EVALUATION OF TWO INDIGENOUS SOUTH AFRICAN SHEEP BREEDS AS PELT PRUDUCERS

By:

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PREFACE

The main aim of any researcher is to provide the producer with tools or to persuade the producer to use these tools to improve breeding methods or management to maximize economical growth without detrimental effects on natural resources.

With this project the main aim was to collect data that could help improve a natural resource of Namibia - the Karakul, which is known for its eco-friendly kind of farming. A suitable place to collect data of such a kind was at Lovedale, one of the eldest Karakul studs in Namibia still active and where the studs' rams and facilities were used. I wish to thank Mr. John Campbell and Mr. Malcolm Campbell for that.

The study was started under the supervision of Mr. G.J. Vermeulen of the Department of Animal and Wildlife Sciences, University of Pretoria. Supervision was later on taken over by Prof. S.J. Schoeman, emeritus professor, University of Stellenbosch and professor extra-ordinary of the Department of Animal and Wildlife Sciences, University of Pretoria. A hearty thanks to him for his guidance and insight which he shared with me. I also want to thank mrs. G. Jordaan of the Department of Animal Sciences at the Stellenbosch University, who helped me with the processing, editing and analysis of the data.

My gratitude to the Karakul Board of Namibia for the grants and loan they made. Without that, this whole study would not have been possible.

I want to thank the following people and institutions for their contribution to the carrying out of this project:

* Karakul Breeders Society for their assistance with grading and managing of the stud forms.
* The Pelt Centre and especially Mr. J. Duffield-Harding for the grading of pelts.
* Mr. W. Visser for his guidance and advice.
* Prof. W.A. van Niekerk of the University of Pretoria for his guidance and support.
* The farmers who helped me to become the base animals at the beginning of the study.

To my husband, children, parents, parents-in-law and brother, my deepest appreciation for their understanding, sacrifices, support and emotional, physical and financial assistance in many ways through this study.

I declare that this thesis that was done for the degree MSc. (Agric.) at the University of Pretoria is handed in by me and that it was not formerly used by me for any other degree at any other university.

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Louisa J. CAMPBELL

HELMERINGHAUSEN – NAMIBIA

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ABSTRACT

Title:	Evaluation of two indigenous South African sheep breeds as pelt producers.
Candidate:	Louisa Jacoba Campbell
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Department:	Animal and Wildlife Sciences
Degree:	MSc(Agric)

Although the Afrikaner and Black-headed Persian were used in several previous studies for upgrading with Karakul rams, this study looked at how fast progress could be made to produce good quality marketable pelts as well as producing ewe material to increase Karakul ewe numbers. Market requirements have also changed in the past years.

After three generations of upgrading it was found that, especially in colour inheritance, faster progress was made as in previous studies with just a small percentage of spotted animals (1.3 % in the F_3-generation.). All economic important pelt traits (pattern, hair quality, texture, lustre and curl type) improved significantly from the F_1 to the F_3 generation and it compares well with the control group (pure bred black and white Karakul).

The type of rams that gave the best results with upgrading, were the less developed type with good hair quality and good pattern forming characteristics (watered-silk and shallow watered-silk).

Pelt types improved from the F_1 which were under average and of poor quality to higher quality pelts which received above average prices on auctions for the F_2 and F_3 generations.

It appears that the Afrikaner and Black-headed Persian can both be used with success in an upgrading program, all depending on what colour breeding (black or white) there is a need for.

SAMEVATTING

Titel:	Evaluasie van twee inheemse Suid-Afrikaanse skaaprasse as pels produseerders.
Kandidaat:	Louisa Jacoba Campbell
Leier:	Prof. S.J. Schoeman
Departement:	Vee- en Wildkunde
Graad:	MSc(Agric)

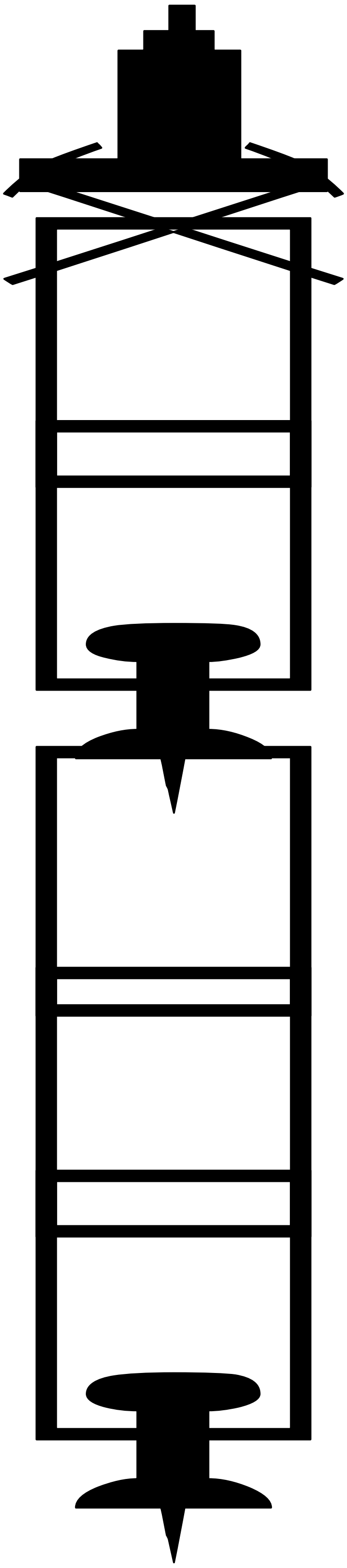
Alhoewel die Afrikaner en Swartkop Persie al in vorige proewe gebruik is vir opgradering met Karakoelramme, is daar met hierdie proef gekyk na hoe vinnig vordering gemaak kan word om bemarkbare, goeie kwaliteit pelse te bekom, asook om ooimateriaal daar te stel om ooigetalle te vermeerder. Markbehoeftes het in die tussentyd ook aansienlik verander.

Na drie generasies van opgradering is gevind dat daar veral in kleuroorerwing vinniger vordering gemaak is as in vorige proewe, met slegs 'n klein persentasie bont lammers (1.3 % in F_3-generasie). Alle ekonomies belangrike pelseienskappe (patroon, haarkwaliteit, tekstuur, glans en krultipe) het betekenisvol verbeter van die F_1 na die F_3 generasie wat goed vergelyk het met die kontrolegroep (suiwer wit en swart Karakoele).

Die tipe ramme wat die beste resultate in opgradering gelewer het, was die minder ontwikkelde tipes met goeie haarkwaliteit en goeie patroonvormende eienskappe (watersy en vlak watersy).

Pelstipes het van die F_1-generasie, wat ondergemiddelde en swak tipe pelse gelewer het, verbeter tot uitgesoekte tipe pelse wat bo-gemiddelde pryse op veilings in die F_2 en F_3 generasies behaal het.

Dit blyk dus dat die Afrikaner en die Swartkop Persie met ewe veel sukses aangewend kan word in 'n opgraderingsprogram, afhangende van in watter kleurteling daar 'n behoefte voor is.



INTRODUCTION

CHAPTER ONE

INTRODUCTION

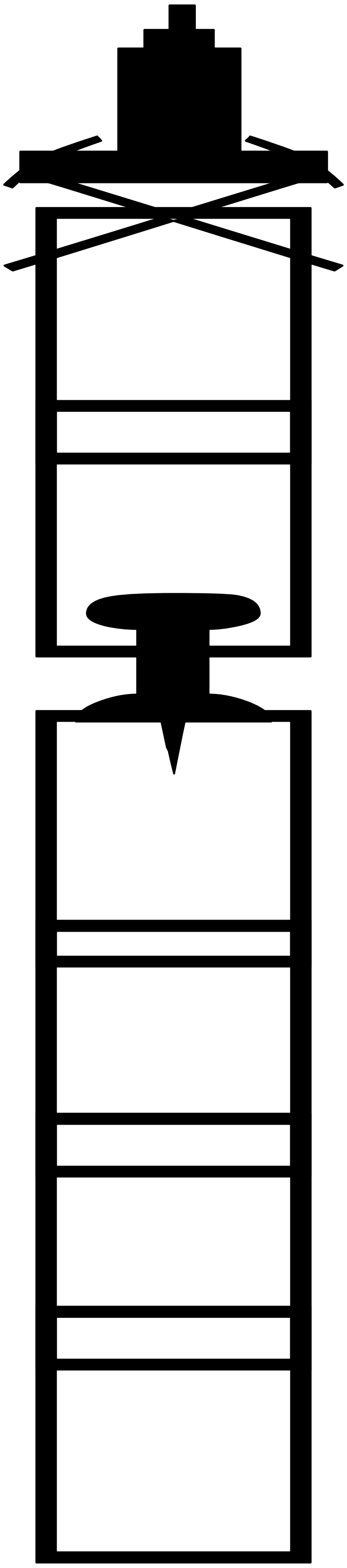
One of the most valuable resources of the sheep industry is breed diversity. Breeds of sheep have evolved over thousands of years, their use and function guided by the ability to adapt and to survive in specific environmental- and production systems. According to Leymaster (2002) the characteristics of each breed have a genetic basis and can therefore be used in structured crossbreeding systems.

Crossbreeding as a means of utilizing differences between breeds has been widely used in sheep breeding overseas, but on a limited scale in southern Africa. In contrast to variation within a breed, the differences between breeds are largely genetic (Coop, 1982). The basis of crossbreeding is the exploitation of hybrid vigour or heterosis. Greatest heterosis is likely when the breeds being crossed differ noticeably in their gene frequencies and the traits being considered are under the control of dominance (Willis, 1993).

Nicholas (1996) stated that with upgrading, which is one of the crossbreeding systems, the main aim is to backcross from one population into another, with the introduction of a new gene or genes into one of the populations, or with the aim of substituting one population for the other.

With Karakul research the two main objectives are to maximize the quantity of pelts produced and to produce pelts of the best quality and appearance (Nel, 1971). In the Karakul industry the main intention of upgrading is to increase numbers of animals. With the large increase (68%) in pelt prices at the latest auction (April, 2006), it is foreseen that there will be a large demand for Karakul ewes and Karakul crossbred ewes. Thus, other breeds, of which the economical productivity can be improved through upgrading to the Karakul, can be used.

The objective of this study was to evaluate the use of white Karakul rams on “Blinkhaar” Afrikaner ewes and black Karakul rams on Black-headed Persian ewes in an upgrading program to determine at which generation suitable pelts could be produced.



GUIDE TO TERMS USED IN THE KARAKUL INDUSTRY

CHAPTER TWO

GUIDE TO TERMS USED IN THE KARAKUL INDUSTRY

For the purpose of this study there will only be concentrated on black and white Karakul. The following are explanations for terms used in the description of Karakul lambs and pelts.

2.1 THE LAMB:

2.1.1 COLOUR

In a breeding system for the production of white Karakul lambs, the colour differs from a pure white to pure black. Differences in colour are assessed as follows:

- ***A-white*** – Completely white with only pigmentation around the eyes and on the extremities of the ears and nose.
- ***B-white*** – Black/brown patches on the head with no black/brown hair on the neck, body or legs.
- ***C-white*** – Clean white body with black/brown allowed on head, tail, legs, umbilicus and groin.
- ***D-white*** – Same as C-white, but with black/brown hair on body allowed.
- ***Spotted*** – Same as D-white, but with bigger black/brown spots on the body.
- ***Black*** – Completely black or with only a small white patch on the head ("kolkop") or a white patch on the tip of the tail ("witkwas") are accepted (Anonymous, 2005b).

2.1.2 CURL-TYPES

There are four main curl types namely watered silk, shallow, developed shallow and pipe curl. These four can not be completely separated from one another because they merge into one another and there are intermediate and extreme types which bring the total accepted curl types on nine different types. Distinction among these types is based on the degree of curl development. The following are short descriptions of the different curl types:

- ***Galliac (GAL)*** – Hair is short and flat on the skin with almost no curl development.
- ***Watered-silk galliac (WS/GAL)*** – The tip of the hair is lifting slightly from the skin and the hair is still a bit smooth.
- ***Watered-silk (WS)*** – The tip of the hair is lifting from the skin.
- ***Shallow watered-silk (VL/WS)*** – The tip of the hair is lifting from the skin and the hair apt to be more raised.
- ***Shallow (VL)*** – Prominent waves with a slight curl into a pipe (1/3).
- ***Shallow-developed (VO)*** - Prominent waves with a second development, slightly more than 1/3 curled into a pipe.
- ***Developed-shallow (OV)*** – Considered developed waves which are almost halfway curled into a pipe. The waves have a definite spacing.
- ***Developed-pipe curl (OV/PK)*** – Underdeveloped, oval shaped pipes which are 2/3 curled into a pipe.
- ***Pipe curl (PK)*** – Developed oval shape pipes curled into a pipe.

Differences in curl types are illustrated in Appendix Figure 1 (a to h).

2.1.3 EXCELLENCE OF PATTERN ("Voortreflikheid van patroon", "VVP")

The excellence of pattern is indicated with a score out of ten. The amount of waves, how low it stretches down the sides, how continuous it is on the back and the wave compiling is all things to take into consideration when allocating a score. The correctness of pattern forming characteristics indicates the number and/or length of waves. Table 2.1 gives an idea of how the score is compiled:

Table 2.1 Excellence of pattern scores out of ten (Anonymous, 1982)

Positive pattern forming characteristics	Negative pattern forming characteristics	Score out of 10
Plenty	None	8 or 9
Considerable	Few	6 or 7
Some	Some	5
Few	Considerable	3 or 4
None	Plenty	1 or 2

Positive pattern forming characteristics are S-hair, second development, lyre, moiré and curls, while negative pattern forming characteristics are bands, feathers, ribs, straight hair, overgrown hair, pine tree arrangement and pelt folds (See paragraph 2.2).

2.1.4 HAIR QUALITY

When assigning a score (from 1 to 9; see Table 2.2) both texture and lustre is taken into consideration.

a) **TEXTURE (Tekstuur)** (How it feels when one strokes over the hair)

These categories are:

- ***Soft*** – weak and non-elastic and the curl is easily disturbed.
- ***Silky and elastic*** – the ideal texture. The feeling is pleasant with a slight resistance. The hair has a stronger resistance and when it is stroked out of place it returns easily to its original position.
- ***Normal*** – Average texture.
- ***Coarse*** – Over-elastic and the feeling is quite harsh. It feels as if the skin has too much material.
- ***Brittle*** – Short, dry and hard and the hair breaks when one strokes over it.

b) **LUSTRE (Glans)**

Lustre is the reflection of light from the hair surface and is best evaluated in sharp daylight. These are subjectively evaluated as:

- ***Glossy*** – Lively reflection with shine soft to the eye – the ideal.
- ***Normal*** – Slight deviation from the ideal.
- ***Metallic*** – Undesired lustre types with an unnatural glittery silver glow like a piece of metal shining in the sun.
- ***Chalky*** – Appearance without shine in white hair – looks chalky.
- ***Dull*** – Without shine.

c) **EXCELLENCE OF HAIR QUALITY**

The excellence of hair quality is also given as a score out of ten. The excellence of the lustre and the texture (the feeling) on the body (back and sides) determine the main score, while the texture on the chest, tail and legs are separately given a score. Table 2.2 gives an explanation of hair quality scoring:

Table 2.2 Hair quality scores as deducted from texture and lustre (Anonymous, 1982)

TEXTURE (BACK AND SIDES)	SCORE OUT OF TEN	LUSTRE
Silky-Elastic	9	Glossy
Silky Elastic	8 8	Glossy
Normal-elastic Normal-silky	7 7	Normal-glossy or Glossy
Silky-soft Normal	6 6	Normal or Normal-glossy
Normal-soft Normal-coarse	5 5	Normal-dull, Normal-metallic or Normal-chalky
Soft Coarse	4 and less 4 and less	Dull, Metallic or Chalky
Normal-brittle	3	Normal or Worse
Coarse-brittle Brittle	2 1	Dull, Metallic or Chalky

2.2 THE PELT

For marketing purposes the pelts are being assessed, taking several characteristics into consideration. These include:

2.2.1 Pattern formation (Anonymous, 2005a)

There are two main formations namely drawn and lyre which are illustrated in Figure 2.1:

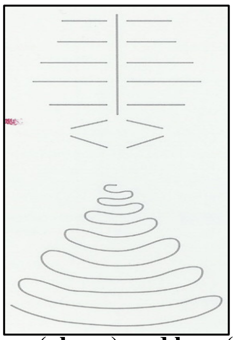


Figure 2.1 Illustration of drawn (above) and lyre (below) pattern formations

Drawn pattern formations are more straightish waves including featherlike and ribbed types as is indicated in Figures 2.2 and 2.3, respectively. These are undesirable pattern forming characteristics:

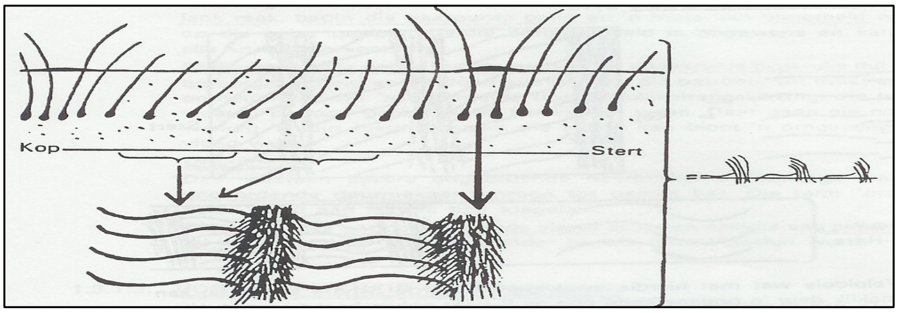


Figure 2.2 Featherlike types

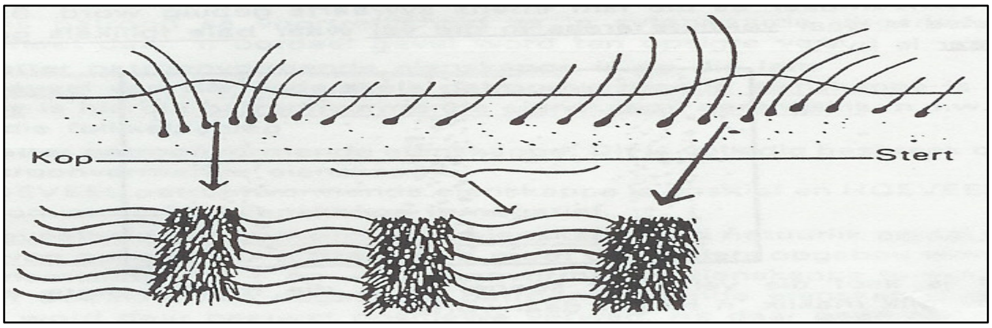


Figure 2.3 Ribbed types

Lyre pattern formations have more S-fibres including pipes as illustrated in Figures 2.4 and 2.5 below:

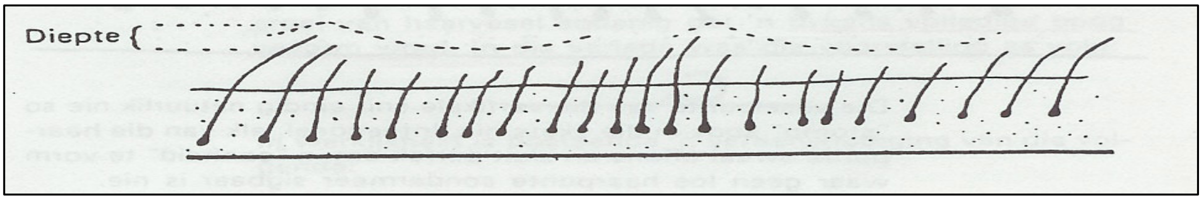


Figure 2.4 S-fibres

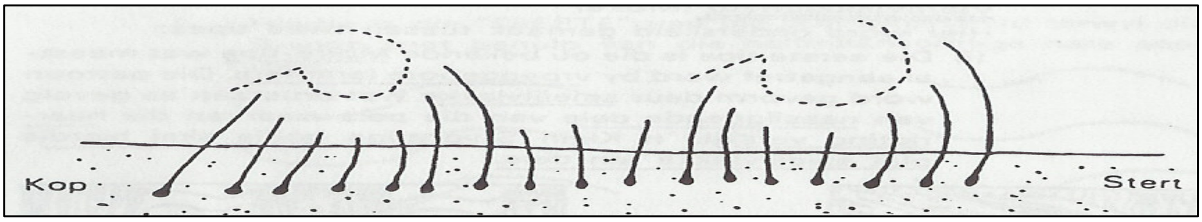


Figure 2.5 Pipes

S-fibres are hair that is complimentary to each other in such a way that an S-type develops inside the waves of a pelt. It can be described as left and right turning semi-lunar hair which together, forms a S, which is the more desirable pattern forming characteristics.

2.2.2 Curl development (Anonymous, 2005a)

Five stages of curl development are recognized as is illustrated in Figure 2.6. Each stage contains classifications that share a certain look and feel:

* Galliac Broadtail – Super fine, extra light weight. Extra short fibre length.
* Broadtail – Watered-silk patterns. Not as thin or light-weight as Galliac Broadtail. Only short fibre length.
* Flat – Generally flat appearance with a slight raised pattern. Fibre lengths can be short to long.
* Semi-flat – A raised pattern with flat spaces in between with short to long fibre lengths.
* Curl – A raised pattern without flat spaces with short to medium fibre lengths.

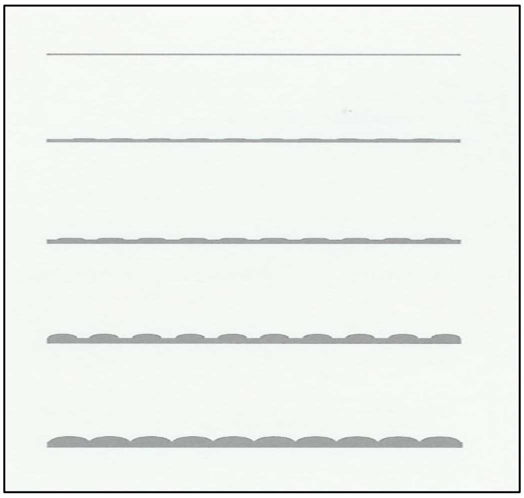


Figure 2.6 Illustrations of the five stages of curl development from Galliac-Broadtail (top) to Curl (bottom)

2.2.3 Fibre quality and pattern excellence (Anonymous, 2005a)

Most of the regular grades are evaluated for fibre quality and pattern excellence. The quality of fibre dictates the silkiness, amount of light reflected and durability of a finished garment.

The different grades are illustrated in Table 2.3:

Table 2.3 Division of fibre quality and pattern excellence in different grades

Grades									
	Selected super	Selected extra	Selected	One	Two	Three	Four	Five	Six
	Regular grades						Low grades	Rejected	
Fibre quality	Superlative	Silky	Silky	Silky-normal	Normal-dull	Normal -dull	Slightly-coarse, metallic, woolly	Coarse, metallic, woolly	Broken fibre
Pattern excellence	Superlative	Extremely good	Good	Good-fair	Fair-broken	Delta			

2.2.4 <u>Fibre length</u> (Anonymous, 2005a)

Eight length categories are recognized as set out in Table 2.4. The two extremes of longest and shortest are rejected and therefore not available for commercial use. The next two longest and shortest are low grades and the remaining lengths fall into what is accepted as regular.

Table 2.4 The eight divisions of fibre lengths

Under-developed	Premature	Extra short	Short	Medium	Long	Overgrown	Outgrown
Rejected	Low grade	Regular grades				Low grade	Rejected

2.2.5 <u>The SWAKARA Classification System</u> (Anonymous, 2005a)

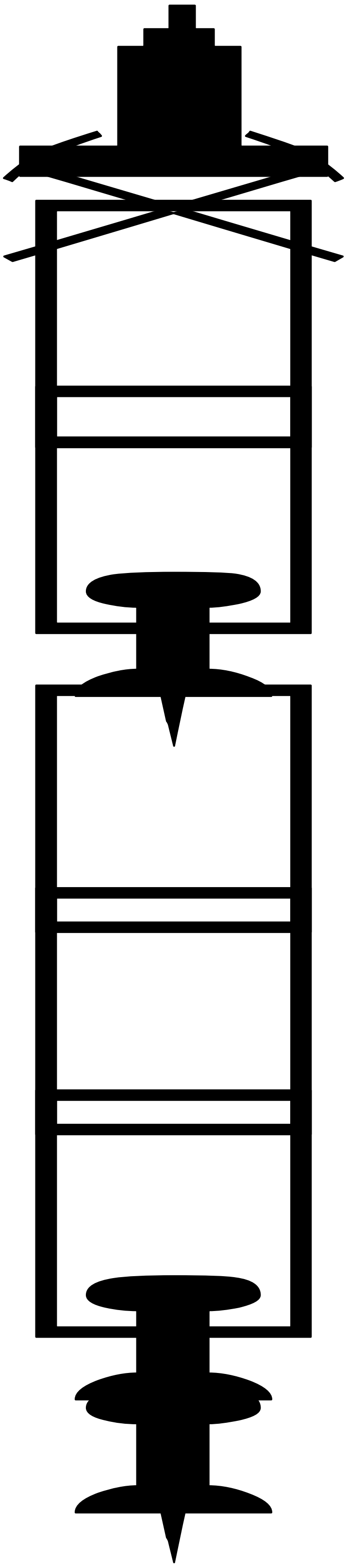
Like a fingerprint, every Karakul is unique. Particular care is taken to produce lots that offer the manufacturer the highest degree of uniformity in size, fibre formation, length, weight, quality and pattern excellence. While the modern Karakul assortment has been refined in theory, all assessments are made by hand and eye, and are therefore subjective. Tables 2.5 and 2.6 explains the division of the SWAKARA classification system with example photographs of each classification in Appendix Figure 2 (a to g) and Figure 3 (a to k).

Table 2.5 Drawn type pelt division

Galliac Broadtail		Broadtail	Flat			Semi-flat
Galliac	D-light Drawn	D-flat	R Flat Light	R flat	Nazucha	T

Table 2.6 Lyre type pelt division

Galliac Broadtail	Broadtail	Flat		Semi-flat				Curl		
D light Lyre	D	P	O	F	M	K flat	N Flat	Q	G	K



OVERVIEW ON THE CURRENT KARAKUL INDUSTRY IN NAMIBIA

CHAPTER 3

OVERVIEW ON THE CURRENT KARAKUL INDUSTRY IN NAMIBIA

3.1 INTRODUCTION AND SHORT HISTORY

The Karakul breed can be seen as one of great antiquity. The word Karakul comes from the ancient Assyrian *Kara-Gjull* which means flower or something of beauty. It has been related that a fine lamb with lustrous black wool so impressed simple shepherds of Bokhara (Uzbekistan) that they compared it with the rose (Anonymous, 1970; Müller, 1985). The breed is also known as *Persian lamb*, because the Persian merchants were the first to export the skins of these animals to the West (Viljoen, 1981; Müller, 1985).

It has been noted that the Karakul owes its fur-bearing qualities to the *Danadar* which is indigenous to West Turkestan, Northern Persia and Afghanistan. The original black *Danadar* was a small sheep with coarse lustrous black wool. The *Danadar* were crossed with the white fine-wool Afghan sheep. This produced the grey *Danadar* which produced skins with small grey curls (Anonymous, 1970). According to general literature (Spitzner & Schäfer, 1963; Anonymous, 1970; Viljoen, 1981; Müller, 1985) at the end of the 19th century the Arabs discovered sheep near the lake Kara-Kul, Bokhara and called them *Arabi*. They had the same characteristics as the black *Danadar* except that they turned grey at maturity. The large *Arabi* is probably the large Karakul, also known as the *Duzbai*, which resulted from a cross of the small *Danadar* upon a fat-rump sheep breed.

It has been discussed by many authors (Thompson, 1938; Nel, 1950; Spitzner & Schäfer, 1963; Theron, 1966; Viljoen, 1981; Albertyn, 1989; Hoffmann, 2003) that the Karakul sheep today is found all over the world. The Karakul was imported into the USA in 1909. The aim was to use crossbreeding with native breeds to enlarge numbers and more rams were imported than ewes. Crossbreeding was done with the Karakul and the Lincoln, Barbados, Coltswold, Cheviot and Merino (examples of the base animals are illustrated in Appendix Figure 4 (a to e)). Crossing the Merino and Cheviot gave the worst results. Karakul pelt production under American conditions could not succeed and the industry came to a dead end before it was properly established. In

Germany the Zackel and Rambouillet were used for crossbreeding with the Karakul. Karakul X Zackel produced high quality pelts, but the crosses of the Karakul with the Rambouillet were of poor quality. Other breeds that were also used were the Somali, the East-Friesian milk sheep and Leicester sheep, which gave good results (Theron, 1966). (Examples of these sheep are illustrated in Appendix Figure 5 (a to e)).

Presently there are only three countries of importance in the breeding of Karakul – West Turkestan, Afghanistan and Namibia. The first Karakul sheep were imported into Namibia in 1907, namely 10 ewes and 2 rams. A second consignment of 23 rams and 251 ewes arrived on 13 February 1909 in Swakopmund (Thompson, 1938; Spitzner & Schäfer, 1963; Viljoen, 1981; Müller, 1985). Over the years the Karakul industry slowly developed into a significant economic force in Namibia. From modest beginnings production took off in the mid 1930's, with just 355 000 Karakul skins being exported during 1934 (Viljoen, 1981; Hofmann, 2003). During the next decades the amount of skins exported, increased and in 1975 a record amount of 4.3 million pelts were sold during the auctions. At its prime, the Karakul industry employed thousands of workers. It is thus not difficult to appreciate that the Karakul industry played a principal role in the utilization of economic potential in southern Namibia.

The hardy Karakul sheep is ideal for use in southern and western Namibia. It is free-ranging, and well adapted to arid conditions. Even during times of drought, it can survive with small amounts of specialized feeding and water as a result of its lower maintenance requirements (Schoeman, 1998; Hoffmann, 2003). Current opinions on the future potential of the Karakul industry vary. Local production of Karakul pelts is increasing at a slower than anticipated rate. The slow increase can in no way be compared to the fast growth and expansion of the Karakul industry in the thirties, where the number of pelts produced was doubled every year. The general opinion is that, as a fashion item, Karakul is a highly unpredictable industry to be in and many producers are hesitant to commit themselves to Karakul. Some feel that while the prices are high, this is due to the low supply of SWAKARA, and hypothesize that it will enter a downward trend as soon as production increases. On the opposite side, the potential for a recovery and significant growth in the industry is clear (Schoeman, 1998; Hoffmann, 2003).

The reason against the quick revival of the Karakul is the fact that the nature of commercial farming activities in the south has changed considerably. Only a handful of commercial farmers have continued to produce Karakul. Others have diversified and entered the more profitable meat industry or tourism (Hoffmann, 2003). Karakul also produces meat, which is mainly marketed locally, because of inferior carcass quality. Besides that, the hides are of a very low quality. Karakul carcasses at abattoirs are penalized with between N$2-00/kg and N$3-00/kg, not only because of the hides but also because of inferior carcass traits (fat tailed type with inferior conformation). Producers must be able to decide under different environmental and marketing conditions whether it is better to produce pelts or meat. It must also be noted that pelt production is in efface a lower risk operation compared to meat production because lambs are slaughtered for pelt production and the ewes do not have to raise a lamb in times of drought and the risk of death during the production process is avoided. This is in addition to the fact that the ewe needs less feed or no extra feed for pelt production in relation to an ewe that has to raise a lamb (Anonymous, 2004).

According to Van Wyk (2005) producers are inclined to compare the income per pelt against the income per lamb carcass to decide which one to increase: mutton or pelt production. The economical basis of Karakul farming is much greater than just pelt prices and other aspects like number of ewes, production risk and reproduction under extensive conditions must all be taken into consideration. He compared the gross production from Karakul relative to that of lamb production. A gross production ratio of Karakul: lamb production is presented in Figure 3.1. This ratio shows the gross production value of pelt fluctuates up and down. It can be concluded that since 1996, Karakul pelt production (higher gross income per ewe) is escalating.

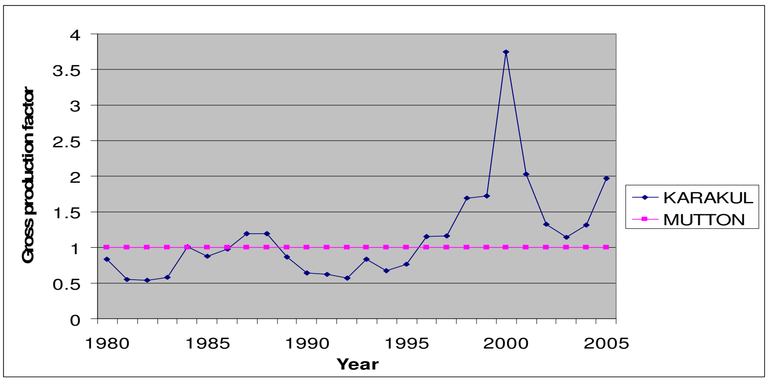


Figure 3.1 Gross production value ratio of Karakul pelt production vs. lamb production (Van Wyk, 2005)

3.2 THE INDUSTRY FROM 1980 TO 2005

3.2.1 THE STUD INDUSTRY

The Karakul industry had its worst time during the 1980's due to lower pelt prices and other related problems. While the Karakul population was about 3.5 million in 1980 with a pelt production of 3 006 817, it fell to 222 832 Karakul sheep in the country in 2003 and a total of 68 203 pelts exported in 2004. This development had a negative influence on the stud industry with the number of stud breeders declining from 751 in 1980 to 53 in 2004 as can be seen from Figure 3.2. From these 53 members only more or less 15 are active breeders (Anonymous, 1980-2005). According to Von Kunow (2001), these members are the reason why the genetic core of the Karakul industry could be preserved and even be improved.

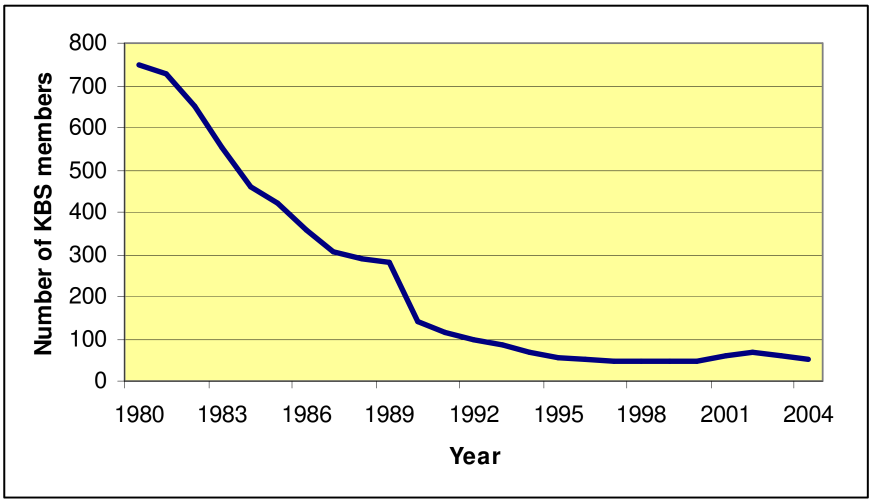


Figure 3.2 Number of members of the Karakul Breeders Society

The Karakul Breeders' Society took the lead in presenting stud auctions in Namibia with the first Karakul Ram auction that was held in 1960. A total of 130 rams from 18 breeders were presented during this first auction. An average price of R151.20 was obtained. The number of rams sold per auction and average prices are presented in Figure 3.3. Since approximately 2000 the prices of white rams exceeded those of black rams. In 1980 the stud auctions reached a high with 44 auctions held over the year with a total of 4 543 rams sold at an average price of R361.00 The highest price ever paid for a Karakul ram was R22 500.00 in 1988 on an auction of Lovedale Farming.

In 2005 only 9 ram auctions were held with a total of 370 rams sold at an average price of N$3 396.00 for black rams and N$4 083.00 for white rams (Anonymous, 1980-2005).

Figure 3.4 shows how the number of Karakul sheep registered per year declined over the last 24 years from 18 374 black studbook animals in 1980 to only 1 229 in 2004 (Anonymous, 1980-2005). Likewise the number of registrations of white Karakul is illustrated in Figure 3.5. A relatively sharp increase in the number of white Karakul since 2001 is clear.

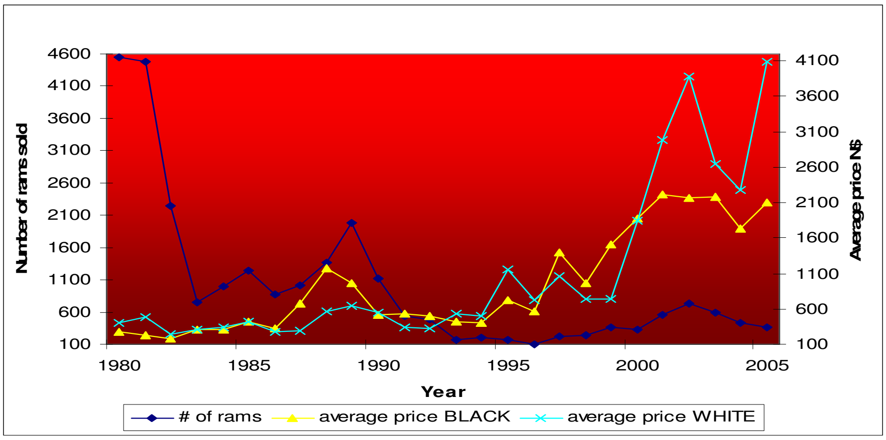


Figure 3.3 Ram sale numbers and average price

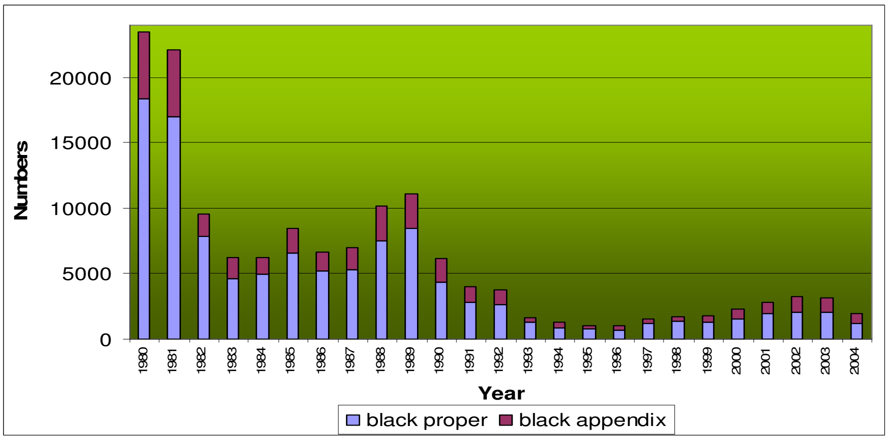


Figure 3.4 Black Stud Karakul registrations per year from 1980 to 2004

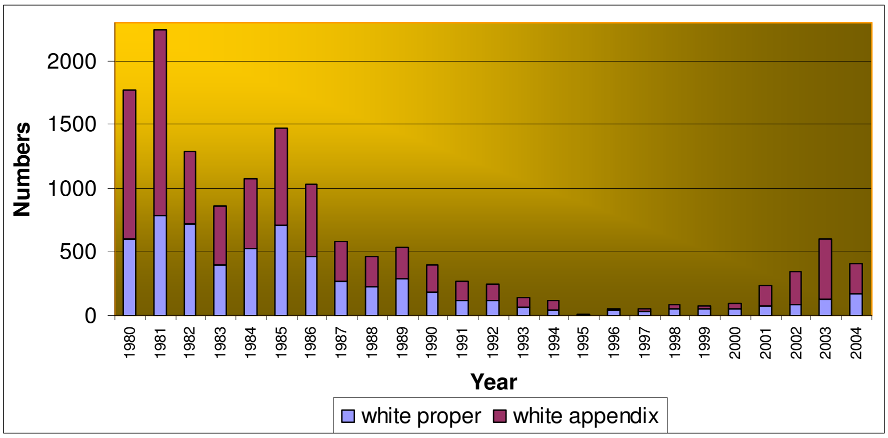


Figure 3.5 White Stud Karakul registrations per year from 1980 to 2004

In Figure 3.6 the total number of rams and ewes alive per year are presented. It shows clearly how registered Karakul animals have declined since 1989. From a total of 34 374 ewes and 4 337 rams in 1989, it decreased to only 10 497 ewes and 1 257 rams in 2004, a decline of 68.5 % over the last 15 years (Anonymous, 1980-2005).

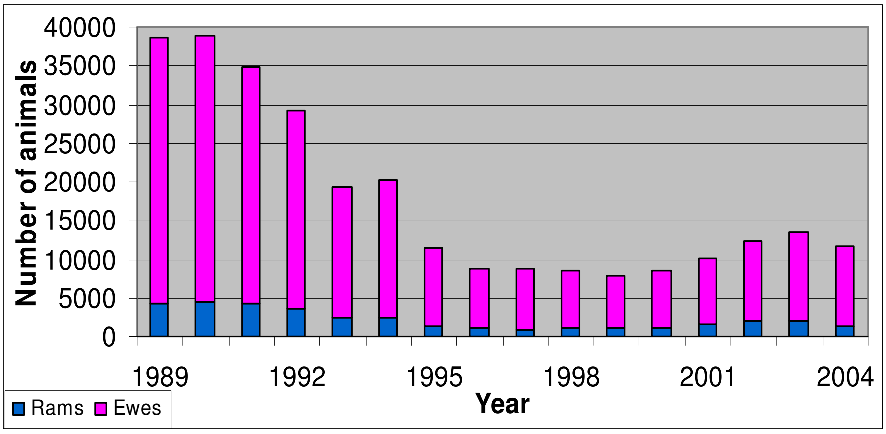


Figure 3.6 Total living registered Karakul stud animals from 1989 to 2004

3.2.2 THE OVERSEAS MARKET AND PELT EXPORTS

The eighties marked the start of problems experienced by the Karakul industry. By 1982, only about 1.4 million pelts were exported, indicating the decline of Karakul pelts on international markets (see Figure 3.7). In 1986 only 0.77 million pelts were still exported. The lowest sales were recorded during 1997, when only 69 535 pelts were exported (Von Kunow, 2001). The total income declined accordingly from N$64.3 million in 1980 to N$16.1 million in 2003 (Anonymous, 2004).

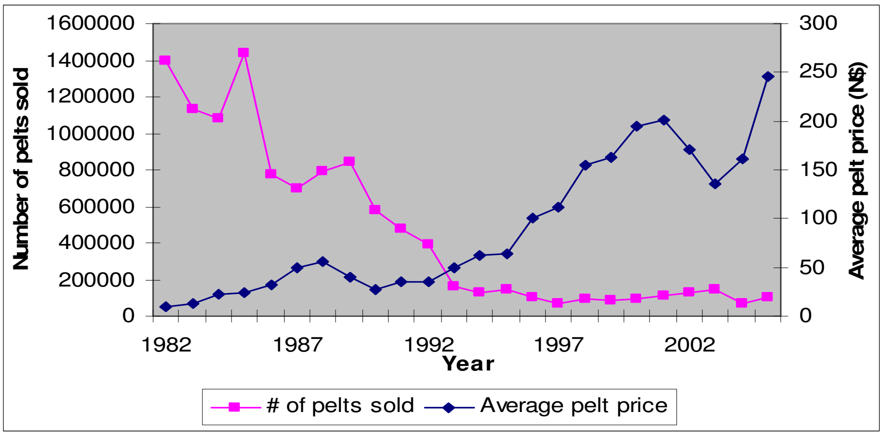


Figure 3.7 Number of pelts sold in comparison with the average pelt price obtained

A combination of various factors led to the problems experienced in the Karakul industry. Schoeman (1998) as well as Hoffmann (2003) postulated that the problems could be traced back to declining prices to a level where production costs exceeded actual income, dumping of inferior quality products by other countries, economic recession conditions in consumer countries, the extensive anti-fur campaigns which went hand in hand with a change in fashion. Lifestyle changed in a short period of time from formal to informal which could be seen in the fashion industry in the negative impact it had on the sale and consumption of fur.

It is notable from Figure 3.8 that from 1982 to 1985 more than 100 % pelts were produced from the national Karakul herd. The high pelt production was due to a drastic reduction in ewes after the lambs were slaughtered when the world market for Karakul pelts tightened (Anonymous, 2004). Pelt production out of the national flock was very low from 1994 due to the following reasons:

- Increased meat production as a result of favourable meat prices
- High input costs
- Poor flock management
- General negativity towards Karakul farming (Van Wyk, 1999).

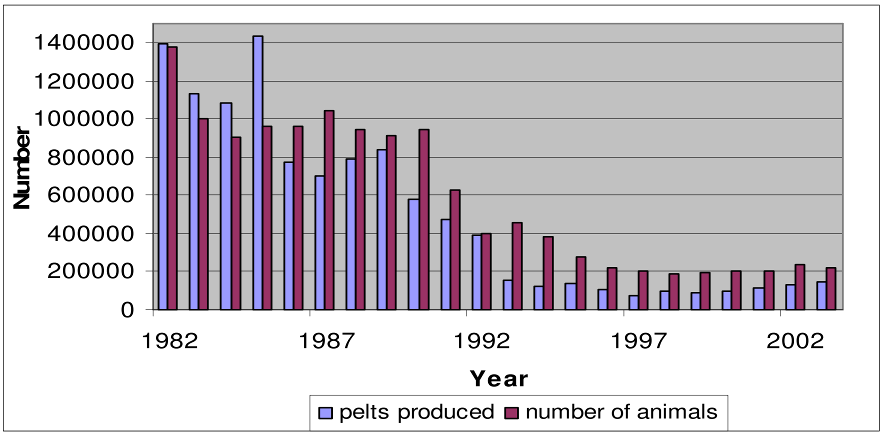


Figure 3.8 Karakul sheep numbers vs. pelt production

Karakul farming is now experiencing a slow recovery following increases in pelt prices since 1996. With the increase in the pelt price the interest in and need for breeding rams also increased as can be seen in Figure 3.9. An all-time high for average ram price was reached in 2005 when the highest average ram price for all rams sold in the year was obtained of over N$3500.

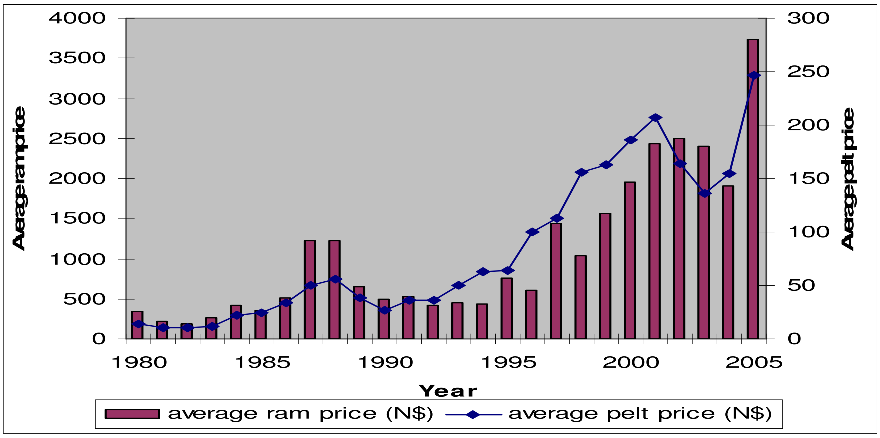


Figure 3.9 Average ram prices in comparison with average pelt prices from 1980 to 2005

In Figure 3.10 the ratio number of pelts: rams is presented. This gives an indication of the confidence of producers in pelt production. In 1996 producers were willing to invest only 6 pelts to buy a ram. The optimism increased in 2003 and 17 pelts were paid on average per ram (Anonymous, 2005b).

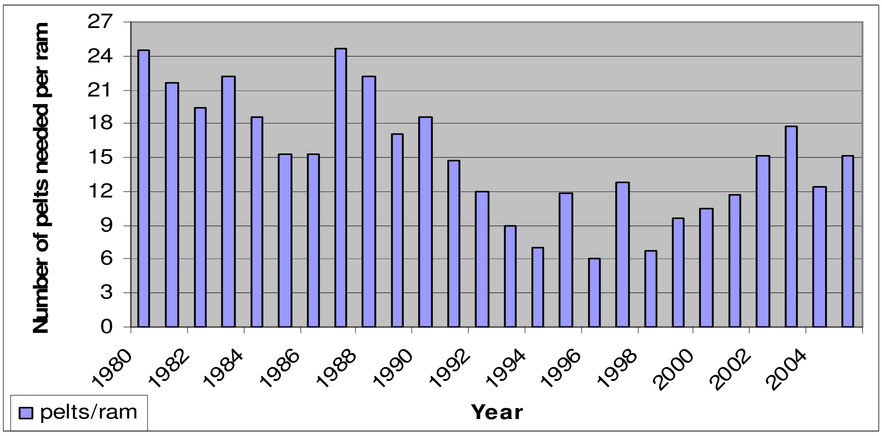


Figure 3.10 Number of pelts needed to buy one ram

The comparison of the profitability between SWAKARA and mutton production is not always easy due to a number of factors. The pelt: meat price ratio is an indication of how many kilograms of meat need to be sold to get level with one SWAKARA pelt sold. The higher the ratio, the more profitable the SWAKARA production is compared to meat production. Figure 3.11 shows the pelt to meat ratio as from 1980. The drop in 2002 in the pelt: meat price ratio is due to the drop in pelt prices and the simultaneous increase in mutton prices (Van Wyk, 2005).

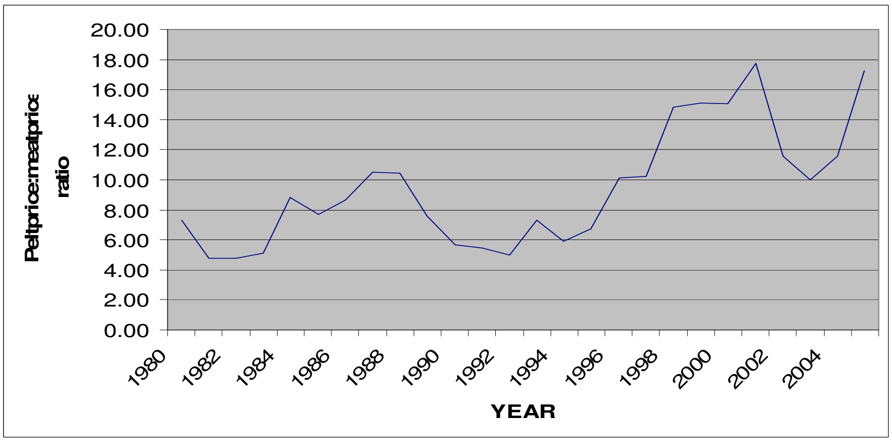


Figure 3.11 Pelt price: mutton price ratio (Van Wyk, 2005)

According to Hoffmann (2003) and information obtained from the latest international furs shows, the current outlook for the Karakul industry is seen as a positive one. During the 90's Italy and Spain were the biggest fur consumers in the world. A new, slow positive trend started to develop in Germany again after Germany, who was a big SWAKARA consumer for years, entered a deep crisis and some big companies specialized in Karakul, closed unexpectedly, as well as some tanneries and chains of shops. Consumptions in Japan remained high, with Hong Kong and Korea that are also big fur importers (Polidori, 1992). The world market is steadily growing, and prospects are looking increasingly favourable due to the apparent economic revival underway in the USA and Japan. In addition, there is major scope for market expansion in Russia and China, due to the high economical growth in these countries. Prices are increasing to levels never experienced before, demand is increasing at a steady rate and potential new markets are being explored in addition to the existing ones. Yet, these market opportunities cannot be fully exploited because of lack of production in Namibia. It is therefore important that breeders in Namibia take steps to increase their production and to increase international production as a whole (Anonymous, 2004).

The extent of the pelt industry, of which SWAKARA is only a small part, is vast. The market wants a variety of pelt types, which includes Karakul as a short haired type compared to others such as mink. That makes SWAKARA as a unique pelt, highly recommended due to its many uses. If Namibia can provide in the demand, higher and more stable prices can be expected in the future. With the exploration of new international markets, Agra Co-operative and the Karakul Board try to keep the market informed about the production of SWAKARA. Projects are launched to stimulate production of Karakul and to resettle Karakul in areas where it is at home (Anonymous, 2004).

Pelt production fits well into the economy; the lower Namibian dollar ensures that exporters benefit from the weaker exchange rate. Pelt production is also preferred in most parts of the south of Namibia where the veld is damaged by overgrazing from mutton production (Anonymous, 2004).

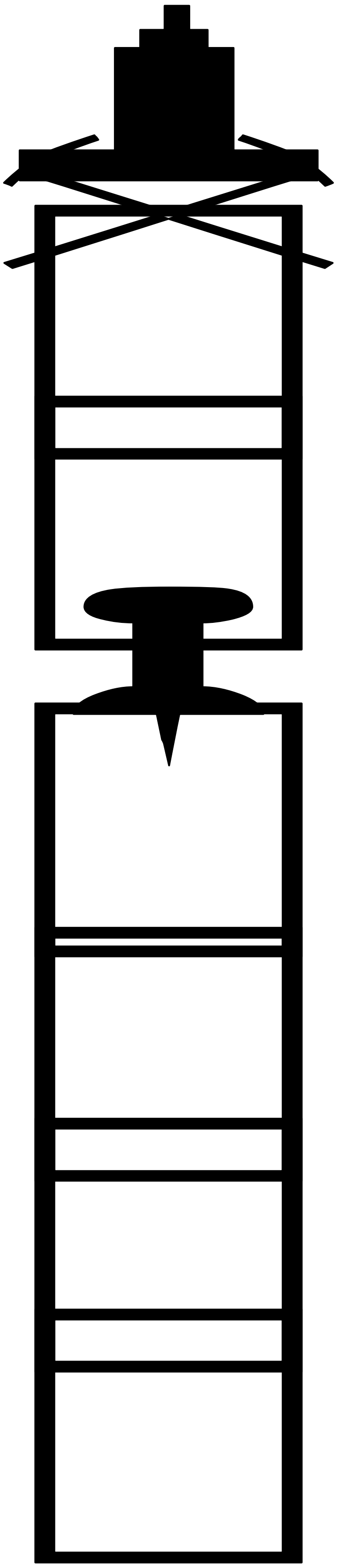
Activities of the Karakul Board to promote the Karakul overseas are:

a) International fairs which are the showroom of the international fur trade.
b) Fur Design Training Services: Contributions to the SWAKARA Creative Seminar where furriers and designers are trained to work with SWAKARA pelts and designs.
c) The Karakul Board is the only member of the International Fur Trade Federation and Deutsches Pelz Institut from the African continent.

d) SWAKARA product guide which shows potential buyers as well as pelt producers and extension officials the wide variety of SWAKARA classifications that make up the SWAKARA assortment.

e) IMCO which is a joint venture between the Karakul Board of Namibia and Nakara CC of Windhoek. The SWAKARA trademark for Germany, Italy and France is registered in the name of IMCO (Anonymous, 2004).

The upwards trend in the pelt price from 2003, together with the increased skin market worldwide, brought new optimism into the Karakul industry. After the sharp increase in pelt prices during the April 2006 auction (68%), SWAKARA is now more famous. A sudden interest from all over the world was the reason for the high prices. The prediction is that this tendency will go on and with the current high prices a correction to a more acceptable buyers' price can be expected with the next auction in September 2006. Thus, the need to enlarge Karakul numbers can not be emphasized enough.



CROSSBREEDING AND UPGRADING AS A MEANS OF INCREASING PRODUCTION– THEORETICAL CONSIDERATIONS

CHAPTER 4

CROSSBREEDING AND UPGRADING AS A MEANS OF INCREASING PRODUCTION – THEORETICAL CONSIDERATIONS.

4.1 INTRODUCTION

Crossbreeding describes crossing individuals of different breeds which can be considered as lines within a species that differ in gene frequencies and performance traits. These frequency differences are a result of emphasis on different traits in deliberate and natural selection. Breeds represent large resources of varying genetic material. Intelligent crossbreeding generates hybrid vigour and utilizes breed complementarities that are important to production efficiency. It often provides an opportunity to make progress in one generation that would require generations of selection to obtain (Van Vleck *et al.*, 1987). Therefore, crossbreeding systems are the domain of commercial animal production because they are designed to maintain hybrid vigour that is important to food and fiber production (Bourdon, 1997).

4.2 GENETIC MODELS – THE THEORY BEHIND CROSSBREEDING

The average performance of a group of animals is determined by their genetic capacity and by the environmental conditions in which they are kept. The genetic component is the aggregate effect of the actions of innumerable genes acting individually and in concert with other genes or groups of genes in the system (Cunningham, 1986).

The genetic models from which working procedures are developed for breeding programs begin at the level of the gene. Cunningham (1986) describes that gene effects can be considered at three levels:

- *Additive effects*: The effects due to single genes acting independently of the remainder of the genotype.
- *Dominance effects*: The effects due to the joint action of gene pairs within loci.
- *Epistatic effects*: The effects due to the joint action of two or more genes at different loci.

4.3 ADVANTAGES OF CROSSBREEDING

Crossbreeding is largely based on the arrangement of favourable dominance effects in each generation. These dominance effects are not cumulative from one generation to the next (Cunningham, 1986). According to Blair (2004) the main advantages of crossbreeding include:

- Improved vitality and performance in crossbred animals.
- Achieving more rapid changes in flock average genetic merit than can be achieved by within breed selection.
- The introduction of new genetic qualities not in the current breed of choice.
- The generation of crossbred offspring that benefit from the complementarity of the parent breeds.
- The recovery of genetic variation in small and/or closed populations.

4.3.1 Heterosis or hybrid vigour (direct and maternal)

Heterosis is defined as the average performance of crossbred progeny to the average performance of the pure breeds that produced the cross. Effects of heterosis have a great impact on productivity of crossbred sheep. The increase in heterozygosity is the basis for heterosis (Leymaster, 2002).

Various types of heterosis are recognized, including parental heterosis (paternal – advantages due to the sire being a crossbred, or maternal – advantage due to the dam being a crossbred) referring to the performance of the two parents, and individual heterosis (advantage of the crossbred individual), referring to non-parental performance (Nicholas, 1996).

Generating hybrid vigour is one of the most important reasons for crossbreeding. Maximum individual hybrid vigour is only obtainable in F_1's, the first cross of unrelated populations (Bourdon, 1997). Traits respond to crossbreeding by exhibiting heterosis. Characters that are non-additive will show the greatest heterosis.

Some general estimates of heterosis in sheep are shown in Table 4.1 (Dalton, 1985):

Table 4.1. Some general estimates (%) of heterosis in sheep (Dalton, 1985)

TRAIT	HETEROSIS %
Barrenness	18
Lambs born/ewe lambing	19-20
Lambs weaned/ewe mated	60
Birth weight	6
Preweaning growth	5-7
Fleece weight	10
Carcass weight	10

The total amount of heterosis in composite traits could therefore be substantial.

4.3.2 Complementarity

Complementarity, as discussed by several authors (Scholtz *et al*, 1996; Leymaster, 2002) is the improved production efficiency that results from crossbreeding systems that let strengths of the sire breed offset weaknesses of the dam breed and strengths of the dam breed counter weaknesses of the sire breed. The sire and dam breeds therefore "complement" each other. Ewes and rams do not equally influence the performance of offspring because lambs are produced, reared and nurtured by ewes. Breed diversity is the main resource that allows producers to benefit from complementarity.

4.4 SYSTEMS OF CROSSBREEDING

A crossbreeding system is a mating system that uses crossbreeding to maintain a desirable level of hybrid vigour and (or) breed complementarity. According to Bourdon (1997), all crossbreeding systems are based on breed diversity. The value of breed diversity is that producers can identify and use a breed or breeds that perform at a level consistent with marketing goals and with production resources such as feed availability, labour, facilities and managerial skills. Breed diversity is even greater if one consider several traits at once rather than a single trait. Traits that impact efficiency in the production system should be determined and target levels of performance established for each trait. Often breeds have similar performance for certain traits but differ for others, whereas some breeds may differ for most traits. When a producer selects and uses a particular breed, the producer is choosing that breed's total package of genetic effects on all traits and thus must selection for a specific breed be made very carefully.

Because each breed has relative strengths and weaknesses across traits, no single breed excels for all relevant traits. Within that lays the basis for strategic use of breeds in structured crossbreeding systems (Leymaster, 2002).

4.4.1 Conventional crossbreeding systems

Conventional systems are mainly for use in meat production and utilize the basis of heterosis and complementarity.

a) Rotational systems

These are systems in which generations of females are "rotated" among sire breeds in such a way that they are mated to sires whose breed composition is most different from their own. It can be spatial where all sire breeds are used simultaneously and are two-breed or three-breed or it can be rotations in time in which sire breeds are not used simultaneously, but are introduced in sequence (Bourdon, 1997).

b) Terminal sire systems

These are systems in which maternal-breed females (purebred or crossbred females that excel in maternal traits like conception rate, litter size, milk and mothering ability) are mated to paternal-breed sires (sires that excel in paternal traits like growth rate and carcass yield) to efficiently produce progeny that are especially desirable from a market standpoint. There are static and rotational terminal systems (Bourdon, 1997).

4.4.2 Synthetic breed development

A composite breed is a breed made up of two or more component breeds and designed to benefit from hybrid vigour without crossing with other breeds (Bourdon, 1997). What distinguishes them from typical crossbreds is not their genetic make-up *per se*, but rather the way in which they are used. Composite breeds provide a simple method to address problems associated with conventional crossbreeding systems. Making crosses among two or more foundation breeds' forms the base generation of a composite breed. Subsequent generations descend from crossbred parents and selection is often practiced to establish distinct characteristics of the new breed (Leymaster, 2002).

Besides these, there are also more complicated or advanced systems which could be consulted in Bourdon (1997).

4.4.3 Upgrading

According to Van Vleck *et al*. (1987) the term grading-up originally referred to successive matings of grade animals to registered animals within the same breed. Nowadays, however, it is the practice of mating purebred sires of one breed to females of another, generation after generation. Thus, in the first generation, the progeny will have 50 %, in the second generation 75 %, and after five generations 96.9 % of the genes of the sire breed. It is an efficient method of replacing one breed by another, which is regarded as being superior and has been used for this purpose in most sheep producing countries. It is usually more effective than the alternative of expanding the numbers in a breed by doing less culling (Coop, 1982).

There are two reasons for grading-up namely to introduce a new gene or genes in a breed where in most situations, three or at the most four crosses, i.e. the original cross and two or three backcrosses, is sufficient to achieve the original aim (Nicholas, 1996) or to totally substitute one breed by another which is illustrated in Table 4.2:

Table 4.2 Grading-up to a migrant breed, M, from any local animals, L (Nicholas, 1996)

GENERATION	MATING PROGRAM	GRADE OF ANIMALS IN SQUARE BRACKETS	PROPORTION OF MIGRANT GENES IN ANIMALS IN SQUARE BRACKETS		
			MIN	AV	MAX
0	L X M				
1	[LM] X M	½ bred	½	½	½
2	[(LM)M] X M	¾ bred	½	¾	1
3	[((LM)M)M] X M	7/8 bred	½	7/8	1
4	[(((LM)M)M)M] X M	15/16 bred	½	15/16	1
5	Etc.	31/32 bred	½	31/32	1

Assuming that a producer has animals of breed A and wants to change over to animals of breed B, one method of accomplishing this is to continually mate his females of breed A and successive crossbreds to males of breed B. In each generation, the proportion of the progeny genes traceable to breed B increases. The proportion of genes from breed A is halved with each generation to the point that there are essentially no genes of breed A remaining in the progeny after eight generations (Van Vleck *et al.*, 1987). The most important point to realize about grading-up is that, except for half-breds, there is variation among the progeny of all other generations, with the respect to the proportion of 'local' and 'migrant' genes. The most likely proportion of migrant genes in any cross is the average, which is the proportion that is used to describe that cross. Breeders cannot tell exactly what proportion of migrant genes exists in any particular animal simply by looking at it, but they can be certain that, on average, animals whose appearance corresponds more closely to the migrant breed are likely to have a larger than average proportion of migrant genes. If breeders do any selection in favour of animals showing migrant-like appearances during their grading-up program (in a mixed population), by the time they have reached second back-cross, their selected progeny will on average have a proportion of migrant genes far higher that 7/8 and probably higher that 31/32 (Nicholas, 1996).

Nicholas (1996) also indicated that the use of continual backcrossing removes all the local genes, and achieves nothing more than replicas of migrant animals. In such a program the local animals have nothing to offer by way of adaptation to local environments. Local animals are usually well adapted to their local environment and therefore they do have some genes that should make a useful contribution to the new breed being developed, provided that the backcrossing does not go too far. Thus continual backcrossing in a grading-up program is sometimes both unnecessary and undesirable.

According to Willis (1993) crossing F_1 with F_1 (to give F_2) results in some advantage due to the mother now being crossbred as opposed to purebred, but individual heterosis in the individual F_2 is halved compared to what it was in the F_1. Accordingly, heterotic effects in grading-up are eventually lost since the net effect is to change from one breed to another. As discussed by Dalton (1985) there is no performance specifications laid down in grading-up programs, but obviously, the greatest success will be achieved by using top proven sires for both pedigree and performance.

Falconer (1981) indicated that the relative amount of heterosis observed in the F_1- and F_2-generations may be complicated by maternal effects. A trait subjected to maternal effects has two components belonging to different generations. The heterosis observed in the F_1 is attributed to the non-maternal part. In the F_2, however, the non-maternal part will lose half the heterosis, but the maternal part will now show the full effect of heterosis since the mothers are now at the F_1- stage. Figure 4.1 demonstrates this situation.

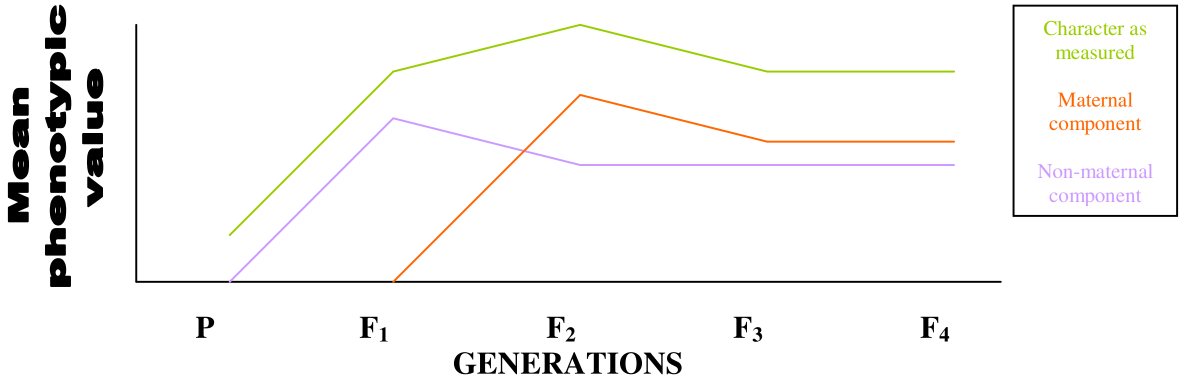


Figure 4.1 Components of performance in crossbred animals (Scholtz *et al*., 1996)

4.5 THE USE OF CROSSBREEDING AND GRADING-UP OF SHEEP

Campher *et al*., (1997) stated: "Crossbreeding does not have a set pattern and a series of factors must be taken into consideration when used, like the adaptability to the kind of breed that is chosen, the purpose of the specific cross and the adaptability of the breed to the environment in which it is going to be used in practice." When considering the benefits of crossbreeding across all animals in a flock and all traits that contribute to profitability, the conclusion of most scientists is that greater financial returns are achieved compared to pure breeding for most production systems (Blair, 2004). In the past crossbreeding for synthetic breed development and upgrading was used in several sheep breeds for various reasons. A few examples are:

4.5.1 CROSSBREEDING IN MUTTON PRODUCTION

The vain attempts to export mutton of the native South African fat tailed sheep to foreign countries caused producers to import mutton breeds from other countries for crossbreeding purposes. New breeds such as the Dorper were developed that was better adapted to South African conditions and could compete with the international mutton market (Campher *et.al*., 1997).

4.5.2 CROSSBREEDING IN WOOL PRODUCTION

Experiments were done by Hofmeyr (1984) on Merino sheep and its crosses with six exotic white-woolled breeds (Cheviot, Bleu de Maine, Border Leicester, Finnish Landrace, Merino

Landschäfe and Texel) to see what the effects of crossbreeding and particularly heterosis was on performance traits and wool properties. The initial aim was to develop a white-wool-meat sheep synthetic breed. The conclusion was made that measured against traditional Merino standards, although the wool of most half-breds lacked quality, it was not as serious as often thought.

4.5.3 CROSSBREEDING IN MILK PRODUCTION

According to Sanna *et al.* (2001) the genetic improvement of milk production could be achieved through crossbreeding and upgrading of local sheep breeds in Italy with imported male lines.

4.5.4 CROSSBREEDING IN PELT PRODUCTION

The Karakul pelt industry in southern Africa is extremely vulnerable because of its total dependency upon the fashion market. It is very sensitive to variation in consumer preferences especially colour. A white Karakul has been developed but the breeding of this white Karakul is problematical, since homozygous white genotypes have lower reproductive and higher mortality rates than black Karakul ewes. A crossbreeding experiment with the Gotland and Karakul breeds with the purpose of developing a white pelt-mutton dual-purpose type of sheep without the sub vital factor of the homozygous white Karakul, was carried out. Gotland rams were crossed with Karakul ewes. It was found that all the colours of the Karakul were dominant over all the colours of the Gotland. The pelt quality of the Gotland x Karakul cross, however, was very poor compared to the standard SWAKARA type produced in southern Africa (Greeff *et al.*, 1984).

During 1973 Romanov-Karakul crosses were used in a sexual activity experiment done by Boshoff *et al.* (1975) to test for several traits, including pelt traits. The results are shown in Table 4.3. The price received for the crossbred pelts were less than the market average and according to Boshoff *et al.* (1975) higher crosses would have been necessary to rectify the pelt defects especially those of metallic, pattern and hair length.

Table 4.3 Pelt traits of 25:75 Romanov-Karakul crossbreds (Boshoff *et al.*, 1975)

TRAIT	CROSSBREDS	PURE KARAKUL
Curl Type	4.1	4.0
Pattern	1.9	3.7
Hair length	5.6	4.9
Hair Quality	4.2	5.3
Lustre	4.2	5.8
Metallic hair	4.8	1.7

In another experiment done by Faure *et al*. (1983) also on Romanov-Karakul crosses, the pelt quality improved as the genetic contribution of the Karakul increased. Curl type and pattern improved substantially with the increase in Karakul genetic contribution. Length and thickness of the hair decreased as the Karakul genetic contribution increased. The percentage deviation of hair stiffness and brittleness of the crosses, from those of the Karakul control flock, decreased in the Romanov-Karakul crosses where the percentage Karakul contribution increased. The occurrence of metallic hair became less with the higher percentage of Karakul genetic contribution, while lustre, extremities and general hair quality improved. However, none of the crosses were suitable for pelt production owing to inferior pelt quality.

4.6 THE DISADVANTAGES OF CROSSBREEDING

According to Blair (2004), in recent years, crossbreeding has been promoted as the mating plan of choice for high performance sheep farmers. While this may well be true for mainstream sheep farmers who are concentrating on lamb production with limited attention to high quality, there are circumstances when crossbreeding is not the best option. These include:

- Effective crossbreeding systems can make the management of an enterprise difficult because there are more different breeding groups.
- There are none or very little selection progress in the flock due to a higher proportion of female animals that has to be slaughtered.
- Combinations of matings to maximize heterosis become depleted, except where F_1's are used as dams and in terminal crossbreeding.
- Effective crossbreeding systems are difficult to sustain themselves and are almost always dependent on the buying in of suitable purebred female genetic material.
- A decrease in heterosis from the F_2 onwards (Scholtz *et al*., 1996).
- An increase in variation if crossbreeding continues beyond the first cross (e.g. a back-cross or an inter se cross).
- Crossbreeding can break up desirable genetic combinations that have been accumulated in a flock over many years of selection (Blair, 2004).

GRADING-UP BLACK-HEADED PERSIAN AND "BLINKHAAR" AFRIKANER SHEEP WITH KARAKUL

CHAPTER 5

GRADING-UP BLACK-HEADED PERSIAN AND "BLINKHAAR" AFRIKANER SHEEP WITH KARAKUL.

5.1 INTRODUCTION

As was indicated in Chapter 3 there is a shortage of Karakul female breeding material. In the Karakul industry it is a known fact that crossbreeding is mainly for enlarging numbers of Karakul. It is thus logical that other breeds could be used to increase Karakul ewe numbers through upgrading. Currently there is an increased shortage in Karakul ewe numbers due to the new interest of commercial farmers in the Karakul industry as well as the aim to resettle Karakul in the communal areas in Namibia. Ewes can not be imported from South Africa because of already low ewe numbers. The successful establishing of a Karakul industry mainly depends on the success with which native breeds could be used for upgrading.

In South Africa and Namibia crossbreeding was done shortly after the first Karakul sheep was imported. Crosses with Afrikaner, Black-headed Persians and Merinos were carried out. According to Theron (1966) from these three, the Merino showed the poorest pelt quality.

To make use of crossbreeding is an ideal option. Information regarding crossbreeding with Karakul was last done in 1979 (Schoeman, 1979). Since then the breeding objectives, market requirements and norms have changed and became stricter within the Karakul industry. Breeding policies changed from the old pipe-curl types that was high fashion in the 1950's and 1960's to the less developed types of watered-silk and shallow watered-silk which is what the fashion world wants at present.

Several researchers had in the past agreed that the Afrikaner and Black-headed Persian are the best breeds for crossbreeding with the Karakul (Frölich & Hornitschek, 1954; Spitzner & Schäfer, 1963; Gouws, *et al*., 1970; Steyn, 1975; Viljoen, 1981). Since 1997 there was a revival in white Karakul due to the demand for more white pelts and more white wool. The wool demand was covered in three years time, but the white pelt demand could not yet be covered.

Around 1999 some producers started with their own breeding plans to enlarge their white Karakul ewe numbers with ewes like Afrikaner, Van Rooy, Damara and Black-headed Persians. Afrikaners turned out to give the best results (not scientifically tested) with white Karakul rams. Due to a demand for more black Karakul ewes as well, the Karakul Board and Karakul Breeders Society suggested that a black Karakul X Black-headed Persian breeding program must be done at the same time as the white Karakul X Afrikaner program. "Blinkhaar" Afrikaner ewes and Black-headed Persian ewes were thus again used for this project. A short discussion of these two breeds will therefore be presented.

5.2 THE "BLINKHAAR" AFRIKANER

The Afrikaner sheep originated from the Middle East and North East Africa. They migrated southward with the Khoi-khoi people, moving into South Africa between 400 and 600 AD. According to Terblanche (1978) at first the sheep were multi-coloured (black, redbrown or grey) and were generally known as Cape fat-tailed sheep. Two subtypes could be distinguished according to the shape of the tail. In the 18^{th} century, Cape Dutch farmers began selecting against coloured coats. These sheep formed the origin of the present day Afrikaner (Ramsey *et al.*, 2001). The name "Ronderib" is derived from the fact that the rib is oval in shape. The "Blinkhaar Ronderib" Afrikaner is a typical fat-tailed arid area sheep type with the ability to store energy in its tail. They have a white creamy covering of hair and wool. Soft, silky white downy wool is found on the under covering of the skin, while the fleece contains soft, long hair. The shiny hair and round-ribbed ("Blinkhaar ronderib") appearance is typical of the breed (Terblanche, 1978). Figure 5.1 show a typical flock of "Blinkhaar" Afrikaners.

Figure 5.1 "Blinkhaar" Ronderib Afrikaner sheep

The reasons why the "Blinkhaar" Afrikaner was used are:

- The colour of the "Blinkhaar" Afrikaner is dominantly white. Crossbreeding with A-white Karakul rams would give only a small percentage of spotted lambs.
- Short hair.
- High fertility (Visser 2000).
- Absence of the sub-vital factor which is present in white Karakul (Visser, 2000).

According to genetic marker studies on indigenous breeds done by Buduramp (2004), the Karakul and Ronderib Afrikaner were grouped together which means that the genetic distance between the two are not great and that there is a phylogenetic relationship between these two breeds. This can be advantageous for the use of the Ronderib Afrikaner in crossbreeding with the Karakul. Figure 5.2 below show the relationship between the Ronderib Afrikaner and Karakul through the neighbour-joining tree and UPGMA tree (Buduramp, 2004).

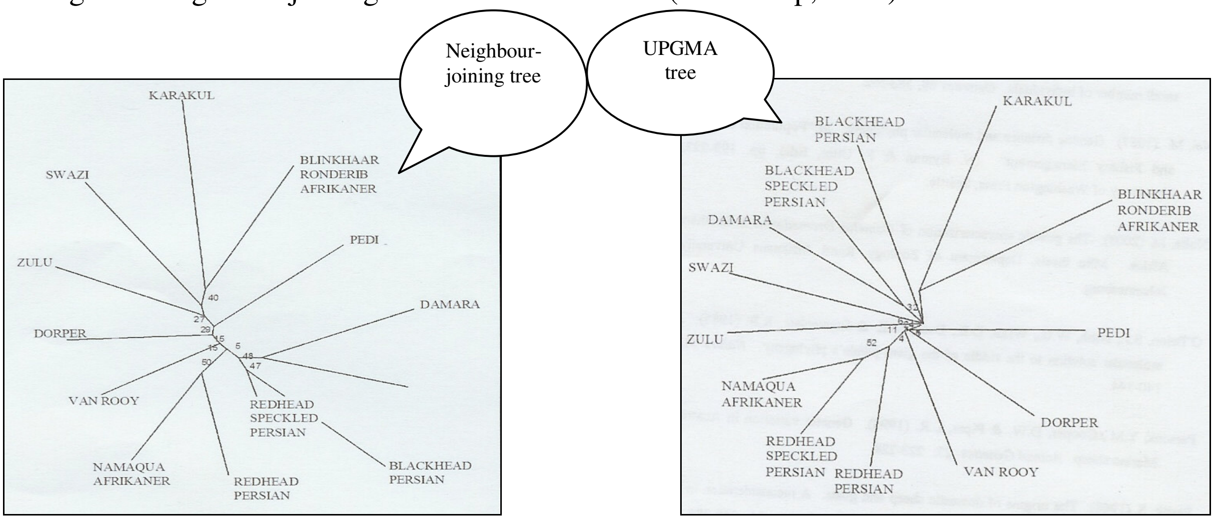


Figure 5.2 Unrooted Neighbour-joining tree and unrooted UPGMA tree representing the genetic relationship between the indigenous and locally developed breeds of Southern Africa (Buduramp, 2004)

5.3 THE BLACK-HEADED PERSIAN

The ancestors of the Black-headed Persian arrived in South-Africa by chance in 1869. A vessel damaged by a storm at sea carried a number of slaughter sheep from Somali. These sheep, one ram and three ewes, were taken to Wellington where the breed was further developed (Campbell & Hofmeyr, 1972; Terblanche, 1978). Figure 5.3 shows a typical flock of Black-headed Persian ewes and lambs.

Figure 5.3 Black-headed Persian Sheep

The Black-headed Persian is classified as a fat-rumped breed. The body covering consists of short, white lime-like kemp, whereas the head is covered with short, shiny black hair. They are extremely fertile and can produce lambs throughout the year (Terblanche, 1978).

This is a hardy, adapted breed and the reasons for using the Black-headed Persian for upgrading, are:

- Recessive gene which limits the black colour to the head. With crossbreeding just a small percentage of spotted lambs will be born (Lundie, 2004).
- Primary follicle arrangement: Narrow primary to secondary hair follicle ratio which corresponds to that of the Karakul (Visser, 2000).
- Short hair.
- High fertility (Visser, 2000).

5.4 MATERIAL AND METHODS

5.4.1 Location

The experiment was carried out on the farm Lovedale, 19 km southwest of Helmeringhausen in the southwestern part of Namibia, located in the so-called "Rooi-rante". The farm is 12 924 ha large and consists of grassland, mountains and riverbeds. The farm is 1 570m above sea level and 120 km directly from the sea. The grazing is a mixture of grass, bush and thorn trees. All the facilities of Lovedale were used, like the pens and kraals for the ewes and lambs just before and after lambing, the photo-room for the photographing of lambs, the pelt room for the processing of the pelts.

5.4.2 Material

The initial base ewes consisted of 97 Black-headed Persians and 185 “Blinkhaar” Afrikaner ewes.

The Black-headed Persian ewes were obtained from three different farms while the “Blinkhaar” Afrikaner ewes were selected at random from a flock at Lovedale. The Black-headed Persian ewes were mated to black Karakul rams and the “Blinkhaar” Afrikaner ewes to white Karakul rams (A and B colour).

The Karakul rams used in the study were purebred stud rams of the Lovedale Stud. Base ewes were marked with different colour ear tags and numbered. Tables 5.1 to 5.10 illustrate the different matings in the different lambing seasons for the base ewes.

Table 5.1 Matings of “Blinkhaar” Afrikaner ewes marked with blue tags lambing in seasons one

Sire Number	Ewe Number	Sire Number	Ewe Number
RWL2772	ABL01	RWL2772	ABL18
RWL2772	ABL02	RWL2772	ABL19
RWL2772	ABL03	RWL2772	ABL20
RWL2772	ABL04	RWL2772	ABL21
RWL2772	ABL05	RWL2772	ABL22
RWL2772	ABL06	RWL2772	ABL23
RWL2772	ABL07	RWL2772	ABL24
RWL2772	ABL08	RWL2772	ABL25
RWL2772	ABL09	RWL2772	ABL26
RWL2772	ABL10	RWL2772	ABL27
RWL2772	ABL11	RWL2772	ABL28
RWL2772	ABL12	RWL2772	ABL29
RWL2772	ABL13	RWL2772	ABL30
RWL2772	ABL14	RWL2772	ABL31
RWL2772	ABL15	RWL2772	ABL32
RWL2772	ABL16	RWL2772	ABL33
RWL2772	ABL17	RWL2772	ABL34

Table 5.2 Matings of "Blinkhaar" Afrikaner ewes marked with blue tags lambing in seasons two

Sire Number	Ewe Number	Sire Number	Ewe Number
CLX9366	ABL01	CLX9366	ABL15
CLX9366	ABL02	CLX9366	ABL16
CLX9366	ABL03	CLX9366	ABL17
CLX9366	ABL04	CLX9366	ABL18
CLX9366	ABL05	CLX9366	ABL19
CLX9366	ABL06	CLX9366	ABL20
CLX9366	ABL07	CLX9366	ABL21
CLX9366	ABL08	CLX9366	ABL22
CLX9366	ABL09	CLX9366	ABL23
CLX9366	ABL10	CLX9366	ABL24
CLX9366	ABL11	CLX9366	ABL25
CLX9366	ABL12	CLX9366	ABL26
CLX9366	ABL13	CLX9366	ABL27
CLX9366	ABL14		

Table 5.3 Matings of "Blinkhaar" Afrikaner ewes marked with yellow and green tags lambing in season one

Sire Number	Ewe Number	Sire Number	Ewe Number
CLX9366	AGR01	CLX9366	AGR11
CLX9366	AGR02	CLX9366	AGR12
CLX9366	AGR03	CLX9366	AGR13
CLX9366	AGR04	CLX9366	AGR14
CLX9366	AGR05	CLX9366	AGR15
CLX9366	AGR06	CLX9366	AGR16
CLX9366	AGR07	CLX9366	AGR17
CLX9366	AGR08	CLX9366	AGR18
CLX9366	AGR09	CLX9366	AGR19
CLX9366	AGR10	CLX9366	AGR20
CLX9570	AGE01	CLX9570	AGE08
CLX9570	AGE02	CLX9570	AGE09
CLX9570	AGE03	CLX9570	AGE10
CLX9570	AGE04	CLX9570	AGE11
CLX9570	AGE05	CLX9570	AGE12
CLX9570	AGE06	CLX9570	AGE13
CLX9570	AGE07		

Table 5.4 Matings of "Blinkhaar" Afrikaner ewes marked with orange tags lambing in season two

Sire Number	Ewe Number	Sire Number	Ewe Number	Sire Number	Ewe Number
CLX9570	AOR01	CLX9570	AOR25	CLX9570	AOR49
CLX9570	AOR02	CLX9570	AOR26	CLX9570	AOR50
CLX9570	AOR03	CLX9570	AOR27	CLX9570	AOR51
CLX9570	AOR04	CLX9570	AOR28	CLX9570	AOR52
CLX9570	AOR05	CLX9570	AOR29	CLX9570	AOR53
CLX9570	AOR06	CLX9570	AOR30	CLX9570	AOR54
CLX9570	AOR07	CLX9570	AOR31	CLX9570	AOR55
CLX9570	AOR08	CLX9570	AOR32	CLX9570	AOR56
CLX9570	AOR09	CLX9570	AOR33	CLX9570	AOR57
CLX9570	AOR10	CLX9570	AOR34	CLX9570	AOR58
CLX9570	AOR11	CLX9570	AOR35	CLX9570	AOR59
CLX9570	AOR12	CLX9570	AOR36	CLX9570	AOR60
CLX9570	AOR13	CLX9570	AOR37	CLX9570	AOR61
CLX9570	AOR14	CLX9570	AOR38	CLX9570	AOR62
CLX9570	AOR15	CLX9570	AOR39	CLX9570	AOR63
CLX9570	AOR16	CLX9570	AOR40	CLX9570	AOR64
CLX9570	AOR17	CLX9570	AOR41	CLX9570	AOR65
CLX9570	AOR18	CLX9570	AOR42	CLX9570	AOR66
CLX9570	AOR19	CLX9570	AOR43	CLX9570	AOR67
CLX9570	AOR20	CLX9570	AOR44	CLX9570	AOR68
CLX9570	AOR21	CLX9570	AOR45	CLX9570	AOR69
CLX9570	AOR22	CLX9570	AOR46	CLX9570	AOR70
CLX9570	AOR23	CLX9570	AOR47		
CLX9570	AOR24	CLX9570	AOR48		

Table 5.5 Matings of "Blinkhaar" Afrikaner ewes marked with red tags lambing in season one and two

Sire Number	Ewe Number	Lambing Season	Sire Number	Ewe Number	Lambing Season
CLX9765	ARO01	1	CLX9765	ARO07	1
RWL2772	ARO01	2	RWL2772	ARO07	2
CLX9765	ARO02	1	CLX9765	ARO08	1
RWL2772	ARO02	2	RWL2772	ARO08	2
CLX9765	ARO03	1	CLX9765	ARO09	1
RWL2772	ARO03	2	RWL2772	ARO09	2
CLX9765	ARO04	1	CLX9765	ARO10	1
RWL2772	ARO04	2	CLX9765	ARO11	1
CLX9765	ARO05	1	CLX9765	ARO12	1
RWL2772	ARO05	2	CLX9765	ARO13	1
CLX9765	ARO06	1	CLX9765	ARO14	1
RWL2772	ARO06	2	CLX9765	ARO15	1

Table 5.6 Matings of "Blinkhaar" Afrikaner ewes lambing in season four and five

Sire Number	Ewe Number	Lambing Season
CLX10202	AFR1	4
CLX10477	AFR	5
CLX10477	AFR2	5

Table 5.7 Matings of Black-headed Persian ewes marked with yellow tags lambing in season one

Sire Number	Ewe Number	Sire Number	Ewe Number
CLX9319	PGE01	CLX9319	PGE05
CLX9319	PGE02	CLX9319	PGE06
CLX9319	PGE03	CLX9319	PGE07
CLX9319	PGE04	CLX9319	PGE08

Table 5.8 Matings of Black-headed Persian ewes marked with orange tags lambing in season one

Sire Number	Ewe Number	Sire Number	Ewe Number
CLX9200	POR01	CLX9200	POR07
CLX9200	POR02	CLX9200	POR08
CLX9200	POR03	CLX9200	POR09
CLX9200	POR04	CLX9200	POR10
CLX9200	POR05	CLX9200	POR11
CLX9200	POR06		

Table 5.9 Matings of Black-headed Persian ewes marked with white tags lambing in season one and two

Sire Number	Ewe Number	Lambing Season	Sire Number	Ewe Number	Lambing Season
CLX9266	PWI01	1	CLX9266	PWI13	1
CLX9266	PWI02	1	CLX9266	PWI14	1
CLX9266	PWI03	1	CLX9266	PWI15	1
CLX9266	PWI04	1	CLX9266	PWI16	1
CLX9266	PWI05	1	CLX9266	PWI17	1
CLX9266	PWI06	1	CLX9266	PWI18	1
CLX9266	PWI07	1	CLX9200	PWI20	2
CLX9266	PWI08	1	CLX9200	PWI21	2
CLX9266	PWI09	1	CLX9765	PWI22	2
CLX9266	PWI10	1	CLX9765	PWI23	2
CLX9266	PWI11	1	CLX9765	PWI24	2
CLX9266	PWI12	1			

Table 5.10 Matings of Black-headed Persian ewes lambing in season two, three and five

Sire Number	Ewe Number	Lambing Season	Sire Number	Ewe Number	Lambing Season
CLX9200	P03	3	CLX9200	P38	2
CLX9200	P08	3	CLX9200	P38	3
CLX9200	P09	3	CLX9200	P40	2
CLX9200	P10	3	CLX9611	P42	2
CLX9200	P12	3	CLX9200	P43	3
CLX9200	P13	3	CLX9611	P43	2
CLX9200	P14	3	CLX9611	P44	2
CLX9200	P15	3	CLX9611	P45	2
CLX9200	P16	3	CLX9200	P47	2
CLX9200	P18	3	CLX9765	P49	2
CLX9611	P18	2	CLX9200	P50	3
CLX9200	P19	3	CLX9765	P50	2
CLX9200	P20	3	CLX9765	P51	2
CLX9200	P21	3	CLX9200	P51	3
CLX9200	P24	3	CLX9200	P52	2
CLX9200	P25	2	CLX9200	P53	2
CLX9200	P25	3	CLX9200	P53	3
CLX9200	P26	2	CLX9611	P56	2
CLX9765	P27	2	CLX9611	P58	2
CLX9200	P28	3	CLX9611	P60	2
CLX9200	P29	2	CLX9200	P61	3
CLX9200	P30	2	CLX9200	P62	3
CLX9200	P30	3	CLX9765	P63	2
CLX9200	P31	2	CLX9200	P64	2
CLX9200	P31	3	CLX9200	P67	2
CLX9200	P34	2	CLX9200	P67	3
CLX9200	P35	2	CLX9500	P68	5
CLX9765	P36	2			

All lambs born in each generation were marked with an aluminum ear tag each with its own number. A pedigree sheet was issued for each lamb where the parents of the lamb were recorded. The gender and status (single or twins) of all lambs were also recorded. Lambs were evaluated by two stud breeders. All lambs were photographed at the age of 24-48 hours for grading purposes and the photos evaluated by the Karakul Breeders Society's Quality Control Panel, which gave the lambs a percentage mark on their quality.

All ewe lambs born within the upgrading program were kept for further breeding of the next generation. Tables 5.11 to 5.18 illustrate the matings of the different ewes in the different generations.

Table 5.11 F_1 ewes mated and lambing in lambing season three

Sire number	Ewe number	Sire number	Ewe number	Sire number	Ewe number
CLX9500	CAB005	CLX9500	CAB125	CLX9777	CABW058
CLX9500	CAB060	CLX9777	CABW002	CLX9777	CABW070
CLX9500	CAB066	CLX9777	CABW003	CLX9777	CABW071
CLX9500	CAB067	CLX9777	CABW006	CLX9777	CABW072
CLX9500	CAB074	CLX9777	CABW009	CLX9777	CABW079
CLX9500	CAB075	CLX9777	CABW010	CLX9777	CABW085
CLX9500	CAB082	CLX9777	CABW011	CLX9777	CABW090
CLX9500	CAB084	CLX9777	CABW014	CLX9777	CABW092
CLX9500	CAB093	CLX9777	CABW021	CLX9777	CABW094
CLX9500	CAB096	CLX9777	CABW022	CLX9777	CABW100
CLX9500	CAB103	CLX9777	CABW026	CLX9777	CABW107
CLX9500	CAB104	CLX9777	CABW028	CLX9777	CABW113
CLX9500	CAB105	CLX9777	CABW029	CLX9777	CABW114
CLX9500	CAB120	CLX9777	CABW030	CLX9777	CABW115
CLX9500	CAB122	CLX9777	CABW052	CLX9777	CABW118
CLX9500	CAB123	CLX9777	CABW056		

Table 5.12 F_1 ewes mated and lambing in lambing season four

Sire number	Ewe number	Sire number	Ewe number	Sire number	Ewe number	Sire number	Ewe number
CLX10202	CABW140	CLX10202	CABW198	CLX10202	CABW280	CLX9739	CABW028
CLX10202	CABW152	CLX10202	CABW205	CLX10202	CABW291	CLX9739	CABW029
CLX10202	CABW154	CLX10202	CABW240	CLX9500	CAB170	CLX10252	CABW141
CLX10202	CABW163	CLX10202	CABW246	CLX9500	CAB230	CLX10252	CABW175
CLX10202	CABW164	CLX10202	CABW248	CLX9500	CAB244	CLX10252	CABW207
CLX10202	CABW174	CLX10202	CABW269	CLX9500	CAB245	CLX10252	CABW243
CLX10202	CABW176	CLX10202	CABW270	CLX9500	CAB319	CLX10252	CABW299
CLX10202	CABW180	CLX10202	CABW275	CLX9739	CABW011	CLX10252	CABW316
CLX10202	CABW183	CLX10202	CABW306	CLX9739	CABW021		

Table 5.13 F_1 ewes mated and lambing in lambing season five

Sire number	Ewe number	Sire number	Ewe number	Sire number	Ewe number
CLX9111	CAB065	CLX9739	CABW014	CLX9739	CABW071
CLX9111	CAB067	CLX9739	CABW022	CLX9739	CABW090
CLX9111	CAB075	CLX9739	CABW030	CLX9739	CABW094
CLX9111	CAB084	CLX9739	CABW052	CLX9739	CABW113
CLX9500	CAB083	CLX9739	CABW056	CLX9739	CABW114
CLX9500	CAB104	CLX9739	CABW057	CLX9739	CABW115
CLX9739	CABW009	CLX9739	CABW070	CLX9739	CABW118

Table 5.14 F_1 ewes mated and lambing in lambing season six

Sire number	Ewe number	Sire number	Ewe number	Sire number	Ewe number	Sire number	Ewe number
CLX9500	CAB066	CLX10377	CABW002	CLX10377	CABW175	CLX10377	CABW279
CLX9500	CAB082	CLX10377	CABW010	CLX10377	CABW180	CLX10377	CABW280
CLX9500	CAB096	CLX10377	CABW058	CLX10377	CABW182	CLX10377	CABW281
CLX9500	CAB103	CLX10377	CABW069	CLX10377	CABW183	CLX10377	CABW302
CLX9500	CAB123	CLX10377	CABW072	CLX10377	CABW186	CLX10377	CABW305
CLX9500	CAB125	CLX10377	CABW079	CLX10377	CABW198	CLX10377	CABW307
CLX9500	CAB133	CLX10377	CABW080	CLX10377	CABW203	CLX10377	CABW316
CLX9500	CAB170	CLX10377	CABW085	CLX10377	CABW205	CLX10061	CAB120
CLX9500	CAB221	CLX10377	CABW100	CLX10377	CABW207	CLX10061	CAB220
CLX9500	CAB224	CLX10377	CABW107	CLX10377	CABW213	CLX10061	CAB244
CLX9500	CAB230	CLX10377	CABW122	CLX10377	CABW232	CLX10061	CAB278
CLX9500	CAB231	CLX10377	CABW127	CLX10377	CABW235	CLX10061	CAB350
CLX9500	CAB319	CLX10377	CABW130	CLX10377	CABW236	CLX10061	CAB355
CLX9500	CAB323	CLX10377	CABW140	CLX10377	CABW237	CLX10061	CAB358
CLX9500	CAB349	CLX10377	CABW141	CLX10377	CABW238	CLX10061	CAB389
CLX9500	CAB352	CLX10377	CABW154	CLX10377	CABW240	DJLW7861	CABW021
CLX9500	CAB354	CLX10377	CABW160	CLX10377	CABW248	DJLW7861	CABW056
CLX9500	CAB356	CLX10377	CABW162	CLX10377	CABW250	CLX10477	CABW026
CLX9500	CAB372	CLX10377	CABW163	CLX10377	CABW260	CLX10477	CABW151
CLX9500	CAB387	CLX10377	CABW164	CLX10377	CABW269	CLX10477	CABW190
CLX9500	CAB389	CLX10377	CABW165	CLX10377	CABW270	CLX10477	CABW200
CLX9500	NRF1	CLX10377	CABW174	CLX10377	CABW275	CLX10061	CAB105

Table 5.15 F_2 ewes mated and lambing in lambing season six

Sire Number	Ewe Number	Sire Number	Ewe Number	Sire Number	Ewe Number
CLX10061	CAB325	CLX10377	CABW338	CLX10377	CABW373
CLX10061	CAB346	CLX10377	CABW360	CLX10377	CABW339
CLX10061	CAB370	CLX10377	CABW363	CLX10377	CABW369
CLX9500	CAB334	CLX10377	CABW333	CLX10377	CABW330
CLX9500	CAB336				

Table 5.16 F_2 ewes mated and lambing in lambing season seven

Sire Number	Ewe Number	Sire Number	Ewe Number	Sire Number	Ewe Number	Sire Number	Ewe Number
CLX10372	CAB381	CLX10400	CABW339	CLX10477	CABW330	CLX10717	CAB334
CLX10372	CAB391	CLX10400	CABW360	CLX10477	CABW385	CLX10717	CAB336
CLX10400	CABW333	CLX10400	CABW363	CLX10377	CABW345	CLX10717	CAB372
CLX10400	CABW338			CLX10377	CABW378	CLX10717	CAB387

Table 5.17 F_2 ewes mated and lambing in lambing season eight

Sire Number	Ewe Number	Sire Number	Ewe Number	Sire Number	Ewe Number
CLX10372	CAB335	CLX10477	CABW347	CLX10477	CABW475
CLX10717	CAB346	CLX10477	CABW400	CLX10477	CABW477
CLX10717	CAB370	CLX10477	CABW424	CLX10477	CABW480
CLX10717	CAB445	CLX10477	CABW430	CLX10477	CABW497
CLX10717	CAB455	CLX10477	CABW437	CLX10477	CABW505
CLX10717	CAB458	CLX10477	CABW440	CLX10477	CABW541
CLX10717	CAB464	CLX10477	CABW444	CLX10477	CABW544
CLX10717	CAB465	CLX10477	CABW453	CLX10477	CABW544
CLX10377	CABW369	CLX10477	CABW470	CLX10477	CABW549
		CLX10477	CABW471	CLX10477	CABW550

Table 5.18 F_2 ewes mated and lambing in lambing season nine

Sire Number	Ewe Number	Sire Number	Ewe Number	Sire Number	Ewe Number
CLX10301	CAB493	CLX10372	CAB381	CLX9366	CABW542
CLX10755	CABW338	CLX10372	CAB391	CLX9366	CABW548
CLX10372	CAB334	CLX9366	CABW333	CLX9366	CABW551
CLX10372	CAB336	CLX9366	CABW363		
CLX10372	CAB372	CLX9366	CABW378		

In the case of ram lambs those which were considered as suitable as pelts were slaughtered, while those which were considered as unsuitable as pelts were kept and raised for meat production purposes.

The following data were recorded:

- Generation: Three generations were completed in the upgrading (F_1 to F_3). This is compared to control flocks (P) (white and black) of the existing stud flocks at Lovedale. The white F-generations were compared to the white control flock and the black F-generations to the black control flock.
- Ewe age at lambing: The age of the ewe with lambing. The age distribution of the ewes at lambing is illustrated in Table 5.30
- Birth weight: Lambs were weighed at the age of 24-48 hours. The distribution of the weights per season and generation are presented in Table 5.27.
- Pelt traits: Curl type, excellence of pattern (VVP), hair quality (lustre and texture), spots, and pelt type were recorded. Curl type traits were grouped as is illustrated in

Table 5.19. The rest was evaluated according to their observed value. Texture and lustre were grouped as illustrated in Table 5.20 and Table 5.21, respectively.

Table 5.19 Curl type groups and number of group

Curl type	Group number
Galiac (GAL)	1
Watered silk galiac (WSGAL)	2
Watered silk (WS)	3
Shallow watered silk (VLWS)	4
Shallow (VL)	5
Shallow developed (VO) & Developed shallow (OV)	6

Table 5.20 Texture groups and number of the group

Texture	Degree of excellence	Number of group
Normal-metallic, metallic, normal-chalky, Chalky, dull, metallic-dull and normal-dull.	Inferior	1
Normal	Intermediate	2
Normal-glossy and Glossy	Superior	3

Table 5.21 Lustre groups and number of group

Lustre	Degree of excellence	Number of group
Normal-coarse, Normal-soft, Soft, Coarse	Inferior	1
Normal	Intermediate	2
Normal-silky, Normal-elastic, Elastic, Silky, Elastic-silky	Superior	3

- Pelt price: The individual pelt prices obtained on auctions for each pelt are illustrated in Tables 5.22, 5.23 and 5.24 sorted according to generation

Table 5.22 Individual pelt prices obtained for lambs used for pelt production in F_1-Generation

Lam number	Pelt Type	Pelt Price	Lam number	Pelt Type	Pelt Price	Lam number	Pelt Type	Pelt Price
CABW008	MG	161.34	CAB110	REJECT	0	CABW181	MG	161.34
CABW018	FLAT2	239.57	CAB131	LGFLAT	50.52	CABW258	SUNCOL	231.68
CABW040	CURL3	122.17	CAB132	LGFLAT	50.52	CABW276	FLAT3	184.96
CABW041	SUNCOL	231.68	CABW138	SUNCOL	231.68	CABW301	REJECT	0
CABW038	SUNCOL	231.68	CAB173	FLAT2b	101.76	CABW314	SUNCOL	231.68
CABW039	REJECT	0	CABW143	SUNCOL	231.68	CABW317	STILLBORN	0
CAB109	REJECT	0	CABW145	SUNCOL	231.68			

Table 5.23 Individual pelt prices obtained for lambs used for pelt production in F_2-Generation

Lam number	Pelt Type	Pelt Price	Lam number	Pelt Type	Pelt Price	Lam number	Pelt Type	Pelt Price
CABW331	FLAT1	300.95	CABW501	FLAT1	300.95	CAB590	DFLAT1	251.18
CABW332	FLAT2	239.57	CABW503	FLAT1	300.95	CAB602	FLAT2b	101.76
CABW342	FLAT2	239.57	CABW506	FLAT3	184.96	CABW598	CURL1	198.38
CABW343	LG	133.60	CABW507	SUNCOL	231.68	CABW622	SUNCOL	231.68
CABW344	CURL2	156.38	CABW508	FLAT2	239.57	CABW623	SUNCOL	231.68
CAB366	O2	145.75	CAB509	RFLAT2	122.22	CAB629	FLAT2b	101.76
CABW368	FLAT1	300.95	CABW519	OSEL	316.41	CABW637	FLAT1	300.95
CABW379	FLAT1	300.95	CAB516	O2	145.75	CABW642	FLAT3	184.96
CAB382	FLAT2b	101.76	CAB517	O1	173.23	CABW643	CURL1	198.38
CABW442	FLAT2	239.57	CAB518	NFLAT2	105.67	CABW647	DAMAGED1	133.60
CABW451	CURL2	156.38	CABW526	CURL3	122.17	CAB657	FLAT3b	184.96
CABW459	CURL2	156.38	CAB528	MKFLAT1	118.62	CABw658	MG	161.34
CAB462	K1	122.80	CABW529	FLAT2	239.57	CAB663	FLAT3b	184.96
CABW468	FLAT1	300.95	CABW532	CURL2	156.38	CABW627	CURL2	156.38
CABW467	CURL2	156.38	CAB569	NFLAT2	105.67	CABw662	FLAT2b	101.76
CABW469	FLAT1	300.95	CAB554	NFLAT2	105.67	CABw671	CURL2b	72.54
CABW478	STILLBORN	0.00	CABW561	FLAT2	239.57	CAB673	T1	138.95
CABW481	SUNCOL	231.68	CABW572	CURL2	156.38	CAB677	M2	105.36
CABW483	CURL1	198.38	CABW573	CURL2	156.38	CAB678	FLAT2b	101.76
CABW496	SUNCOL	231.68	CAB589	O2	145.75	CAB706	FLAT2b	101.76
CAB709	FLAT2b	101.76	CABW766	FLAT1	300.95	CABW799	CURL2	156.38
CAB715	DSELb	272.30	CAB771	O1	173.23	CABW802	CURL2	156.38
CAB718	FLAT2b	101.76	CABW768	FLAT3	184.96	CABW803	FLAT2	239.57
CAB719	FLAT1b	124.87	CABW769	CURL1	198.38	CABW804	FLAT1	300.95
CAB740	CURL2b	72.54	CABW773	FLAT1	300.95	CAB806	FLAT1b	124.87
CAB743	NFLAT1	139.29	CABW776	FLAT2	239.57	CABW807	CURL1	198.38
CABW741	CURL2	156.38	CABW778	FLAT1	300.95	CABW808	OSEL	316.41
CABW739	SUNCOL	231.68	CAB785	KF1	152.07	CABW811	DSEL	355.03
CABW742	FLAT3	184.96	CABW779	CURL3	122.17	CABW812	FLAT1	300.95
CAB753	DAMAGED2	89.29	CABW780	CURL2	156.38	CABW809	CURL1	198.38
CABW749	FLAT2	239.57	CABW782	CURL3	122.17	CABW810	FLAT1	300.95
CABW747	DSEL	355.03	CABW783	FLAT1	300.95	CABW817	CURL3	122.17
CABW748	SUNCOL	231.68	CABW786	FLAT3	184.96	CABW820	P2	140.90
CABW750	OSEL	316.41	CABW788	FLAT3	184.96	CABW823	KF2	126.46
CABW751	CURL2	156.38	CABW794	FLAT2	239.57	CABW825	SUNCOL	231.68
CABW752	FLAT3	184.96	CABW781	FLAT1	300.95	CABW829	FLAT3	184.96
CAB754	KF2	126.46	CABW784	MG	161.34	CABW839	OSEL	316.41

Table 5.23 Individual pelt prices obtained for lambs used for pelt production in F_2-Generation (continued)

Lam number	Pelt Type	Pelt Price	Lam number	Pelt Type	Pelt Price	Lam number	Pelt Type	Pelt Price
CAB757	DAMAGED2	89.29	CABW787	FLAT1	300.95	CABW843	M2	105.36
CAB758	O2	145.75	CABW791	CURL2	156.38	CABW840	FLAT3	184.96
CAB759	GALIAC	184.9	CABW792	FLAT1	300.95	CABW844	CURL1	198.38
CABW761	OSEL	316.41	CABW797	FLAT1	300.95	CABW846	FLAT2	239.57
CABW762	REJECT	0.00	CAB798	P1	198.83			

Table 5.24 Individual pelt prices obtained for lambs used for pelt production in F_3-Generation

Lam number	Pelt Type	Pelt Price	Lam number	Pelt Type	Pelt Price	Lam number	Pelt Type	Pelt Price
CABW534	CURL2	156.38	CABW697	SUNCOLb	31.86	CAB731	MG	161.34
CAB563	O1	173.23	CAB698	FLAT3	184.96	CABW733	K1	122.80
CAB604	O2	145.75	CAB702	O2	145.75	CABW736	MG	161.34
CABW615	CURL1	198.38	CAB703	O2	145.75	CAB737	REJECT	0.00
CAB648	CURL2b	72.54	CABW716	MG	161.34	CAB756	FLAT2	239.57
CAB661	F	249.49	CABW721	MG	161.34	CABW772	FLAT1	300.95
CABW684	FLAT2b	101.76	CAB724	MG	161.34	CABW830	DSEL	355.03
CABW687	MG	161.34	CAB726	CURL2b	72.54	CABW789	CURL3	122.17
CABW690	CURL2b	72.54	CAB728	DLSELb	351.44			
CAB704	RFLAT2	122.22						

Evaluation was done subjectively according to the procedure and scale laid down by the Karakul Breeders Society (Anonymous, 1982) and was discussed in Chapter Two.

- <u>Colour</u>: Lambs were grouped according to their pelt colour in either black or white (A, B, C and D-white), as was discussed in Chapter Two.
- <u>Destiny of the lamb</u>: There were four different categories namely stud breeding (all ewe lambs which were used further on for breeding), flock (only the pure bred control flock where ewe lambs that were not suitable for further stud breeding or for pelt production were categorized as flock animals), mutton production (all ram lambs not suitable for pelt production), and pelt production. Pelts were individually marked according to the number of the lamb and each pelt was separately evaluated and graded at the Karakul Pelt Centre in Windhoek. From there they went to the Pelt auctions in Copenhagen, Denmark.

- Lambing seasons: The date of birth of all lambs were recorded and according to that grouped in nine lambing seasons in different times of the year as illustrated in Table 5.25 below. This was done to combine the year/season effect.

Table 5.25 Lambing seasons during the 5 years of the experiment

Season Number	Season	LAMBING SEASON
1	Autumn/Winter	13 April 2001 to 27 July 2001
2	Spring/Summer	23 September 2001 to 16 December 2001
3	Spring/Summer	15 September 2002 to 12 December 2002
4	Summer/Autumn	05 February 2003 to 30 May 2003
5	Winter	1 June 2003 to 30 August 2003
6	Spring/Summer	1 September 2003 to 11 December 2003
7	Autumn/Winter	22 April 2004 to 6 August 2004
8	Winter/Spring	27 August 2004 to 24 October 2004
9	Summer	2 January 2005 to 23 February 2005

- Sire type: Sires were identified and grouped according to the curl type of the rams in order to see if curl type had any effect on the different traits that were evaluated. The number in each category is presented in Table 5.26. The total number of rams used was 46 (in the upgrading and the pure bred flocks together).

Table 5.26 Sire types grouped according to curl type

GROUP NUMBER	CURL TYPE	NUMBER OF RAMS IN TYPE
1	Shallow (VL)	10 (5 Black and 5 White)
2	Shallow-watered silk (VLWS)	15 (8 Black and 7 White)
3	Shallow-developed (VO)	2 (Black)
4	Watered silk (WS)	17 (11 Black and 6 White)
5	Watered silk-galiac (WSGAL)	2 (Black)

5.4.3 Statistical procedures

All data were analyzed with Proc GLM from SAS (1996). In the beginning the whole model were used where all possible variables were included:

- Generation
- Dam age at lambing
- Season of birth
- Sire/Ram type

- Gender
- Sire system (Black or White rams)
- Birth weight of lamb

These variables were then taken out of the model one by one when they were not significant until a final model was created which only included variables which specifically influenced a pelt trait.

For the analysis of ordered categorical traits with a relative long scale such as hair quality score, VVP score and KBS Classification percentage, fixed effect linear models were used (Proc GLM; SAS, 1996).

For those categorical traits which were not ordered, the logistic regression procedure, Proc Genmod (Proc GENMOD, SAS, 1996) was applied. This was done when the dependant variable did not have arithmetical significance. Curl type, lustre and texture were analyzed with Proc Genmod.

5.5 RESULTS AND DISCUSSION

From the objectives of this study it is clear that marketable pelts must be produced as fast as possible. There are fixed effects which can not be changed but has an effect on the pelt quality and traits:

5.5.1 FIXED EFFECTS (Independent Variables)

a) **<u>Birth weight and sex of animals</u>**

Birth weights of all the lambs born were recorded and are presented in Table 5.27. Average birth weight among the different generations ranged from 3.7 kg to 4.0 kg with an average of 3.8 kg within lambing seasons while within the generations, the average birth weight varied between 3.5 kg and 4.1 kg among the nine lambing seasons.

Table 5.27 Average birth weight of lambs born in each season according to generation

	Generation				
Season	**F1**	**F2**	**F3**	**P**	**Average**
1	4	3.9	4.1	3.8	**4.0**
2	3.9	4.2	3.5	3.8	**3.9**
3	3.7	4.1	3.5	3.9	**3.8**
4	3.7	4.3	2.9	3.7	**3.7**
5	3.9	4.1	2.9	3.9	**3.7**
6	3.8	4	3.8	3.8	**3.9**
7	3.9	4.1	4	3.9	**4.0**
8	3.7	3.9	3.3	3.9	**3.7**
9	3.9	4.1	3.8	3.9	**3.9**
Average	**3.8**	**4.1**	**3.5**	**3.8**	**3.8**

Studies done at the different Namibian research institutes (Gellap-Ost, Kalahari & Neudamm) during 1954-1960, also indicated that with the upgrading done on Karakul X Black-headed Persians the average birth weight of the F_1-generation was 3.7 kg, the F_2-generation 4.2 kg (higher most likely because of the heterotic effect) and the F_3-generation 3.9 (Anonymous, 1962). Other authors found that the birth weight of pure-bred Karakul lambs averaged between 3.8 kg and 4.5 kg (Matter, 1973; Greeff *et al.*, 1984; Albertyn, 1989; Visser & Piek, 1992). The average birth weight (for all generations) for the Karakul X "Blinkhaar" Afrikaner in this study was 3.9 kg and that of the Karakul X Black-headed Persian was 3.8 kg which is not significantly different (P>0.05). Steyn (1975) also stated that the Karakul X Black-headed Persian gave birth to smaller lambs than the Karakul X "Blinkhaar" Afrikaner.

As can be seen from Tables 5.28 and 5.29 birth weight had a significant effect (P<0.001) on the mean squares for curl type, hair quality, KBS classification % and VVP for all generations (control group included), while it had no significant (P>0.05) effect on VVP where only the F-generations were considered.

Birth weight had a significant effect on texture (P<0.0001). According to Faure (1978) birth weight has a moderate positive genetic correlation with curl size and hair length. Hair length and curl size are again positively correlated with hair quality thus having an influence on texture. Birth weight had a significant effect (P<0.001) on lustre as well.

Table 5.28 The influence of independent variables on pelt traits (all generations included)

Sources of variation	Df	Traits - Mean squares and % contribution		
		Curl type %	Hair quality score %	VVP %
Birth weight	1	2.96***	0.42**	0.50***
Sex of lamb	1	2.72***	0	0.44**
Dam age	1	1.34***	0.22**	0
Generation	3	3.54***	23.52***	26.10***
Sire type	4	1.4***	0.35*	0.88***
System	1	0.58**	2.46***	0
Season	8	2.05***	0	0.98***
LSMean		3.10	6.27	4.85
R^2 Model		0.171	0.337	0.383

(*=P<0.05; **=P<0.01; ***=P<0.001)

Table 5.29 The influence of independent variables on pelt traits (only F-generations)

Sources of variation	Df	Traits - Mean squares and % contribution			
		Curl type %	Hair quality score %	Class %	VVP %
Birth weight	1	2.01***	2.37***	0.40*	0
Sex of lamb	1	0.93**	0	0	0
Dam age	1	0.96**	1.24**	2.58***	0
Generation	2	2.41***	16.51***	17.69***	10.48***
Sire type	3	2.12***	0	0.68*	3.3***
System	1	0	9.03***	0.96**	0
Season	8	6.6***	0	0	2.0*
LSMean		2.8	5.68	55.00	3.97
R^2 Model		0.2	0.27	0.28	0.16

(*=P<0.05; **=P<0.01; ***=P<0.001)

According to Schoeman (1998) there is a variety of environmental effects that have an influence on pelt traits such as the sex of the lamb and age of the dam at lambing. The ratio of ram lambs: ewe lambs were 51.6 : 48.4. The same ratio (51.6:48.4) was recorded in research studies done on Gellap-Ost, Namibia during 1963 to 1966 (Anonymous, 1968). Studies done by Matter (1973) showed a ratio of ram:ewe of 54:46, which does not differ substantially from the present study ratio.

Pelt traits that were significantly affected by the sex of the lambs (as illustrated in Tables 5.28 and 5.29) were curl type and pattern score. With curl type the ewe lambs produced a significantly (P<0.0001) higher curl development (3.4) than the ram lambs (3.0) and 2.7 % of the variation in curl type, with the ewe lambs that had a more developed curl type than the ram lambs. This is supported by results obtained by Nel (1966), Van Niekerk (1971), Schoeman & Albertyn (1992) and Albertyn *et al*. (1993). This is only of theoretical importance as the sex of the lamb can not be chosen. It is, however, still important especially for the adjustment of these traits for the estimation of genetic parameters and prediction of breeding values (Schoeman, 1998).

Sex of the lamb accounted for only 0.44 % of the variation in pattern score (VVP), with the ewe lambs that had a significant better VVP than the ram lambs ($P<0.0001$). Hair quality or KBS Classification % were not affected. This correlates well with results found in earlier studies (Nel, 1966; Van Niekerk, 1972; Greeff *et al*., 1991; Schoeman & Albertyn, 1992; Albertyn *et al*., 1993).

b) <u>Ewe age at lambing</u>

The age distribution of the ewes at lambing is illustrated in Table 5.30. It was only the P-generation ewes that varied between 12 and 84 months (1 and 7 years) of age. The F_1 ewes' (dams of the F_2 lambs, column 3, Table 5.30) ages varied between 11 and 46 months (1 and 4 years) with lambing, while the F_2 ewes' (dams of the F_3 lambs, column 4, Table 5.30) ages varied between 11.5 and 29 months (1 and 3 years). There were no older ewes than 46 months in the crossbred generations because of the length of the study

Table 5.30 Distribution of ewe age at lambing and the number of lambs born in each ewe age interval over the different generations

Ewe age at lambing (in years)	Number of lambs born				
	F_1	F_2	F_3	P	Total
1	0	94	40	137	271
2	112	125	30	284	551
3	236	160	0	225	621
4	0	37	0	216	253
5	0	0	0	141	141
6	0	0	0	90	90
7	0	0	0	76	76
8	0	0	0	37	37
Total	348	416	70	1206	2040

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Age of the ewe had a significant influence on curl type, hair quality score and lustre. It was shown by various authors (Nel, 1966; Le Roux & Van der Westhuizen, 1970; Van Niekerk, 1971; Schoeman, 1998) that hair quality, curl development and pelt thickness deteriorated with increasing age of dam. Albertyn & Schoeman (1990) found that all pelt characteristics showed a small, but significant deterioration with increasing ewe-age.

Several authors (Mostert, 1963; Nel, 1966; Le Roux & Van der Westhuizen, 1970; Van Niekerk, 1972; Schoeman & Albertyn, 1992; Albertyn *et al*., 1993) found that pattern score was significantly affected by ewe age at lambing (deteriorating with aging of the ewe). It was not the case in this study.

Ewe age at lambing had a significant ($P<0.0001$) effect on KBS Classification % with the percentage becoming higher as ewes became older, up to 4 years of age (the oldest ewes in the F-generations). It also contributed to 2.58 % ($P<0.0001$) of the variance in KBS Classification %.

c) <u>Generation</u>

Tables 5.28 and 5.29 illustrate what the influence of the independent variables on the different pelt traits was in the present study. It is clear that generation is the most important contributor to the variance in curl type, hair quality score and VVP. It accounts for 3.5 % in curl type, 23.5 % in hair quality score and 26.1 % in VVP of the total variance in all three traits.

If the generations are evaluated without the control group and only among the three crossbred generations (F_1 to F_3), then generation also is the most important contributor in hair quality score (16.51 %), VVP (10.48 %) and KBS classification % (17.69%), but not in curl type.

The influence of generation on texture is presented in Figure 5.4. It clearly illustrates how the texture increased to the superior types in the F-generations compared to the corresponding decrease in the inferior types.

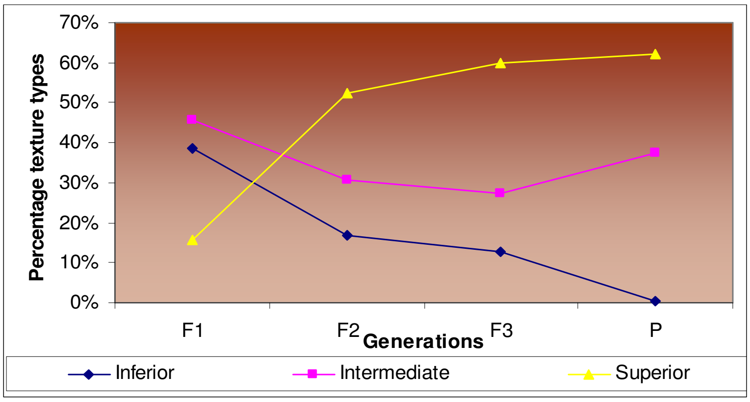


Figure 5.4 The frequency distribution (%) of the texture types within the generations in comparison with the P-generation (control group)

The influence of generations on the frequency distributions of inferior, intermediate and superior lustre types are presented in Figure 5.5. It is evident that there is an increase in the superior types from the F_1 to the F_3 with a corresponding decrease in the inferior types. This decrease is especially evident between the F_1 and F_2 generations where there was a significant difference between the F_1 and F_2 generations for lustre type. Likewise, there is a small increase in the intermediate types in successive generations. Generation had the greatest influence on lustre with significant effect ($P<0.001$).

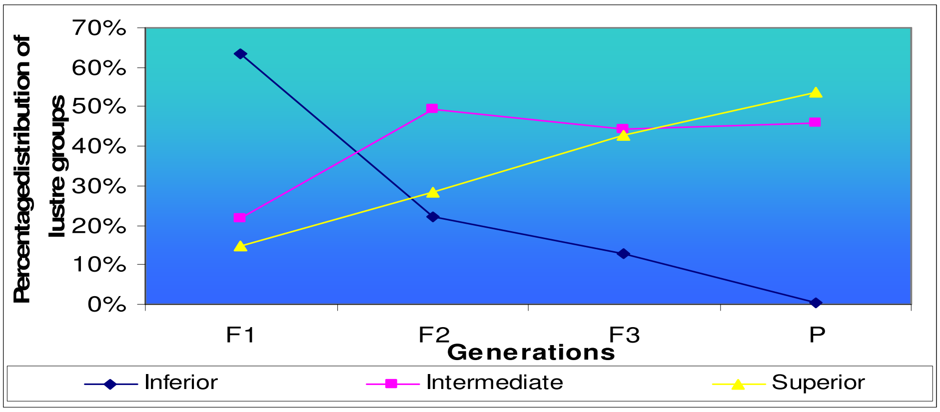


Figure 5.5 The distribution of the lustre groups within three generations in comparison with the control group (P-generation)

d) <u>Sire Type</u>

Table 5.31 shows the pattern score distribution among the different ram types. There were only significant differences in VVP mean values between the shallow developed (VO) ram type and the shallow (VL) ram type (P<0.001). The shallow developed (VO) ram type produced the highest VVP score (4.85). The rest did not differ significantly from each other. Heinichen & Badenhorst (1953) indicated that there were no significant differences between the use of pipe curl rams and shallow curl rams, while Gouws *et al.* (1970) showed that the use of pipe curl rams in grading up proved to be more advantageous than shallow curl rams, mainly because it yielded less spotted pelts. Research studies done on Neudamm experimental farm showed that watered-silk rams produced weaker pattern on Karakul X Black-headed Persian than Karakul X Karakul (Anonymous, 1964).

Table 5.31 The pattern score distribution among the different ram types

Ram Type	VVP LSMEAN
VO	4.86
VL	4.26
VLWS	4.43
WS	4.54
WSGAL	4.49

According to Schäfer (1966) there was a distinct difference among crosses with different types of Karakul rams, but he could not determine which phenotype produced the better results. He suggested that the better results would be achieved by using Karakul rams with a wide variety of curl types which also have good hair quality.

The shallow developed (VO) ram type significantly differed from all the other ram types used for curl development. It produced the highest curl development (3.9) compared with the others that averaged at a curl development of three. According to Gouws *et al.* (1970) pipe curl rams produced a significantly (P<0.05) higher degree of curl development, which correlates well with the present study results.

From Table 5.32 it is clear that ram types which were of a more developed type had an inferior effect on hair quality, while the watered-silked type of rams gave the best hair quality. This is in contrast with studies done by other authors (Anonymous, 1964; Gouws *et al.*, 1970) who found that the more developed ram types were better for upgrading purposes and produced better lyre pattern types in generation 1, while lustre was inferior. There was also no substantial difference between the watered-silk and pipe-curl type of rams for hair quality (lustre and texture) (Anonymous, 1964). In the present study the shallow (VL) curl rams bred lambs with better excellence of pattern, lustre and hair length.

Table 5.32 Hair quality score within the different ram types used

Ram type	Hair Quality LS MEAN
WSGAL	6.06
WS	6.14
VLWS	6.03
VL	6.01
VO	5.84

Although the shallow watered-silk (VLWS) type of rams produced a higher KBS Classification % mean (57.2 %), than the other ram types (56.0% to 56.4%), these differences were not significant. Thus the curl type of the ram did not play an important role in the KBS % a lamb received.

e) Sire System (Black or White rams)

According to Steyn (1975) the type of Karakul ram to use in a crossbreeding program with Black- headed Persians must have fine hair and a very prominent back pattern, because of the natural thick hair and typical pine-tree pattern of the Black-headed Persian, which are both undesirable characteristics. With the White Karakul X "Blinkhaar" Afrikaner the Karakul rams used, must have short hair because the natural hair of the Afrikaner is longer and softer than that of the Black-headed Persian.

Average hair quality score was lower (not significantly) in lambs from the Black Karakul rams X Black-headed Persian ewes (5.8) compared to the White Karakul rams X "Blinkhaar" Afrikaner ewes' (6.2) matings. The different colour systems used (black vs. white rams) contributed to 0.96 % ($P<0.01$) of the variance in KBS Classification % with the offspring of the black rams having a mean of 55.8 % and those of the white rams a mean of 57.3 %. There was also a significant effect ($P<0.001$) on lustre.

f) Season of lambing

Lambing season is the most important variable in curl type, if only the F-generations are considered, where it accounts for 6.6 % of the total variance (Table 5.29). According to

Gouws *et al.* (1973) an increase in curl development is mainly the result of a high protein level, which could be due to the difference in kind of feed available during the different lambing seasons.

The usefulness of pelts through upgrading is determined by the speed with which the dependant variables can be established:

5.5.2 Dependant variables

a) <u>Destiny of the lambs</u>

The number of lambs born in each generation in each season is illustrated in Table 5.33. There were only 70 F_3-lambs born due to the fact that the study could not proceed and had to be terminated earlier than anticipated.

Table 5.33 Number of lambs born in each generation in each season

SEASON	F_1	F_2	F_3	P	Total
1	125	0	0	171	296
2	192	0	0	83	275
3	29	49	0	172	250
4	1	35	0	20	56
5	1	22	0	78	101
6	0	89	13	244	346
7	0	106	15	203	324
8	0	18	29	160	207
9	0	97	13	75	185
Total	348	416	70	1206	2040

Table 5.34 shows the percentage of lambs in each destination category in each generation. There were only flock animals in the control group, because all the ewe lambs in the F-generations were used for further breeding. The flock animals were those ewe lambs in the control group that were unsuitable for further stud breeding or unsuitable for slaughtering for their pelts. Lambs used for pelt production were only ram lambs and those ewe lambs that died before 48 hours of age or were still-born.

Table 5.34 Frequency distribution (%) of lambs in each destination category among the different generations

Destination	F_1 %	F_2 %	F_3 %	P %
Breeding	43.97	43.27	41.43	25.87
Flock	0	0	0	13.43
Mutton	50.29	26.68	20	3.81
Pelt	5.75	30.05	38.57	56.88

It can be seen that with progress from F_1 to F_3, more lambs were suitable for pelt production and the number of lambs left for mutton production became less. This correlates with studies done by Heinichen & Badenhorst (1953) and Gouws *et al.* (1970) who showed that pelts from F_1-generation lambs were of an inferior quality and could not be used for pelt production. Heinichen & Badenhorst (1953) found that the percentage of suitable pelts in the 1st generation Karakul X Black-headed Persian were 14 % while in the 5th generation it improved to 86 %.

b) <u>Colour of pelts and lambs</u>

The appearance of black spots on white pelts is, together with the sub-vital factor in white, the biggest problem in breeding of white Karakul. Colour contributes most to the price of pelts. Spotted pelts are much cheaper than those of black, white and grey pelts (Schoeman, 1979; Duffield-Harding, 2002). A one-way frequency distribution of the generations and colour of the lambs is presented in Table 5.35. The P-generation was all the lambs born out of the stud ewes for the same period as the crossbred lambs and they represent the pure-bred Karakul. They were used as a control group to compare the other generations with. As can be seen from Table 5.35, there were very few spotted (C- and D-White) animals in all generations with no C-white animals in the F_3-generation in any of the years.

In studies done by Gouws *et al.* (1970) more spotted lambs (D-white) occurred in their first generation crosses between the black Karakul X Namakwa-Afrikaner (86.6 %) and black Karakul X Black-headed Persian (44 %). Even in the F_3-generation a percentage of 17.3 % for the black Karakul X Namakwa-Afrikaner and 10.7 % for the black Karakul X Black-headed Persian were recorded.

Table 5.35 Frequency distribution of lambs born in each generation in each year of the study according to colour

Year	GENERATION and COLOUR																				Total
	F_1					F_2					F_3					P					
	BL	AW	BW	CW	DW	BL	AW	BW	CW	DW	BL	AW	BW	CW	DW	BL	AW	BW	CW	DW	
2001	36	8	49	6	4	39	45	49	5	5	9	16	6	0	0	263	20	7	3	1	571
2002	22	5	18	0	0	19	17	12	0	0	4	3	0	0	1	138	7	3	0	1	250
2003	17	22	63	0	0	35	22	33	0	0	3	5	2	0	0	263	15	23	0	0	503
2004	23	11	55	0	0	35	25	42	0	1	8	5	2	0	0	282	13	28	0	1	531
2005	2	1	5	0	1	7	4	18	0	3	1	1	4	0	0	113	4	18	0	3	185
Total	100	47	190	6	5	135	113	154	5	9	25	30	14	0	1	1059	59	79	3	6	2040
%	28.5	13.5	54.5	2	1.5	32.5	27	37	1	2.5	35.5	43	20	0	1.5	87.8	5	6.5	0.2	0.5	100

(BL=Black; AW=A-white; BW=B-White; CW=C-White; DW=D-white)

Schoeman (1979) also found that with Black crossbred ewes (second and third generation White Karakul X Black-headed Persians) the percentage of spotted lambs when crossed with pure white Karakul rams was 7.3% in the F_1-generation. In this study, if the C-white and D-white percentage of lambs are put together, the percentage of spotted lambs in the F_1-generation was 3.1 % and in the F_3-generation, 1.4 %.

Heinichen & Badenhorst (1953) found that with the black Karakul X Black-headed Persian only 39 % of the lambs in the 1st generation were completely black and in the 3rd generation there were 88 % of the lambs that were completely black. In the current study all of the lambs (100 %) born from the black Karakul X Black-headed Persians were black with no spotted lambs been born.

c) Important pelt traits

Theron (1966) found in his studies that there were only significant differences between the first and second generations Karakul X Afrikaner and Karakul X Black-headed Persian for characteristics like hair length, curl size, pattern score, hair thickness, lustre and hair quality. Results obtained in the present study showed that all of the generations significantly ($P<0.05$) differed from each other and from the P-generation (control group Karakul) in hair quality, lustre and pattern score (VVP).

Table 5.36 shows how the Least Square Means for pattern score (VVP), hair quality score, curl type and the KBS Classification % improved almost linearly from the F_1 to the F_3

generation towards the P-generation. This correlates well with studies done by Schoeman (1979) where white Karakul rams X Black-headed Persians ewes showed a similar improvement in mean values for pattern score, hair quality score and curl type from the F_1 to the F_3 generation.

Table 5.36 Mean values for VVP, hair quality, curl type and KBS Classification % for three generations in comparison with control group (P-generation)

Generation	VVP LSMEAN	Hair Quality LSMEAN	Curl Type LSMEAN	KBS Classification % LSMEAN
F_1	3.55	4.94	2.75	53%
F_2	4.30	5.93	3.07	57%
F_3	4.90	6.35	3.39	61%
P	**5.60**	**6.71**	**3.48**	

i) Curl type

Curl type is the degree of curl development and varies from smooth (galliac) to more curly (pipe curl). Several authors (Nel, 1966; Schoeman, 1968; Schoeman & Nel, 1969; Van Niekerk, 1972) had shown that a higher degree of curl development is negatively associated with pelt price. According to Steyn (1962) the first Karakul that came into Namibia was mainly of a narrow curl type which did not show a lot of pattern or character. The late A.D. Thompson was the pioneer in the selection for less developed types, which resulted in the smooth types for which SWAKARA became popular.

Selection for good hair quality can lead to lambs which show less curl, bigger and broader curls, longer hair and inferior pattern (Faure, 1978). There is a positive correlation between hair quality and curl size and hair length (Van Niekerk, *et al*., 1968). In studies done by Heinichen & Badenhorst (1953) the Karakul X Merino gave a better curl type and pattern score than the Karakul X Black-headed Persians and Karakul X Afrikaners in the first generation, but thereafter the Karakul X Black-headed Persian was superior to the Karakul X Merino and Karakul X Afrikaner.

In the present study the distribution of the F_1-generation to the F_3-generation curl types compare well with the P-generation with watered-silk and watered-silk galliac curl types that were the most common. There was a significant difference ($P<0.0001$) between the F_1- (2.7) and F_2- (3.0) and F_1- and F_3-generations (3.4) for curl development, but no significant difference ($P>0.05$) between the F_2- and F_3-generation and the F_3- and P-generation (3.5). This correlates well with studies done by Faure *et al*. (1983) on Karakul X Romanov and Schoeman (1979) on White Karakul X Black-headed Persian who also showed that with an increase in genetic contribution of Karakul, both curl type and pattern improved.

Figure 5.6 shows the frequency distribution for the different curl types per generation. As can be seen from Figure 5.6, the F-generations' curl types showed the same distribution pattern as the control group (P-generation). Schäfer (1966) indicated that the F_1 -generation had a poor curl development which improved from the F_2-generation onwards. Karakul X Black-headed Persians had more than double the curl type score which were also smaller than the Karakul X Afrikaner. According to Gouws *et al*. (1970) curl development also improved from F_1- to F_3- generation (from 1.7 to 4.5) with the Karakul X Black-headed Persian that produced slightly better curl development than the Karakul X Namakwa-Afrikaner, although no significant difference occurred between these two breeds.

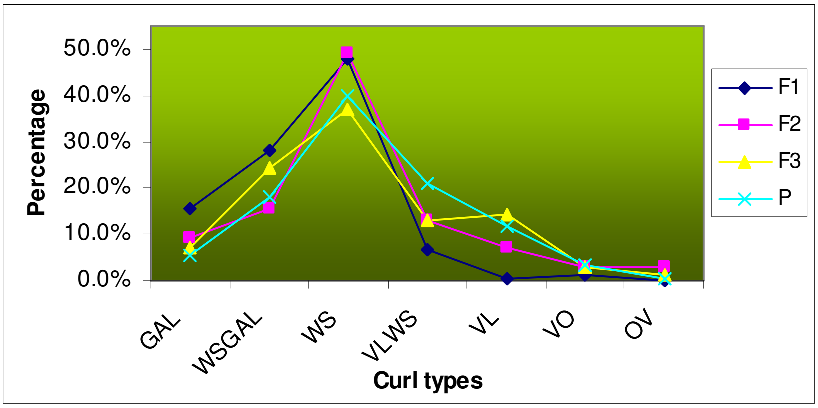


Figure 5.6 The frequency distribution (%) of the different curl types in the different generations

Examples of the different curl types in each generation obtained, can be seen in Appendix Figures 6 (a to f) to 12 (a to c). From these photo's it is also possible to see how the quality of the lambs improved from the F_1-generation to the F_3-generation.

ii) Hair quality

According to Van Niekerk (1980) it would be beneficial to the pelt industry if more emphasis is laid upon hair quality than pattern excellence due to its heredity, economical value and genetic correlations with other pelt characteristics. Improvement in hair quality will lead to a higher income because of its economical value. Hair quality scores, as assigned by the breeders, are determined by the texture and lustre of the fibres as was presented in Table 2.2 earlier.

Table 5.37 shows how hair quality score improved from F_1 (5.1) to F_3 (6.3). There was a significant difference ($P<0.0001$) between least square means of the F_1-generation and the F_2-, F_3- and P-generations (6.7), while the F_2- and F_3-generations did not differ significantly ($P>0.05$) from each other. The F_2-generation did differ significantly ($P<0.0001$) from the P-generation, while the F_3-generation did not differ significantly ($P>0.05$) from the P-generation.

Table 5.37 The Least Square Means for Hair Quality score for all generations

Generation	Hair Quality LSMEAN
F_1	5.12
F_2	5.92
F_3	6.28
P	6.74

Schoeman (1979) indicated that for hair quality the F_1- and F_2-generations of White Karakul X Black-headed Persians differed significantly ($P<0.01$) from the control group, while the F_3-generation did not differ significantly. It would seem that after three generations of upgrading an acceptable quality type can be produced. According to several authors (Schäfer, 1966; Theron, 1966; Gouws *et al*. 1970) hair quality improved from generation to generation. Schäfer (1966) found that the F_3-generation still substantially differed from the pure-bred Karakul. Gouws *et al*. (1970) illustrated that the Karakul X Namakwa-Afrikaner produced better results for hair quality (lustre, less metallic hair, less brittle hair) than the Karakul X Black-headed Persian and Karakul X (Namakwa X Black-headed Persian).

Figure 5.7 illustrates the distribution of the hair quality among the different generations. The higher frequency (43.1 %) of score 5 allocated to the F_1-lambs compared to higher scores for generations F_2- and F_3-lambs (scores 6) is also apparent.

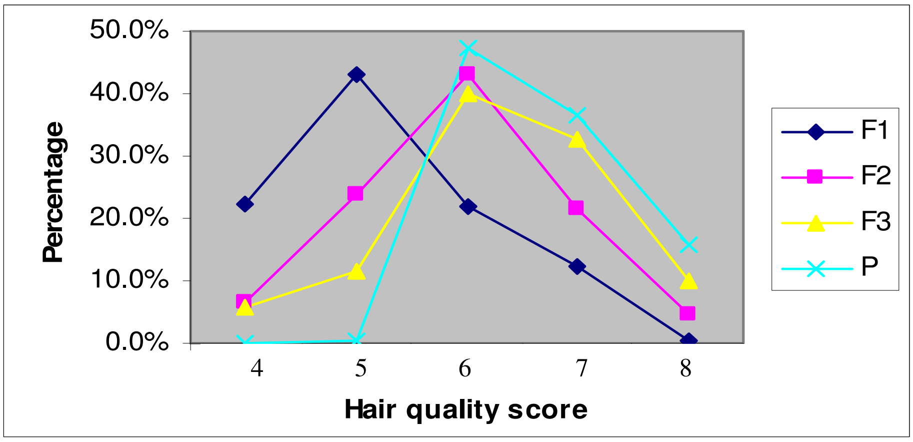


Figure 5.7 Frequency distributions (%) of hair quality score among the different generations

1) Texture

Table 5.38 indicates the frequency distribution of the different texture types according to colour of the lamb (black vs. white) also in comparison with the P-generation. It is evident from Table 5.38 that the white lambs (Karakul X “Blinkhaar” Afrikaner) of the crossbred generations had a softer touch (silky and normal-silky) than the black lambs (Karakul X Black-headed Persians) which were more coarse and normal-coarse.

Table 5.38 The frequency distribution (%) of the different texture types – Black vs White lambs

Texture group	Texture Type	F-generations colour %		P-generation colour %	
		Black	White	Black	White
Superior	Silky	5.36	38.39	37.95	18.30
	Elastic	1.18	1.18	91.76	5.88
	Elastic-silky	0	5.88	82.36	11.76
	Nor-elastic	5.15	5.15	83.94	5.76
	Nor-silky	5.54	49.23	37.23	8
Intermediate	Normal	19.84	20.64	53.44	6.08
Inferior	Nor-coarse	77.19	17.54	3.51	1.76
	Coarse	66.67	33.33	0	0
	Nor-soft	9.23	90	0	0.77
	Soft	4	92	0	4

Theron (1966) found that Karakul X Afrikaner had a significant ($P<0.01$) softer touch in the second generation (no information available on the first generation), but no significant difference between the Karakul X Afrikaner and Karakul X Black-headed Persian from the third generation onwards. In the present study the F-generations (in general) had a higher percentage lambs in the inferior texture group in comparison with the P-generation lambs which were more in the superior texture group.

2) Lustre

Chalky lustre types are only present in white lambs while metallic and dull types are only present in black lambs as is illustrated in Table 5.39.

Table 5.39 The frequency distribution (%) of the different lustre types – Black vs White lambs

LUSTRE GROUP	LUSTRE TYPE	F-generations colour %		P-generation colour %	
		Black	White	Black	White
Inferior	DULL	100	0	0	0
	CHALKY	0	100	0	0
	MET-DULL	100	0	0	0
	METALLIC	100	0	0	0
	NOR-DULL	88.9	0	11.1	0
	NOR-CHALKY	0	99.2	0	0.8
	NOR-MET	95	2.5	1.25	1.25
Intermediate	NORMAL	9.8	26.3	56.5	7.4
Superior	NOR-GLOSSY	2.4	24.8	64.5	8.3
	GLOSSY	0	13.4	73.2	13.4

The 2.5 % frequency for normal-metallic in the F-generations was due to D-white lambs where the lamb was described as white, but the black patches had a metallic lustre. The White Karakul X "Blinkhaar" Afrikaner produced a higher percentage of lambs with an intermediate (26.3 %) and superior (38.2 %) lustre than the Black Karakul X Black-headed Persian (intermediate – 9.8 % and superior 2.4 %). Theron (1966) also found that 80.2 % of the Karakul X Afrikaner had an above average lustre compared with Karakul X Black-headed Persian that had a 70.9 % above average lustre.

There was a significant ($P<0.01$) better lustre with the Karakul X Afrikaner than the Karakul X Black-headed Persian in the first generation. According to the frequency distribution of the different lustre types illustrated in Table 5.40, most was of a normal-glossy and normal distribution, except the F_1 generation that also had a peak at normal-chalky, chalky and metallic-dull. Those are all inferior lustre types. It, however, improved from the first generation to the third generation with less of the inferior lustre types (dull to normal-metallic). The tendency of the crossbred generations' lustre types were to the P-generation (the control group), which correlates well to earlier studies done by Heinichen & Badenhorst (1953). They indicated that lustre improved from the first generation, where 80 % of the Karakul X Black-headed Persian lambs had a bright "blue-black" lustre type to 97 % in the third generation.

Table 5.40 Frequency distribution (%) of the different lustre types among the different generations

LUSTRE GROUP	LUSTRE TYPE	F1 %	F2 %	F3 %	P %
Inferior	DULL	0.6	0.2	0.0	0.0
	CHALKY	7.8	1.2	0.0	0.0
	MET-DULL	10.3	1.0	1.4	0.0
	METALLIC	4.3	1.7	2.9	0.0
	NOR-DULL	0.0	3.8	0.0	0.2
	NOR-CHALKY	27.0	7.7	1.4	0.1
	NOR-MET	13.2	6.5	7.1	0.2
Intermediate	NORMAL	21.8	49.5	44.3	45.8
Superior	NOR-GLOSSY	14.7	23.1	32.9	37.8
	GLOSSY	0.3	5.3	10.0	16.0
	Total frequency	348	416	70	1206

Theron (1966) indicated that there was only a significant difference in the first generation. The other generations had no significant difference in lustre and the differences also became progressively smaller.

According to Heinichen & Badenhorst (1953) the success of lustre heredity are determined by the extend of which lustre are inherited from the individual rams used. It is thus important to determine the breeding value of the rams from their pedigrees and their ancestors' pedigrees for lustre.

3) Hair length

According to Schoeman (1998) hair length is negatively correlated with pattern score, so that selection for a higher pattern score will result in shorter hair. An improvement in hair quality score, on the other hand, would result in longer hair. In general, despite the low positive mean genetic correlation between pattern score and hair quality, there is a complicated, negative antagonism between these two traits.

When pelts are categorized before auctions, white pelts in general are not separated for hair length other than grade "D-selected" which is short to medium in hair length. All coloured pelts are usually longer in hair length than their black counterparts. This could be due to more selection that has been applied to black pelt production over a longer period of time than coloured pelts or just because of a difference in genetic material. Tests on all classification types of pelts, measuring hair length with a ruler, indicated that it is possible to have a curl with short hair and also possible to have a watered-silk with long hair (Duffield-Harding, personal communication, 2005). Nel (1966) indicated that in general curled types have longer hair than shallow types; larger curls are associated with longer hair and small curls with shorter hair. Pfeifer (1953) also illustrated that the most valuable pelt grades, regardless of curl type, have relatively short hair.

In this study hair length was only evaluated on some of the pelts that were sold and not on every lamb that was born. Table 5.41 gives an indication of the hair length grades of the pelts that were sold during the time of the study. Of the pelts that were evaluated for hair length, 79.1 % were regular grades, with 7.7% of the pelts that were low grades and 3.1 % that were rejected because of too long hair. There were 10.1 % of the mixed type (had parts with long and short hair which could not be classified in a specific hair length category).

Table 5.41 Hair length grades and -categories of pelts sold in the different years of the study

Hair length Grades	**Hair length categories**	**Year**				
		2001	**2002**	**2003**	**2004**	**2005**
Rejected	**Underdeveloped**	0	0	0	0	0
Low grade	**Premature**	0	0	0	0	0
Regular grades	**Extra short**	0	0	0	0	2
	Short	0	0	1	5	1
	Medium	3	0	20	23	31
	Long	2	1	2	6	5
Low grade	**Overgrown**	0	0	1	3	6
Rejected	**Outgrown**	3	1	0	0	0
	Mixed	4	1	2	4	2
	Total	**12**	**3**	**26**	**41**	**47**

iii) Excellence of pattern

Schäfer (1966) indicated that the Black Karakul X Black-headed Persians produced pelts with a better pattern than the White Karakul X Afrikaner. Gouws *et al*. (1970) furthermore illustrated that pattern excellence improved with 100 % from 1.2 in the F_1-generation to 2.5 in the F_3-generation.

Table 5.42 gives an indication of how the pattern score improved from the F_1 to the F_3 generation in comparison with the mean of the P-generation. Out of this table it would be possible to conclude that one more generation would be needed, because the difference between the F_3 and the control group (P) is still 14.5 % ((5.5-4.8)/4.8*100). One more generation would possibly decrease the difference between the upgrade generations and the control group even more.

Table 5.42 The mean pattern score of the different crossbred generations in comparison with the P-generation

Generation	VVP LSMEAN
F_1	3.55
F_2	4.29
F_3	4.77
P	5.45

Table 5.43 shows the distribution of excellence of pattern among the different generations. The F_1 generation peaked at a VVP of 3 while the F_2, F_3 and P generations all peaked at a VVP of 5. There was a significant difference ($P<0.0001$) in peak VVP from $F_{1,}$ to F_2 and F_3, which means that the VVP improved notably from the F_1 to the F_2 generation. However, there was no significant difference ($P>0.05$) between the mean VVP of the F_2 and F_3 generation. All of the generations differed significantly ($P<0.0001$) from the P-generation.

Table 5.43 The frequency distribution score for pattern among the different generations.

Generation	Frequency allocated score (%)							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
F_1	0	20	32	26	20	1	0	0
F_2	4	7	11	27	40	10	1	0
F_3	0	6	9	21	46	17	1	0
P	0	0	2	10	41	33	12	1

d) Karakul Breeders Society (KBS) Classification percentage

The Karakul Breeders Society (KBS) classify lambs and take several characteristics into account to decide which animals are suitable for breeding. According to Schoeman (1969) the KBS gives more attention to pattern than hair quality in their classification. In this study a panel of judges assessed each lamb according to a photograph taken of the lamb together with the breeder's value allocated to the lamb. A classification was awarded to each lamb by this panel of judges, depending on its phenotypic value, irrespective of what happened with the lamb (pelt production, mutton production or further breeding).

Table 5.44 indicates how the Least Square Mean for Classification % improved from the F_1 (52%) to the F_3 (61 %). There were significant differences ($P<0.0001$) among generations with the percentage becoming higher from F_1 to F_3 generation. The mean for the three generations was 55 % and the F_2 and F_3 generations were above the mean.

Table 5.44 The KBS Classification % (LSMean) distributions among the different crossbred generations

Generation	KBS Classification % LSMEAN
F_1	0.52
F_2	0.57
F_3	0.61

e) Pelt price

Several authors have shown that pelt price is predominantly determined by curl type, pattern score (VVP), hair quality score and hair length traits (Nel, 1966; Schoeman, 1968; Schoeman & Nel, 1969; Van Niekerk, 1972; Gouws, 1974). The most important aspects, however, which must be considered when choosing the type of base material for upgrading purposes for the production of pelts is the pelt price and the total income from the pelts.

In general there was an improvement in the pelt type and pelt price (as illustrated in Table 5.45 and Figures 5.8 and 5.9) over the five years of the study as the number and quality of F_2 and F_3 pelts increased. This was found in other studies as well (Gouws *et al*., 1970; Schoeman, 1979) where the upgraded generations also showed an improvement in pelt price from the first generation to the third generation.

Figures 5.8 and 5.9 show the analysis of the average auction pelt price and the price obtained for the pelts sold from the study animals in each auction held over the five years. There was an upwards trend from the first auction where only F_1 pelts was offered to the last auction that included more F_2 and F_3 pelts.

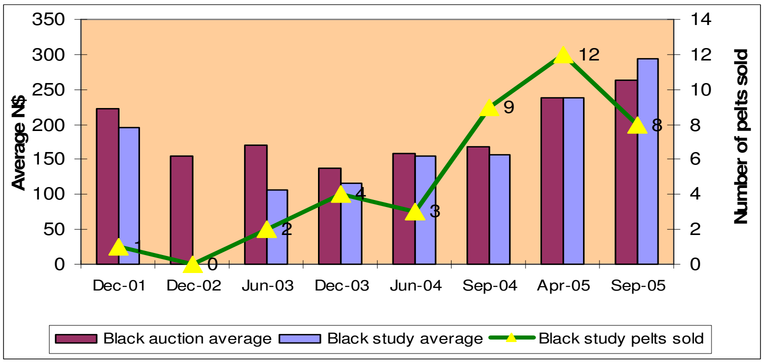


Figure 5.8 The comparison between the average auction pelt price and the average pelt price obtained for the study black pelts

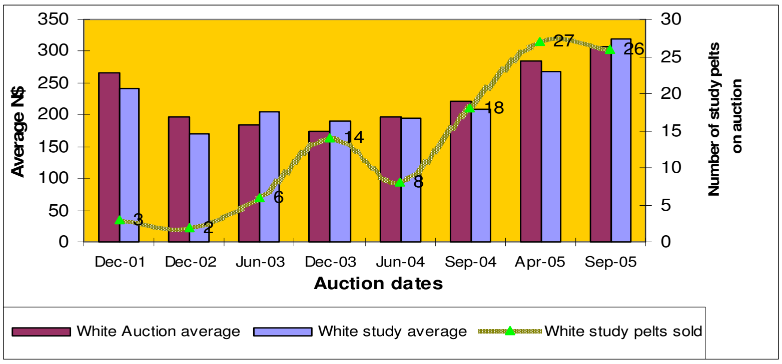


Figure 5.9 The comparison between the average auction pelt price and the average pelt price obtained for the study white pelts

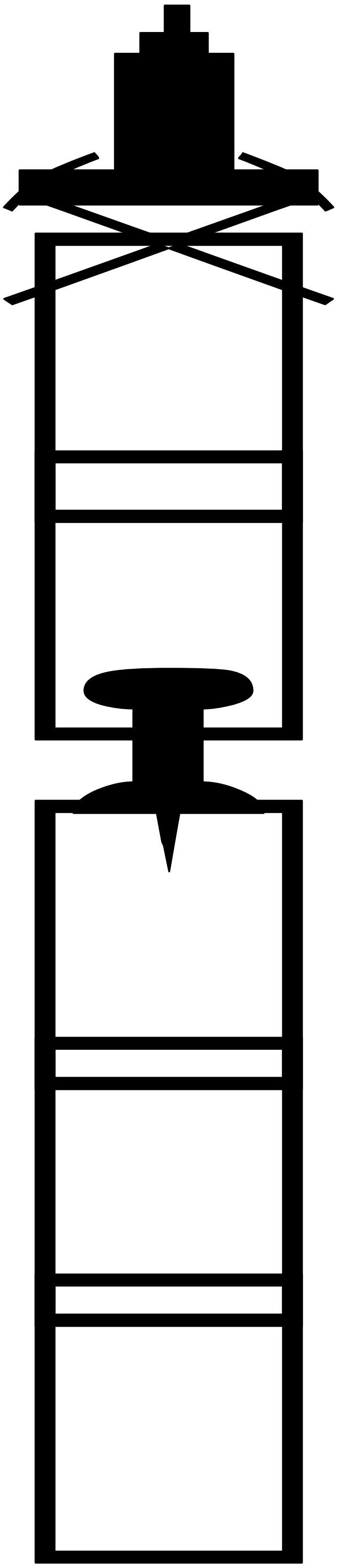
Pelt prices obtained at auctions (as seen in Table 5.45) were taken as an average over the five years of the study. The price for each pelt type for each auction in each year was taken and an average price was acquired for that specific pelt type as a measure to show the variation in pelt price in the different pelt types. The better pelt types increased from 2001 to 2005 with more higher priced pelts (in other words better quality pelts) in 2004 and 2005 when more F_2 and F_3 pelts were marketed. Examples of the different pelt types can be seen in appendix Figures 2 and 3.

Table 5.45 Number of pelts in each pelt type (with hair length) marketed with the average price obtained in the 5 years of the study

Hair length	Pelt type	Year					Average price for pelt type
		2001	2002	2003	2004	2005	
Outgrown/underdeveloped	**Reject**	3	1	0	1	1	0.00
Long	**NF2**	0	0	1	0	0	104.85
Short	**P2**	0	0	1	0	0	129.10
	Diverse	7	1	7	2	14	132.99
	Curl 2 black	0	0	0	1	1	138.06
Short	**M2**	0	0	0	2	1	150.66
Medium	**T1**	0	0	0	1	0	153.02
	Flat 2 Black	1	0	1	2	4	153.06
	Medium size (white)	0	1	1	2	10	157.74
Medium	**K1**	0	0	1	0	1	165.36
Medium	**O2**	0	0	1	3	1	178.49
Long	**RF2**	0	0	1	0	2	184.79
	Curl 3 White	1	0	0	1	1	188.41
	Spotted	0	0	0	2	1	192.73
	Curl 2 White	0	0	6	6	13	195.02
Short	**D1**	0	0	0	1	0	197.01
Medium	**KF2**	0	0	0	0	1	197.99
Long	**NF1**	0	0	0	0	1	213.17
	Flat 3 White	0	1	0	5	5	222.47
Medium	**O light 2**	0	0	0	0	1	232.24
	Curl 1 White	0	0	3	4	3	235.85
Short	**F**	0	0	0	1	0	242.46
Medium	**O1**	0	0	0	0	1	265.91
Short	**Dflat1**	0	0	0	1	0	269.40
	Flat 2 White	2	0	6	4	8	276.87
Medium	**O sel**	0	0	1	0	0	305.69
Medium	**KF1**	0	0	0	0	1	305.72
Medium	**O light 1**	0	0	0	0	2	310.39
	Flat 1 White	0	0	2	2	12	335.85
Medium	**O light sel**	0	0	0	0	1	350.70
Extra short	**DL Lyra Sel**	0	0	0	0	2	376.46
	Total # pelts	**14**	**4**	**32**	**41**	**88**	**210.20**

5.6 CONCLUSIONS

- There is a need to increase Karakul ewe numbers in the national flock, especially in white Karakul.
- Because of the exceptionally higher prices for ewe material, upgrading seems the most appropriate way to increase ewe numbers.
- Black-headed Persians and "Blinkhaar" Afrikaner sheep are the most obvious breeds to use for upgrading owing to their availability as well as their adaptability in the regions where Karakul are farmed with.
- Pelt traits and prices increased linearly from F_1 to F_3, with acceptable pelts being produced in the F_3-generation.
- Hair quality (and finer hair) in Karakul rams used for upgrading are more important in Black-headed Persians while VVP in the Karakul rams used for upgrading in "Blinkhaar" Afrikaner, are more important.
- Owing to circumstances the author had no control of the project terminated too soon. More pelts of F_3 and F_4 should have provided more reliable information.



SUMMARY

CHAPTER 6

SUMMARY

a) Crossbreeding as a means of utilizing differences between breeds has been widely used in sheep breeding. In contrast to variation within a breed, the differences between breeds are largely genetic. With upgrading in this study the main aim was to backcross from one population into another, with the aim of substituting one population for the other.

b) The primary aim of this project was to crossbreed "Blinkhaar" Afrikaner ewes with White Karakul rams and Black-headed Persian ewes with Black Karakul rams to see how many generations it would take to upgrade in order to get acceptable pelts for marketing as well acceptable breeding ewes to increase the Karakul ewe flock.

c) The secondary aim was to determine what the quality of the crossbred product (pelt) was, per generations when "Blinkhaar" Afrikaners and Black-headed Persians were used as base material.

d) A guide was included which describes the most important Karakul terms used in the industry just to make it easier for the reader to understand all the terms.

e) An overview on the current Karakul industry was set out which concentrated on a short history of the Karakul and an overview on the stud and pelt industries in Namibia and overseas.

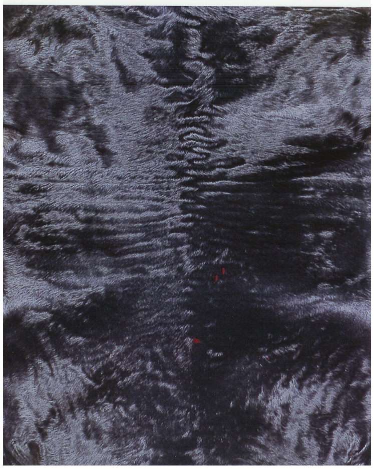
f) The theoretical considerations for crossbreeding and upgrading were explained with definitions, fundamental aspects of crossbreeding and upgrading discussed and the uses, benefits and disadvantages of crossbreeding and upgrading included.

g) A discussion of the project followed with a short introduction on why the "Blinkhaar" Afrikaner and Black-headed Persians were used for crossbreeding with an outlay of the material and methods used and the results were discussed.

h) In the results the most important factors were:

- ✓ Three generations were obtained: 348 F_1, 416 F_2 and 70 F_3 animals, a total of 834 animals. Generation was the most important contributor to the variance in curl type, hair quality score and pattern score. It accounted for 3.54 % (curl type), 23.52 % (hair quality) and 26.1 % (pattern) of the total variance ($P<0.001$).
- ✓ The percentage spotted animals were 3.1 % in the F_1-generation and 1.4 % in the F_3-generation. Faster improvement was made in colour, with substantially less spotted animals than in previous studies done by other authors.
- ✓ Ewe age at lambing had a significant influence on curl type, hair quality, lustre and KBS Classification %, while pattern score was not affected by ewe age.
- ✓ The pelt quality improved with generation with the better pelts in the F_2 and F_3 generation. More pelts could be marketed in the F_3 generation than in the F_1 generation. There was an upwards trend in pelt price from the F_1 to the F_3 generation, with above auction average prices obtained in the last auction for F_2 and F_3-pelts.
- ✓ There was a gradual improvement in curl type with a significant difference ($P<0.0001$) between generation 1 and 2 and 1 and 3 with no significant difference ($P>0.05$) between generation 2 and 3 and 3 and the control group. The highest frequency was in the less developed range (WSGAL and WS) which compare well with the control group.
- ✓ The hair quality score improved from a least square mean of 5.1 in the F_1 generation to 6.3 in the F_3 generation. The control group had a least square mean of 6.7. The average hair quality score was lower in black lambs (black Karakul X Black-headed Persian) than white lambs (white Karakul X "Blinkhaar" Afrikaner), which could be due to the fact that Afrikaner sheep has thinner hair than Black-headed Persians and has a softer touch to the hair. There were a higher percentage of black lambs in the inferior texture and lustre group than white lambs.
- ✓ Pattern score improved with a least square mean of 3.5 in the F_1 to 4.8 in the F_3 with the control group LS mean of 5.5. Because of the relative big difference (14.5 %) between the F_3-generation and the control group, one more generation would possibly decrease the difference between the upgrade generations and the control group even more. The more developed type of rams gave the higher pattern score.

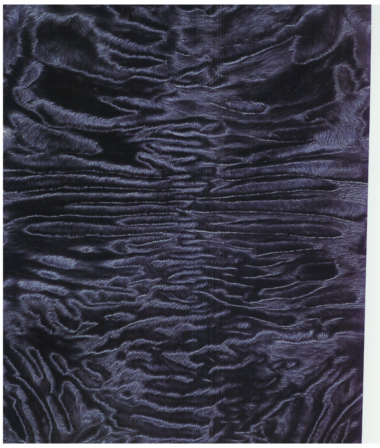
- ✓ The average KBS Classification percentage improved from 52 % in the F_1 to 61 % in the F_3-generation.
- ✓ Shallow developed (VO) ram types significantly (P<0.0001) differed from all the other ram types and produced the highest curl development and pattern score, but had an inferior effect on hair quality. The watered-silk type of rams (WS) produced the best hair quality score, while the shallow (VL) curl rams bred lambs with better excellence of pattern (VVP), lustre and hair length. Although shallow watered-silk rams (VLWS) produced the highest KBS Classification %, it was not significantly (P>0.05) higher than the other rams and ram type, thus did not play an important role in KBS Classification % a lamb received. Better results would be achieved by using Karakul rams with a wide variety of curl types which also have good hair quality.



a) Galliac

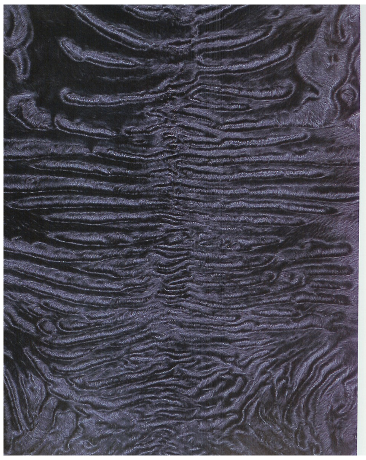
b) D-light drawn

c) D-Flat

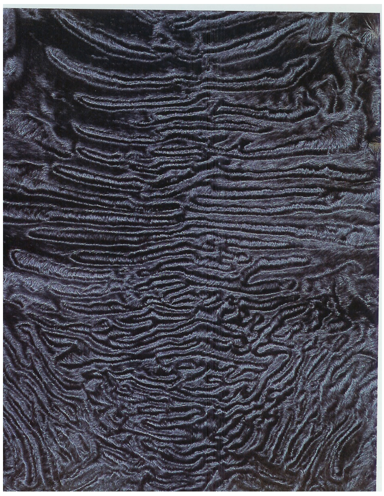


d) R Flat light

e) R Flat

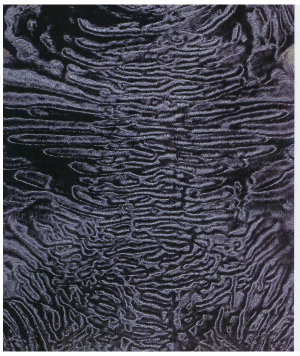


f) Nazucha

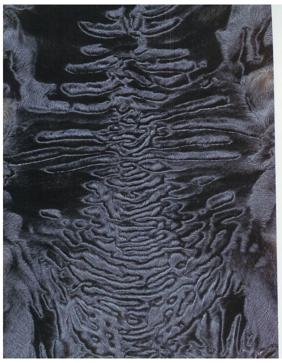


g) T

Figure 2 Examples of drawn pelts

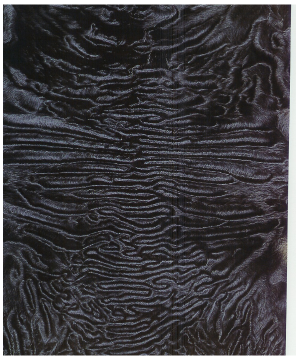


a) D Light Lyre

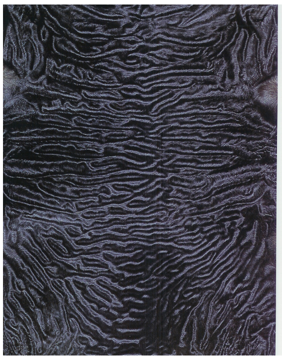


b) D

c) P

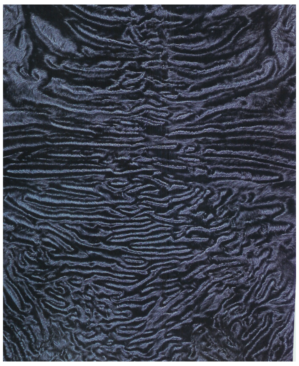


d) O

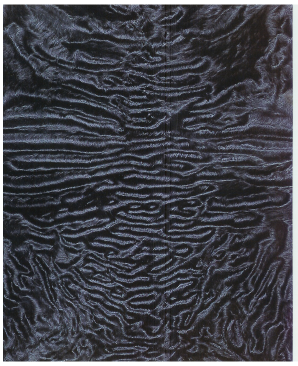


e) F

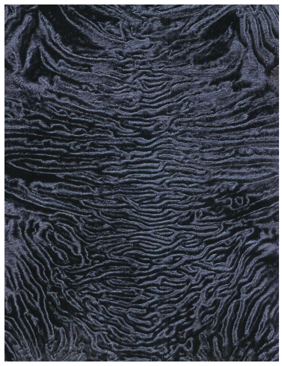
f) M



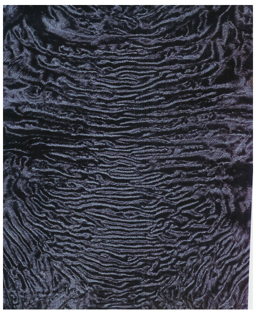
g) K-Flat



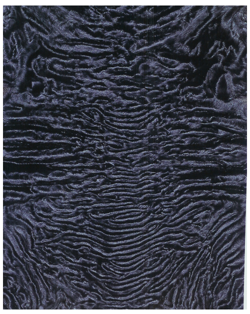
h) N-Flat



i) Q



j) G



k) K

Figure 3 Examples of Lyre pelts

a) Cheviot

b) Coltswold

c) Lincoln

provided by Lynn Magedson

d) Barbados

e) Coloured Merino

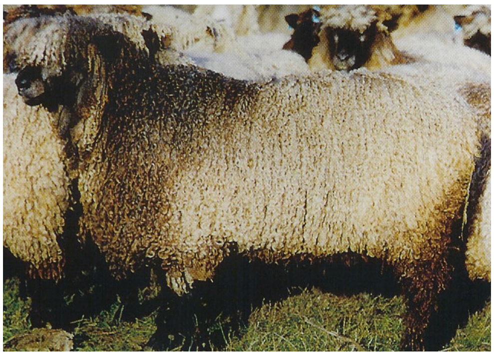
Figure 4 Examples of sheep breeds used in crossbreeding with Karakul in America.

a) Rambouillet

b) Zackel ewe with lamb

c) Somali

d) Fresian Milk Sheep



e) Leicester

Figure 5 Examples of sheep breeds used for crossbreeding with the Karakul in Germany

a) F_1 Galliac Black

b) F_1Galliac B-White

c) F_2 Galliac Black

d) F_2 Galliac A-White

e) F_3 Galliac Black

f) F_3 Galliac A-White

Figure 6 Examples of Galliac curl type F_1 to F_3 generation

a) F_1 Watered silk Galliac Black

b) F_1 Watered silk Galliac B-white

c) F_2 Watered silk Galliac Black

d) F_2 Watered silk Galliac A-White

e) F_3 Watered silk Galliac Black

f) F_3 Watered silk Galliac A-white

Figure 7 Examples of Watered silk Galliac curl type F_1 to F_3 generation

a) F_1 Watered silk Black

b) F_1 Watered silk B-White

c) F_2 Watered silk Black

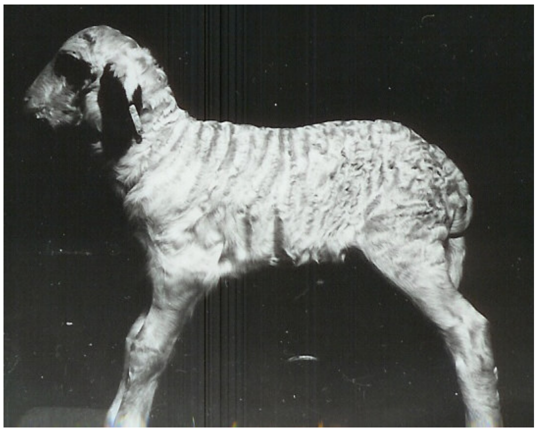
d) F_2 Watered silk A-White

e) F_3 Watered silk Black

f) F_3 Watered silk A-White

Figure 8 Examples of Watered silk curl type F_1 to F_3 generation

a) F_1 Shallow watered silk Black



b) F_1 Shallow watered silk B-White

c) F_2 Shallow watered silk Black

d) F_2 Shallow watered silk B-White

e) F_3 Shallow watered silk Black

f) F_3 Shallow watered silk A-White

Figure 9 Examples of shallow watered silk curl type F_1 to F_3 generation

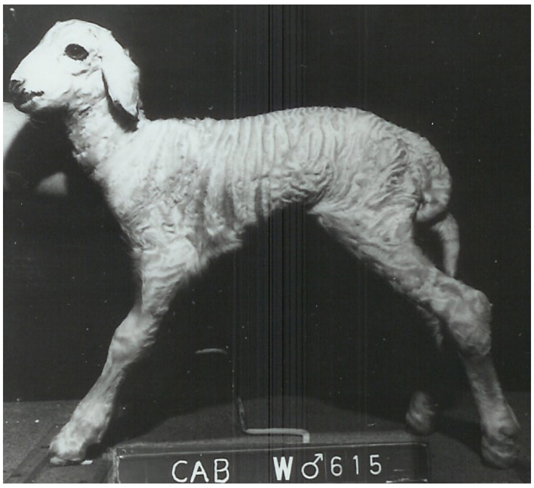
a) F_1 Shallow Black

b) F_1 Shallow B-White

c) F_2 Shallow Black

d) F_2 Shallow B-White

e) F_3 Shallow Black



f) F_3 Shallow B-White

Figure 10 Examples of shallow curl type F_1 to F_3 generation

a) F_1 Shallow developed Black

b) F_2 Shallow developed Black

c) F_2 Shallow developed A-White

d) F_3 Shallow developed Black

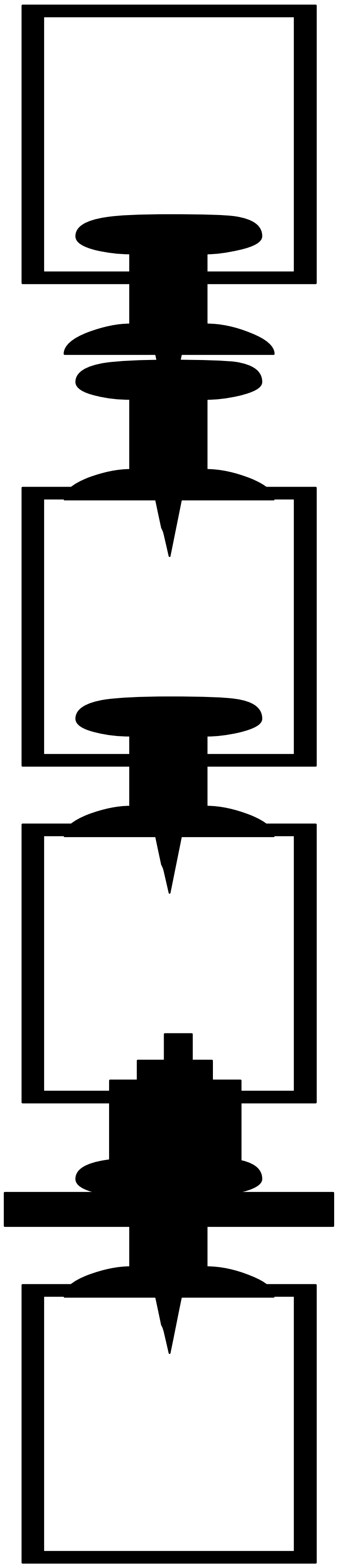
Figure 11 Examples of shallow developed curl type F_1 to F_3 generation

a) F_2 Developed shallow Black

b) F_2 Developed shallow B-White

c) F_3 Developed shallow pipe curl Black

Figure 12 Examples of developed shallow curl type F_2-generation and Developed shallow pipe curl F_3-generation



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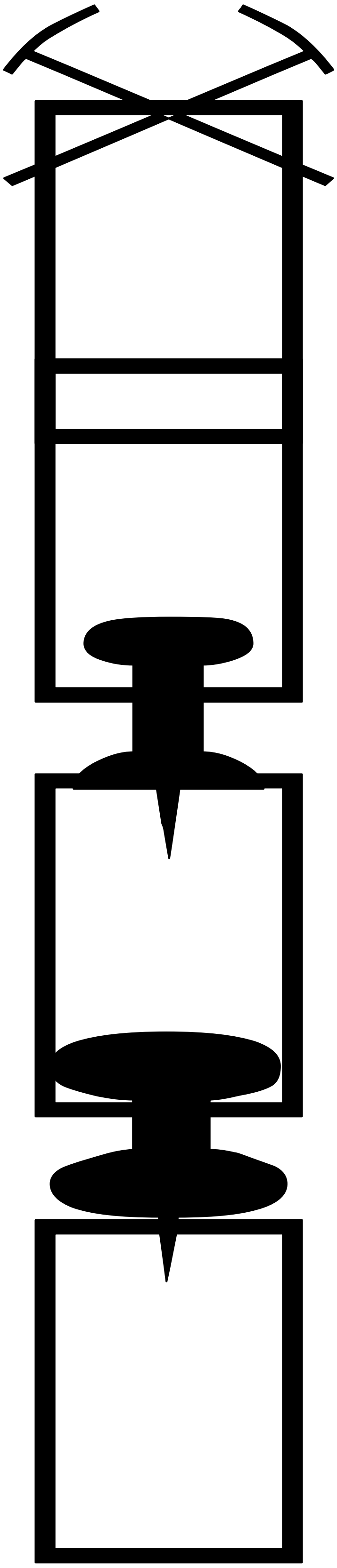

a) Galiac

b) Watered silk Galiac

c) Watered silk

d) Shallow watered-silk

e) Shallow

f) Shallow developed

g) Developed Shallow

h) Developed shallow pipe curl

Figure 1 Different curl type examples of pure bred karakul