotton have also been developed to produce high quality, light weight, wash and wear suiting material.

Angora fibre is usually blended with another fibre such as wool to improve its performance both in processing and fabric wearability. French Angora products usually contain 20% wool, however; to gain the properties of Angora in the finished product no more than 30% Angora fibre is required in the fabric. Angora can be successfully blended with a range of natural and synthetic fibre to maintain the desired fabric characteristics of pure Angora fabrics. Fabrics containing a high Angora fibre content are only suitable for hand washing. Machine washable fabrics can be produced if the Angora fabric contains 50% of a synthetic fibre such as polyester.

4. Angora Production and Management Issues

Rabbit farming in Australia is prohibited in Queensland and the Northern Territory, as well as being subjected to regulations in the other States and Territories. Thus potential Angora rabbit farmers will need to consult with their local regulatory authorities before undertaking an Angora rabbit production enterprise. The regulatory agencies in each state have state departments responsible for agriculture.

4.1 Housing

Angora rabbit production is an intensive animal production system and as such is subject to Australian regulations for intensive animal production. In Australia rabbits can only be intensively housed for commercial production and the facilities must be rabbit proof to prevent escape of the housed rabbits. Housing systems must be in accordance with the Model Code of Practices for the Welfare of Animals – Intensive Husbandry of Rabbits (1991). Intensive animal industries are also subject to planning regulations in agricultural zones and cannot be undertaken in residential and rural-residential areas. Local government bodies should be consulted before an Angora rabbit enterprise is undertaken to establish what local planning approvals are required for intensive animal production and to establish if Angora rabbit farming is categorized as 'intensive livestock agriculture' in that area.

Sheds for housing rabbits should be dry, vermin proof and draft-free. Rabbit sheds should also be well ventilated to prevent ammonia build up and insulated to minimize temperature extremes inside the sheds.

The Western Australian Angora industry in the late 1980s used one level wire cage systems rather than multi-level systems used in the dominant Angora producing countries. The flat systems can allow dung to build up underneath the cages for a longer period of time whereas the multi-layer systems were considered to have cleaning problems. Wire cages are considered to be easier to clean and help with even air distribution. This style of caging however is not used in the other major Angora producing countries with France and China both use prefabricated concrete caging that they claim is superior to wire caging for Angora rabbit production. The flooring is claimed to reduce leg problems and the solid walls prevent fleece quality problems of rabbit contact between cages.

French rabbit cages have solid sides, top and floor with a narrow slit at floor level on the rear wall to allow for urine drainage. The floors are sloped to assist urine and any water spillage to drain away out of the rear of the cages. The cages usually stacked three cages high, but occasionally are four tiers high. An individual shed consists of two facing rows with a light roof over the rows and sealed ends in the shed. The sheds are designed to minimize the impact of low winter temperatures. The cage floors are spread with straw and fresh straw added weekly with the straw bedding being completely replaced every month. Water is supplied by nipple drinkers and feed supplied manually at set daily allowances.

China also uses prefabricated concrete cages but does not use solid flooring. The floors are bamboo slats (13 mm gaps) with urine and faeces draining away to the rear of the cage bank from the solid concrete top of the cage below, assisted by regular cleaning. Thus the air gap between the cages is higher and allows the rabbits to be farmed at higher environment temperatures and humidity than the French industry would consider prudent for Angora production. The Chinese industry operates with temperatures into the mid 30^{o}C and into the high 90%s for relative humidity during summer. The Chinese housing systems are thus probably more suited to the temperatures and humidities ranges found across much of Australia. Also the self-cleaning slat flooring would lower labour inputs in

comparison with the French straw bedding systems, thus making the Chinese Angora cage system overall more suited to a wide range of Australian environments.

Cage sizes are recommended in the Australian Standards are sufficient to allow the rabbits to move around, to feed and drink without difficulty, and to lie on their sides.

Australian minimum cage size allowances for space are:

- Doe and litter to 5 weeks of age:– 0.56 m^2 total area
- Rabbits 5 to 12 weeks of age:– 0.07 m^2 per rabbit
- Rabbits 12 weeks and over in cages:– 0.18 m^2 per rabbit
- Adult does and bucks for breeding:– 0.56 m^2 per rabbit

These are minimum size cages for a medium-side rabbit, e.g. New Zealand White and should be adjusted on a body weight for the larger Angora rabbits. Cages for rabbits over 12 weeks old should not be less than 45 cm high and should be of sufficient height to allow rabbits to sit upright with ears fully erect.

The French Angora cages are based on a standard size of 60 cm wide, 50 cm deep and 50 cm high for each adult rabbit.

The Chinese cages have average dimensions of 76 cm wide, 61 cm deep and 46 cm high with slatted floors. The cage size for the does is increased to 91 cm in depth with the slatted floors requiring the use of nesting boxes to protect the litters whereas in the French cages straw bedding also doubles as a source of nesting material for the doe. The nesting boxes are 35 cm wide, 30 cm deep and 28 cm high, and are usually made of untreated timber. If nesting boxes are used the boxes should be made of non-absorbable material to facilitate cleaning between litters. The nesting boxes should be introduced complete with nesting material (usually wheat straw) at least two days before the litter is due.

The shed environment should be constructed to control the extremes of temperature as the optimum range for Angora rabbits is 10 to 25^{o}C. However, the temperatures range in Angora producing countries from below freezing (France and China) to the high 30s (China). These temperature ranges are successfully modified by shed and cage design without the use of air-conditioning or forced ventilation. Cheng *et al* (1991) in a multiple regression model found that high temperatures significantly reduced fibre production. High summer temperatures also reduced feed intake with a 5.6% reduction in feed intake compared to spring and 10.6% reduction in wool cut in Cheng *et al* (1991) report. Average monthly temperatures in summer were 23.1^{o}C and 11.1^{o}C in spring. These results suggest that temperature has an indirect effect via a significant reduction in food intake and this effect should be taken into account when predicting potential fibre production.

Studies in France have also found that winter wool harvests are higher than summer harvests (See Table 2). Rougeot and Thebault (1983) attributed these differences in seasonal production to variations in photoperiod. Histological studies revealed that some hair follicles disappeared in spring and declined further in summer. Implants of melatonin have been successfully used to suppress the summer fall in wool production (Rougeot 1986; Lanszki *et al*. 2001). Artificial lighting has not been used extensively in the Angora rabbit industry probably due the cost of lighting for animals kept at low housing densities compared to other forms of intensive animal industries. Thus the drop in summer wool production is likely to be a combination of both day length and temperature effects depending upon the geographical location of the Angora rabbit.

Table 2. Effect of season on harvested Angora wool where 100 in spring represents 157g of fibre (adapted from de Rochambeau and Thebault 1990 – early types rabbits)

	Winter	Spring	Summer	Autumn
	Fibre production relative to spring production			
Seasonal production (100 equiv to 157g of fleece	106	100	90	105

4.2 Nutritional Requirements

Angora rabbits are a fully housed animal and as such need to be fed a balanced diet to produce 1.0-1.4 kg per year of fibre. This represents approximately 0.30 of the rabbit's body weight, the highest keratin production per kg liveweight found in any fibre-producing animal. In sheep, goat or camelids, this ratio is generally less than 0.10. Protein utilization (ratio of protein retained in fibre to protein used for fibre growth) in Angora rabbits is estimated to be 0.43, double the efficiency of an estimated 0.20 to 0.25 for Merino sheep to produce wool (Liu and Master 2003).

Not only does the Angora have a high rate of fibre production, they are also shorn at 3 monthly intervals by blade or plucking. Fibre production rate varies over the 3 month period between wool harvests, and thus feed allowancess are adjusted to meet both changes in fibre growth and energy requirements for body heat losses incurred immediately after shearing. Complete, well balanced pellet diets have been developed and the feed offered to the rabbit varies according to the time after shearing to maintain liveweight and maximize fibre production.

The nutritional requirements are summarized in Table 3. There are no major differences between countries or Angora breeds in dietary requirements (Lebas *et al* 1998). Dietary roughage, supplied once or twice per week as straw bedding in France, is not essential for health or wool production in the Angora rabbit (Rougeot *et al*. 1980).

Table 3. Nutritional requirements for adult Angora rabbits of fibre production (from Lebas *et al* 1998)

		Source of recommendations		
Nutrient	Unit/kg	Germany	China	Current work
Digestible energy	MJ	9.6-109	10.0-11.7	10.5
Lipids	G	20	30	30
Crude fibre	G	140-160	120-170	140
Crude protein	G	150-170	150-160	160
Digestible protein	G	-	110	122
Lysine	G	5	7	7
Methionine+cystine	G	7	7	8
Arginine	G	6	7	6
Minerals				
Calcium	G	10	10	8
Phosphorus	G	3-5	5	4
Sodium	G	2.5		3
Potasium	G	7		13 maximum
Chlorine	G	4	-	4
Sulphur	Mg	-	-	400
Magnesium	Mg	300	-	300
Iron	Mg	50	-	50
Copper	Mg	10	20	50
Zinc	Mg	50	70	50
Manganese	Mg	10	30	10

Vitamins				
A	IU	6000	6000	10,000
D3	IU	500	900	800
E	Mg	20	50	40
K	Mg	1	-	1

The sulphur amino acid requirements for Angora rabbits are reasonably high. These requirements should be met as much as possible from dietary protein sources with some sulphur amino acid supplementation for high fibre producing rabbits. Thesulphur amino acid requirements can be successfully met using feed grade D, L-methionine although cystine under some circumstances can have advantages for fibre production. Methionine supplementation is required once Angora rabbits exceed an annual production rate of more than 1,000 g per year of fibre. Arginine supplementation is also required to maximize fibre growth in rabbits, and the diets are usually supplemented with 1 g of arginine.

The nutrient requirements for the reproducing doe are higher than the non-reproducing does. Dietary protein concentrations need to be increased by 10 g/kg and digestible energy content increased to 11.7 MJ/kg. Dietary concentrations of lysine, methionine plus cystine, and arginine are also suggested to be increased by 1 g/kg of the values shown in Table 3 (Liu and Zhang 1993).

The diet is fed as a pellet on a daily basis with restricted rates of feeding to prevent obesity and nutritional problems with the rabbits. Angora rabbits fed pelletted rations do not appear to be able to successfully regulate daily intake as some rabbits have been observed to consume up to 500 g per day during the first 2 weeks after wool harvesting. This can lead to nutritional disorders, such as enterotoxaemia, which occurs when pellets are fed *ad libitum*.

The current recommended feeding rates for adult Angora rabbits are:

First month after shearing	1,200 g per animal per week;
Second month after shearing	1,100 g per animal per week;
Third month after shearing	1,000 g per animal per week.

The weekly ration must be distributed equally over six days of the week with a one day fast. French Angora rabbits are manual fed so that the rabbits are individually checked for any animal health problems while they are being fed. The one day fast is to prevent the development of hair balls in the stomach (trichobezoard). The one day fast facilitates the rabbits in voiding of ingested hair in hard faeces.

The feed requirements for the different stage of growth and reproduction are shown in Table 4 and the feeding requirements are based on the nutritional concentrations for pelletted rabbit feed in Table 3.

Table 4. Liveweight, weight gains and daily intake for rabbits during growth and reproduction

Physiology status	Liveweight (kg)	Weight gain (g/day)	Intake (g/day)
Weaner rabbits, 3 months and older	0.5 to 2	25 to 30	60 to 135
Growing rabbits	2.5 to 3.5	10 to 15	150 to 170
Pregnant does	3.5 to 4.0		>170
Lactating does	3.5 to 4.0		>220

4.3 Livestock Sources and Breeding

Angora rabbits available in Australia are predominately from rabbit fanciers and the genetic value of this source of stock is unknown for fibre production.

New Zealand had an expansion of the Angora rabbit industry based mainly on imported German Angora bloodlines in the 1980s. Some of these bloodlines were imported into Australia but the numbers rapidly declined with the fall in fibre prices. One 'commercial' farm still operates in New Zealand as tourist venture called 'The Shearing Shed'. 'The Shearing Shed' has been reluctant to make available breeding stock to other breeders.

Angora City (Rabbits) Pty Limited, Gyra, NSW imported French Angora rabbits into Australia in late 2001. These rabbits are planned to be a new start to an Angora rabbit fibre industry in Australia. The availability of rabbits from Angora City (Rabbits) Pty Limited to other rabbit farmers is unknown at this time. Australian quarantine guidelines are now in place for importation of Angora rabbits from France and thus further importations would be possible if other operators wished to enter the industry.

Alternatively, a new entrant to the industry could source Angora rabbits from rabbit fanciers to slowly build up to commercial production. Entrants to the French Angora industry are suggested to start with 20 does and 4 bucks, breeding up slowly to full commercial production (Rougeot and Thebault 1989). This advice is based on the view that the new entrant with this number of rabbits to start with can learn about Angora farming while the numbers are slowly being built up to a commercial operation. There are well established genetic guidelines for using this approach to increase to a commercial unit without incurring high levels of inbreeding. However, breeding up from rabbit fanciers would only be an option if imported stock is not available or only available at high prices compared to the value of the fibre produced.

The German Angora industry produced a high quality product based on small holders with the fibre being collected and classed centrally for processing. This may have merits in Australia and the Alpaca industry could be used as a model for the collection and sale of small parcels of fibre to processors or the international market.

Heritability for fleece traits has been established for both German and French Angora rabbit types. Allain *et al* (1999) results showed that selection decisions on animal replacement can be made in French Angora rabbits after the second shearing at 21 weeks of age. The heritability estimations for total fleece weight were similar across age and ranged from 0.31 to 0.42. The only other heritability estimation for total fleece weight in German Angora rabbits found mainly low heritability estimations, not significantly different from zero (Garcia and Magofle 1982). In the French Angora there is no genetic correlation between total fleece weight and live weight except at the first shearing. This is contrary to the findings for the German Angora where there is a positive relationship between total fleece weight and body weight (Caro *et al* 1984). Heritability for some of the production traits in the Chinese coarse wool Angora are shown in Table 5 (Lin *et al* 1995; Zhao *et al* 1995). The heritability for fleece weight is lower than that recorded for the French Angora but the Chinese Angora rabbits have similar a heritability value for liveweight as that determined by Allain *et al* (1999) in French Angora rabbits.

Table 5. Heritability of some production traits in Chinese coarse wool Angora rabbits

Trait	Heritability
Liveweight	0.43
Fleece weight	0.30 – 0.33
Bristle content	0.13 – 0.21

China has also established a system of State rabbit breeding farms to improve rabbit productivity. The breeding farms with more than 10,000 does are Tianyu Rabbit Co. Ltd., Zhenghai Rabbit Co. and Jingling Rabbit Breeding Farm located in Zhejiang and Jiangsu Provinces of south east China. There are also a number of medium size rabbit breeding farms of about 1,000 does in the south eastern and eastern regions of China.

Females produce more wool than males with the differences ranging from 2 to 20% (de Rochambeau and Thebault 1990). Females are predominately used for fibre production with males being retained for breeding purposes only in France. The French Angora has a higher difference for wool production between the sexes than the German Angora as German Angora breeders have placed more emphasis on selection for total fleece weight in the males. Castration has been suggested as a means of improving the fibre production of males not required for reproductive purposes.

4.4 Shearing and Fleece Handling

Angora rabbits are first shorn at 8 weeks of age and then at approximately 3 monthly intervals. Wool removal is by plucking in France using a depilatory agent (Lagodendron ®, Proval Company, Paris) to assist with hair removal. This depilatory agent is a pelletted supplement, feed for one a day after the fast, approximately 5 days before plucking. Other countries growing Angora rabbits use either clippers or scissors for fibre removal. In cold weather a strip can be left along the back line until the rest of the body re-grows fibre and then the backline fibre is removed. Alternatively a box is provided in the cages to protect the rabbit from cold until there is sufficient hair growth to insulate the rabbit. Shearing can also be timed to reduce heat stress on the animal during the peak of the hot summer. Shearing time is estimated to be between 10 and 15 minutes per rabbit depending upon the skills of the shearer.

Fibre harvesting with Lagodendron must be planned around the reproductive cycles of the female Angora rabbit. Lapodendron must not be administered to pregnant or lactating females. The mating period is therefore limited to 4 weeks after harvesting in order that gestation and lactation periods are completed before the next wool harvest is due.

The fleece is grade in approximately 5 grades during shearing. These grades for France are:

1A.W	including long >6 cm for down and bristle
1B.W	includes long and woolly wool
2.W	includes short wool >6 cm for down
C.F.W.	clean, felted wool
1D.W	dirty wool

China likewise uses 5 grading lines but due to coat type differences grade fibre on the basis of fibre length and coat structure with less emphasis on the variation within the fleece. There are no nation-wide classing standards for Angora fleeces in China, with the classing requirements being determined by the growers and the markets they are supplying into at the time of shearing.

An example of Chinese wool lines are:

First grade	5 cm single coated fleece
Second grade	3 to 4 cm single coated fleece
Third grade	6 cm or longer double coated fleece
Forth grade	4.5 to 5 cm double coated fleece
Fifth grade	3 to 4 cm double coated fleece

The fleeces are bagged into plastic bags to prevent felting during transport.

4.5 Diseases of Angora Rabbits

Angora rabbit farming, like all intensive housed animal systems, must ensure high levels of hygiene are maintained to reduce the incidence of disease. Table 6 is a listing of the common diseases of the Chinese Angora industry and the treatments used to minimize the risks of disease. Vaccination is the most common preventative with the only exception being Coccidiosis where coccidostats are used in-feed to control this internal parasite.

Table 6. Some of the Angora rabbit diseases of China and the treatments used to prevent the disease

	Critical age	Treatment
Viral Diseases		
Rabbit Haemorrhagic Disease or Rabbit Calicivirua	All rabbits older than 1 month of age	Vaccinated twice per year
Bacterial disease		
Pasteurellosis	All ages, most susceptible at 2 to 6 months	Vaccinated twice per year
Salmonellosis	All ages	Vaccinated twice per year
Staphylococcosis	All ages	Vaccinated twice per year
Cilia-associated respiratory bacillus	All ages	Vaccinated twice per year
Clostridium piliformis	Older than 20 days	Vaccinated twice per year
Parasites		
Coccidiosis	All ages, most susceptible after weaning	In-feed coccidostats

5. Potential for Angora fibre production in Australia

Australia has the potential to enter the Angora rabbit production industry, however this step should not be taken lightly.

5.1 Strengths

Australia has a long tradition in the production of high quality Merino wool. This experience in the grazing of wool sheep has lead to the successful introduction of mohair, cashmere and alpaca fibre production into Australia. These industries have become established and produce fibre for both the domestic and international markets. Alpaca is the most recent animal fibre industry to be introduced in Australia and its economics are still dominated by the price of livestock for breeding, with only a minor part of the income coming from fibre production. Although this industry is new it now has in place systems to dispose of the clip on a commercial basis.

All the above fibre industries are grazing based systems whereas Angora rabbit production is an intensive industry. The wool industry has a niche market of super fine wool production from housed sheep. Sheep housing and diets are significantly different to those required for Angora production but there are in place the skills necessary to produce and market an expensive fibre from within the wool industry. Australia now has a growing meat rabbit industry that has the potential to provide the necessary rabbit production skills. The competitive pig and poultry intensive livestock industries in Australia are also potential sources of expertise for the Angora rabbit industry. These industries have the experience of intensive animal production that includes skills in shed design, pen design, waste handling and production of formulated rations.

Australia has extensive technical skills in animal fibre production and processing that can be utilized to the advantage of a potential Angora industry. These technical skills could be used to develop products from the fibre that are currently not being filled by the traditional textiles made from Angora wool.

Australia has extensive skills in producing and managing sheep to produce super fine wool. The ultra fine end of the sheep flock is managed by skilled operators to produce a high value, low volume product. Angora fibre has the potential to fit naturally into and in some case add to this high value, low volume market by the use of fibre blends.

5.2 Opportunities

Angora fibre production provides an opportunity for small landholders around the city fringes to develop a viable rural industry on small acreages that are not applicable for the more traditional rural industries in Australia. The industry also is a natural extension of the new animal fibre industries that have developed in Australia in the last 20 to 30 years. The Chinese industry has been scaling back due to reduced prices but Angora fibre demand tends to follow the fashion cycles for the Angora look. The scaling back of the Chinese industry may provide a window of opportunity for a fledgling Australian Industry to enter with novel products that the Chinese do not produce. The Australian industry would need to be aware that this window of opportunity is narrow. China would have the capacity to rapidly grow animal numbers to enter any new market, if the market was large enough to warrant the cost of switching market segments.

Breeding of Angora rabbits with low bristle content or bristle removal during processing may provide an alternative to high value fabric based on as Shahtoosh. Shahtoosh has a fibre diameter of approximately 11.5 microns, a minimum fibre diameter of 6 and maximum of 17 microns. This fibre diameter range is well within the fibre diameter distribution of Angora rabbit down. Australia may have an opportunity to specialize in the production of Angora fabrics based on breeds with low bristle content and/or develop processing systems to remove any bristles that are present in Angora fleeces. Chinese Angora rabbit breeding programs with double coated rabbits showed that it was possible to achieve a single coated rabbit with a low level of bristle in the fleece. However, there were serious problems with wool felting on the rabbits and the handling of the fibre in the processing systems. This led the Chinese industry to breed for a double coated Angora over the past two decades to reduce the incidence of wool felting on the rabbit. The Chinese and French industry currently produces fibre that are not suitable for the production of next to skin fabrics wear due to the high micron bristle fibres in the yarns. Chinese textile training institutions were of the opinion that Angora was not suitable for next to skin wear due to the bristle content of the yarns produced. However, Germany until the late 1980s produced extensive lines of next to skin wear as sport underwear and light weight suiting fabric. There are small quantities of these products still on the market as health wear products. German processors also produced wash and wear fabric for the men's suiting market.

If Australia is to enter the Angora fibre industry it should strongly differentiate itself from the traditional fluffy Angora look and produce a fibre suitable for next to skin wear. Australia already has extensive experience and a strong reputation for producing this type of fibre from the wool industry. This ultra-fine end of the market is of high value with a 12.1 µm bale of wool selling for AUD$1,500 per kg, far in excess of that achieved for Angora fibre of not too dissimilar fibre diameter characteristics.

5.3 Weaknesses

Australians have a love/hate relationship with rabbits where they are considered, and legislated against as an introduced pest species in rural areas but kept as pets in cities and are central characters of many children's stories. There is also likely to be a great deal of reluctance by the rural community to consider Angora fibre production as a serious alternative to the currently available alternative natural animal fibres.

Australian rabbit production is at an international disadvantage as the Australian rabbit industry is prohibited by law against vaccination for fibroma (myxomatosis). However, Australia can vaccinate against Rabbit Calicivirus Disease.

There is a small domestic craft market of Angora fibre in Australia for home spinning. Some Angora rabbit fanciers in Australia sell spun product but these operators only have small numbers of rabbits usually German or English Angoras. There are currently no commercial markets for domestically produced raw Angora fibre in Australia and this would need to be developed in the early phases to absorb the initial low volumes of fibre produced during industry development. The new Australian industry would also need to establish links with the international Angora trade as the quantity of Australian produced fibre increased. Currently Australia does not feature in the Angora trade as a supplier let alone as a reliable supplier.

Australian labour costs are higher than those of China, the major producer of Angora fibre. Both China and France have extensive experience with the processing of Angora fibre, experience that does not currently exist in Australia. This may be a critical step in the development of the industry as France still maintains a presence in the Angora industry by retaining ownership of the fibre until at least the yarn stage of processing. Australia does not have this processing base within the country to draw upon for production of yarn from small batches of fibre.

The Australian textile industry also has limited potential to produce and market Angora fabrics whether they are the traditional fluffy fabrics or high quality next to skin wear fabrics. Australia does not process a large proportion of its ultra-fine wool within the country with the largest proportion is being processed off-shore in either Europe or Japan.

5.4 Constraints

Australia's potential to operate in the Angora industry at the present time is constrained by the availability of locally sourced livestock. Australia has imported Angora rabbit livestock previously and has done so recently but these animals tend to be expensive and limited in number. The Angora wool types produced from imported Angora rabbits will be similar to that currently on the market from traditional supplying countries that Australia will be now competing against with its new industry. With these animals Australia will not have a competitive position in the market place in the early phases of the industry and thus make the longer term prospects risky without considerable capital inputs to ensure production of large quantities of fibre at a low price to meet the needs of the current Angora processing industry. However, these animals are a potential base to breed animals suitable for the next to skin wear market. This will place time and animal numbers constraints on the industry until the suitable lines can be developed to meet supply requirements for commercial processing of light weight fabrics.

An Australian Angora industry of any sort will have problems of supply and developing systems to supply industrial processing needs. This build up of fibre supplies will be a critical phase where the industry needs to develop to such a level that it is considered to be reliable commercial supplier. The international Angora processing industry currently buys all supplies from established producers, with Australia not currently featuring in this trade. Likewise Australia does not have a commercial processing industry that can absorb the small supplies that Australia is likely to produce for a considerable time period during the build up phase of the industry. This lack of fibre production and fibre processing capability will severely test any new Australian Angora industry. However, these constraints may be overcome with a direct linkage to a commercial processor interesting in developing a 'new' line of products based on novel sources.

There are limited technology packages and technical skills available in Australia for Angora rabbit production. However, some of this can be acquired overseas and much of the technical information could be obtained from translation into English of French and Chinese technical information currently available to these industries. However there would need to be some policy support for the establishment and expansion of the Angora rabbit industry in Australia particularly in the area of technical support. This would be particularly the case during the start up and expansion phase where there are only limited numbers of animals available and small parcels of fibre coming onto the market.

The small numbers of animals available tends to force up the price of livestock beyond the economic potential of the animal for fibre production creating a longer term problem for the industry with over-capitalisation in livestock. The small quantities of fibre produced are not large enough for commercial manufacturers to deal with from a processing perspective unless blended with fibre sourced from elsewhere that has the potential to remove the uniqueness of the fibre from a novel source.

5.5 Labour and Estimated Costing

Current French industries estimations are that each rabbit requires approximately 4 hours labour per year. Thus it is possible for one person to operate a 500 rabbit unit and times allowances for individual operations is outlined by Rougeot and Thebault (1989).

The French Angora industry prices for individual animals are based on approximately twice the value of the animal's annual fibre production for production rabbits. At current estimated French fibre prices this would value Angora rabbits at approximately AUD$150 with producing life of approximately four years. Angora rabbits on average produce approximately 1.2 kg fibre per year. The current international price for raw fibre at the farm gate is approximately AUD$20 per kg for the total fleece. Plucked French Angora is valued higher and estimated to be AUD$50 per kg but all this fibre is processed to yarn by the French Angora Rabbit Farmers Union with a net value of AUD$75 per kg of fibre in France.

The Chinese Angora industry can still operate at these historically low fibre prices because of the low cost for labour in China. The total cost of production is estimated to be AUD$16.34 per kg of fibre, and the farm gate price is AUD$25.81 for plucked fibre. The fibre price varies according to quality and is some 20% lower for clipped fibre compared to plucked fibre. China, like France operates on about 500 adult rabbits for a family or one person operator, this includes feed processing in the case of China. On the larger farms tasks are more specialized, for example, one person will manage about 200 breeding does. Reduced numbers per person is due to the time required for maintaining nesting boxes for the does. Rabbit shearing is also becoming a specialist task within the large farms.

A fibre producing rabbit consumes approximately 53 kg of feed per year and rabbit pellets are currently valued at AUD$400 per ton (based on price for meat rabbit pellets). On these figures a rabbit consumes AUD$21.20 of feed to produce 1.2 to 1.4 kg of fibre. The 2001 import price into France for Angora was AUD$23.44, returning between AUD$28.13 to 32.82 worth of fibre per animal per year. This is leaves between AUD$6.93 to 11.62 to cover other operating costs, including return on capital. The French industry can only continue to operate while it sells the fibre as yarn or finished product and at current world prices, this is likely to be the situation that will exist for Australia.

6. Conclusions and Recommendations

6.1 Conclusions

The conclusion from this study is that a small Angora rabbit industry is unlikely to be economically viable in the medium term selling unprocessed fibre on the international market based on current world prices. If Australia does enter this industry it should follow the production models from France and Finland where the fibre producers maintain ownership of the fibre to at least the yarn phase of production.

There are likely to be greater opportunities for market development into the next to skin wear and light weight fabrics where the Angora industry does not currently have a significant presence. If the industry is to develop in this direction it would necessitate the Australian industry developing local expertise in the production and manufacture of this type of product. All of this development need not take place in Australia and could be carried out in association with specialist overseas processors. The Australian industry would have to ensure that it retains ownership of both products and technologies to maintain any sort of commercial advantage into the future.

Angora production for textiles involves producing sufficient quantities of fibre to achieve a critical mass necessary to develop the fabric types in sufficient quantities to ensure an ongoing market presence. The nature of the raw product is that it is readily transported and can be bulked into lines of similar quality. As such this does allow an Angora cooperative or buyer to accumulate fleeces from a diverse range of locations and suppliers to a central processing facility.

There are no production constraints to developing an Angora industry in Australia, except at this stage, limited access to livestock. This constraint can be overcome although at a cost in time or money. The development of new fabric and garment types will also likely be expensive in the development phase and once they enter the market place will be subject to mimicry if the products are successful. This mimicry can to some extent be protected against by trade marks and designs. There will always be a requirement of yarn, fabric and garment developers to continue research and development in order to maintain a competitive advantage in the market place.

6.2 Recommendations

6.2.2 Location of Research

Ideally Angora rabbit research and development should be located within existing groups with experience in animal breeding, animal nutrition, fibre production and fibre metrology expertise. This animal production research should be coordinated with existing Angora research groups overseas. This Australian group would become the source of technical information for the developing industry. This research should be undertaken in association with the embryonic industry now developing in Australia.

6.2.3 Technical Information

Although there is some technical information available in Australia from the 1980s and in published journals, there is a need to disseminate both Chinese and French technical information. This could be aided by translating these sources into English.

6.2.4 Housing

Research could be undertaken in Australia into suitable housing that will reduce housing costs and increase the areas where the rabbits can be farmed without extensive cooling systems being required to maintain a suitable production environment. The Chinese Angora industry indicates that this is possible.

6.2.5 Disease Control

Australia needs to develop the means to control the common diseases of intensively housed rabbits. China relies heavily on vaccination programs to control disease and these vaccination programs need to be developed in Australia for an Angora industry to operate in a cost effective manner.

6.2.6 Cost Effective Fibre Harvesting

With rabbits being shorn every three months, an Australian Angora industry needs to develop cost effective wool harvesting systems. The French industry relies on Lagodendron as a plucking aid. Australia should investigate this option along with Bioclip, as well as some of the chain shearing technologies being developed within the wool industry.

6.2.7 Fibre Processing

The processing technology and developments could be undertaken by existing processing and textile research groups in Australia. This will allow for Australian ownership of the technology and the possibility of building Angora fibre processing skills in Australia as the industry grows. This could allow for the development of new products from Angora fibre and the potential of Angora to be blended with high quality Australian wool to meet premium market requirements for textiles.

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Appendix A

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