Dohne Merino sheep production: Progress, Challenges and Prospects

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Abstract

Sheep production is multi-dimensional in utility, promoting global human and economic growth and, most notably, food security (dietary protein source for humans). The Dohne Merino (DM) breed and its unique features, such as adaptation, lambing rate, survival rate, maternal quality, wool traits, and meat quality, have earned international recognition and acceptance as one of the best among sheep breeds. Presently, this dual-purpose breed is in high demand by both major and minor sheep-producing countries by both commercial and smallholder farmers. It can be assumed and projected that by 2030, Dohne merino will have taken a more significant percentage of the genetic composition of all the sheep breeds in the World. This could play a huge role in the national development goal of food security for all by 2030 adopted by South Africa from WHO international development plans. Therefore, this paper aimed to highlight the unique features of Dohne merino and its prospect in South Africa and the World's food security by 2030.

Keywords: Sheep production; Dohne Merino; food security.

Background

Sheep (*Ovis aries*) are among the first animals domesticated around 9000 B.C. (Zygoyiannis, 2006). Most present-day sheep breeds such as Dorper, Dohne Merino, Suffolk, Lincoln, Corriedale (Mcmanus *et al*., 2014), SA Mutton Merino, Hampshire, South down, Karakul, and Dorset Horn, among others in the World, emanated from Western Asia. Where domestication began, some of the original breeds were: The bighorn, the Argali, the Urial found in Asia, and Mouflon in Europe (Ryder, 2007; Lv *et al*., 2015). Sheep production has spread and has been established in far-reaching geographical regions. This is due to their adaptability to relatively poor-nutrient diets, tolerance to extreme climate conditions, and ease of management (Kijas and Townley, 2009). Sheep adaptability can also be attributed to their petite frame and ability to utilize forbs, buds, twigs, dry leaves, fruit, and flowers of woody plants during drought coupled with low water requirements (Hinch, 2017). In addition, sheep have low feed requirements, higher reproductive rates, and are small enough to be consumed by an average rural family in a day or two; hence, no refrigeration facilities are needed (Tibbo, 2006).

Sheep produce meat, milk, fibre, and hides, while dung from sheep generates economic relevance due to its use in organic farming. Over 60 % of the area is prone to drought and famine in arid and semi-arid regions. The rearing of sheep in such areas can contribute towards risk reduction in the economy by providing an alternative to crop farming (Shinde and Sejian, 2013). Sheep production, however, has its constraints, which include susceptibility to diseases and gastrointestinal parasites (Sejian *et al*., 2012; Begg *et al*., 2017). Although sheep thrive under poor-quality natural rangelands, productivity usually suffers when optimum nutrition requirements are not met (Ben Salem, 2008).

Nutrition profoundly influences sheep's ability to produce quality mutton and wool (Xu *et al*., 2017). Hoffman et al. (2016) reported vital increases in growth performance when sheep are fed a diet with high protein levels. A well-balanced ration is key to boosting sheep's immune system to resist parasites without compromising animal performance. However, this is not always the case with smallholder farmers in rural communities who depend on natural pastures since sheep pick up gastrointestinal parasites and other disease-causing parasites because of their feeding habits, such as grazing near the ground. Nevertheless, sheep production is considered a major meat industry in the future (for both smallholder and commercial farmers) because of its efficiency of mutton production from poor nutrient diets, the rate of reproduction, and adaptability to climate change (Gowane *et al*., 2017).

1. Sheep production: Origin, domestication, and migration into Africa

Sheep (Ovis aries) are believed to have been among the first animals to be domesticated. They played a significant role in food and material production in the human community and have spread globally following human movements (Colledge *et al*., 2005; Chessa *et al*., 2009). Table 1 shows sheep breeds, their primary purpose, and where they are found worldwide. Sheep domestication probably started during the hunting era before the agricultural revolution. Most of the present-day sheep emanated from Western Asia, where domestication of sheep began. The Urial sheep in central Asia, Iran, and China is regarded as the ancestor of most of today's domestic sheep (Scherf, 2000; Lv *et al*., 2015). Also, the wool sheep present in Africa and Asia are regarded as descendants of the Urial breed. Pieces of information from archaeological and molecular data show that sheep's domestication commenced in the Fertile Crescent region spanning Central Anatolia to the north of the Zagros Mountains (Tapio *et al*., 2006; Zeder, 2008). Reports from the Food and Agriculture Organization–Domestic Animal Diversity (FAO, 2015) database showed that, out of 1311 breeds of sheep around the World, 758 are found in Europe and Caucasus, followed by Asia and Africa with 318 and 122 breeds, respectively. Asia has nearly half of the World's sheep population of about 1.2 billion, with a high percentage in China, India, and Iran (Pichler *et al*., 2017).

In Africa, sheep are classified morphologically into four types: thin-tailed with hair, thin-tailed with wool, fat-tailed, and fat-rumpled (Epstein, 1971; Soma *et al*., 2012). Archaeological records showed that the migration of sheep to the southern part of Africa occurred about 2000 years ago (Plug and Badenhorst 2001). However, there were 122 recognized sheep breeds in Africa as of the year 2000 (Taberlet *et al*., 2008). Some notable breeds of sheep available globally are presented in Table 1 below; however, the principal aim is to focus on the most popular breed in South Africa, the Dohne Merino sheep.

Table 1: Breeds of sheep, purpose rearing, and location in the World.

Type of Breed	Function/purpose	Location	References
Merino	Wool	Originated in Spain, it has spread to Australia, New Zealand, China, South Africa	(Cloete *et al*., 2012)
Dorper	Meat	South Africa	(Snyman, 2014)
Karakul	Meat	Central Asia, Turkey	(Snyman, 2014)
Red Massai	Meat	East Africa, especially Kenya, Uganda, Tanzania	(Konig *et al*., 2017)
Barbados black belly	Meat	Caribbean region, in Peru and Mexico	(USEPA, 2009)
East Friesian	Milk and meat	Germany, Holand, New Zealand, Sweden	(David *et al*., 2017)
Fat-tailed Awassi	Milk and meat	South-west Asia, Iraq, Syria, Jordan, Israel, Lebanon	(David *et al*., 2017)
Asaf breed	Milk and meat	Israel	(David *et al*., 2017)
Chios breed	Milk and milk	Greece	(David *et al*., 2017)
Soviet Merino	Fine	Russia, Siberia	(Deniskova *et al*., 2018)
Poll Dorset	Meat	Australia	(Begg *et al*., 2017)
Suffolk	Meat	United Kingdom (Origin), Presence notable in all European countries and beyond	(Villagra-Blanca *et al*., 2015)
Texel	Meat	Netherlands (Origin), famous in Australia, Europe, New Zealand,	(Carneiro *et al*., 2010)

		United States, and Uruguay	
Hampshire	Meat	England and many parts of Europe	(Carneiro *et al*., 2010)
Corriedale	Wool and meat	Originated from New Zealand but are found in Australia, South America.	(Carneiro *et al*., 2010)
South African Mutton Merino (German Merino)	Wool and meat	South Africa	(Achaeampong-boateng *et al*., 2017)
Dohne Merino	Meat and wool	South Africa, Australia, New Zealand, South America.	(Naidoo *et al*., 2016)
Turkidale	Wool and meat	Tuki tuki in New Zealand and Australia	(Jawasreh *et al*., 2018)
Superfine wool	Wool	Higher rainfall area of Australia (Northern, Central, and Southern Tableland of New South Wales, parts of Victoria, and most Tasmania)	(Li *et al*., 2016)
Dormer	Meat	South Africa	(Chulayo and Muchenje, 2013)
Black-head Persia	Meat and leather	South Africa, Somalia, and Saudi Arabia	(Chulayo and Muchenje, 2013)
West Africa Dwarf	Meat	West and Central Africa (Senegal to Chand, Gabon, Nigeria, Cameroon, and the Republic of the Congo	(Jiwuba *et al*., 2017)
Criollo	meat	Central America	(Ocampo *et al*., 2017)
Tefrom	Wool and meat	New Zealand	(Diaz *et al*., 2015)
Waziri	Wool and meat	Waziristan area and Bannu district in NWF Province in Pakistan	(Ahmed *et al*., 2017)
Van Rooy	Meat and good leather	South Africa, especially in Bushveld part of Gauteng province	(Molotsi *et al*., 2017)
Polwarth	Wool and meat	Originated from Australia but they are present in	(Salehiam *et al*., 2015)

		New Zealand and South American	
Nilgiri	Wool	Nilgiri district of Tamil Nadu State in India	(Saxena *et al*., 2015)

1.1 Global Sheep Production Trends

The population of sheep in the World in 1961 was 994 million, and by 2000 it grew to about 1.060 billion (FAO, 2009) with a percentage increase of 6.22. However, during this period, the African continent recorded the highest percentage increase of 82.3, followed by the Asian continent with 78.3 in the same period. This translated to African and Asian countries having a meaningful increase in sheep meat and milk production. The world sheep population in Table 2 indicates an increase (10.7%) from 1.06 billion in 2000 to 1.17 billion in 2013 (FAO, 2013). Asia accounts for over 40 % of the World's sheep population among the continents, followed by Africa with 27.1%. In the same period, only Asia and Africa experienced an increase in the sheep population. At the same time, the other nations witnessed a decline in sheep number, with Oceania (Australia and New Zealand) recording the highest (-33.9%) (Cardellino, 2015).

Table 1: Sheep population in the World between 2000 and 2013

Country	**Sheep population (heads)**			
	2000	**2013**	**Change (%)**	**Global (%)**
Asia	414 248 800	526 590 642	27.1	44.9
Africa	246 505 821	325 338 760	32	27.7
Oceania	160 828 340	106 351 147	-33.9	9.07
Europe	146 694 240	129 650 518	-11.6	11.1
EU (28)	123 202 970	97 553 758	-20.8	8.32
America	90 805 157	84 902 123	-6.50	7.24
World	1 059 082 358	1 172 833 190	10.7	100

Source:(FAO, 2013)

From 2013 to 2016, the world sheep population shifted from 1.172 million to 1.173 million (0.044 % increase within 3 years), with improvement in most nations compared to the stats data from 2000 to 2013 (Table 3). The highest increment was reported in Africa (42.6 %), followed by Asia (23.5), while Europe recorded the most significant decline of -66.7% within this period.

Table 3: Sheep population in the World between 2013 and 2016

	Sheep population (heads)			
Country	**2013**	**2016**	**Change%**	**Global %**
Asia	414248800	511711463	23.5	43.6
Africa	246505821	351579045	42.6	30
Europe	146694240	131059072	-10.7	66.7
America	90805157	83849797	-7.7	7.1
Oceania	160828340	95154412	-40.83	8.1
World	1059082358	1173353790		

As of 2016, China has the largest sheep population in Asia, with 15.8% of the World's total sheep population and 35.1% of the entire Asia sheep population. It is followed by India, Iran, Pakistan, and Turkey (FAO 2013). In Africa, Sudan, Nigeria, Ethiopia, and Algeria hold the bulk of sheep. From 2000 - 2013, the sheep population in Ethiopia increased by 142 %, Nigeria by 50 %, Algeria by 44.8%, and Sudan by 13.9% (FAO 2013). In the Americas, the top five countries with the largest sheep population are Brazil, Argentina, Peru, Bolivia, and Mexico, while in Europe, the United Kingdom, Russian Federation, Spain, Greece, Romania, and France hold the largest number of sheep (FAO 2013; Skapetas and Kalaitzzidou, 2017).

2. The Dohne Merino Sheep

Dohne Merino is a synthetic dual-purpose (wool and meat) South African sheep bred in 1939 locally in Eastern Cape, Stutterheim, by the South African Department of Agriculture. The breed is a product of a cross between South African Merino ewes and German Mutton Merino rams (Casey and Wilson, 2016). The limitation to Merino sheep farming was low fertility, high mortality, susceptibility to fleece rot, and blowflies because of the excessive skin fold. In addition, the grazing habits of Merino are of intensive management that leads to high input costs, which affects farm profitability. The hardy and adaptable breed was developed to meet the quest for a more versatile and significant income-generating animal with high fecundity (Swanepoel, 2006; Van Wyk, 2011). Initially, it was bred for semi-intensive farming in the Eastern Cape grassland regions, but its capability to thrive under various conditions resulted in the breed's fame and expansion to other provinces in South Africa and beyond (Cloete *et al*., 1998; Van Wyk *et al*., 2008; Van Wyk, 2011). The Dohne Merino is one of the leading woolled sheep breeds in South Africa. Because of its spread in the country of origin, Dohne

Merino sheep have also been exported to other prominent sheep-producing countries such as Australia, New Zealand, Peru, Uruguay, Argentina, China, and Russia.

The Dohne Merino sheep are mainly white, with rams and ewes usually polled. The lambs grow relatively faster and reach 25 to 35 kg live weight within 100 days of age. The average live body weight of the mature Dohne Merino ewes is between 50 and 65 kg, while the mature ram's average live weight varies from 80 to 100 kilograms (Cloete and Cloete, 2014). The fleece production of this breed is between 3.5 and 5 kg per year (Mvinjelwa *et al*., 2014), while their wool has an average fibre diameter of 17 to 21 microns. The plain-bodied, open-faced, and breech-free outlook of Dohne Merino (DM) improves reproduction efficiency and reduces flystrike/glass seed issues. This also attracts powerful welfare and animal activist lobbyists who intend to undermine and control livestock production globally.

Dohne Merino (DM) has developed a unique combination of adaptive traits that best respond to pressures from the local environment (Peters *et al*., 2010). This includes disease tolerance, nutrient availability and quality fluctuation, extreme and harsh climate conditions, the ability to survive and reproduce for a long time, and sometimes poor quality feed (Nsoso *et al*., 2004; Sejian *et al*., 2010). Burgess (2016) reported parasite tolerance and resistance of Dohne Merino. Therefore, farming with livestock such as Dohne Merino sheep that is robust and adaptable to harsh environments is vital in developing countries, especially semi-arid and arid environments.

2.1 Production Systems for Dohne merino sheep

Sheep production systems vary from one continent to another depending on climate, feed availability, customs, parasites, diseases, market information, technical capacity, and tradition of the people (Dagnew *et al*., 2017). The most common production systems worldwide for sheep are extensive (meat and milk), intensive (dairy), and traditional pastoralism. These production systems can offer quality welfare for sheep provided that good quality management practices such as veterinary care feed supplementation are provided (Morris, 2017).

The Dohne Merino was developed to cover the gap in semi-intensive farming in the sour veld in Eastern Cape, South Africa. Due to its ability to adapt to divergent weather conditions, it is also suitable for traditional pastoralism, as this production system is associated with risks of unpredictable climate change. Smallholder farmers have adopted Dohne Merino, which can produce mutton, milk, and wool with little or no supplementation (Mwanda *et al*., 2020).

The major challenge in an extensive sheep production system is the lower inputs with high welfare risks. Hanekom (2010) observed that an intensive or extensive production system has no effect on the post-mortem muscle pH and temperature, drip loss and cooking loss, ribeye area, area, muscle weight, and carcass yield of Dohne Merino sheep. The overall physical attributes of the muscles of the lamb carcass were unaffected by the production system. No statistical difference exists between the intensive and extensive production systems on the sensory quality (flavour, aroma, initial and sustained bite, first bite, residue) and instrumental tenderness. An extensive production system produces larger lambs with heavier carcasses, while lambs have a higher dressing percentage under intensive production. However, no statistical effect was recorded in both instances (De Brito *et al*., 2017).

In a study carried out by Nowers et al. (2017) on the production system, it was observed that there is no statistical effect found in the weight gain between Dohne Merino sheep kraaled (between 16:00hr and 8:00hr) and Dohne Merino that was unrestricted. Likewise, the two groups greasy fleece weight, fibre diameter, and clean yield percentage were similar. Therefore, the type of production system for Dohne Merino did not matter as it would express its genetic potential.

The intensive sheep production system has significant capital, land (minimum of 118 hectares), and substantial hired labour. It also involves innovations, technology, and better management practices. These include selection for better performance and higher reproductive traits, multiple lambing per annum system, artificial mating practices, hormones to induce multiple offspring, monitoring of pregnant ewes, harmonized breeding system, and controlled mating. High levels of expertise and preparation are involved. Also, nutritional up-grading, the season of the year, breeding, stage, and health condition of the sheep are considered (Taye *et al*., 2016).

Early weaning of lambs in the intensive production system can lead to reduced lamb growth rates and stress as they will be separated from their mothers. According to Cloete and Cloete (2015), the total lamb production per ewe lambed of Dohne ewes was higher than the mean production of Merinos by 18.5% under intensive production. Therefore, it can be concluded that the Dohne Merino has clear advantages for growth, lamb survival, and mature size over other sheep breeds.

2.2 Reproductive performance of Dohne merino sheep

2.2.1 Lambing rate

Under intensive sheep production systems, the breeding of Dohne Merino allows more than one lambing opportunity per year (Gaunt *et al*., 2010). This causes the production of Dohne Merino to have the edge over others in that it can produce lambs when sheep products are usually inadequate, resulting in higher income for the producers (Fisher, 2001; De-Nicolo, 2007). A higher reproductive rate in the Dohne Merino was observed by Graham and White (2005), who put its reproductive rate at 17% better than a fine wool Merino, German Merino, or Superfine wool breed. It is worth noting that weaning improvement is driven mainly by an increase in twin lamb survival. This is a vital profit driver and reduces the cost per kg of the products (Browne, 2018).

2.2.2 Survival Rate

It is one thing for a breed to have a high lambing rate, but its survival is even more critical. Dohne Merino exhibits both features even better when compared to Suffolk and Merino breeds of sheep. Lambs born by Dohne Merino were reported as being heavier and having a greater survival weaning rate than those born by pure breeds (Cloete and Cloete, 2014). Likewise, the total weight of lamb weaned was higher in Dohne Merino ewes due to the excellent mothering ability of the breed than other breeds such as Dormer, German Merino, or Dorper breed. Lean (2016) observed that under high, medium, or low rainfall environments, the Dohne Merino is more productive regarding weaning weight, fecundity, higher survival rate, and profitability than fine wool Merinos and a crossbreed prime lamb enterprise. The Dohne Merino filled the gap between high mortality rates and low fertility, which are the significant limitations of most sheep breeds, especially the Merino breed (Swanepoel, 2006).

2.2.3 Growth of the Dohne Merino Sheep

Hawkins (2016) reported fast growth and early maturity in a paddock, feedlot, and free-grazing Dohne Merino. Browne (2018) observed that Dohne Merino lambs could have an average weight gain of 318 g/d in a feedlot and convert poor-quality feeds into mutton, wool, and milk. Hawkins (2016) also reported that Dohne Merino lambs are fast-growing and have significant weight gain, giving room for their early maturity. Though they mature early, they maintain good muscle definition and structure. Webb et al. (2010) validated the fecundity of Dohne Merino ewe in their research. It was also concluded that protein supplement has no significant effect on ovulation rate, pregnancy status, or the number of the lamb born per ewe or weight after lambing under a semi-intensive system. This suggests that in the regions with low protein sources for sheep, the reproductive performance of Dohne Merino can still be evident. This was not true for other breeds like Dorper, German Merino, or Dormer with lower weights when protein percentages when reduced in their diet.

2.2.4 Mutton production

One of the qualities that give value to meat is the tenderness (Shear force value) of the meat (Chulayo *et al.*, 2015). Meat from Dohne Merino is more - tender at first bite during sensory evaluation than mutton from other sheep breeds (Cloete and Cloete, 2014). Likewise, Li et al. (2016) observed that eye muscle and fat depth (cm) are higher in Dohne Merino than in Merino. Cardellino (2016) discovered the differences in fat depth between the Dohne Merino and the Merino with 0.41 and 0.39 cm, respectively, as shown in Figure 1. Although the Dohne Merino had a high-fat depth, it is still favourable for tender, lean meat. Hence, meat from Dohne Merino could be favourably compared to Merino and other sheep breeds. Figure 2 shows the eye muscle depth of the Merino and the Dohne Merino, with the Merino having a low eye muscle depth of 2.4 cm and the Dohne Merino 2.7cm. An animal's positive eye muscle depth can produce offspring with high-quality carcasses and greater muscling (Brown and Swan, 2016).

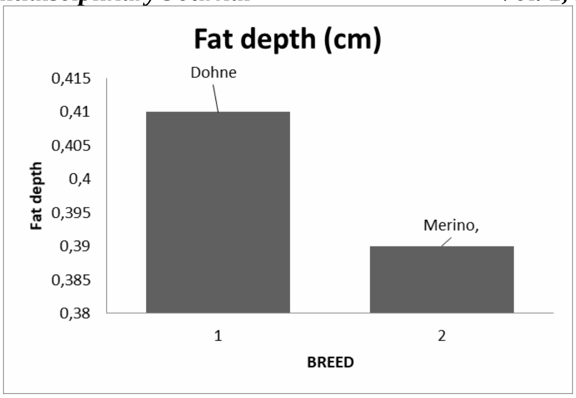

Figure 2: Meat trait of sheep (fat depth in cm).

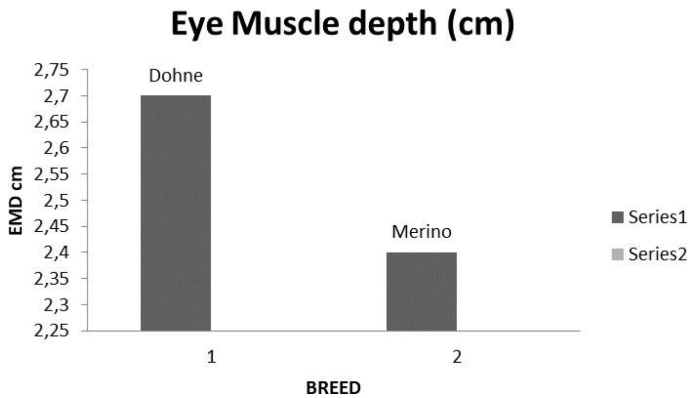

Figure 3: Meat traits of sheep (Eye muscle depth in cm).
Source: Cardellino (2016)

2.2.5 Wool Production

The quality of wool is in fibre diameter, crimp, yield, colour, and staple length. However, fibre diameter is the most critical single wool characteristic that determines the price and quality of wool (DAFF, 2016). Dohne Merino wool shows an average of 0.6 microns finer with a staple length of about 2 mm longer and a 1% higher clean yield than the South African Merino wool clip (Ferreira, 2017). Likewise, the wool production potential (WPP) through which hardness is measured with a linear relationship on gross margins has been steady at the optimum of 5-6 % in the last ten years (Delport, 2017). Therefore, with Dohne Merino, good clean fleece weight, yearling fibre diameter, and other wool parameters can be maintained. In Figure 3, the clean fleece weight of Dohne Merino (2.1cm) is less than the Merino (2.3cm) but more significant than other sheep breeds. Likewise, in Figures 4 and 5, the wool weight at shearing and the fibre diameter of Dohne Merino is higher than that of different sheep breeds. Merwe et al. (2021) alluded that the Dohne Merino ewes produced the finest wool than the South African Mutton Merino and Dormer ewes. Despite the differences, the Dohne Merino still stands out as the most favourable and promising sheep breed in the wool production industry.

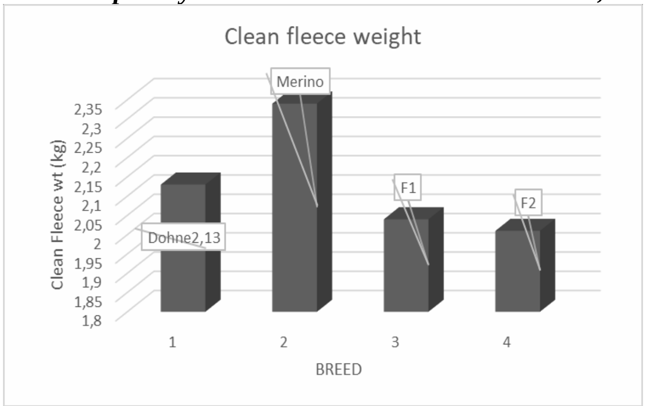

Figure 4: Clean fleece weight of DM sheep compared to other breeds

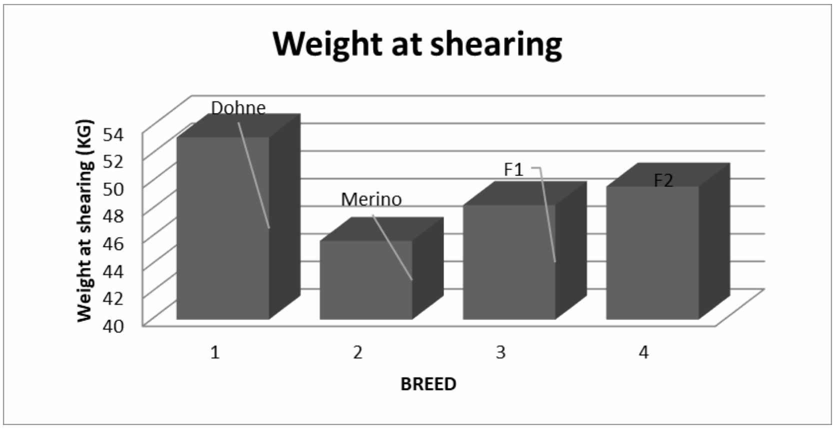

Figure 5: Wool weight of DM sheep compared to other breeds

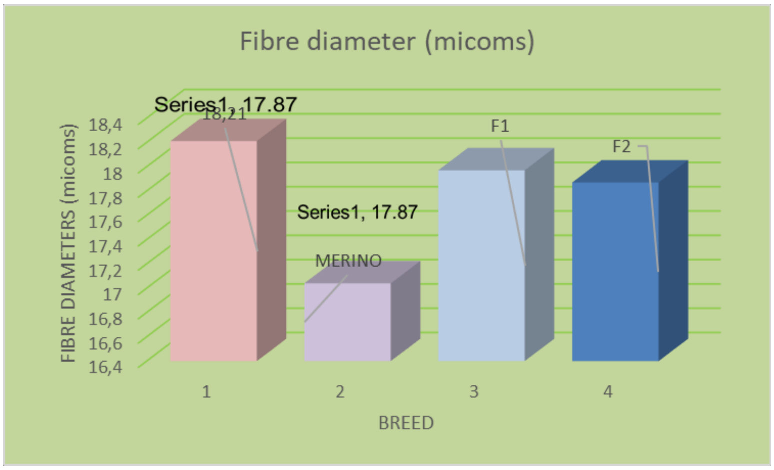

Figure 6: Fibre diameter of DM sheep compared to other breeds

2.3 The contribution of Dohne Merino to food security in different continents

2.3.1 Africa: The Dohne Merino is native to Africa and was bred in South Africa around 1939. Since then, the breed has gained popularity in South Africa and other African countries. Due to its ability to withstand the arid and semi-arid weather conditions in most parts of Africa has relieved farmers in these areas as they have resorted to rearing the Dohne Merino (Wyk *et al*., 2008). The breed has spread from South Africa to other African countries due to its high fertility and fast lamb growth rate (Cloete, 2016). The Dohne Merino improved the wool industry in South Africa (around 40% of the SA wool sheep) and Africa; due to its high-quality wool and ease of management, most farmers have resorted to wool production (Ikusika *et al*., 2020). The breed has filled the gap of low fertility and high mortality rates, which were the limitations of other sheep breeds, including the Merino, and has boosted the sheep industry (Swanepoel, 2006).

2.3.2 America: The South American sub-continent is a large and uneven area with 12 independent countries with different ecological environments. Sheep production (meat and wool) and other fibres are essential to their economy. The animal fibre being produced in this region is wool, with a capacity of 102 million kg (greasy), and alpaca fibre, with a 4 million kg capacity (Cardellino and Mueller, 2008). The Dohne Merino breed was introduced to this continent in 2002 for the first time through Uruguay, followed by Chile, Falkland Island, Argentina, and Peru. The introduction of Dohne Merino has yielded fruitful and profitable results through increased sheep numbers, involvement of the Dohne Merino in crossbreeding programs, and improved sheep industry. In these countries, it has been predicted that the breed will continue to be a very effective tool for enlarging market opportunities for mutton and wool (Cardellino, 2016).

2.3.3 Oceania: Producers of Merino commercial sheep in Oceania had a major shift in selling place with one that gave them less revenue for wool than mutton in the late 1990s. Unknowingly, sheep breeders in Australia and sheep farmers in the Republic of South Africa (RSA) had been facing the same market problems for over a decade. Some commercially focused Merino breeders responded to this shift in the market by reproducing a kind of Merino known as the Dohne Merino, which had a production equilibrium to match this market demand. Australian breeders acknowledged Dohne Merino's prospect in meeting the changing market demands. In 1998, the first purebred Dohne Merino embryos were imported from South Africa. (McMaster, 2015), Since then, Dohne Merino has significantly grown in Australia, so much so that about 20 % of breeding ewes in Australia are Dohne Merino breeds (Casey and Wilson, 2016).

2.3.4 Contribution of Dohne Merino to specific countries

The introduction of the Dohne Merino in 2003 resulted in its use in crossbreeding programs with the local breed. It increased the lambing rate, a reduction of 5-8 microns in wool diameter. A 40 – 50 % increase in the total revenue from the wool was observed. Most sheep farmers resorted to rearing the breed, contributing to sheep numbers (McMaster, 2015). In Brazil, the breed assisted in upgrading the local breed, increasing the lambing percentage. The Dohne Merino introduction in Peru in 2005 brought about a 5-6-fold increase in farm income (FAO, 2013). It has led to fine wool production, increased productivity, maturity weight, and carcass weight. The local breeds have been upgraded, and sheep numbers have also increased (Vivanco, 2014). The main contribution of Dohne Merino has been a considerable reduction of microns with little "blow out from hogget to adult, big, framed meat carcass and increased lambing percentage since its introduction in the Falkland Islands in 2003 (Cardellino, 2016).

In Uruguay, the Dohne Merino was introduced around 2002, becoming involved in crossbreeding with the Corriedale breed. It increased the export and income from sheep by increasing the local sheep numbers (McMaster, 2015; Cardellino, 2016; De Barbieri *et al*., 2017). The introduction of the Dohne Merino in Argentina (2005) resulted in improved weaning and carcass weight (>10 %), better meat quality and trait (less fat, bigger eyes muscle area), a significant reduction in the wool diameter with better colour, better maternal ability, higher overall productivity and increase in the sheep population (Villagra- Blanco *et al*., 2015). Around 1998/9, the Dohne Merino was introduced to Australia and New Zealand. Since then, farmers have increased income through improved lambing and mutton production, resulting in more international sheep trade with other countries (Casey and Wilson, 2016).

2.4 Challenges to Dohne merino sheep production

2.4.1 Climate Change

A long-time alteration of weather is known as climate change, and one of the significant contributors is greenhouse gasses (GHG). These changes are cooler to warmer, with a rise of 1.8 - 4 0C postulated in the next 100 years (depending on the GHG emission rate) (IPCC, 2018). Livestock contributes about 18% of the total anthropogenic GHG emission (Thornton, 2010), which implies a need to revisit these production systems to mitigate global warming. Sheep are seen as an animal for the future because they can survive and strife in vulnerable climates such as droughts, disease outbreaks, increased natural disasters, glaciers, and ozone layer depletion (Gowane *et al*., 2017). Though sheep are vulnerable to changing climate, they are relatively more resilient than large ruminants. However, feed intake, growth rate, genetic variation, and other traits of importance are affected due to changes in environmental factors such as temperature, humidity, and rainfall. These determine the availability of forages and pathogen prevalence (Safari *et al*., 2005); (Ghafouri-Kesbi and Notter, 2016); Gowane *et al*., 2017). Therefore, selecting more adaptable breeds of high fecundity, such as Dohne Merino, South African Mutton Merino, Superfine wool, Dormer and Merino, is essential for future production. Dohne Merino, as a dual-purpose sheep, has a better place in sheep production as it contributes to reducing GHG, which plays a significant role in climate change. Brock et al. (2013) reported that the total emission per kilogram of greasy wool increased with increased fibre diameter, reduced fleece weight, and the selection of dual-purpose sheep (meat and wool). Likewise, Cottle and Cowie (2016) reported that using the life cycle assessment (LCA) approach for sheep production, dual-purpose sheep have low GHG emissions of about 8.6kg/CO2 of kg in New South Wales.

2.4.2 Gastro-intestinal parasites

One of the major causes of sheep losses is parasites (Tolu and Savas, 2016). Parasitism affects the metabolism of proteins, decreases feed intake and improves the proneness of sheep to other diseases (Mavrot *et al*., 2015). Since sheep graze close to the ground, they tend to pick up parasites as they are close to their dung. This exposes sheep to parasitic ova and, subsequently, parasite load. Bhat (2011) reported that gastrointestinal and other parasites reduced profits and increased weight loss by approximately 15% and 50%, respectively. As much as the Dohne Merino sheep can withstand and adapt to extreme conditions, at one point, productivity is affected by the intensity and severity of parasites. Hence, measures must be implemented to prevent losses in sheep numbers, especially in arid and semi-arid regions of Africa where smallholder farmers neither dip nor supplement sheep.

2.5 Genetic improvement

There is room for genetic changes in Dohne Merino owing to a reduction in the global demand for wool and increased demand for mutton. In recent decades, there has been increased economic pressure on dual-purpose sheep breeds to produce more meat and, at the same time, grow finer wool (Adams and Cronje, 2003). Hence, more emphasis has been placed on the reduction of mean fiber diameter (MFD), clean fleece weight (CFW), and increases in body weight (BW). The ensuing breed policy served to secure the breed's competitive position in South Africa and the international livestock industry as a progressive dual-purpose breed. Li et al. (2016) reported that traits such as weaning weight, yearling weight, yearling fat depth and yearling eye muscle depth are below-average heritability. However, these traits can be improved by using breeding techniques such as line breeding (narrow-sense heritability). In addition, breeds such as Dorper and South-Africa mutton merino can be used to crossbreed Dohne Merino to improve mutton production. The introduction of Dohne Merino into different fine wool sheep breeds in China (such as Xinjiang Fine wool sheep, Inner Mongolian fine wool) and Gansu Alpine Fine wool in America has improved fleece weight, staple length, fiber diameter, and clean fleece yield as well as the mutton quality. Therefore, the continual introduction of the Dohne Merino breed in crossbreeding with local breeds could bring about global improvement of both wool and mutton quality due to its unique traits.

3. Prospects of the Dohne Merino

The unique features of the Dohne Merino in both wool and meat production explain its choice as the sheep of today's World. In Circle H. Farms (pty) Ltd, Australia, the Dohne Merino has proven to be the ultimate dual-purpose breed (Lean, 2016; Browne, 2018) due to the ability to manipulate its gene composition to suit the current demand and to adjust to environmental condition. Therefore, change is imperative and not an option. If adjustments are not made, the Dohne Merino that has embraced technology so effectively in the past will miss opportunities such as those provided by genomics and will fall by the wayside. (Delport, 2017; Browne, 2018). The genetic composition of Dohne Merino gives room for its traits of high sustainability in any given environment. However, there is a need for Dohne Merino sheep farmers to utilize organic supplements to curb the issue of nutrition and parasites. Fossil shell flour can protect and eliminate internal parasites and strengthen the animal's immune system (Ikusika *et al*., 2020). This can improve the Dohne Merino production as the breed to curb global food security issues.

The rearing of the Dohne Merino can uplift smallholder farmers to boost their returns with reduced cost of production as it is a hardy and easy to manage breed. This is only possible if they practice proper management practices such as supplementation when feed is not adequate, good veterinary services, and the use of organic, safe food, which enable the production of safe and high-quality products (Mapiliyao *et al*., 2012). The Dohne Merino performs excellently under good management; this is vital. It is also critical to practice genomics and crossbreeding programs so that the genes are improved for any environment, for better production, and to pass on the unique characteristics of the Dohne Merino to other sheep breeds worldwide. Communal farmers must need to be informed about the Dohne Merino sheep to adopt it to improve production. Commercially, the Dohne Merino is an excellent breed to produce high-quality wool and mutton that meets market demand at a reduced cost of production, resulting in high returns.

Conclusion

The Dohne Merino, being a dual-purpose sheep with excellent genetics, will be able to contribute considerably towards meeting the demand for food due to its unique features that tick all boxes (meat, wool, and surplus lambs). Above all, its outstanding traits enable it to perform excellently in any environment. In addition, it can restore the sheep population in nations that are experiencing a reduction in sheep production because of its high fecundity. The contribution of livestock to food security could be guaranteed through the continuous introduction of Dohne Merino sheep.

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