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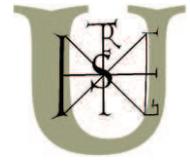
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DEVELOPMENT AND USES OF EASY CARE SHEEP

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1. INTRODUCTION

1.1 SUMMARY OF EASY CARE SHEEP

An easy care sheep is a sheep that requires minimal shepherding, sheds its fleece, is a non-selective eater, has excellent mothering ability and has a higher resistance to common diseases such as fly strike. Easy care shedding sheep tend to come in two types, they either have a hair coat that is moulted yearly similar to other mammals or they have a short wool and hair fleece which is shed in early summer. These shedding sheep account for 10% of the world's sheep population and include a large number of different breeds. In recent years there has been an increased interest by the lamb production industry for an easy care sheep. Due to the low price of wool, especially wool of dual purpose breeds, over the last thirty years and the increasing resistance of blowfly to chemical agents there has been a desire for a sheep that does not require shearing and therefore has a lower likelihood of being affected by fly strike.

In this thesis I focused on the increasing popularity of the composite easy care shedding breeds which are produced solely for meat and leather production. These breeds have been developed all over the world. Using the genetics of the Wiltshire Horn, a native English naturally shedding sheep, a number of different composites breeds have been developed such as the British Easycare and Exlana, as well as the Australian Wiltipoll. The genetics of hair sheep have also been used. Such as the Blackhead Persian, an African fat-tailed hair sheep was used in the development of the South African Dorper, and the Caribbean hair sheep were used in the development of the Katahdin, a composite breed developed in the USA. Some research has been undertaken into the traits of the easy care sheep with more needing to be performed.

The genetics of wool shedding have been researched intensely over the last 5 years with conclusions being drawn that the ability to shed wool is controlled by a single autosomal dominant gene, while the extent of shedding is a understood to be a polygenic multifactorial gene with effects such as age of animal, sex and birth type all affecting how much wool was shed from known shedders (Pollott, 2011).

The resistance of shedding breeds to fly strike have been quite well researched, with Wiltshire Horn(WH) - Merino crosses being analysed for fly strike, with results showing that over half the ¼ WH- ¾ Merino being affected by fly strike, while below 10% of ½ WH- ½ Merinos were found to be affected (Rathie et al., 1994; Tierney, 1978). Given the fact that the shedding have no or less wool means there is less areas for the blow fly to lay it's eggs and therefore less myiasis.

When it comes to worm burdens, easy care breeds tend to differ depending on their descendants. The Caribbean hair breeds have been found to have resistance to internal parasites (Gamble and Zajac,1992) and the Katahdin which is descended for the Caribbean hair breed, the Virgin Island White (also known as the St Croix) also have been found to have a resistance (Burke and Miller,2002). There has been limited research into the British composite breeds but anecdotal evidence shows that they do appear to have a lower worm burden then wool breeds however this may be more to do with the fact that they are kept at a lower stocking density than other more intensively kept sheep, which has been found to have an effect on worm burden counts (Thamsborg et al., 1996).

The maternal ability of the easy care breeds is of high priority given that in order for them to be easy care they need to be able to need limited human intervention at lambing time. In research they have found that sheep descended from more primitive breeds such as the Wiltshire horn or the native hair breeds, tend to need less help at lambing time compared to the more intensively kept sheep due to the fact they never have had (Dwyer et al., 2005). Therefore natural selection has eliminated those primitive sheep that did have problems lambing and has left those that lamb easily. It is this trait that the breeders of easy care sheep have being trying to harness with years of selective breeding and rigorous culling policies.

The main goal of this thesis is to research and review a number of journals, articles, papers and books based on my topic in order to analyse the different breeding programs of easy care sheep, their traits and future uses in the meat production industry.

1.2 THE BREEDS

In this study I mainly focused on three of the current most successful easy care composite shedding breeds, Easycare, Dorper and Katahdin, as well as two of the newer easy care composite breeds, in Australia, the Wiltipoll and in the UK, the Exlana.

1.2.1 EASYCARE

The Easycare, as shown in <u>Figure 1</u>, is a composite shedding breed from Britain which through rigorous culling and selective breeding has been developed as a low maintenance yet prolific sheep with high meat yields.

Breed Development:

1963 – In Anglesey, North Wales Iolo Owen experienced a terrible abortion storm, with his lambing percentage dropping to 60%, in his flock of circa 2000 Welsh Mountain ewes. He had no choice but to close the flock and begin breeding his own replacements. He owned a small flock of Wiltshire Horn sheep and had always been impressed at how little shepherding was needed with them during lambing as well as the fact that shearing was not necessary as they shed their wool coat in the summer, a trait of the breed which also meant they didn't need to be dipped for ectoparasites. The main problem with the Wiltshire Horn however was the horn, which

Figure 1: Easycare rams (Easycare Sheep Society, 2011)

both sexes of the breed have. So he decided to try crossing the Wiltshire Horn with the Nelson-type Welsh Mountain breed to get rid of the horns and increase the hardiness of the breed.

1965 - The breeding of the Wiltshire Horn- Welsh Mountain crosses began, which Mr Owen named "Easycare".

2001 - By this time Mr Owen had a well-established flock of 2,000 Easycare sheep. However there was an outbreak of Foot and Mouth disease in Britain in this year and all but 150 of Mr Owen's flock were culled causing a huge setback in the breeding programme. With these 150 and his son's flock of 1000 which were outside the cull zone, they were able to rebuild the breed.

2003 onwards - The Easycare Sheep Breeder's Society was formed and the breed has gone from strength to strength with them spreading all over Great Britain as well flocks as far

afield as Ireland, Holland and Germany (Easycare Sheep Breeder's Society, 2011). The Easycare breed has continued to increase its numbers going from 13,000 ewes mated in 2003 to 101,000 ewes mated in 2012 in the United Kingdom. There has also been an increase in the number of farms breeding Easycares, growing from just 29 farms in 2003 to over 300 in 2012 (EBLEX survey, 2013).

Mr Owen has always made his selection based on performance of the animal as opposed to the appearance of the sheep. In order for it to be considered an Easycare the sheep must be polled and free from wool, with a thin wool free tail (Easycare Sheep Breeder's Society, 2011).

Therefore instead of a breed standard, these are the main features of the Easycare:

- No shearing & minimal shepherding
- Average body weight for ewes of 60 kg
- Lambs- 1.8 per Ewe, reared
- Easy lambing ewes
- Good growth rate: Lambs should be 17 kg carcass weight by 12 weeks
- High meat yield
- Strong sires
- Well protected: Should be able to withstand extremes of weather
- Thrives on lowland grass

Over the last fifty years, Mr Owen has incorporated all these traits to produce the Easycare sheep we have today (Easycare Sheep Breeder's Society, 2011).

1.2.2 DORPER

The Dorper, as shown in Figure 2, is a hardy, prolific sheep renowned for its maternal instincts as well as high quality meat and leather production.

Breed Development:

1930's - The South African government came to the realization that a new breed of sheep was needed that could produce quality meat even in the most arid areas of the country. The Department of Agriculture put a lot of time and research into finding the best crossing of breeds to accomplish their requirement.

Figure 2: Dorper ram (British Dorper Society, 2012)

1940's - After trying a number of different breeds they decided on the British Dorset Horn, renowned for its prolific lambing abilities and high quality meat, with the Blackhead Persian, a fat-tailed African breed of hair sheep. Mr David Engela was the man in charge of the cross breeding programme located at Grootfontein College of Agriculture.

1950's - Mr RY Edmeads arranged a meeting of a number of farmers and thus started the Breeder's Society. It was on this occasion that, after much deliberation, they decided on Dorper for the breed name, taking the first syllable of the two breeds: **DOR**set Horn and Blackhead **PER**sian.

1960's - Some of the farmers decided to concentrate on breeding out the colour of the Dorper, preferring an all-white animal, creating the White Dorper. At first the White Dorper was separated as a new breed but later, in 1964, it was decided to form an affiliation between the two types of Dorper, given that both groups still had the same aim in the production traits of the animal. The breed standard of both the Dorper and White Dorper are outlined in the table below (Table 1). Both are now included in the Dorper Sheep Breeder's Society.

1996 - The first Dorpers were introduced to Australia via imported Dorper embryos. The new breed was at first met by hostility by the sheep breeding population of Australia but after seeing how well it adapted to the Australian environment, demand for the breed grew. It is now one of the fastest growing sheep breeds in the country, due to its growth rate, maternal qualities and easy management (SA Dorper Breeder's Society, 2014).

Today - The Dorper breed continues to go from strength to strength becoming one of the most popular breeds in South Africa and has been exported to many different countries. The Dorper genes contribute to a number of new breeds such as the Australian White and the Exlana.

Table 1: Breed standard for the Dorper (SA Dorper Breeder's Society, 2014)

General appearance	Symmetrical and well-proportioned with a calm temperament	
Head	Strong and long with triangle shape. Widely spaced eyes. Long ears are preferred. A developed horn base or small horns are the ideal on a ram. The head must be covered with short black hair in the Dorper and white hair in the White Dorper.	
Neck	Medium length, broad in the ram, long and graceful in the ewe	
Shoulder	Firm, broad and strong with good muscling in the ram	
Chest	A medium protrusion of the chest with correct foreleg placement .	
Body	Long, deep body with well sprung ribs and a broad full loin. The back should be long and straight. A dip behind the shoulders is allowed.	
Hindquarters	Long and wide rump.	
Legs	Strong pasterns and hooves not too widely split. Strong hocks without a tendency to turn in or out. Culling faults: X-legs, sickle, cow, or straight hocks.	
Reproductive organs	Male	Scrotum of the ram should not be too long and the testicles should be of equal size and not too small
	Female	Well-shaped udder
Wool	Short, loose, light mixture of hair and wool and with a natural clean underlying kemp.	
Colour & Pigmentation	Dorper	White with black confined to the head and neck. Black spots can be present on the underline of the body and on the legs are permissible. Undesirable traits: Brown hair around the eyes, pigmented teats, white under the tail or white hoofs
	White Dorper	A white sheep, fully pigmented around the eyes, under the tail, on the udder and the teats.

1.2.3 KATAHDIN

The Katahdin are a breed of hair sheep developed by Mr Michael Piel in the late 1950's in Maine, USA. He hoped to create a breed for lamb production that did not need to be sheared.

Breed Development

1950's – Mr Piel imported young African Hair sheep from the Virgin Islands. All were under 1 year old, born triplets, unrelated for many generations, and wool free with wool free siblings. The first year, in December 1957, the African hair ram lamb was used for breeding to ewes of different breeds including the Tunis, Southdown, Hampshire, Suffolk, and the African hair ewe lambs. From then on, Piel went about crossing many different breed combinations in order to develop a breed with the characteristics he desired. These are shown in the table below (Table 2). The traits most important to him were the hair coat, meat-type conformation, high fertility, and flocking instinct.

1970's - Through rigorous crossing and back crossing of his sheep, Piel finally felt he had reached his goal of a meat sheep that did not need shearing. He selected 120 ewes that he considered to be the best examples of what he was seeking and named them Katahdin after Mt Katahdin in Maine. In 1975 he imported some Wiltshire Horn to cross with the Katahdin to help improve the size of the breed. The Wiltshire Horn influence increased in the late 1970s as scale and bone improved.

1980's - They started finding that there were a lot undesirable traits of the Wiltshire Horn such as the horns, decreased prolificacy and flocking instinct as well as being flightier to handle, so in the early 1980's they started selecting against horns which then decreased the influence of the Wiltshire Horn on the Katahdin breed and strengthen the maternal traits again. From the early 1980's on, the breed's popularity began to increase. They had people buying their stock from the southern states of the USA as they found the breed were very tolerant of the heat due to their wool free state. The Breeders Association, Katahdin Hair Sheep International was started in 1985. The first flock book animal inspection was conducted in 1986 and first members of the association joined in 1987.

2000's - By 2008, there was over 75,000 Katahdin sheep registered and recorded, and in 2013, Katahdin Hair Sheep International registered more sheep than any other breed in the United States (Katahdin Hair Sheep International, 2014).

Table 2: Katahdin breed standard (Katahdin Hair Sheep International, 2014)

General appearance	A medium-sized sheep with a hair coat and an alert

	appearance; head erect and legs squarely placed.
Head	Polledness preferred, but horns and scurs are acceptable.
Eyes and Ears	Eyes wide set and ear carriage horizontal
Neck	Strong, medium length, extends into the shoulder. A ram's neck may be covered by a mane of hair
Shoulders	Shoulder blades have good width between and are level with or slightly higher than the back.
Chest	Wide and deep enough to provide plenty room for good heart and lung capacity. Slightly less width than hindquarters in females.
Back and Loin	Strong, smooth, and broad; loin long, wide, deep and well-fleshed
Abdomen	Large capacity for carrying lambs (bottom or side line should not necessarily be straight)
Rump	Wide with rounded appearance
Tail	Variable length, preferably undocked
Legs	Medium length, Sound leg structure: properly angled at hock, front legs straight, strong pasterns, straight feet free of defect. Muscles of the thigh are thick, with obvious muscularity on the inner and outer thigh, carried down to the shank.
Hair Coat	No discrimination is made as to colour on any part of the body. The coat shall preferably consist of hair rather than woolly fibres.
Defects	• Over-or undershot jaw • Very light bone structure • Weak shoulders or back • Sickle-hocked legs • Weak pasterns or splayed hooves

1.2.4 WILTIPOLL

The Wiltipoll, as seen in Figure 3, is a new breed of easy care sheep. They were developed in Kars station, New South Wales, Australia. They are a shedding composite breed developed for prime lamb production.

Development began in 1993 when the Hughes family bought Wiltshire Horn rams and using a back crossing program mated them with 1,200 Poll Merino ewes. Since then they have created a flock of complete wool shedding ewes to produce prime lamb. Their aim was to develop a polled, shedding sheep that still produce top quality lamb at a lower cost and that could thrive on poorer quality pasture.

The poll gene was introduced by crossing a purebred Wiltshire Horn ram to a polled Merino ewe. The first cross was then back crossed to a Wiltshire Horn for four generations until the fifth cross of 96.87% Wiltshire Horn blood was reached. Once this backcrossing phase was completed the interbreeding phase began. Fifth crosses that retained the poll gene were mated together to become the foundation of the Wiltipoll breed. A registered Wiltipoll sheep must not require shearing, must comply with the breed standard, as outlined in the table below (Table 3), and must carry a minimum of 96.87% Wiltshire horn blood (Australian Wiltipoll Association Inc. 1998).

Table 3: **Wiltipoll** **breed standards** **(Australian Wiltipoll Inc., 1998)** **Association**

Figure 3: Young Wiltipoll ram (Australian Wiltipoll Association Inc., 1998)

Head	Male	Depressions in the skull on horn location. One or both depressions may contain small bone knob or short keratin scur ≤ 12mm long.
	Female	Depression in the skull on horn location. One or both depressions may contain small bone knob or short keratin scur.

Face	Wide, medium length, white	
Eyes	Dark pigmentation around the outer edge of the eye encouraged.	
Ears	Long and broad	
Nose	Wide nostril, dark colouring on flesh part	
Neck	Male	Medium length and wide from back of ears and gradually enlarging in all lines to a strong full junction at the shoulder.
	Female	Lighter, more feminine
Shoulder & Chest	Wide and deep	
Back & Loin	Long and level, good covering	
Ribs	Well sprung with a full heart girth	
Legs	Forelimbs	Straight, wide apart
	Hind limbs	Meaty to a well angled hock
Skin	Pink. Gradual elimination of black ticking	
Wool Shedding	Very short wool is shed annually in the spring and early summer by both sexes. It begins on the neck, chest and shoulders. The underline and breech are wool free all year round.	

1.2.5 EXLANA

The Exlana is a newly developed breed of wool shedding sheep, first revealed in 2013. It is the brainchild of a group of eight farmers, now known as Sheep Improved Genetics Ltd (SIG), in the southwest of England who strived to develop an easier managed, lower input sheep.

The Exlana is a composite of 14 different breeds. It has been bred so that in winter it has a coat that is similar to wool but it does not exceed a length of 2cm or a weight of 1kg. They moult in the spring and can shed multiple times during the summer leaving a much shorter coat similar to hair. The aim of the Exlana is to have them shed just once in the year. In the autumn the shedding ceases and the sheep grows a thicker coat which helps them cope extremely well in all weather.

In 2006 a brainstorming day was held with twenty sheep farmers deciding what was needed to produce the perfect ewe. There was a unanimous decision to remove the need to shear their sheep and thus reduce the associated health issues and costs. They wanted to develop a breed that shed its wool therefore needing less intervention and a decreased risk of fly strike.

Semen and embryos of Katahdin and Dorper sheep were imported from Canada and South Africa. The Barbados Black Belly, a hair breed from the Caribbean was also included. These were used on a small proportion of the 3500 ewes. Wiltshire Horn and Easycare rams were used on the remaining ewes in the SIG nucleus flock. The nucleus flock of ewes were made up of Lleyn, Mules and mule variants sired by the Blue Faced Leicester as well as Berrichon, Texel and Suffolk half breeds. From this nucleus flock a group of elite animals were selected.

All ewes were fitted with an electronic tag and put into a data collection programme. This programme was able to record details of specific traits such as lambing ease based on how much if any assistance the ewe needed, milk available to the lamb at birth, mothering ability, birth weight, lamb vigour. SIG believe performance recording to be necessary in finding and selecting superior rams to provide the improved genetics for future development of the Exlana breed (Sheep Improved Genetics Ltd, 2011).

2. SURVEY OF LITERATURE

2.1 MATERIALS AND METHODS

In this thesis I have chosen to base my knowledge on several journals and articles I have collected and are listed in my references. I used a number of different journal databases including "Science Direct", "PubMed" as well as "CAB abstracts", to find the most up to date articles in order to research my topic. I examined and analysed these papers and their results which are referenced throughout the thesis where necessary.

To find out more about the Easycare and other composite shedders I have visited the web pages of the Breeds societies: Easycare sheep society: www.easycaresheep.com , British

Dorper sheep society: www.dorpersheepsociety.co.uk , Katahdin hair sheep international: http://www.katahdins.org/, Australian Wiltipoll association: http://www.wiltipoll.com/, and the Exlana breeders: http://www.sig.uk.com/. In addition I have used different websites such as Signet (http://www.signetfbc.co.uk/), the UK national genetic evaluation service for sheep, and EBLEX (http://www.eblex.org.uk/), the organization for English sheep and beef industry which have been very useful in researching the prevalence and uses of different breeds of easy care breeds in the UK.

The main goal with my work has been to analyse the breeding programs of different easy care sheep breeds and, to look at the advantages and disadvantages of breeding easy care sheep, and have tried to look at possibilities regarding uses of these sheep in the future. I have used all this information available to me in order to investigate the merits and uses of easy care sheep in today's sheep industry.

2.2 EASY CARE TRAITS

2.2.1 WOOL SHEDDING

Wool shedding is "the absolute loss of fleece, as observed macroscopically, over the whole or any significant part of the body area. This type of shedding should be distinguished from the shedding of individual fibres which may or may not be sufficiently coordinated and extensive to cause the loss of parts of the fleeces" as defined by Slee (1959). This is one of the most sought after traits of the easy care sheep breeds and the leading reason for their increased popularity.

The shedding easy care sheep can be seen as a return to the ancient sheep which always shed their wool. The Mouflon (Ovis orientalis orientalis) is one of the ancestors of the

domestic sheep and looks quite different in comparison to the sheep we are familiar with as instead of a thick wool coat, the Mouflon has a long coarse coat of hair with a short downy undercoat which is shed in late spring/early summer as is similar with other mammals e.g. horse, cow and goat. There is proof of man selecting towards a woollier sheep as far back as 6000 B.C when it was seen how the wool could be used for clothing and blankets (Chessa et al., 2009).

One of the main reasons for the shift toward a wool free sheep is the fact that one of the greatest expenses for a shepherd is the costs involved in shearing sheep yearly as well as other labour costs involved such as fly strike treatment, dagging, crutching etc. These costs outweigh the returns on the fleeces. For example in Britain in 2013 the price for the fleece of a medium wool sheep was on average £1.04 per kg wool: Suffolk = £1.05 per kg, Romney = £1.22 per kg, Welsh Mountain = £0.75 per kg (The British Wool Marketing Board, 2013). Each sheep has an average fleece weight of between 2 and 4 kg. Wool prices would need to increase to more than £2.96/kg to make wool production economic for most British farmers (White, 2011).

In the last 10 years there has been a huge amount of work and research performed to help understand the genetics behind the wool shedding process. Once the shedding is understood then the aim is to perfect a DNA test in order to be able to easily select for the genes.

Merrick et al. (2003) investigated fleece covering of Dorper and Dorper crossbreeds given the increased interest in developing a shedding meat producing sheep in New Zealand. They used a scoring system based on that of Archer et al. (1982) which was based on body regions. They used a 5 point scale with 1 being a full fleece covering and 5 being no wool at all. Weight, length and consistency were all analysed. This system enabled them to find permanent changes in the fleece of different breeds. The result of their study determined that a non-shedding breed must be back crossed repeatedly to a shedding breed in order to acquire a fully shedding sheep (Merrick et al., 2003).

In 2011, Pollott underwent a study analysing the genetic data of a group of sheep of different breeds and composite breeds known for their wool shedding ability. The purpose of the study was to find out how wool shedding was inherited, subdividing this into two categories: The capability of the sheep to shed as well as the speed of the shedding. For

this study they mated known shedding rams, in this case they used Wiltshire Horn and composite shedding breeds (Easycare, Dorper, Katahdin) with non-shedding ewes (Suffolk, Texel, Friesland, Lleyn). These were crossed and produced the first cross generation which were then subsequently backcrossed to shedding rams to produce the first backcross generation.

They implemented a number of different Mendelian analyses on the information collected from the shedders, non-shedders, first cross generation and back cross generation lambs. These included autosomal dominant, autosomal recessive, sex linked dominant and sex linked recessive. The results of these analyses concluded that there is a strong likelihood of an autosomal dominant gene being in control of wool shedding. This would signify that a sheep would only need one copy of the gene in order to shed its wool. The possible breeding results are shown in the table below (Table 4). Pollott named this suggested autosomal dominant gene the "shedding switch gene" (Pollott, 2011).

Table 4: Breeding outcome possibilities for the "shedding switch gene". SS: Shedder with 2 copies of the gene, SN: Shedder with 1 copy of the gene, NN: Non-shedder (Pollott, 2011)

Ram	Ewe	Lamb SS	Lamb SN	Lamb NN
SS	NN	0	100	0
SS	SN	50	50	0
SS	SS	100	0	0
SN	NN	0	50	50
SN	SN	25	50	25
SN	SS	50	50	0
NN	NN	0	0	100
NN	SN	0	50	50
NN	SS	0	100	0

They used a range of different quantitative analyses on the known shedders to determine the mode of inheritance for the speed and extent of wool shedding, testing both genetic and environmental factors. For this they used a 5 point wool shedding score (See Table 5), developed by Dolling et al. (1993). The result of this shedding score determined that the extent of wool shedding was a polygenic trait, therefore controlled by a number of genes. The heritability for lambs was 0.55 and a lower heritability of 0.26 in sheep of every age. They observed a huge difference in genetic potential when it came to the breed or composite breeds. They determined "the greater the proportion of genes from shedding breeds in a particular cross the greater the wool shedding score" (Pollott, 2011).

Table 5: Basic wool-shedding scoring system (Pollott, 2011)

Score	Description
5	Wool shed from all the wool-growing area (WGA)
4	Wool shed from more than 3/4 of the WGA(but some wool still present)
3	Wool shed from more than 1/2 but less than 3/4 of the WGA
2	Wool shed from less than 1/2 of the WGA but evidence of some shedding
1	No wool shed from the WGA

In their Mendelian analyses of lambs they discovered that not all shedders will shed their wools as lambs. In this study 11% did not shed. However the likelihood of there being different traits in control of shedding in lambs and in older animals is small as they discovered that the genetic correlation between lambs and older animals (above 2 years old) was 0.94 for the same trait. They found that the wool scores of lambs were affected by age (higher scores in older lambs) as shown in the figure below (Figure 4), sex (higher scores in females), type of birth (higher in singles compared with multiples), year (environmental) and genetic type. The older animals were affected by age, year and genetic type.
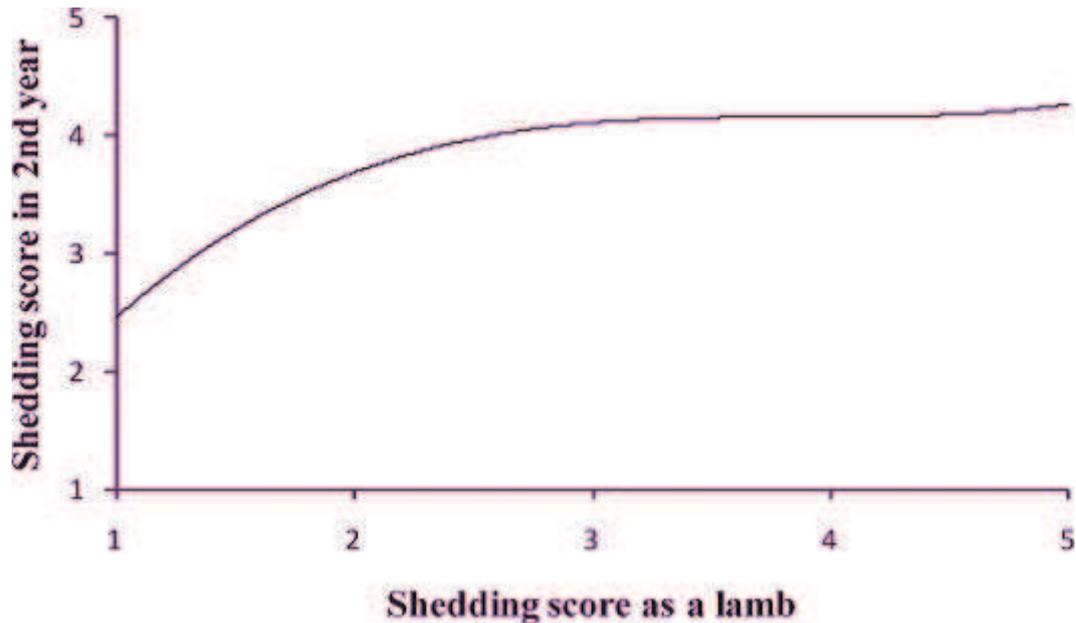
Figure 4: Correlation between shedding scores of lambs and 2 year old sheep.1 = no wool shed from the wool-growing area; 2 =wool shed from < 1/2 of the wool-growing area; 3 = wool shed from between ½ and ¾ wool-growing area; 4 = wool shed from > 3/4 of the wool-growing area; 5 = wool shed from all the wool-growing area (Pollott, 2011)

In 2013, a group of researchers performed a study on a flock of Easycare sheep to try and further understand the genetic control of wool shedding. They focused on finding the areas of the genome containing loci responsible for this wool shedding ability. Over 8 years, 2002 to 2010 they recorded data from 565 Easycare sheep. In the June of the animals second year, they were scored for wool loss, examples of which are shown in the figure below (Figure 5), using a 10 point system developed by the farmer in charge of the flock, as shown in the table below (Table 6).

Table 6: 10 point wool scoring system (Matika et al., 2013)

Description	Wool Score
Full fleece	0
Fleece loss opens the neck and tail area	1
Fleece loss widens around the neck and/or tail area	2
Remaining fleece resembles large waist coat	3
Remaining fleece resembles waist coat	4

Remaining fleece resembles small waist coat	5
A band of fleece remains on the back	6
Fleece tufts remain on gigot	7
Fleece tufts remain on shoulder and/or tail	8
Clean	9

In order to further understand the genetics involved in wool shedding they performed three different genetic analyses. The first of which was a heritability analysis. They used a number of different model types in order to establish the heritability of the shedding. In the linear mixed model they used results of the shedding scores as a continuous trait resulting in a high heritability of on average 0.8., higher than the results Pollott came to in his 2011 study. The second genetic analyses underwent was a Bayesian segregation analysis. This was used to examine the "shedding switch gene" (Pollott, 2011) hypothesis. Using the Bayes factors, they concluded that it was strongly likely that there is a locus responsible in the majority of wool shedding, and that it is probably dominant.

Figure 5: Wool Score 3, 5 and 7, respectively (Matika et al., 2013)

They then performed a genome wide association study (GWAS) in order to map out the areas of the genome responsible for wool shedding. For this they used 200 animals, with wool scores ranging from 0 to 9. They were able to estimate the response of each locus to dominance given that they were using a wide variety of shedders. They discovered two main areas of the genome where it is most likely the wool shedding mutation occurs.

They did a quantitative survey of the trend of wool loss on the shedding Easycare, finding that in the animal with an intermediate shedding score, the wool was must likely to be retained on the back and hindquarters of the sheep, which they found to be consistent with moulting pattern of other species, beginning on the belly and moving across the body in a wave like pattern (Plikus and Chuong, 2008). They came to the conclusion that more works needs to be done in order for us to completely understand the genetics of wool shedding (Matika et al., 2013).

2.2.2 FLY STRIKE RESISTANCE

Fly strike can cause a large amount of pain and suffering in a sheep if left. Given that easy care shedding sheep have no or less wool than other breeds, especially baldness of the belly, breech, and legs means they tend to be less likely to suffer from myiasis in warm summer months as there is less areas on the sheep for the blowfly to lay its eggs. The blowfly strike causes major problems for shepherds, it is both expensive and time consuming.

Shedding breeds have been proven to be more resistant to fly strike due to the fact they shed their wool (Litherland et al., 1992). With increased insecticide resistance in the blowfly (Clark and Mackenzie, 1987) and raised welfare concerns over the practices of mulesing and docking (Lee and Fisher, 2007) shepherds are eager to find another way to solve the huge problem with fly strike in sheep. In recent years there have been many studies performed investigating the use of shedding sheep genes to decrease the risk of blowfly strike.

 Litherland et al. (1992) performed a study comparing shedding sheep breeds (Wiltshire Horn) with non-shedding sheep (Merino, Romney) and their resistance to fly strike. Thirty lambs of each breed were used and checked every third day for signs of fly strike and checked once a month for dags (soiled matted wool on the hindquarters of a sheep) which were then scored on a 5 point scale with 5 having the most amount of dags (See Figure 6). They concluded that the Wiltshire Horn are not as attractive to the blowfly given they have less wool and a low dag score. In their data they found that the Wiltshire Horn had the lowest number of dags of all the breeds tested (Litherland et al., 1992).

In 1994, Rathie et al. investigated the effect of blowfly strike in Wiltshire Horn- Merino crossbreeds. In their study an average of 50.4% of ¼ Wiltshire Horn -¾ Merino were affected by breech strike in comparison with only 8.45% of ½ Wiltshire Horn -½ Merino. They found that an increase in breech bareness was observed when Wiltshire Horn was increased in the crossings. They also found that the more Wiltshire Horn genes in the animal the less likely it was to be affected by blowfly (Rathie et al, 1994).
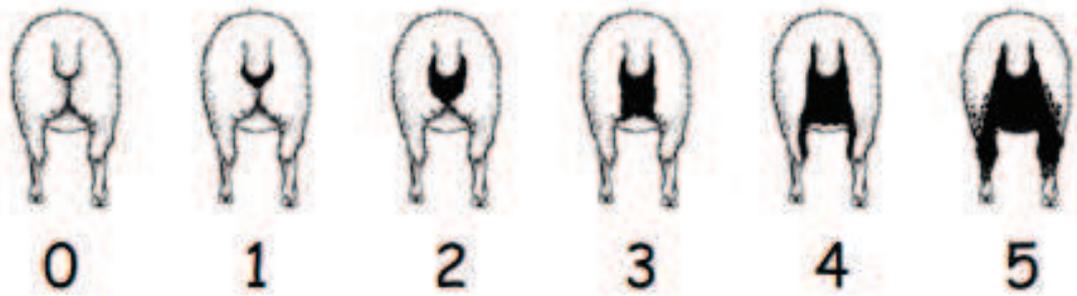
Figure 6: Dag scoring system. 0 = No dags, 5 = Highest number of dags (Young, 2006)

In 1997, Scobie proposed a genetic resolution to the problem of fly strike of the breech by breeding animals with a breech free of wool and a shorter tail (Scobie, 1997). A flock was bred with these goals in mind – wool free head and legs as well as breech and belly (Scobie et al, 1999). They then underwent a series of experiments to ascertain whether their hypothesis of a wool free breech would decrease risk of fly strike. They developed a scoring system for breech bareness with 1 being the woolliest and 5 being the barest (See Figure 7). For the study they used a number of different breeds of both shedding (Wiltshire Horn) and non-shedding. In their experiments no animal with a 4 or 5 breech score showed any sign of fly strike as shown in Figure 8. Most of the animals scoring 4 or 5 breech bareness were the Wiltshire Horn (Scobie, 2007).

Figure 7: Breech Bareness Score. 1= Most woolly, 5 = Barest (Walker and Young, 1996)

In a 2008 study two composite flocks were inspected to see the correlation between breech bareness and the dagginess of the animal. The dag score method (Larsen et al., 1994) was on a 5 point scale with 1 being no dags and 5 being the most amounts of dags. Of the two flocks, one of them was a cross of Perrendale with Wiltshire Horn as well as a White Dorper ram. The other was a Romney flock crossed with East Friesian and Texel. The results of this study found that the Perrendale/Wiltshire Horn composite flock had a higher heritability for breech bareness than the Romney flock. It was found that the White Dorper ram increased this notably. They found that a barer breech had a lower dag score (Scobie et al, 2008).
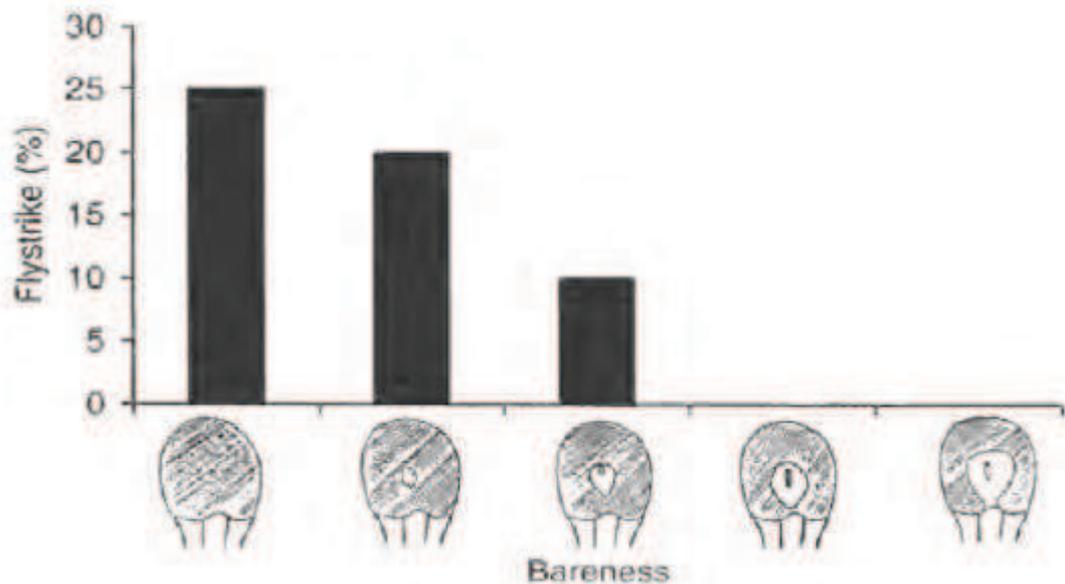
Figure 8: Percentage sheep affected by fly strike according to breech bareness score (Scobie, 2007)

2.2.3 FOOT ROT RESISTANCE

Anecdotal evidence would suggest that easy care breeds have a resistance to foot rot however this has not been proven. Resistance to foot rot has been shown to be a heritable trait with wool breeds such as Merino being more susceptible to foot rot than British breeds like Dorset Horn, Romney (Emery et al., 1984).

In one study in 2007, they tested different breeds including Dorset, hair sheep such as St Croix and composite breeds such as ¾ Dorper and Katahdin, to see if there are differences between the breeds to virulent foot rot including exposure as well as response to treatment. They observed only slight differences between the breeds (Burke and Parker, 2007).

The fact that producers of easy care sheep have found less foot rot problems than other breeds may be due to the fact that they practice a lower stocking density, as an example, Mr Owen practices a stocking density of 2 ewes per acre/ 5 per hectare with his Easycare sheep (Easycare Sheep Society, 2011). A study in 2004 investigating lameness in sheep found that when stocking sheep, greater than 8 sheep per hectare had a higher prevalence of lameness and inter digital dermatitis than sheep stocked at less than 8 per hectare (Kaler and Green, 2009).

2.2.4 NEMATODE RESISTANCE

There has been a huge interest in genetic resistance of sheep to internal parasites in recent years to which easy care sheep have been central to. There have been several studies documenting the resistance of hair sheep to nematodes (Baker et al., 1998; Wildeus and Zajac, 2005). The Caribbean hair breeds in particular (Gamble and Zajac, 1992) as historically they would have been exposed to more gastrointestinal parasitic infections than some of the African hair breeds such as the Blackhead Persian (Vanimisetti et al., 2004).

In 2002, a study was performed investigating the parasitic resistance of Dorper, Katahdin and St Croix lambs post weaning. For this they used both natural and artificial infection of the lambs with Haemonchus contortus. They underwent 3 experimental infections, first during the winter grazing, secondly during the summer grazing and thirdly an artificial infection. The result of their investigations showed that when the lambs had low worm burdens the resistance was similar between the Dorper and the other breeds however as the worm burdens increased, differences developed between the breeds with St. Croix being the most resistant, followed by Katahdin and then Dorper (Burke and Miller, 2002).

In one study they compared the resistance of hair sheep with that of wool sheep to investigate if there is in fact a difference in the two groups. The hair sheep used in this study were crosses between VIW (Virgin Island Whites) and Barbados Blackbelly sheep and the wool sheep were composites of Dorset, Rambouillet and Finnish Landrace. Faecal egg counts (FEC) and packed cell volume (PCV) were tested every week and the results correlated. They discovered there was a major difference between the hair sheep and the wool sheep, with the hair sheep having a much lower FEC, as shown in Figure 9 and a higher PCV indicating that they are more resistant to nematode infection (Notter et al., 2003).
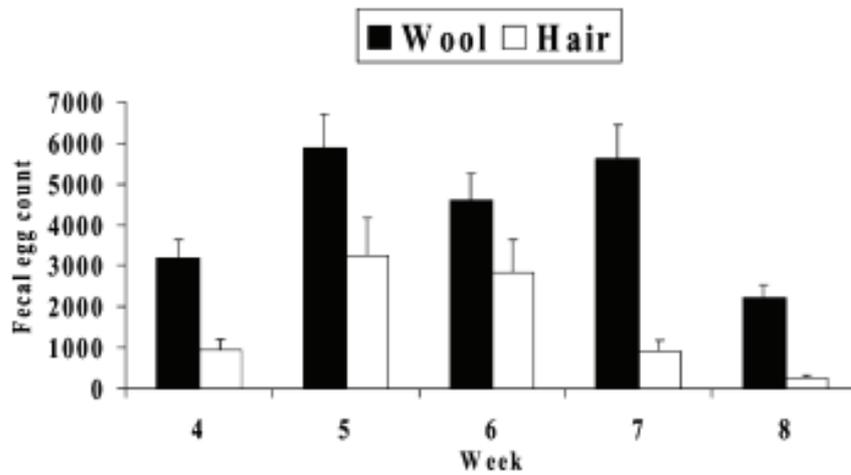
Figure 9: Faecal egg count (measured in eggs per gram) of Hair and Wool lambs following nematode infection (H. contortus) over a period of 8 weeks (Notter et al., 2003)

In another study, Vanimisetti et al. (2004), investigated over a 3 year period the resistance of composite hair breeds to Haemonchus contortus. Breeds included were Katahdin, Dorper crosses, Dorset crosses and pure hair sheep crosses of St Croix and Barbados Blackbelly. They investigated both natural and artificial infections. For the artificial, the ewe lambs were dewormed with levamisole and 2 to 4 days later dosed with 10,000 H. contortus larvae, while they use the male lambs for the natural infection, deworming them at the same time as the ewe lambs and then returning them to pasture. They found that the Katahdin showed a consistently higher resistance to the parasite than the Dorper or the Dorset, which given the fact that the Katahdin is descended from the Caribbean hair breeds is in keeping with other reports of resistance in the breeds (Gamble and Zajac, 1992; Burke and Miller, 2002). In the case of the Dorper they discovered that they had a similar if not lower resistance to parasitic infection than the Dorset, showing a higher FEC in the artificial infection. As observed in the study, the fact that the Dorper is descended from the Blackhead Persian which originated from an arid environment that would not have been exposed to a large amount of internal parasites, and therefore less likely in developing a resistance to them. They did find that the Dorper maintained a higher PCV level to the Dorset, which suggest that although the Dorper is not resistant to infection it may have resilience when infected (Vanimisetti et al., 2004).

In the case of Wiltshire Horn composite breeds, there has not been much evidence of resistance to parasites. In the case of the Easycare breed, they have found low worm burdens. Also in the Wiltipoll breed they have found low worm burdens in comparison to other breeds and don't routinely drench their flocks unless there are signs of parasitic infection such as if they are thinner than the others or scouring which is usually around 10 per 300 ewes (Australian Wiltipoll Association Inc., 1998). This could be due to lower stocking density of theses breeds. In Ireland the average stocking rate is 10 -14 ewes per hectare (Lynch and Hanrahan, 2010).

 In one study they investigated the effect of increasing the stocking rate over 2 years. They used three different stocking rates, low (9 ewes per hectare), medium (13 ewes per hectare) and high (17 ewes per hectare). They found that the higher the stocking density the higher the level of infection as shown in the figure below (Figure 10). Both years of the study showed that the higher the stocking density the higher the number of larvae in the pasture (Thamsborg et al., 1996).
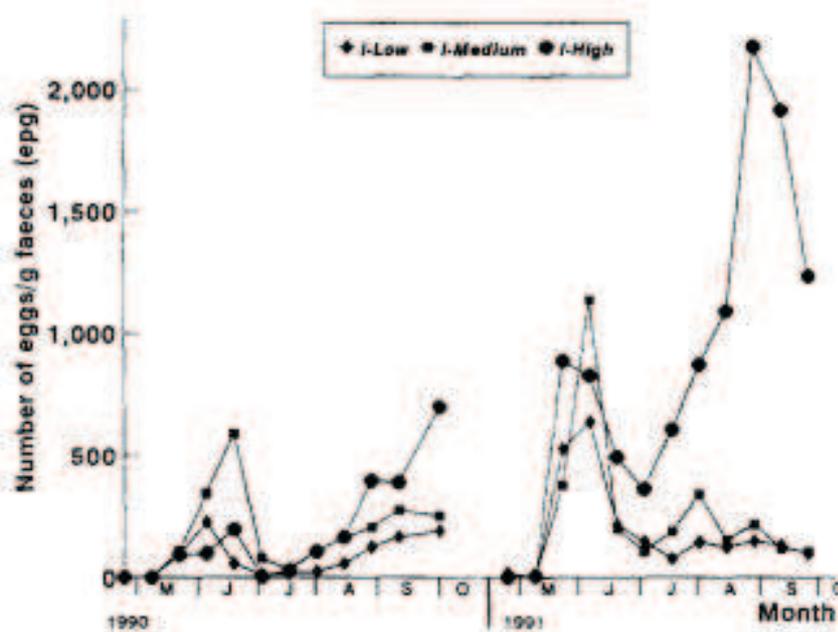
Figure 10: Mean trichostrongyle FEC of lambs in two year study. I-low= Infected low stocking rate pasture (9 ewes per hectare), I-medium= Infected medium stocking rate pasture (13 ewes per hectare), I-high= Infected high stocking rate pasture (17 ewes per hectare) (Thamsborg et al, 1996)

2.2.5 MOTHERING ABILITY

One of the major opportunities for composite shedders in today's breeding is as a way to add a maternal ewe line to a flock. Both the Caribbean hair sheep as well as the Wiltshire horn are known for their mothering abilities and high fertility (Dwyer, 2007).

In one study they found that there is a huge difference in mothering ability between sheep breeds with the more primitive breeds like the Caribbean hair breeds and the Wiltshire Horn showing a higher level of mothering care (Dwyer, 2007). This study also showed that sheep kept in a low input production system such as the Easycare, will form a stronger bond between ewe and lamb given the fact they have space to go and find seclusion and privacy which instinct tells them to do, an option not available to them in more intensive indoor systems (Poindron et al., 1997). There is also a decreased risk of mis-mothering and stealing of lambs given the increased space per ewe (Dwyer, 2007). The ewe-lamb bond can develop better in these systems also given the fact they are not disturbed or moved by the farmer.

Murphy et al. (2004) found that a ewe should be left at the site of lambing for at least 6 hours after birth in order it develop a proper bond with her lamb (Murphy et al., 1994). A good indicator of how well the ewe and lamb have bonded is the Maternal behaviour score, which is shown in <u>Table 7</u>, it is calculated on the basis of how the ewe responded to her lamb being picked up by the shepherd (O'Connor et al., 1985; Everett-Hincks et al., 2008).

Table 7: Maternal Behaviour Score (O'Connor et al., 1985)

1	Ewe flees from shepherd, shows no interest in the lamb and doesn't return.
2	Ewe retreats further than 10 m but comes back to her lamb as the shepherd leaves them.
3	Ewe retreats to such a distance that tag identification is difficult (>5 m).
4	Ewe retreats but stays within 5 m.
5	Ewe stays close to the shepherd during handling of her lamb.

In one study they found that in breeds that need less human intervention at lambing is because they are derived from breeds that never have had intervention at lambing. While it's the sheep bred in more intensive high input systems tend to need more human intervention (Dwyer et al., 2005).

3. CONCLUSION

3.1 CURRENT USES OF EASY CARE SHEEP

For many years now the sheep industry has been looking for ways to decrease expenses and labour while still being profitable. The development world wide of different breeds of easy care sheep have helped to achieve this goal. The costs and labour involved in wool and fly strike make the idea of a low input easy care shedding sheep highly desirable to a farmer, and is one of the main reasons that these breeds are going from strength to strength, breeds such as the Katahdin, which in 2013, registered more sheep than any other breed in the United States (Katahdin Hair Sheep International, 2014).

These easy care sheep are perfect for the extensive pastures they were bred for as they are hardy animals. As shown earlier sheep kept on extensive systems with a lower stocking rate are likely to have a decreased risk of foot rot (Kaler and Green, 2009) and a lower worm burden (Thamsborg et al., 1996). Those bred from the Caribbean hair breeds, like the Katahdin, have a resistance to nematodes.. This makes their genetics very important in the further development and work of sheep resistant to nematodes (Notter et al., 2003).

The fact easy care sheep have such a little amount of wool there is a huge decrease in the chances of them developing fly strike (Rathie et al., 1994; Tierney, 1978). The genetics of easy care shedding sheep have been used by Scobie to help him develop a breed of Merino which is still dual purpose as it has been bred to have less wool on the breech and belly, some of the major areas that the blowfly strikes (Scobie et al, 2002).

The shedding composite breed's maternal instinct and ease at lambing is extremely important as they have been developed to not require assistance during the birth. Any of the ewes that did require assistance are rigorously culled, which has helped in the development of the easy care sheep.

There are many merits to the use of easy care sheep and given the wide array of breeds developed the farmer can choose which traits he finds most important whether its parasite resistance, mothering ability or decreased risk of fly strike. I feel that there is a place for these sheep in the lamb production industry in order to help reduce labour costs yet still produce quality lamb.

3.2 THE FUTURE

A lot of work has been done in the development of easy care sheep but there is still more to do. The "shedding switch gene" (Pollott, 2011) discovery will hopefully mean huge changes in the genetic testing of the shedding composite sheep. Such a test has not yet been developed. The need for a genetic test is high as it will help to identify lambs that do not shed but that do carry the gene and to identify whether an animal is heterozygous or homozygous for the shedding gene (Pollott, 2011).

Signet have established some and are aiming to develop further breeding values (EBV) for a wider range of performance recorded traits and indexes with a higher emphasis on maternal performance and shedding for easy care sheep. This will shift the focus of breed selection from muscle gain and fat depth etc, used when looking for terminal sires, to include more economically relevant traits alongside the established terminal traits of importance. Data on the traits of interest will be recorded across a range of flocks.

The Wiltshire Horn performance-recording group was established in the last ten years, creating estimated breeding values (EBVs) that would prove extremely useful to sheep farmers considering introducing wool shedding to their flocks. They use a wool scoring system (see Table 5) in their performance reviews. The wool score is performed on young ewes coming out of their first winter. This is to decrease the chance of non-genetic causes interfering with the results as body condition score and number of lambs can change the timing of shedding in older ewes. The aim is to collect the shedding scores when half of the sheep are shedding. There is major differences in genetics between the easy care shedding composite breeds and the native shedding breeds such as the Wiltshire Horn, therefore further work needs to be performed and data collected to perfect their EBVs.

The topic of easy care sheep has become a constant part of the annual meetings of EBLEX in Britain as well as Sheep Ireland in Ireland over the last ten years, showing that the interest in easy care sheep is most definitely on the rise.

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