The bio-ecology of the sheep scab mite *Psoroptes ovis* (Acari: Psoroptidae) Hering (1835)

By

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Preface

This study was carried out under the auspices of the Department of Zoology and Entomology, University of the Free State, Bloemfontein, from January 1997 to September 1999 under the supervision of Prof. L.J Fourie and Prof. D.J. Kok.

This study represents original work by the author and has not been submitted in any form to another University. Where use was made of the work of others, it has been duly acknowledged in the text.

Theresa Meintjes

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General introduction

Background

Sheep scab, which is caused by the mite *Psoroptes ovis*, is one of the oldest diseases known to man. The disease is mentioned in the Bible (Lev. xxii, 22), as well as in the writings of Cato the Censor about 180 B.C (Babcock & Black, 1933). According to Downing (1936) it was not until 1809 that Walz recognized that it was a mite that is the causative agent for sheep scab, irrespective of the fact that the mite could be seen with the naked eye. In 1835, Hering named this mite *P. ovis*.

Prolonged efforts were made by countries throughout the world to eradicate the disease, but in spite of their intense efforts, sheep scab remains a serious veterinary problem and an impediment to sheep husbandry. Several of the main sheep rearing countries succeeded in ĕrādicating sheep scab. In South Australia for example, it was eradicated in 1870, and was regarded with such seriousness that all infested sheep and their contacts were destroyed and all carcasses, fencing and infested pastures were burned when it was reintroduced in 1878 (Kirkwood, 1986).

Sheep scab was eradicated from Norway in 1894, New Zealand in 1885, Canada and Sweden in 1927, and Denmark in 1929. It was also eradicated from Lesotho in 1935 (Flower, 1978), but as was the case with the UK (eradication in 1952), it reappeared in 1973. In Germany the disease was almost eradicated soon after 1948 but was also reintroduced in 1973. In Brazil the disease was kept well under control for 20 years but

there was a resurgence in 1976 (Kirkwood, 1986). A similar sequence of events occurred in Hungary where the disease was eradicated in 1965, but reappeared in 1978. In Argentina the first case of sheep scab was reported in 1820, and according to Kirkwood (1986), the failure to control the disease was due to resistance developing to gamma HCH which was used to control the mite.

History of sheep scab in South Africa

In South Africa sheep scab has been a problem since the 17th century (Kirkwood, 1986). Simon van der Stel, 17th century governor in the Cape of Good Hope warned butchers not to sell inferior, scabby sheep to the troops and citizens of the Cape. In 1693 he promulgated regulations to prevent the spread of the disease and said that infested sheep infected pastures and kraals (Erasmus, 1979). Sheep scab continued to be a problem and in 1874 regulations in all four provinces were in operation to combat the disease. Ordinance 11 of 1885 introduced an amendment to the sheep scab law. A special section was included allowing the appointment of scab inspectors and scab councils (Erasmus, 1979).

The wide distribution of sheep scab in the beginning of this century necessitated drastic measures, for example compulsory dipping (Orange River Colony Ordinances, 1903), according to which every sheep owner was compelled to dip every sheep in the country between 1 April 1903 and 14 May 1904. Lime sulphur was used as a dipping agent, and by the late 1930's sheep scab was thought to have been successfully eradicated. Between 1940 and 1966 periodic sheep scab outbreaks were, however, still reported in specific parts of the country. These outbreaks were thought to be mainly due to the movement of sheep. In Mpumalanga, Northern Province and Northern Kwa Zulu-Natal trek sheep that moved to winter grazing were believed to be the cause of outbreaks that appeared periodically in the area. Illegal traffic of sheep between Botswana and the North West Province also had similar effects in these parts (Erasmus, 1979). Between

1945 and 1949 benzene-hexacloride (B.H.C or lindane), provided effective protection against *P. ovis* infestations (O'Nuallian, 1966). By 1973 B.H.C was still the only approved insecticide used against *P. ovis* (Kirkwood, 1985).

As early as 1976 a liaison committee was implemented between members of the Department of Agriculture and the Veterinary Chemical Association of South Africa to supply additional chemical compounds which could be used in the control of sheep scab. A series of substances became available and it was decided that all dips, which were to be used, must have an active constituent that is effective specifically against sheep scab (Erasmus, 1979). Diazinon, an organophosphate, and Lindane, an organochlorine (Donnelly, 1996) were the main active ingredients used in the different sheep scab remedies that became available early in 1979. Propetamphos another organophosphorous compound was also used, although it was less popular than diazinon. During the 1980's the organochlorines were withdrawn from the market due to environmental concerns and meat residues. Compounds which are presently used for scab control in sheep belong to the following chemical classes: Organophosphates (phoxim, diazinon), pyrethroids (flumethrin, deltamethrin, cypermethrin), and avermectins (ivermectin, doramectin) (Bomann, 1996).

During 1978 sheep scab was so widely spread in South Africa that a decision was made to introduce a single compulsory dip which should take place within a specific time period. It was realized that this would not eradicate the disease but the incidence would hopefully, after repeating it over a few years, decrease to such an extent that the remaining problem areas could be cleaned up with simultaneous dips. The Department of Agricultural Engineering Science (University of Pretoria) drew up plans for dip facilities and made these available to farmers. Legislation was prepared and the regulations as published in Government Gazette NR. 1531 of 1963 revised and adjusted. The ratification of the law and grant for funds was implemented in time for the second compulsory dipping which started on 1 October 1979 and ended on 30 June 1985. For

the first year (1 October 1979 – 31 January 1980) the compulsory dip program implicated that every sheep in South Africa should be dipped once a year, under supervision of a scab inspector or the State Veterinarian. If a farmer successfully completed the compulsory dip, a dip certificate was issued.

Many farmers who dipped came to the realization that dipping was advantageous to control sheep scab as well as other external parasites. Unfortunately it was also true that very little co-operation was obtained in certain areas, and at the end of January 1980 there were still 141 593 undipped sheep in South Africa (Bruckner, 1984). The compulsory dip program was considered not to be totally successful according to Bruckner (1984) and the possible reasons for this were as follows:

* There was not enough manpower available
* Not all the farmers participated in the dip program
* Farmers lied about dipping their sheep
* Dips were not prepared to the recommended strength
* Some livestock speculators were responsible for the spreading of the disease
* Sale pens did not have satisfactory dip facilities.

In spite of the above-mentioned problems the compulsory dip program was continued during the years 1981 – 1985. According to Bruckner (1984), 83,6% of the total sheep population of the Republic was dipped during the period 1 July 1982 and 30 June 1983, and the reported numbers of sheep scab declined during 1983. Bruckner (1984) was convinced that the increase in sheep scab incidence for 1983 -1984 was attributable to the indifference and negative attitude of farmers towards the control mechanisms. The compulsory dip program was, however, continued for another year from 1 July 1984 to 30 June 1985 but it was a single dip, without supervision and took place on a date that the owner nominated. Compulsory dipping was suspended on 30 June 1985.

Occurrence

The number of sheep infested with sheep scab in South Africa, as recorded by the Department of Animal Health in Pretoria for the period 1993 – 1996, indicated that there was a steady increase in geographical distribution of sheep scab (Figure 1.1a-d), but the total number of scab infested sheep for this period declined. Approximate figures from the Department of Animal Health, Pretoria, indicated that a total number of 24 890 sheep were known to be infested with sheep scab in 1993 in the former Transvaal (including North West, Gauteng, Mpumalanga and Northern Province), compared to the 25 151 and 24 600 reported sheep scab infested sheep in the Cape Province (including Northern, Western and Eastern Cape) and the Free State, respectively. In Kwa Zulu-Natal there was a total of 3136 scab infested sheep during 1993. During 1994, the total number of known scabby sheep in the Cape Province declined to 21 268, and in the Free State to 16 962. The number of known scab infested sheep in Kwa Zulu-Natal declined to 1117 during 1994, and from the former Transvaal only 17 676 scabby sheep were reported (Fig. 1.2). Unfortunately these figures do not reflect the true situation with regard to sheep scab incidence in South Africa. It is generally accepted that these figures represent only a small percentage of the number of sheep infested with sheep scab in South Africa because many farmers do not report the disease.

Even though there was an increase in geographical distribution of sheep scab in the Northern Cape Province during the period 1993 - 1996, the reported number of scabby sheep never exceeded that of the Central and Southern Free State. Several factors could influence the prevalence of a disease such as sheep scab in a certain area. These factors include differences in stock enterprises, climatic differences, and geographical characteristics of the area.

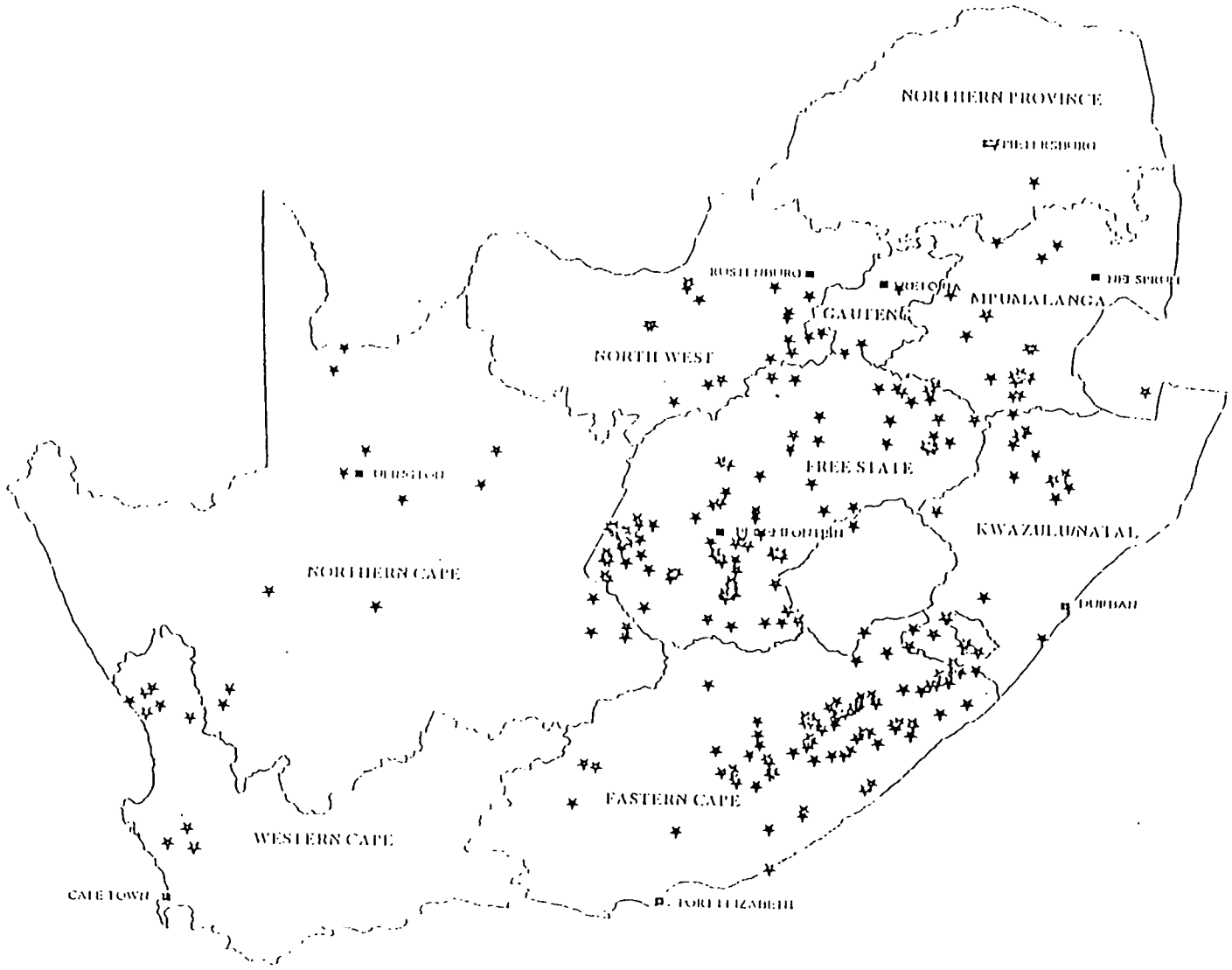


Figure 1.1a: The distribution of reported sheep scab outbreaks in South Africa during 1993.

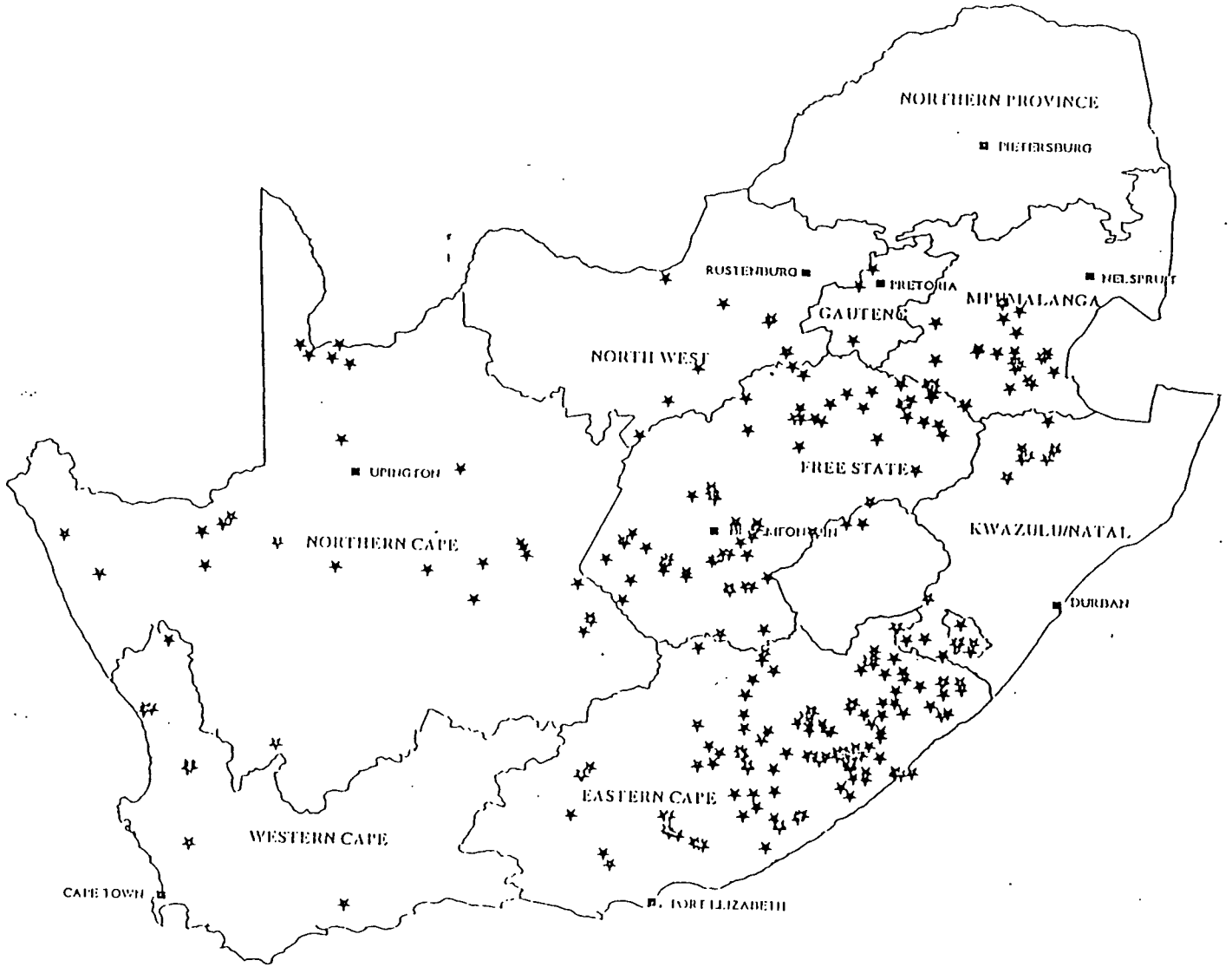


Figure 1.1b: The distribution of reported sheep scab outbreaks in South Africa during 1994.

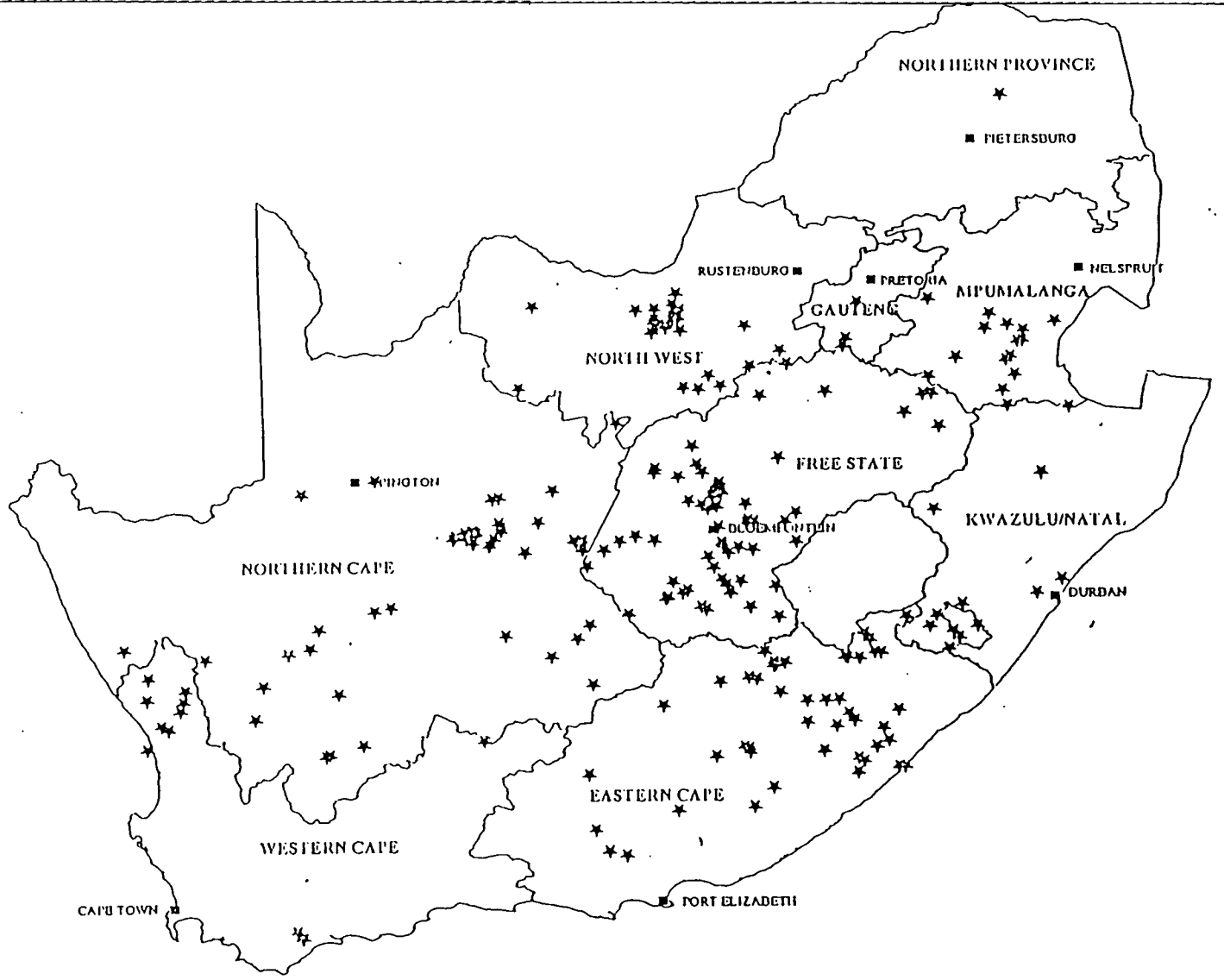


Figure 1.1c: The distribution of reported sheep scab outbreaks in South Africa during 1995.

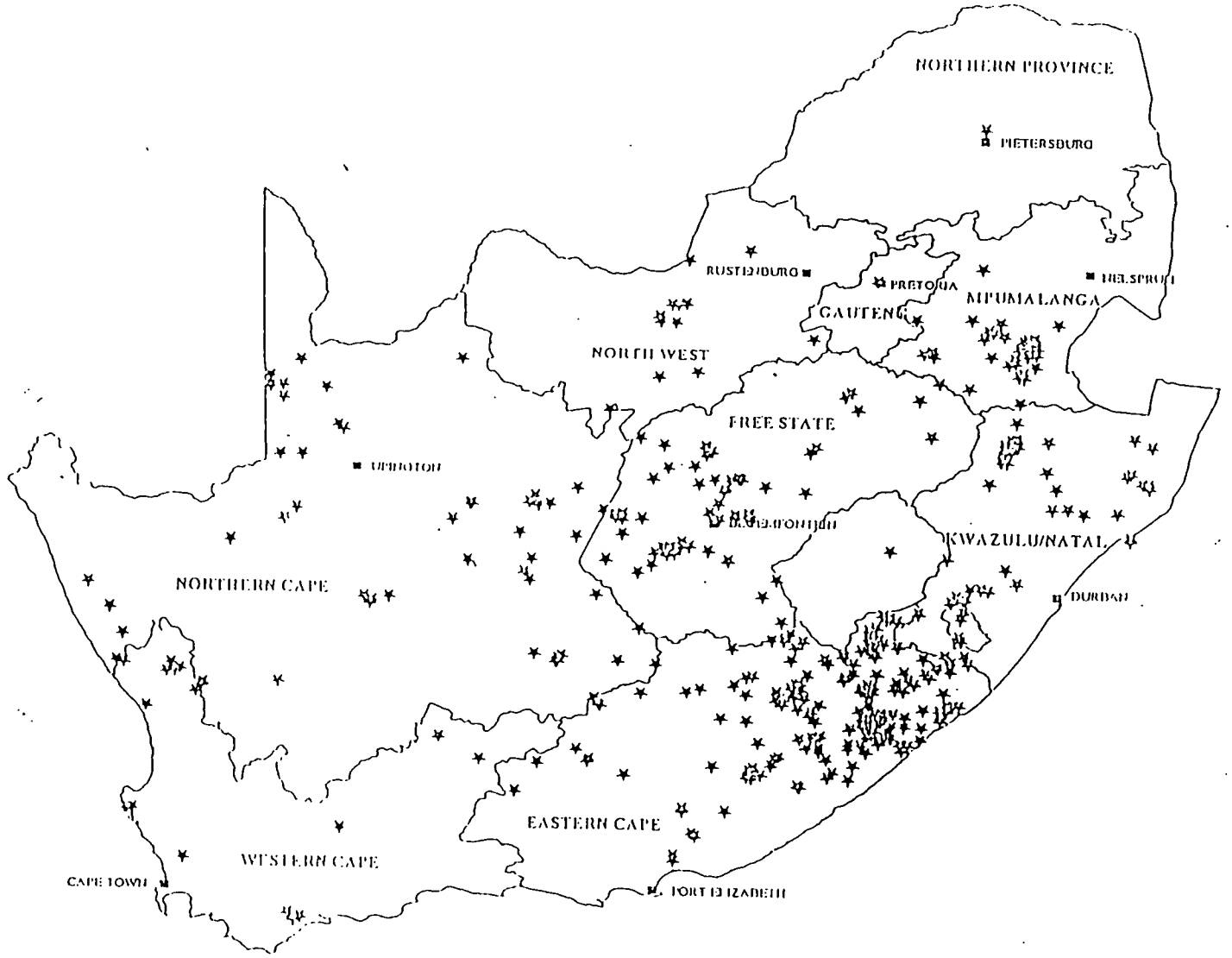


Figure 1.1d: The distribution of reported sheep scab outbreaks in South Africa during January 1996 – November 1996.

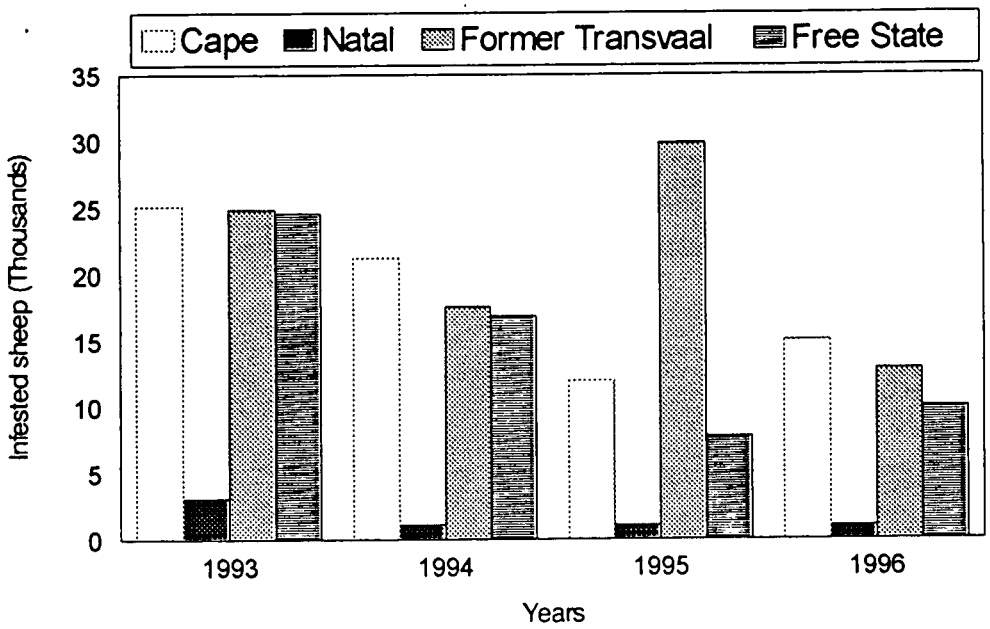


Figure 1.2: The number of *Psoroptes ovis* infested sheep in South Africa during 1993 – 1996.

Main objectives of the study

Almost nothing is known about the biology of *P. ovis* adapted to the specific conditions of the South African climate. During recent years, limited research was conducted on sheep scab in South Africa. The information presently available on sheep scab is mainly due to work done in foreign countries. The bulk of the research on the biology of this mite is conducted in England and although the information generated is very useful it cannot be extrapolated directly to *Psoroptes ovis* that occurs in South Africa.

The main objectives of this study were as follows:

- To give a brief overview of the taxonomy, morphology and life cycle of *P. ovis*
- To determine the adverse effects of *P. ovis* infestation on the host
- To examine possible foci of infestation, and host specificity
- To determine the effect of abiotic factors on the off-host survival of *P. ovis*
- To assess the nature and extent of sheep scab infestations in certain selected small-scale farming communities compared to a selected commercial farming area.

Chapter 2

Taxonomy, morphology and life cycle

Taxonomy

The Acari is undeniably the most heterogeneous order of the Arachnids. Seven suborders of Acari are recognized, of which four include parasitic forms: Metastigmata, Mesostigmata, Prostigmata and Astigmata (Soulsby, 1982).

The higher classification of mites is based primarily on the presence or absence of stigmata and their position on the body. The classification of mites may be complicated by the fact that individuals within a species may be highly variable morphologically and behaviourally. As a result the precise status of a number of specific and sub-specific groupings is unclear and the subject of ongoing debates (Kettle, 1984). *Psoroptes ovis* belongs to the suborder Astigmata. The Astigmatid mites are distinguished from the other orders by not having visible stigmata posterior to the coxae of the second pair of legs. The Astigmatid mites associated with vertebrates are skin parasites and include the families Demodicidae, Sarcoptidae and Psoroptidae (Kettle, 1984). Psoroptidae comprises of four genera namely *Caparinia*, *Otodectes*, *Chorioptes* and *Psoroptes*.

Based upon host species identity, location of mites on the host, and the length of the outer opisthosomal setae (OOSL), Sweatman (1958) studied the validity of the species of *Psoroptes* and recognized as valid the following:

a) *Psoroptes ovis* (Hering 1835) Gervais 1841- the cosmopolitan body mite of domesticated sheep, bighorn, cattle and horses.

b) *Psoroptes natalensis* Hirst 1919- the body mite of domesticated cattle, the zebu and Indian water buffalo, in the Republic of South Africa, South America and New Zealand.

c) *Psoroptes cervinus* Ward 1915- ear mite of the bighorn and the body mite of wapiti.

d) *Psoroptes equi* (Hering 1838) Gervais 1841- body mite of the horse, donkey and mule.

e) *Psoroptes cuniculi* (Delafond 1859) Canestrini & Kramer 1899- a cosmopolitan species which occurs in the ears of the rabbit, goat, sheep, horse, donkey, mule and possibly gazelle. Also a temporary body mite of horses without occurring in the ears.

According to Boyce, Elliot, Clark & Jessup (1990), Sweatmans' (1958) taxonomic scheme is based upon the assumption that *P. cuniculi* is primarily an ear mite that may spread onto the body, whereas *P. ovis* is strictly a body mite that cannot spread to the ears. In contrast to Sweatman (1958), Boyce, *et al.*, (1990) suggested that the OOSL of the *Psoroptes* spp should be used to examine the phylogenetic relationships among populations of *P. ovis* rather than used as a definitive character upon which species identification can be based.

Phylogenetic relationships

Yunker (1955) illustrated a possible phylogenetic relationship of Psoroptidae with other families in the supercohort Acaridiae (Fig. 2.1). The author divided the supercohort Acaridiae into three cohorts namely:

1) Acaridia: including mites which are free-living and/or found in phoretic association with other arthropods.

2) Ewingidia: which includes morphological intermediates.

3) Psoroptidia: which includes parasitic mites.

Sweatman (1957) constructed a dendogram of the family Psoroptidae based on both biological and morphological data (Fig. 2.2). The author indicated that Psoroptidae divides into two natural subfamilies namely, Psoroptinae with *Psoroptes* and Chorioptinae with *Chorioptes*, *Otodectes* and *Caparinia*. The characteristics separating the two subfamilies are:

1) Their comparative size: *Psoroptes* is structurally larger than *Chorioptes*, *Otodectes* and *Caparinia*.

2) The Psoroptinae have long jointed, pedunculated carnuncles on their legs, while those on the Chorioptinae are short and unjointed.

3) Differences in feeding mechanisms. Chorioptinae feed by chewing. Psoroptinae on the other hand, feed by piercing and chewing. They cause direct damage to the skin and are truly parasitic.

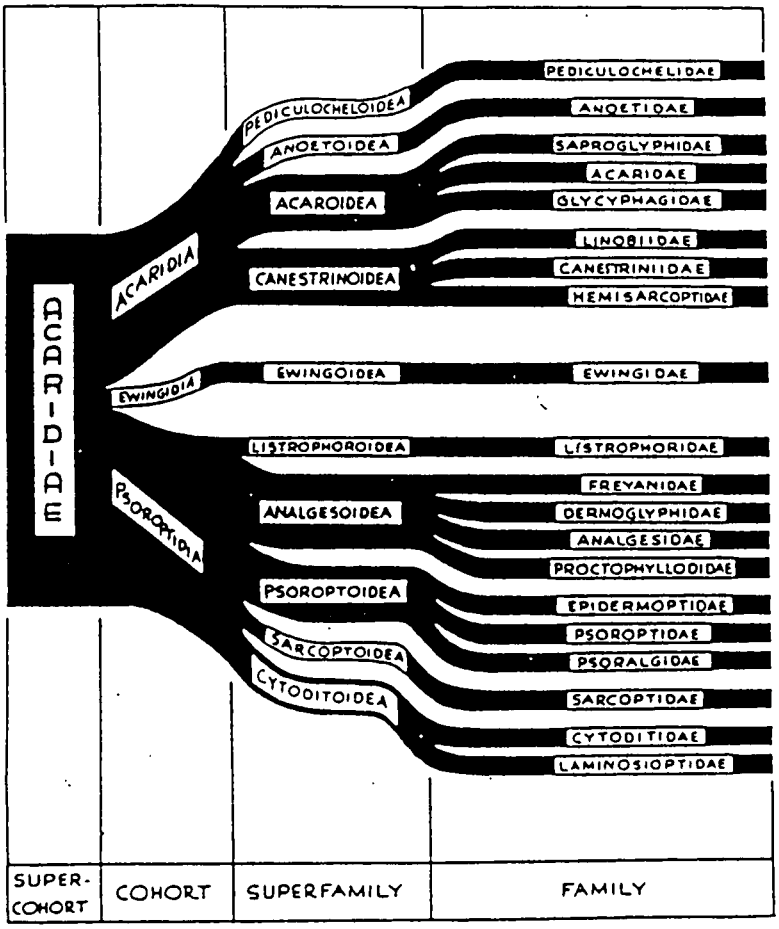


Figure 2.1: The possible Phylogenetic relationship of Psoroptidae with the other families in the supercohort Acaridiae (after Yunker, 1955).

According to Bates (1996) it is at present not known exactly how *P. ovis* feeds. It is known that the mites possess long, sharp, barbed chelicerae, capable of piercing and scraping the skin. The sheep scab lesion itself is not the direct result of the mites feeding

but it is in fact a form of allergic dermatitis to the mite excreta. The heat and humidity produced by the inflammation forms the micro-climate needed for mite survival and the leakage of serous exudate forms the basis of the mites' nutrition (Bates, 1996).

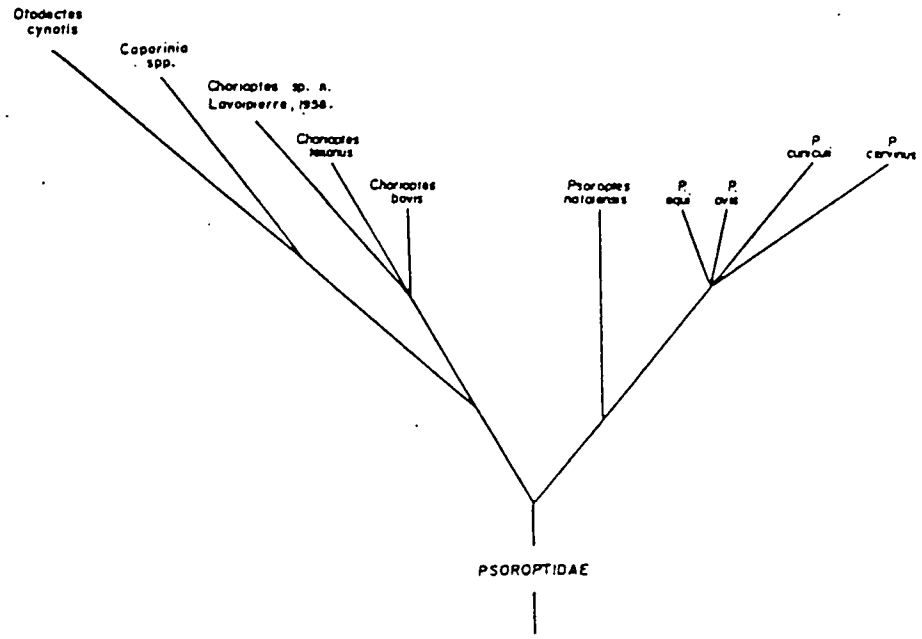


Figure 2.2: A dendogram of the family Psoroptidae based on biological and morphological data (according to Sweatman, 1957).

The ear mites *P. cuniculi, P. cervinus* and *Chorioptes texanus* are placed approximately at the same phylogenetic level because they all display sexual dimorphism in the nymphal stages. All three of the latter mites can, and sometimes do, infest the body and

are pathogenic. Within the Chorioptinae subdivision, the genus *Chorioptes* is placed closer to Psoroptinae than *Caparinia* or *Otodectes* since *Chorioptes*, like *Psoroptes* parasitizes herbivores while *Caparinia* and *Otodectes* are natural parasites of carnivores and an insectivore (Sweatman, 1958).

Morphology

Psoroptes ovis is an obligatory (Soulsby, 1982), non-burrowing (Tarry, 1974), surface feeding acarine which is the causative agent of psoroptic scabies or mange in cattle and sheep (Soulsby, 1982; Stromberg & Fisher, 1986). It is a small whitish mite 0.5 - 0.6 mm in length, with a head longer than it is wide (Hungerford, 1990), oval shaped (Soulsby, 1982), usually visible to the naked eye (Johnson, 1906; Hudman, 1962) and brownish at one extremity. The third and fourth pairs of legs are visible from above. This is not the case with the Sarcoptidae (O'Brien, 1992a).

The dorsal surface of the body is devoid of scales and spines but the cuticle shows very fine striations (Hudman, 1962; Soulsby, 1982). An acarine body seldom shows segmentation, but can be divided into two sections, the anterior gnathosoma (or capitulum) and the posterior idiosoma. The gnathosoma is composed of the mouthparts. The idiosoma is divided into the anterior part, to which the four pairs of legs are attached, called the podosoma and the area behind the legs, the opisthosoma (Fig. 2.3). The legs are composed of seven segments, including the pretarsus, which distally bears the ambulacrum (O'Brien, 1992a). The most important recognition features for *P. ovis* are the pointed mouthparts (Fig. 2.3A), the three jointed pedicles bearing funnel-shaped suckers or pulvilli on most of the legs (Fig. 2.3B) and the rounded opisthosomal tubercles of the male (Fig. 2.3D) (Tarry, 1974; Meleney, 1985; Martin, Aitken & Stobo, 1991).

The compact gnathosoma comprises the chelicerae, palps and hypognathum. The chelicerae are laterally compressed with relatively long digits; the movable digit working in a vertical plane. The tongue-like labrum lies in the pre-oral trough and dorsal to it are a pair of pores that probably represent the openings of ducts of the salivary glands (Buxton, 1920; Rafferty & Gray, 1987).

The digestive system of *P. ovis* is similar to that of the oribatid type mite, but according to Beetham (1997) four additional anterior diverticula are seen dorsal to the ventriculus midline. The digestive system consists of a pharynx, oesophagus, ventriculus, four anterior diverticula and two posterior diverticula connected to the ventriculus, colon, postcolon and anal atrium. The oesophagus in *P. ovis* connects to the ventriculus in an anterioventral position. The nervous system is a single circum-oesophageal nerve mass located in the prosomatic region of the body with all nerve types extending from this ganglion to sensory and effector organs. Paired ovaries are visible in female *P. ovis* indicating the presence of paired oviducts (Beetham, 1997).

Figure 2.3: Morphology of an adult *Psoroptes ovis* mite

A: Gnathosoma with mouthparts

B: Segmented leg of an adult female mite

a: pretarsus with funnel shaped suckers

C: The body segmentation shown in an adult *P. ovis* female

a: gnathosoma

b: podosoma

1: leg i

2: leg ii

3: leg iii

4: leg iv

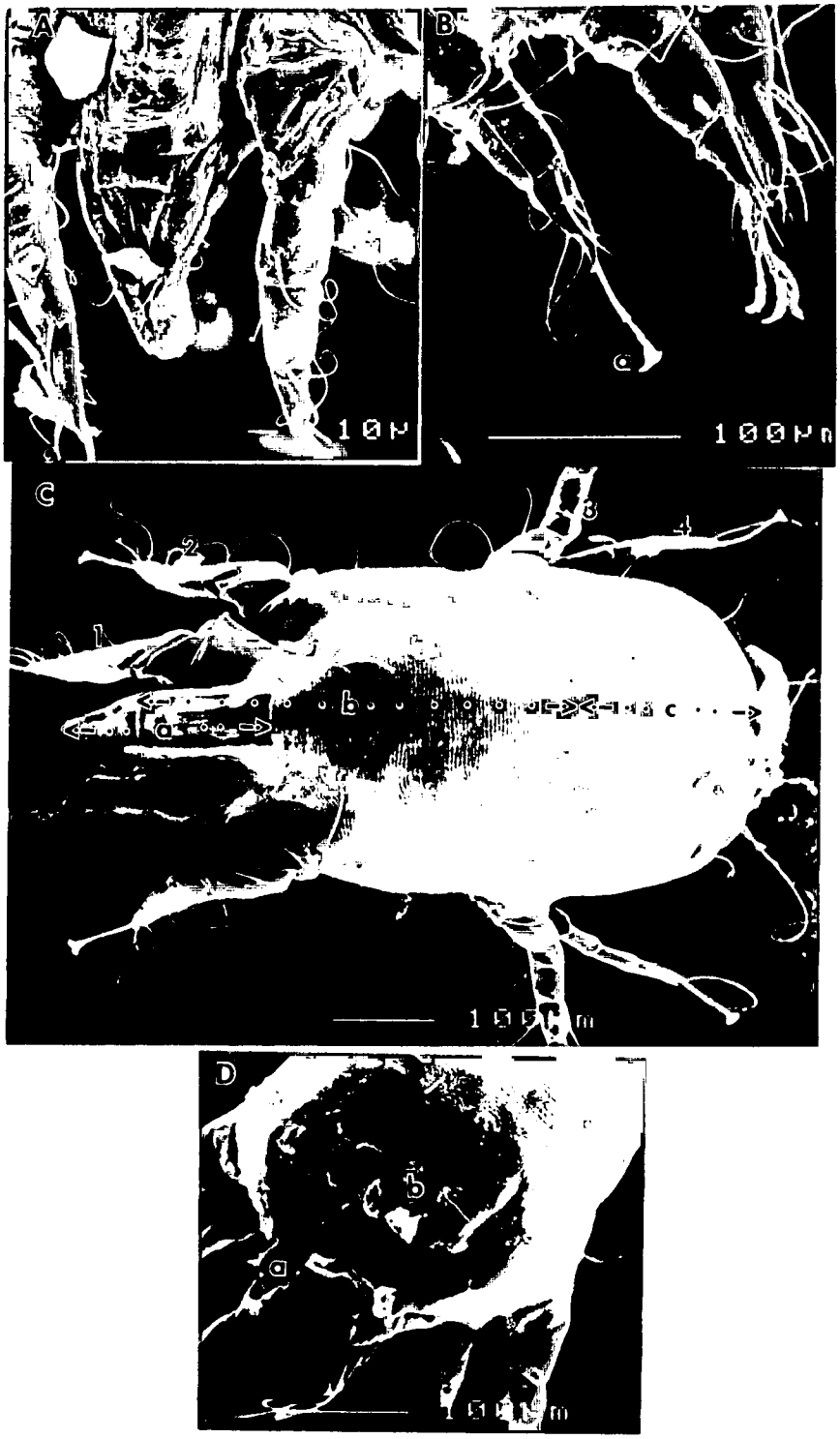
c: opisthosoma

b + c: idiosoma

D: Posterior dorsal view of an adult *P. ovis* male

a: opisthosomal tubercles

b: dorsal sclerotized area


A
10μ
B
100μm
C
1
2
3
4
a
b
c
1 0 0 μm
D
a
b
1 0 0 μm

Life Cycle

The life cycle of *P. ovis*, first described by Gerlach (1857) consists of the egg, pre-larva (which develops within the egg), six legged larva, eight legged male or female protonymph, male deutonymph, or pubescent female, adult male or the ovigerous female (Fig. 2.4). Moulting (ecdysis) occurs between instars (Bates, 1996), when the mite enters a resting or quiescent phase (Shilston, 1915; Downing, 1936), which lasts 12 to 48 hours. This phase is characterized by immobility, the mite assuming a characteristic position, with the front legs stretched outwards. All the internal organs undergo liquefaction, with the exclusion of certain germinal cells. The rapid multiplication of these cells give rise to a new form which breaks through the old covering in the same way the larva emerges from the egg (Bates, 1996).

The time required for the completion of the life cycle for *P. ovis* has been reported by a number of authors. There is a great lack of certainty and a wide variation in the statements on the length of time required for the hatching of the egg and the duration of the various stages (Shilston, 1915). According to Sweatman (1958), eggs on the skin of the sheep are reported to hatch after a period of 1 to 4 days. If eggs are separated from the skin, an average of 2,7 days are required for hatching, and in fleece a few inches from the hide, egg incubation takes up to 10 days (Downing, 1936). Stockman (1910) quotes the classical life cycle as 12 to 16 days. According to Shilston (1915) the life cycle extends over a period of 11 days. According to O'Brien (1992a) the average life cycle takes 15 days. It is, however, most likely that the length of the life cycle depends on the temperature and microclimate, and the period of incubation of the eggs could be affected directly by extrinsic factors (Sweatman, 1958).

According to Johnson (1906), a single pair of mites can produce the enormous number of 1500 000 individuals in three months. Kirkwood (1983) calculated that 25 mites could give rise to over a million in only 12 weeks.

Eggs

Eggs are produced at a rate of about 1-3 per day. The rate of egg production appears to be inversely related to ambient temperature (Babcock & Black, 1933). The egg is elliptical, about 250 μm long and has a white, shiny surface. The shell has two bosses on the same side and one towards the end of the egg. Egg cleavage is along the longitudinal axis (Sweatman, 1958). After the first 24 hours the egg becomes almost transparent and shortly before hatching a brownish area may be seen at one end, due to the coloured chitinous foreparts of the pre-larva showing through the shell (Downing, 1936).

Larvae

The larvae (which are not sexually dimorphic) have three pairs of legs (Fig 2.5A). The first two pairs of legs bear ambulatory (funnel shaped) suckers and the third pair of legs has two long bristles (Hudman, 1962). When newly hatched, the larva is a small (330μm) elongate oval mite, almost transparent, except for the capitulum and the legs, which at first are a pale brown colour but later develop into a deeper brown (Downing, 1936). The larva has a sclerotized rectangular propodosomal plate with a pair of short propodosomal plate setae near the posterior corners. The remainder of the integument is finely striated.

The first 24 to 36 hours of the larval stage are spent on feeding on skin secretions from the host. Whilst feeding, the larva increases in size and has an opaque white appearance. For the last 12 to 24 hours of this phase the larva ceases to feed and becomes quiescent before ecdysis takes place (Downing, 1936).

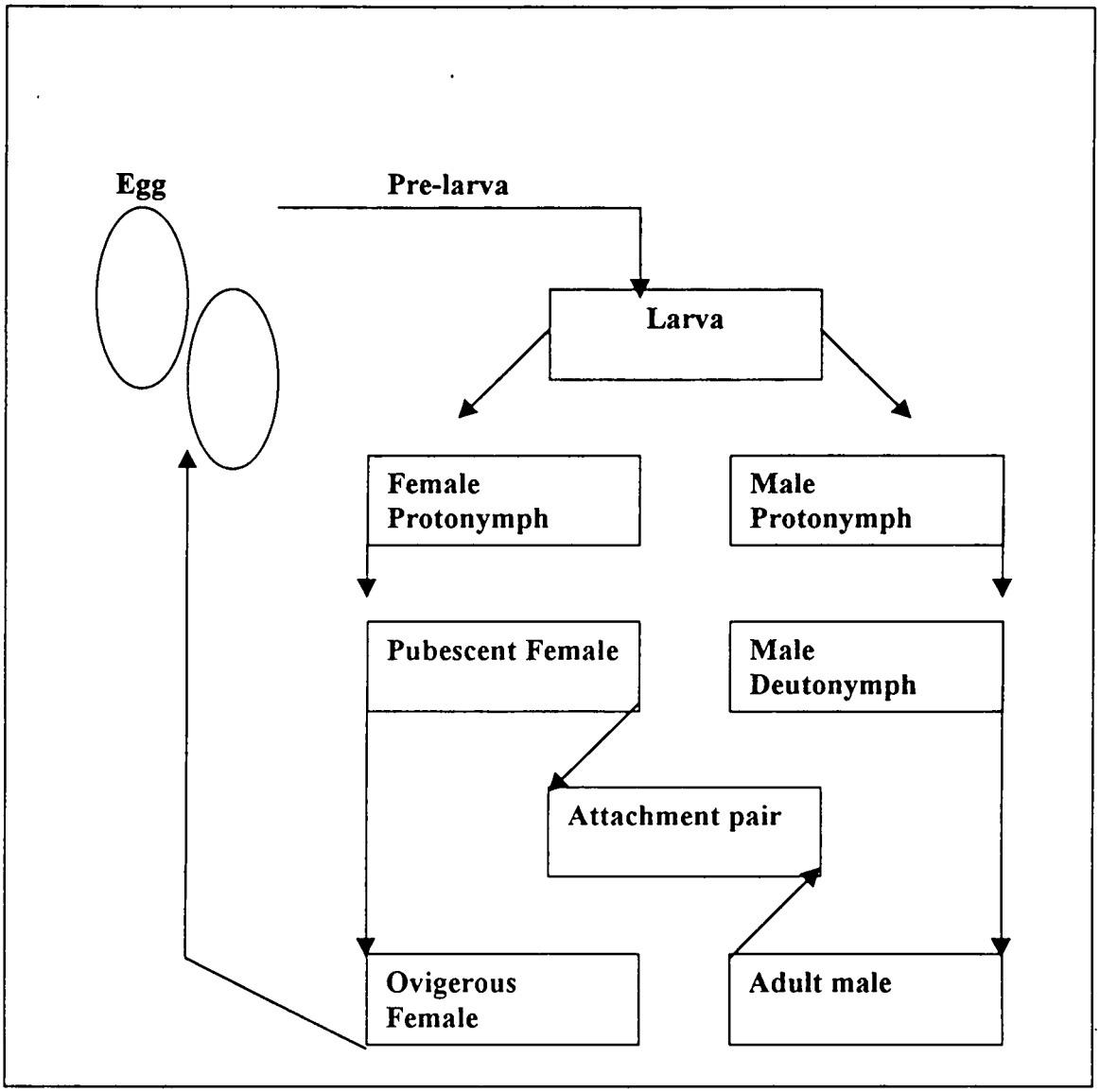


Figure 2.4: A schematic representation of the life cycle of *Psoroptes ovis*. The larva develops into either a male or female protonymph. The pubescent female forms an attachment pair with the adult male. After copulation the ovigerous female lays eggs.

Male and female protonymphs

The male and female protonymphs are about 400 μm long and have four pairs of legs (Fig. 2.5B & C). According to Sweatman (1958) this stage is essentially the same for males and females, with the exception that the female protonymph has a pair of posterodorsal suckers (Fig. 2.5D). The idiosoma and gnathosoma are much the same as in the larva, except that they are longer. The male protonymph possesses a propodosomal plate and the same setae as the larva, with one additional pair of short idiosomal setae in the medioterminal position (Sweatman, 1958).

For the first 24 hours after escaping from the larval skin the male- and female protonymph feeds on the skin secretions of the host and grows. At this time the sex of the next stage can be determined by the size of the resting nymph, were the smallest usually giving rise to the males. The female protonymph then enters a quiescent period lasting from 24 to 36 hours, after which the pubescent female emerges. If the nymphs are destined to become males the nymphal stage is prolonged. In this case the feeding period usually lasts for 48 hours and the quiescent stage 72 hours (Downing, 1936).

Male deutonymph

The male deutonymph (Sweatman, 1958), or male tritonymph as referred to by Fain (1963), is similar to the protonymph but is about 450 μm long. According to Sweatman (1958) the immature characters persist in this stage.

Pubescent female

The pubescent female (Sweatman, 1958), or female tritonymph (Fain, 1963), is similar to the female protonymph except in size. It is up to 670μm long. The pubescent female stage lasts from three to four days, and during the first two days increase in size is rapid, while the period of quiescence preceding moulting is usually about 36 hours (Downing, 1936). The dorsal, and ventral surfaces, gnathosoma and legs are identical to those of

the male deutonymph with the addition of a pair of dorsoposterior copulatory suckers (Sweatman, 1958). The third and fourth pairs of legs are furnished with two long bristles each in the place of the suckers (Shilston, 1915).

The pubescent female feeds on skin secretions and skin lipids of the host for a short time and, if an adult male is available an attachment pair forms. The pubescent female stage usually lasts for two days, but may be as long as four days (Downing, 1936).

Figure 2.5: Scanning electron microscope photos of the larvae and nymphal stages in the life cycle of *Psoroptes ovis*

A: Lateral view of a larva

1: leg i with funnel shaped suckers

2: leg ii with funnel shaped suckers

3: leg iii with bristles

B: Ventral view of a female protonymph

a: gnathosoma

b: posterodorsal suckers

C: Latero-ventral view of a female protonymph

a: gnathosoma

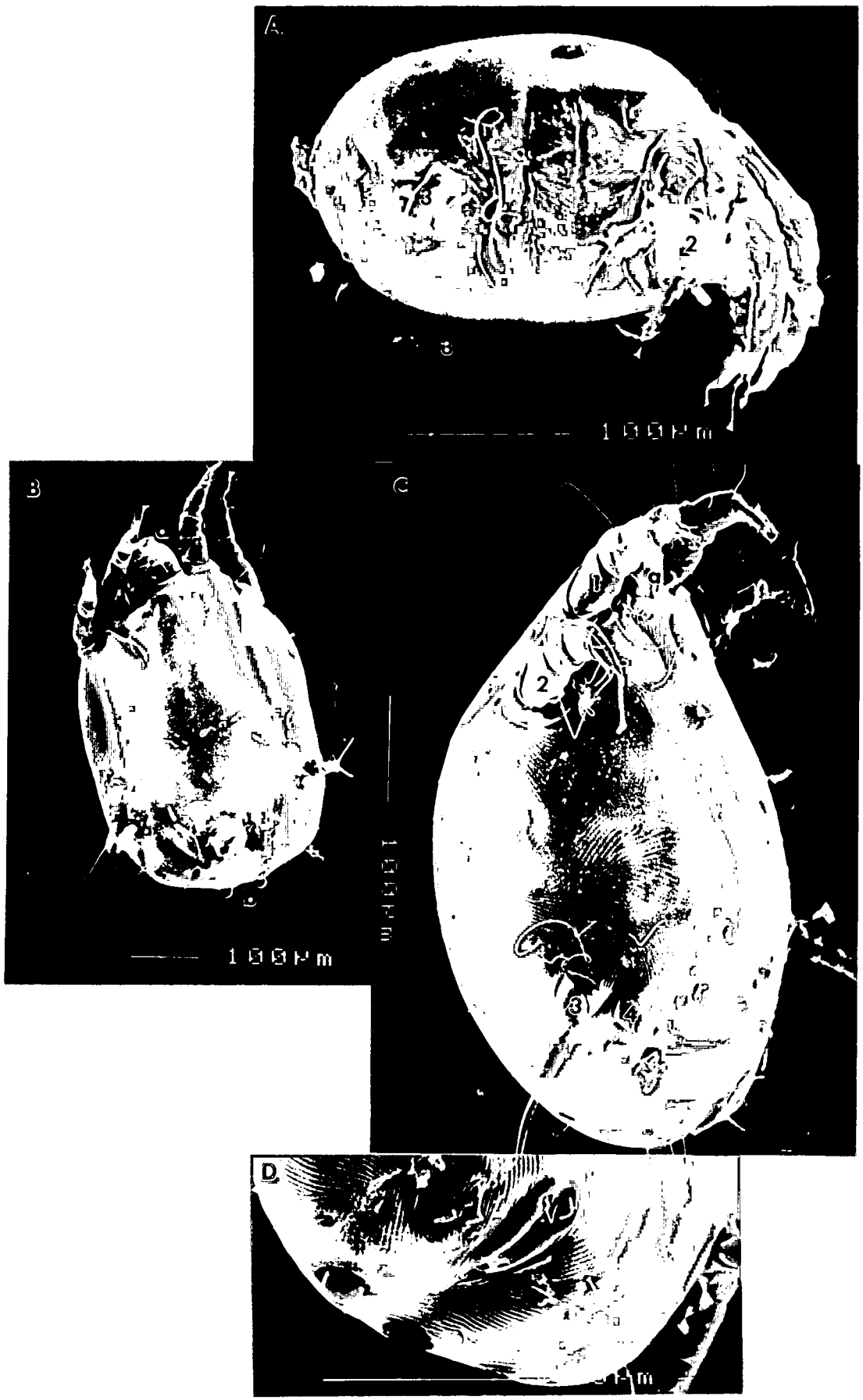
1: leg i

2:leg ii

3: leg iii

4: leg iv

D: Close-up view of the posterodorsal suckers of a female protonymph


A.
3
2
3
100μm
B
100μm
C
100μm
2
3
4
D.
100μm

Adult males

The transformation to adult males is marked by distinct morphological changes. Adult males have a pair of brown copulatory suckers posteriorly, on the ventral surface, lateral to the anus (Sweatman, 1958). Terminally situated is a pair of large opisthosomal tubercles which bears two long and three moderately short setae each (Hudman, 1962). The first three pairs of legs are long and bear trumpet-shaped, sucker-like pulvilli attached to three jointed pretarsi, whilst the fourth pair is very short and bears only hairs (Hudman, 1962). Besides the propodosomal plate there is also a large sclerotized area that covers much of the hysterosoma (Fig. 2.6A & B). In the central metapodosomal region (ventral) the reproductive apparatus is present together with a pair of setae.

The longevity of the male appears to be approximately one month. It is not known how many times copulation may take place during its lifetime, but the male searches actively for pubescent females and copulates freely (Downing, 1936). The male is readily recognised by its smaller size, and it seldom exceeds 550 μm in length (O'Brien, 1992a).

Ovigerous females

P. ovis adult female mites are about 750μm long (O'Brien, 1992a) and can be easily distinguished by their relatively larger size. They have jointed pretarsi and pulvilli on the first, second and fourth pairs of legs (Soulsby, 1982), and bristles on the third pair of legs (Hudman, 1962). This stage is morphologically similar to the immature stages. The dorsoposterior genital sucker of the pubescent female does not occur on the ovigerous female, but she acquires a ventral thoracic vulva (Sweatman, 1958). The vulva consists of a transverse slit and is located between the coxae of the second pair of legs (Downing, 1936; Sweatman, 1958). Two or three pairs of setae are located behind the vulva (Fig. 2.6C).

According to Downing (1936) the actual duration of ecdysis of the pubescent female into the ovigerous female is relatively short. Feeding of the ovigerous female commences immediately after emergence from the moulted skin and it continues feeding for one or two days. It appears as if the bulk of its nutritive material is ingested in its first engorgement although it may also feed again in the intervals between oviposition (Downing, 1936).

After feeding the ovigerous female is considerably larger and its body becomes quite opaque, losing the semi-transparent appearance of the younger stages (Shilston, 1915). Immediately after engorgement oviposition commences (Downing, 1936). The first egg may be laid 24 hours after the last moulting, or nine days from the time of hatching of the larva from the egg (Shilston, 1915). There is a considerable variation in the longevity of the ovigerous female and the rate of egg laying. Stockman & Berry (1913) estimated the total eggs laid as 15 to 30, and the duration of the life of the adult female as eight days. Shilston (1915) found considerable variations but states that under favourable conditions the number may exceed 90 eggs per female. The longevity of the ovigerous female on the sheep is estimated to be 30 to 40 days (Downing, 1936).

Figure 2.6: Scanning electron micrographs of the adult male and the ovigerous female *Psoroptes ovis*.

A: Dorsal view of an adult male.

a: gnathosoma

b: first pair of legs

c: 2nd pair of legs

d: 3rd pair of legs

e: 4th pair of legs

f: sclerotized area

g: ophistosomal tubercles

h: ophistosomal suckers

B: Dorsal view of gnathosoma of an adult male

a: gnathosoma

b: first pair of legs

c: striations

C: Ventral view of an ovigerous female

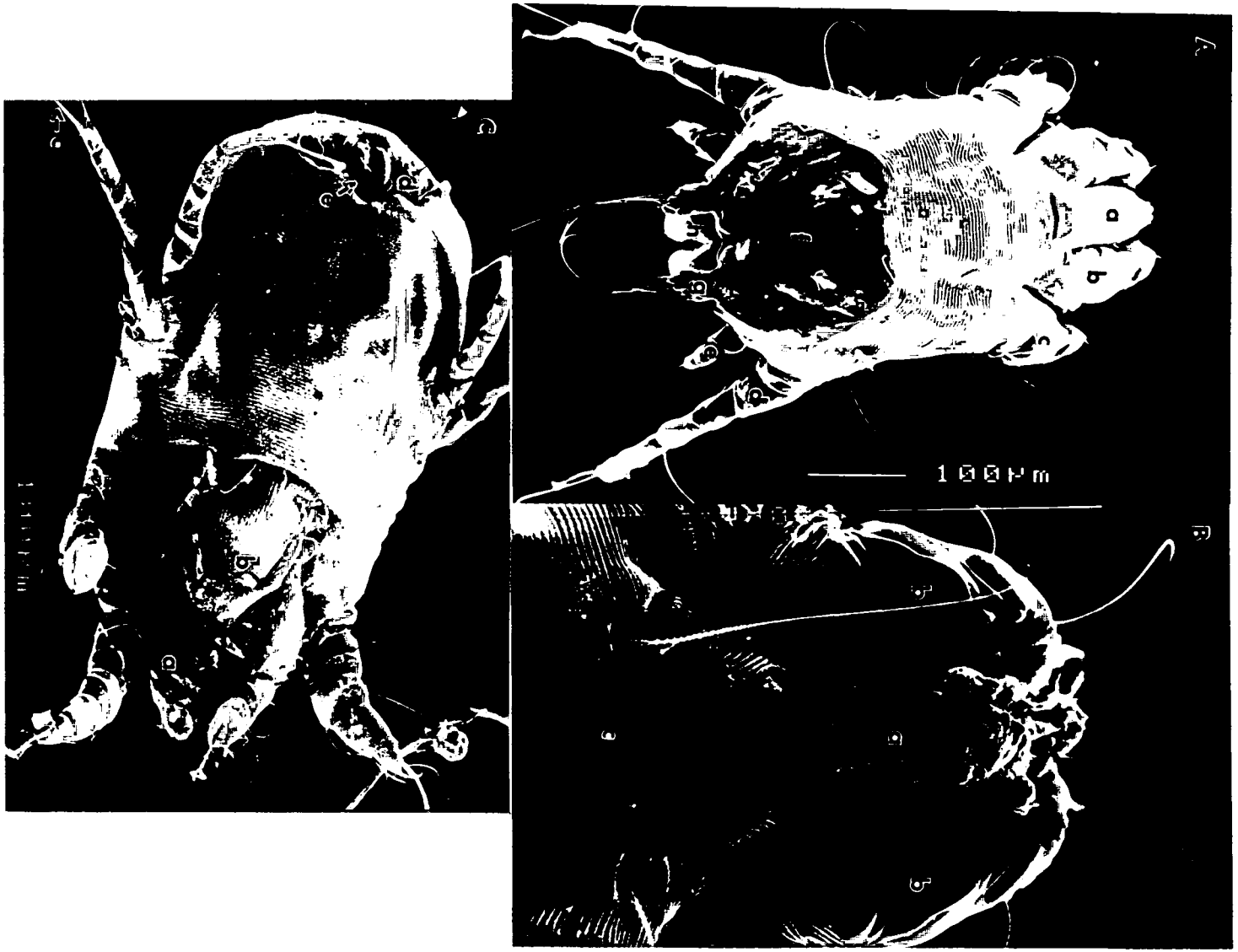
a: gnathosoma

b: thoracic vulva

c: bristles on the third pair of legs

d: anal plate

e: anus


100μm

Attachment pair

Commencement of the life cycle is dependent on the formation of an attachment pair (Guillot & Wright, 1983). According to Shilston (1915) the attachment pair (Fig. 2.7A & B) usually remains united for about 24 hours although the duration may be shorter when female numbers greatly exceed that of males. The adult male attaches to the pubescent female "dragging" her around for 12 to 24 hours while she moults. The attachment of male *Psoroptes* mites to the pubescent females may be compared to the 'guarding' behaviour of the male *Tetranynchus* mites, where the reproductive fitness of these mites depends upon the ability of the male to locate and defend his guarding position over the quiescent female (Guillot & Wright, 1983). The close and firm attachment of male *Psoroptes* mites to the immature female would assure a receptive female for mating after she moults to the adult stage (Sweatman, 1958).

Sweatman (1958) suggested that males mate precisely at the time of ecdysis of the pubescent female to the adult stage but Guillot & Wright (1983) stated that copulation commences immediately after ecdysis of the adult female. An adult male apparently uses its short 4th pair of legs to grasp and hold the pubescent female during attachment, and uses its opisthosomal suckers to hold fast to the posterior surface of the pubescent female (Fig. 2.7B). A male accomplishes copulation as it bends ventrally and partially slides over the dorsal opisthosoma of the female. This motion juxtaposes the aedeagus (intromittent organ) of the male (Fig. 2.7A) and the bursa copulatrix, which is on the anal plate of the adult female. The bursa copulatrix (sperm induction pore) is a raised, cone shaped structure connected by a coiled duct, to a seminal receptacle, which is located dorsally between the ovaries of the adult female. Copulation lasts for several minutes and is repeated several times during the attachment period of adult males and adult females. It is not known whether a female will mate again after separation from the adult male (Guillot & Wright, 1983).

Figure 2.7: A *Psoroptes ovis* attachment pair consisting of an adult male and pubescent female

A: Ventral view of an attachment pair

a: short 4th pair of legs of the adult male

b: aedeagus (intromittent organ) of an adult male

c: pubescent female

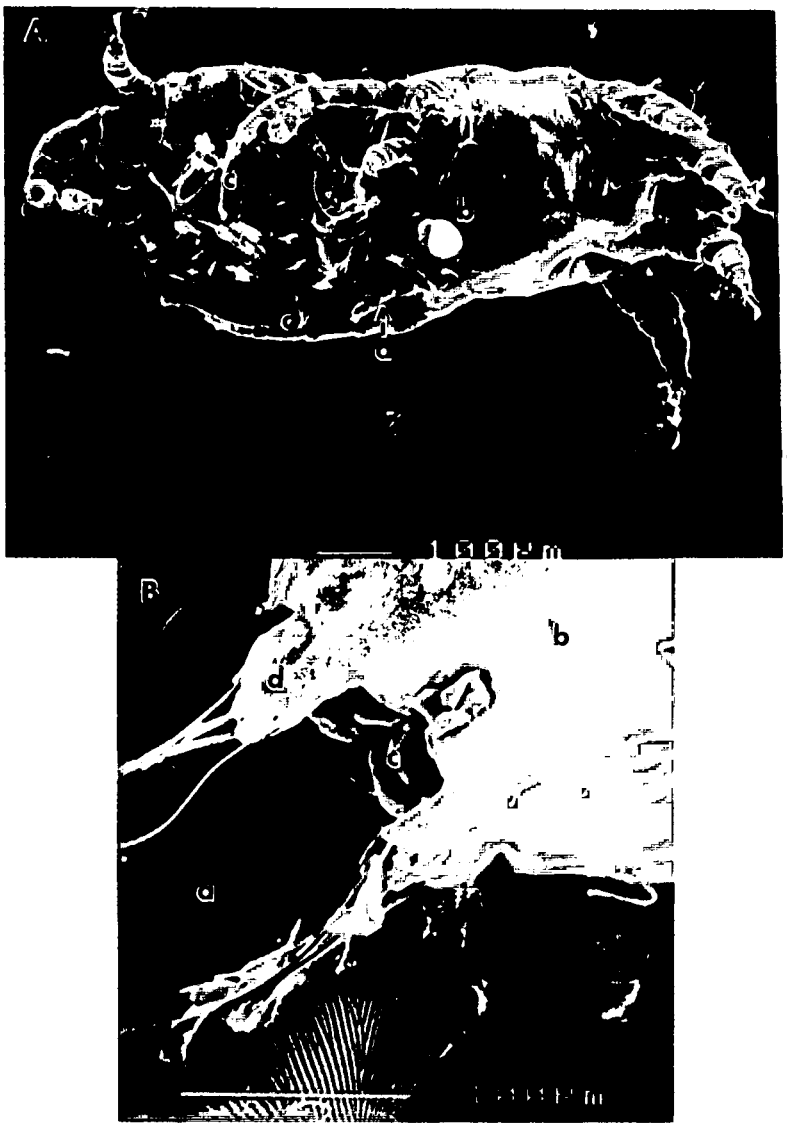
B: Close-up dorsal view of an attachment pair

a: dorsal opisthosoma of a pubescent female

b: dorsal opisthosoma of an adult male

c: opisthosomal suckers of an adult male

d: opisthosomal tubercles of an adult male


A
B
b
d
a

Chapter 3

Host haematology and blood biochemistry

Introduction

Relatively little is known about the dermopathology and the humoral- and cell-mediated responses in animals infected with *Psoroptes ovis* (Losson, Detry-Pouplard & Pouplard, 1988). Arthropods and their products are known to effectively stimulate the host immune system, and a broad spectrum of immune responses is stimulated by arthropod-associated moieties. Reactions elicited depend on such factors as the nature of the immunogen, the route of presentation, the immune response capabilities of the exposed host, and the history of prior antigen exposure (Nelson, Bell, Clifford & Keirans, 1977; Wikel, 1982).

Information related to the discipline of immunology has increased dramatically during the past two decades, and the area of immunoparasitology has received considerable attention. Knowledge gained from these studies has greatly increased our understanding of many aspects of the host-parasite relationships and the immunopathologic consequences of parasitic infection. The vast majority of these studies have focussed on protozoans and helminths, with little attention given to ectoparasite infestations (Wikel, 1982).

Apart from the dermatological symptoms, physiological changes have also been associated with scabies, but little is known about the pathophysiological effects that

P. ovis or other mites have on their hosts (Arlain, Ahmed, & Vyszenski-Moher, 1988; Arlain, Morgan, Rapp & Vyszenski-Moher, 1995).

The specific objective of this study was to examine the blood biochemistry and haematological changes of Merino and Dorper sheep, artificially infested with *P. ovis*.

Material and Methods

Donor sheep

Infective material was collected from scabby sheep in Botshabelo, a predominantly black farming community located approximately 55km east of Bloemfontein. The mites were collected from the infested sheep by scraping off scabs, close to the skin, with a scalpel blade. The wool and mites were transferred directly to two healthy Merino sheep. The infective material was held in position with an elastic band wrapped around the fleece of the receiving sheep. After establishing a positive lesion growth (± six weeks), these two sheep were used as donor sheep. The donor sheep were kept in quarantine to prevent cross infestation with other sheep. The donor sheep received treatment against sheep scab as soon as their lesions extended over 80% of their bodies. They were treated with a single subcutaneous injection of Dectomax® (obtained from Phizer Animal Health Division, (Pty), Ltd., South Africa.) at a dose of 1.5 ml per animal. Prior to the treatment of the donor sheep mites were collected from them and transferred to two uninfested animals, which subsequently served as donor sheep.

Experimental sheep and infestation procedures

Five healthy, year-old Merinos and five healthy, year-old Dorper sheep were purchased from farms in the Fauresmith district in the Free State, during March 1997. On arrival, the sheep were tagged for identification and vaccinated against enterotoxaemia. Prior to purchase the sheep were treated against internal parasites, and were castrated. The sheep were fed on a ration of alfalfa and maintenance pills (obtained from Senwesco, Viljoenskroon, South Africa), with water supplied *ad libitum*.

About two weeks after purchase, the sheep were individually infested with *P. ovis* and placed separately in two quarantine camps. The mites were collected from a heavily infested donor sheep by scraping off the scabby material close to the skin with a scalpel blade. The mites were subsequently separated from the wool under a stereomicroscope with a brush or the tip of a needle, and placed in a clean glass vial. Modifications of the method used by Riner & Wright (1981) were made to collect the mites from the wool. One of the modifications involved the placing of the wool and scab in a Petri dish on a magnetic stirrer set at 35°C (O'Brien, Gray & O'Reilly, 1994a). The heat and vibration from the stirrer plate increased the movement of the mites, and they could easily be collected whilst migrating from the wool.

Each sheep was infested with 15 ovigerous females, 15 males, two attachment pairs and four eggs. The wool on the back of the sheep was parted, the mites were placed in the parting and an elastic band twisted around the fleece at the placement site. The sheep were examined one week after infestation to assess whether any lesions were formed.

The following criteria were used as confirmation of positive lesion development:

- Wet wool at the placement site due to nibbling of the sheep,
- The presence of a small papule, yellow in colour, with a moist surface on the skin of the sheep,

- The presence of live mites,
- A greenish periphery on the skin around the yellow papule,
- If the sheep reacted by turning its head, and smacking its lips if the infested part was handled, it was used together with the above-mentioned criteria to indicate positive infestation.

Blood samples were taken every fortnight after initial infestation and continued for a period of 14 weeks. Ten weeks after the initial placement of the infective material, the sheep were treated with a Dectomax® injection (1,5 ml per animal administered subcutaneous). The last blood samples were taken four weeks after treatment.

Blood samples and serum collection

On every assessment day, blood was collected, prior to feeding, from the jugular veins of the sheep with the aid of evacuated blood collection tubes. Only the tubes used for the haematology contained heparin as anticoagulant.

The following parameters were recorded during the haematological study: haemoglobin (Hb, g/l), white bloodcell count (WBC, 10^9/L), and differential white bloodcell count, neutrophils (N), lymphocytes (L), monocytes (M), eosinophils (E) (all 10^9/L) using a Technicon H1 blood analyser. The analyses were performed at the Haematology Department of the University of the Orange Free State.

For the blood biochemical analysis the amount (REL%) of serum albumin and serum globulin present was determined. After clotting, the blood samples were centrifuged and the serum was removed and diluted with 20µl B-2 Barbital Buffer and 5µl serum. The relative percentage albumin and globulin were then determined using a Paragon Electrophoresis System SPE serum protein electrophoresis kit (obtained from Beckman instruments (Pty), Ltd., South Africa). All the data were subjected to an analysis of variance (ANOVA) to determine if significant differences in the haemaglobin and serum

biochemical values occurred between Merino and Dorper sheep. The different mean two-weekly values were subjected to a t-test.

Results

Haematology

Haemoglobin: The haemoglobin values recorded on the different assesssment days are summarized in Table 3.1. Two weeks post infestation the haemoglobin values for both the Merino and Dorper sheep were within the normal range (11-14 g/l). The haemoglobin value for the Merino sheep was 8.66 g/l at 10 weeks post infestation, compared to the 10.78 g/l for the Dorper sheep. In the Dorper sheep the Hb-concentration remained fairly stable during the infestation period, varying from 11.3 to 10.78g/l (Fig. 3.1). The haemoglobin values of the Merino and the Dorper sheep started to increase steadily after treatment.

The haemoglobin values for the two groups differed significantly after eight weeks infestation. The analysis of variance (ANOVA), with time as covariate, indicated that the haemoglobin concentration differed significantly between the Merino and Dorper sheep ($p=0.001$), and a significant difference occurred over the 14 week observation period ($p=0.014$).

WBC: Two weeks post infestation the WBC for both the Merino and Dorper sheep were within the normal (4.3 – 12 $x10^9$/l) range (Table 3.1). The WBC for the Merinos dropped from 10.74 $x10^9$/l at two weeks post infestation to 8.2 $x10^9$/l at 10 weeks post infestation. The values for the Dorper sheep varied between 12.06 $x10^9$ /l on week +2 to 8.6 $x10^9$ /l on week +14 (Fig. 3.2; Table 3.1).

Neutrophils: In the case of the Merino sheep the neutrophil count varied within the normal (3 - 11.5 $x10^9$/l) range (Fig. 3.3; Table 3.1). The lowest value (2.5 $x10^9$/l) was recorded at 10 weeks after infestation. In the case of the Dorper sheep the values in general, except for week +2, were below the normal range. No pattern was discernible (Fig. 3.3). The differences between the two sheep breeds were significant (p=0.001).

Lymphocytes: The Merino sheep showed a steady decline in the mean lymphocyte counts from 6.56 to 4.62 $x10^9$/l over the 14 week observation period (Fig. 3.4; Table 3.1). A similar pattern was evident for Dorper sheep where values varied between 7.38 – 3.16 $x10^9$/l (Fig. 3.4; Table 3.1). The mean lymphocyte count for Dorper sheep remained within the normal (1.6 – 7.5 $x10^9$/l) range. The differences between the two sheep breeds were insignificant (p = 0.755).

Monocytes: The recorded values fluctuated within the normal 0 – 0.6 $x10^9$/l range (Fig. 3.5). There were no significant (p = 0.507) difference between the two sheep breeds.

Eosinophils: The mean eosinophil counts remained within the normal (0 – 1.0 $x10^9$/l) range for the Merino sheep. The highest mean count (0.96 $x10^9$/l) was recorded eight weeks post infestation. The mean eosinophil concentration for the Dorper sheep varied slightly above the normal range for the first six weeks post infestation. Values within the normal range were recorded on weeks 8, 12 and 14 post infestation (Fig. 3.6). The mean eosinophil counts differed significantly (p = 0.005) between the two sheep breeds.

Table 3.1: Haematological values (mean ± SD) for Merino (group 1) and Dorper sheep (group 2) during *Psoroptes ovis* infestation and after treatment and recovery from the disease.

		Infestation period (weeks)					Post treatment		Normal range
Parameter	Group	+2	+4	+6	+8	+10*	+12	+14	
Haemoglobin (g/l)	1	11.22 (0.77)	10.14 (0.79)	10.14 (0.68)	8.72 (0.65)	8.66 (0.47)	8.8 (0.59)	9.3 (0.64)	11-14
	2	11.3 (0.85)	10.3 (0.61)	10.3 (0.61)	10.98 (0.34)	10.78 (0.52)	12.16 (0.53)	11.94 (0.52)	
WBC ($x10^9$/l)	1	10.74 (1.50)	10.54 (1.26)	10.54 (1.26)	10.54 (1.45)	8.2 (0.94)	11.34 (1.89)	9.02 (1.57)	4.3-12
	2	12.06 (2.75)	11.14 (2.03)	11.14 (2.03)	9.68 (2.22)	10.18 (2.32)	8.62 (1.9)	8.6 (1.84)	
Neutrophils ($x10^9$/l)	1	3.68 (0.62)	3.38 (0.50)	3.38 (0.50)	3.5 (0.67)	2.5 (0.44)	4.34 (0.93)	3.6 (0.67)	3-11.5
	2	3.2 (0.40)	2.94 (0.62)	1.94 (0.62)	2.7 (0.39)	2.64 (0.19)	2.58 (0.4)	1.88 (0.20)	
Lymphocytes ($x10^9$/l)	1	6.56 (1.04)	6.5 (0.81)	6.5 (0.81)	5.5 (0.85)	4.8 (0.52)	6 (1.02)	4.62 (1.04)	1.6-7.5
	2	7.38 (2.04)	6.78 (1.83)	6.78 (1.83)	6.14 (1.78)	3.16 (1.83)	5.36 (1.48)	6.08 (1.60)	
Monocytes ($x10^9$/l)	1	0.22 (0.06)	0.34 (0.11)	0.34 (0.11)	0.3 (0.05)	0.14 (0.4)	0.24 (0.6)	0.26 (0.10)	0-0.6
	2	0.3 (0.05)	0.2 (0.06)	0.2 (0.06)	0.18 (0.04)	0.14 (0.4)	0.16 (0.02)	0.22 (0.07)	
Eosinophils ($x10^9$/l)	1	0.14 (0.07)	0.18 (0.07)	0.18 (0.07)	0.96 (0.35)	0.64 (0.10)	0.42 (0.15)	0.14 (0.08)	0-1.0
	2	1.08 (0.47)	1.1 (0.45)	1.1 (0.44)	0.52 (0.20)	1.02 (0.41)	0.44 (0.10	0.32 (0.10)	

* animals were treated after the week +10 blood collections

Table 3.2: Serum biochemical values (mean ± SD) for Merino (group 1) and Dorper sheep (group 2) during *Psoroptes ovis* infestation and after treatment and recovery from the disease.

		During infestation					Post treatment		Normal
Parameter	Group	+2	+4	+6	+8	+10*	+12	+14	range
Albumin	1	49.26 (2.42)	45.32 (2.375)	48.88 (2.359)	45.16 (0.987)	38.64 (1.873)	37.4 (1.644)	45.66 (2.14)	28-34
(g/dl)	2	58.12 (2.62)	57.86 (2.62)	63.42 (3.37)	62.32 (3.561)	55.16 (3.308)	54.84 (2.178)	59.42 (1.33)	
Globulin	1	50.74 (2.42)	54.68 (2.3)	51.12 (2.359)	54.84 (0.981)	61.36 (1.873)	62.6 (1.64)	54.34 (2.14)	32-43
(g/dl)	2	41.88 (2.62)	42.14 (2.62)	36.58 (3.37)	37.68 (3.561)	44.84 (3.308)	45.16 2.178)	40.58 (1.334)	

* animals were treated after the week +10 blood collection

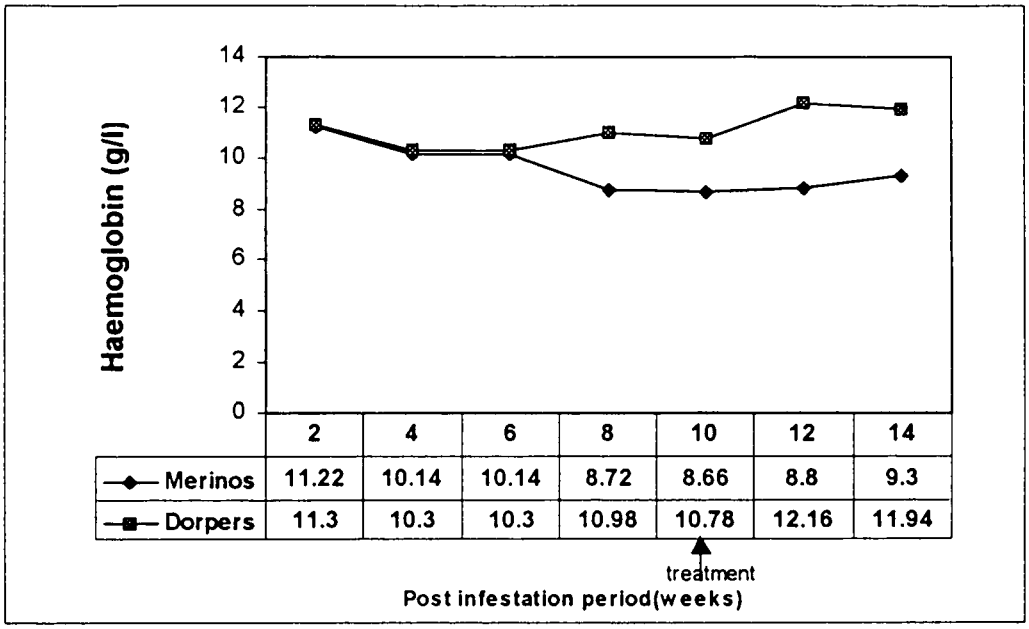


Figure 3.1: The mean haemoglobin (g/l) values recorded on *Psoroptes ovis* infested Merino and Dorper sheep during a 14 week observation period.

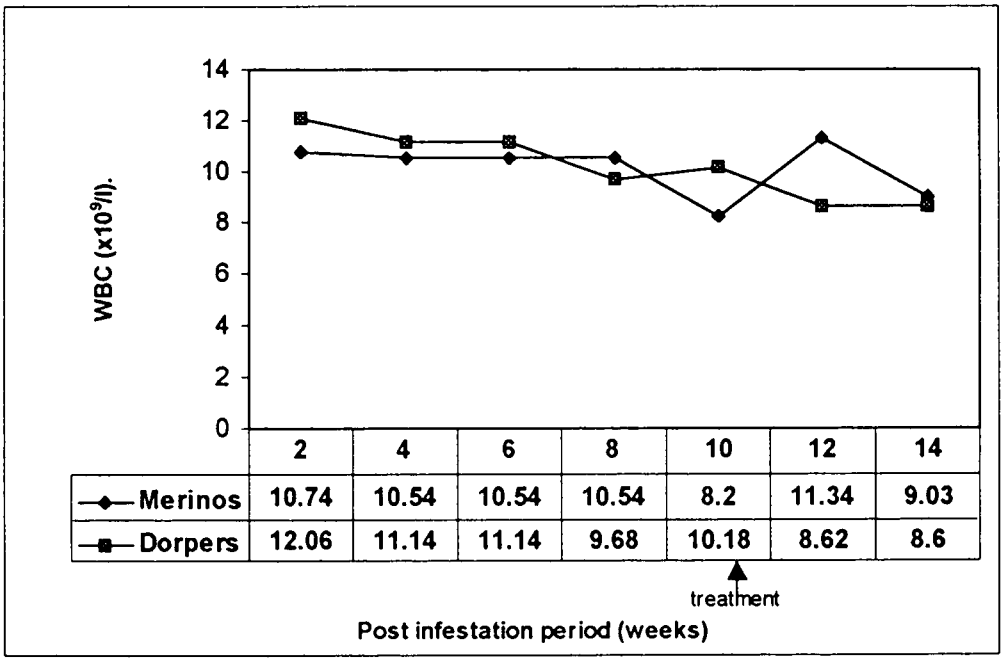


Figure 3.2: The mean WBC ($x10^9$/l) recorded on *Psoroptes ovis* infested Merino and Dorper sheep during a 14 week observation period.

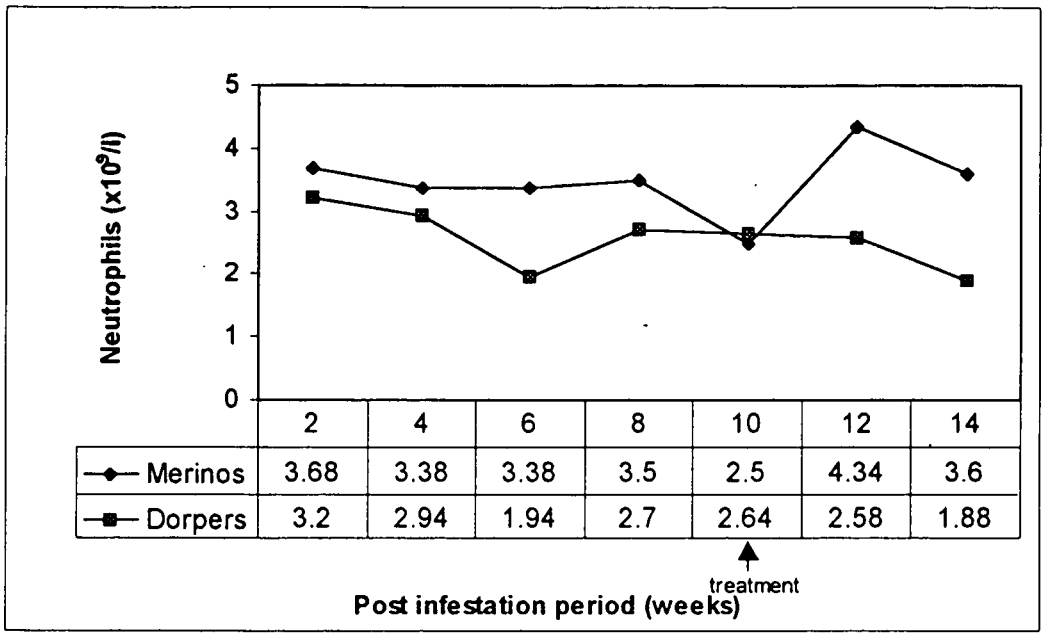


Figure 3.3: The mean neutrophil count (x10^9/l) recorded on *Psoroptes ovis* infested Merinos and Dorper sheep during a 14 week observation period.

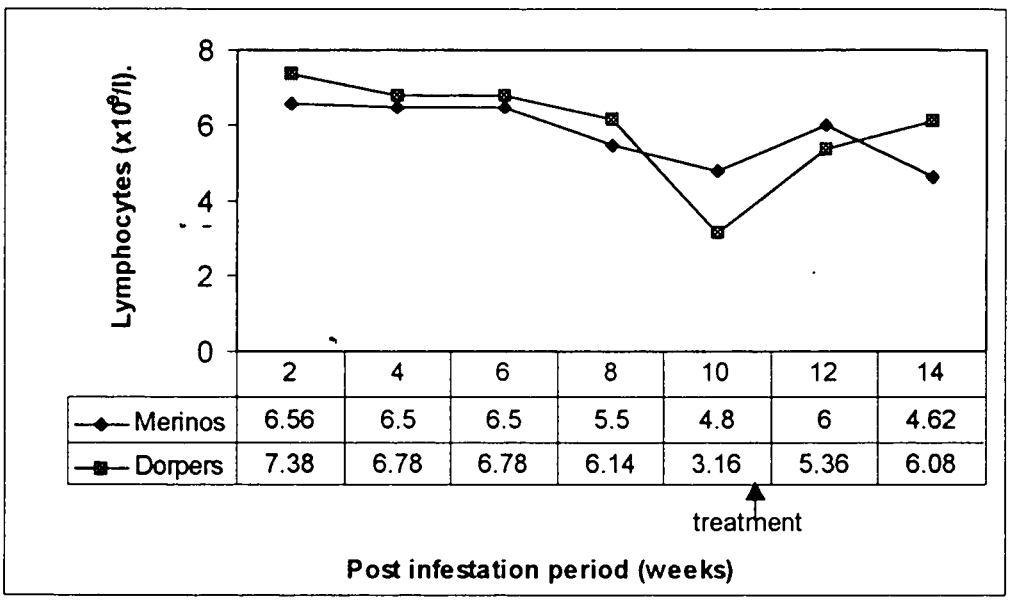


Figure 3.4: The mean lymphocyte count (x10^9/l) recorded on *Psoroptes ovis* infested Merino and Dorper sheep during a 14 week observation period.

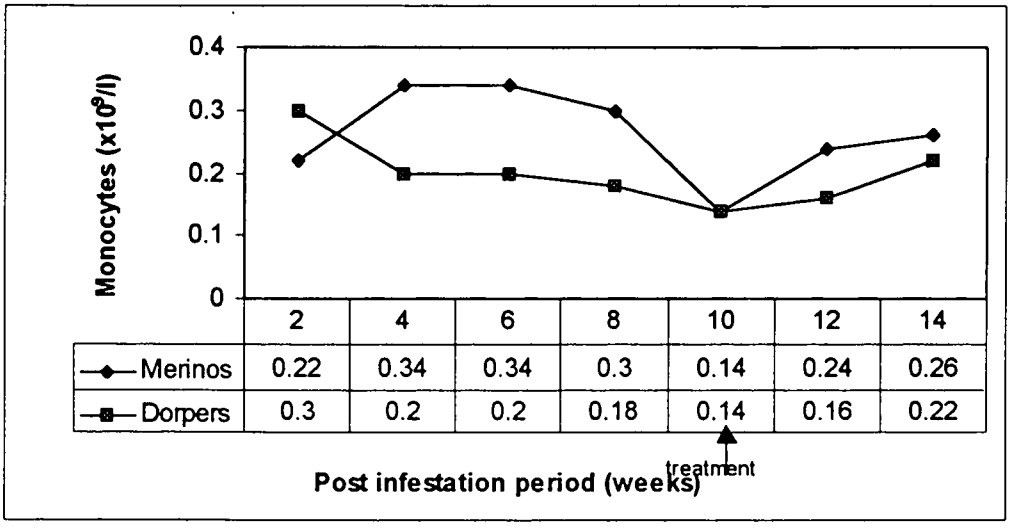


Figure 3.5: The mean monocyte count (x10^9/l) recorded on *Psoroptes ovis* infested Merino and Dorper sheep during a 14 week observation period.

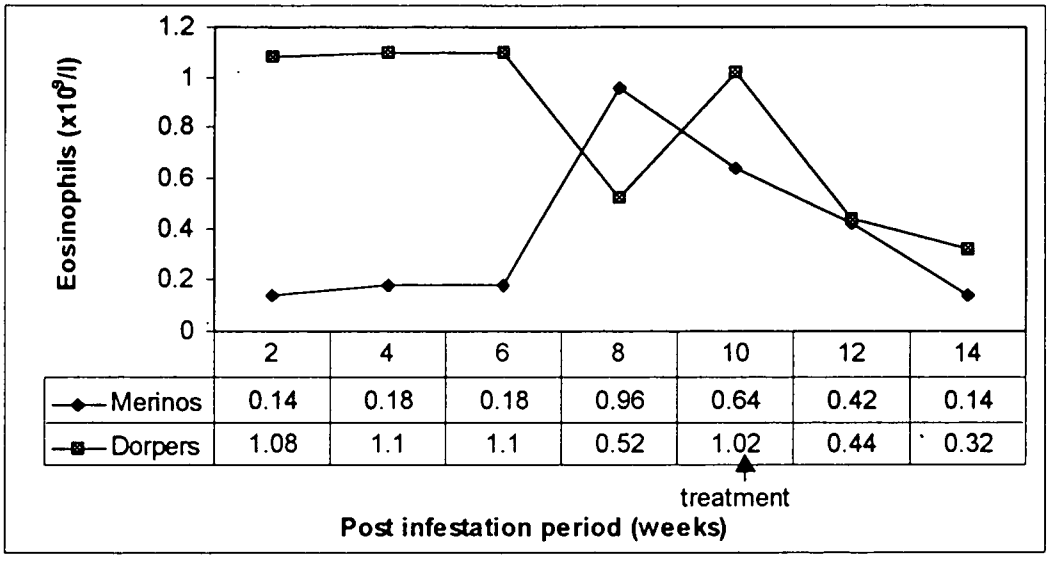


Figure 3.6: The mean eosinophil count (x10^9/l) recorded on *Psoroptes ovis* infested Merino and Dorper sheep during a 14 week observation period.

Serum biochemistry

Albumin: The albumin values for both sheep breeds were substantially above normal (28 – 34g/dl) values (Fig.3.7; Table 3.2). The Merino sheep displayed a slight drop in albumin concentration at 10 (38.64g/dl) and 12 weeks (37.4g/dl) post infestation. The Dorper sheep showed a steady increase in serum albumin concentration up to eight weeks post infestation after which the value declined (weeks 10 & 12) but increased again to 59.42 g/dl on week 14. There was a highly significant ($p = 0.001$) difference between the albumin values for the Merino and Dorper sheep.

Globulin: The normal globulin values vary between 32-43 g/dl (Table 3.2). Two weeks after infestation the globulin values for the Merino sheep were 50.74 g/dl, and reached a maximum value (62.36 g/dl) at 12 weeks post infestation (Fig. 3.8). The mean globulin concentration for the Dorper sheep was 41.88g/dl at two weeks post infestation, and reached a minimum value (36.58g/dl) six weeks post infestation after which it increased to reach a maximum value (45.16g/dl) at 12 weeks post infestation. The peak globulin concentrations recorded 12 weeks post infestation corresponded to the time when the clinical condition of the sheep appeared to be worst. The globulin values recorded for the Merino and Dorper sheep differed significantly ($p<0.05$).

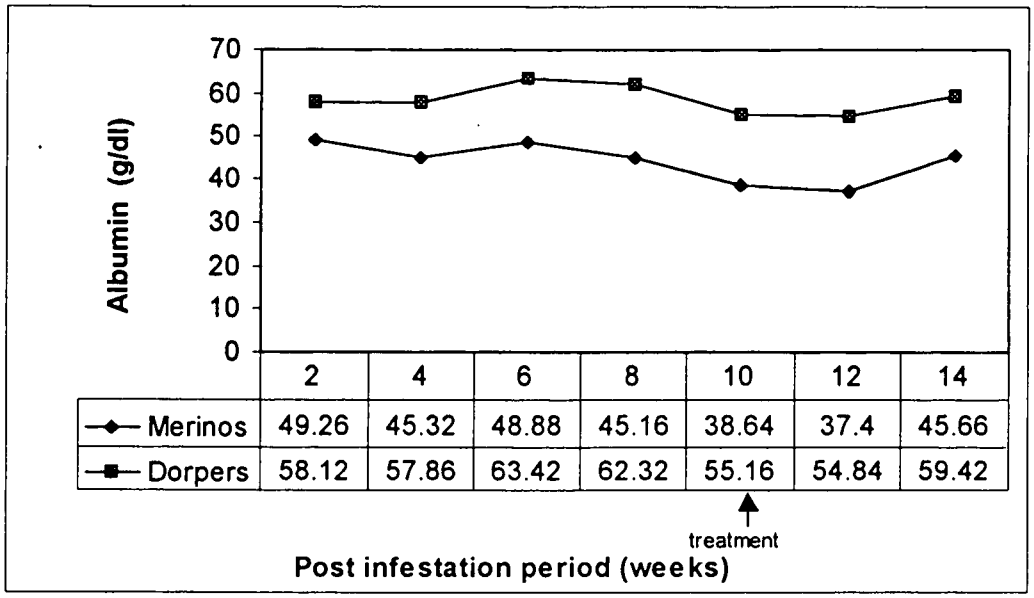


Figure 3.7: The mean albumin values (g/dl) recorded on *Psoroptes ovis* infested Merino and Dorper sheep during a 14 week observation period.

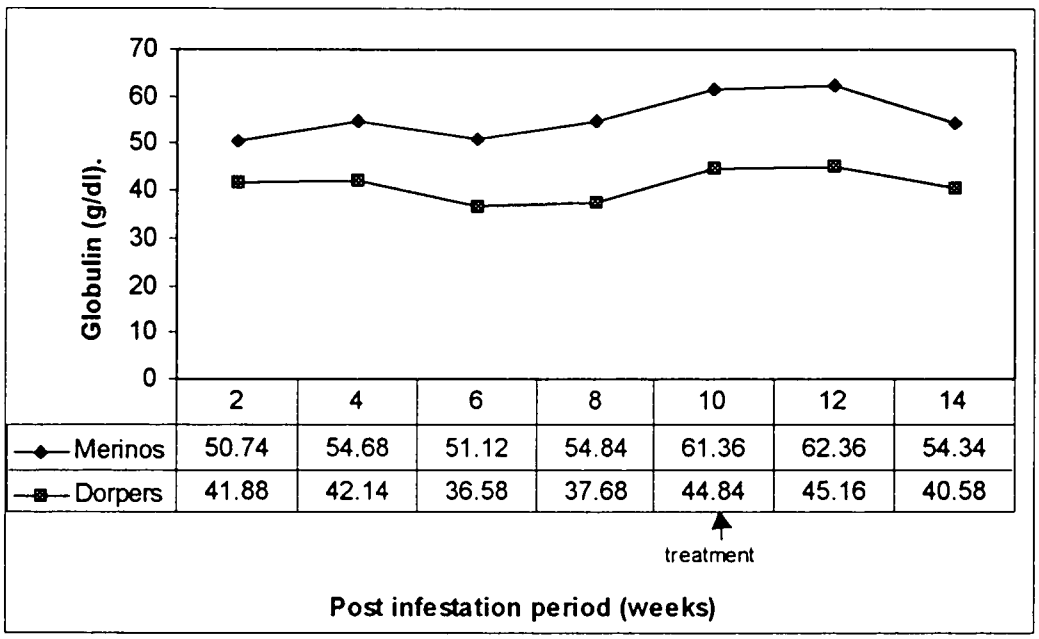


Figure 3.8: The mean globulin values recorded on *Psoroptes ovis* infested Merino and Dorper sheep during a 14 week observation period.

Discussion

The reduction in the haemoglobin concentration is very difficult to explain. According to Shuster & Marks (1967) skin diseases can lead to anemia. Inflammation of the skin can contribute to an increase in the plasma volume and this then contributes to the anemia. According to O'Brien, Robinson, Gray & O'Reilly (1995), Wright & DeLoach (1981) suggested, after using radioactively labelled erythrocytes, that *P. ovis* and *P. cuniculi* feeding on rabbits do ingest erythrocytes. However, this does not occur in sheep (Rafferty & Gray, 1987), because of the much thicker epidermis of sheep and therefore the feeding of *P. ovis* on the skin of the sheep cannot be the cause of anemia.

Sinclair & Kirkwood (1983) investigated the feeding behaviour of *P. ovis* and concluded that on sheep these mites feed on or within the outer epidermal layers, ingesting mainly lipid. In the present study Merino sheep showed an initial drop in haemoglobin levels, and it subsequently decreased as the lesion size increased. O'Brien, *et al.*, (1995) also found that the haemoglobin concentration of scab infested sheep decreased, and suggested that *P. ovis* infestation might lead to the suppression of erythropoiesis. This was supported by Nelson *et al.*, (1977) who noted that erythroblast mitosis was arrested in the prophase during the terminal stages of severe louse infestation.

According to Guillot & Wright (1983) neutrophils are the most sensitive indicators of progressive and regressive scabies in cattle. Neutrophil decrease in the peripheral blood is closely associated with active mites and may be caused by the rapid efflux from the circulating granulocyte pool. Although neutrophils are not a dominant feature of the inflammatory response in the dermis, the rapid emigration of neutrophils from the vascular

compartment into the scab over an extensive surface area can cause neutropenia (Stromberg & Guillot, 1987).

In the present study the Merino sheep showed a decrease in neutrophil numbers at the peak of the scab infestation and an increase after treatment. O'Brien, *et al.*, (1995) suggested that the temporary rise in the neutrophils after treatment of sheep suffering from severe sheep scab may be due to the death of large numbers of mites, with the release of antigens from them. Persistently decreasing numbers of circulating neutrophils, may compromise host defenses in the gastrointestinal and respiratory tracts and predispose the animal to secondary infections which cause death in some cases of severe scabies (Guillot & Wright, 1983).

The lymphocyte count for both groups of sheep showed a steady decline over the infestation period with a fairly pronounced drop at the acute stage of the disease. Similar results were found by Losson, *et al.*, (1988) on cattle infested with *Psoroptes ovis*. Stress due to handling of the sheep (O'Brien, *et al.*, 1995), and the continued stress due to chronic dermatitis can, however, lead to the decline in lymphocyte numbers (Stromberg & Guillot, 1987b).

Increases in the numbers of circulating eosinophils have long been associated with parasitic infestations (Nelson, *et al.*, 1977). Eosinophils differ from other leukocytes in their genesis and maturation, their morphology and biochemistry, and their functional ability. According to Weller & Goetzl (1979) eosinophils possess apparently unique capabilities to modulate immediate-type hypersensitivity reactions by virtue of specific biochemical constituents that degrade mast cell-derived mediators. During the present study the eosinophil reaction in the Merino sheep followed the clinical condition with the highest recordings made at 8 and 10 weeks after infestation, respectively. The reaction of the Dorper sheep was quite the opposite to that of the Merino sheep. The failure of the Dorper sheep to develop

eosinophilia when challenged with *P. ovis* could reflect genetic differences in the capacity to respond to inflammatory mediators which are also reflected in lesion growth (Chapter 5). Dorper sheep did not establish or displayed a humoral response. Weller & Goetzl (1979) mentioned that the eosinophils arrive after the humoral phase has been established irrespective of the specific time course of the hypersensitivity reaction. According to O'Brien, *et al.*, (1995) this can support the hypothesis that the cutaneous response to the mites is a hypersensitivity reaction. Cochrane (1994) also reports that lambs infested with *P. ovis* had enlarged reactive lymph nodes due to the build-up of eosinophils. The skin was also thicker than normal, resulting from the reactive lymph nodes draining the skin. According to Weller & Goetzl (1979), the eosinophils in the enlarged lymph nodes are not required for the immune response, but are engaged in the endocytosis of antigen-antibody complexes.

During the present study the albumin levels of both Merino and Dorper sheep remained high above the normal range, but the reason for the elevated levels is difficult to explain. The effects of *P. ovis* infestation possibly caused the progressive lowering of the albumin levels in Merino sheep throughout the infestation period. Anorexia, a feature of severe scab, can have an effect on the albumin levels. Decreased albumin levels could indicate chronic liver disease or kidney damage (Fisher & Crookshank, 1982). It has been shown (Chapter 4) that *P. ovis* infestation significantly affects the body mass of Merino sheep compared to non-infested sheep. The difference may be as much as 23.43% after 16 weeks. In Dorper sheep the effect was less apparent, explaining perhaps the observed differences in the albumin concentrations. A fall in albumin values due to sheep scab infestations has previously been recorded (O'Brien, *et al.*, 1995).

Increases in globulin values in animals can indicate antibody production and inflammation. In Merino sheep globulin values increased steadily to peak 12 weeks after infestation. The

Dorper sheep, on the other hand had slightly elevated globulin values on the 10 & 12th week after infestation, which indicates that the inflammatory response in this breed is much less pronounced and this is also manifested by retarded lesion growth (Chapter 5). O'Brien, *et al.*, (1995) monitored the haematology and blood biochemistry during the developmental and regression of psoroptic scabies in sheep. The authors reported that psoroptic scabies in sheep affects the concentration of both albumin and globulin, causing a fall in albumin and a rise in globulin.

According to O'Brien, *et al.*, (1995) a delay in the return of globulin levels to normal, as observed in the Merino sheep, may be due to the persistence of the mites and mite particles which act as antigens in the fleece of the sheep. The globulin levels in Dorper sheep remained within the normal range although a slight decrease was observed four weeks after treatment. The fleece of Dorper sheep is less dense and shorter compared to Merino sheep and this could lead to the easier shedding of dead mites or mite material. The total lesion growth on the Dorper sheep was significantly less than that of the Merino sheep (Chapter 5) and the total antigenic stimulus is therefore much less compared to that of the Merino sheep. The severity of the haematological and serum biochemical changes strongly corresponds to the number of mites and the extent of the disease (DeVaney & Ziprin, 1980; Pruett, Guillot & Fisher, 1986). The differences observed between the two sheep breeds supports this contention.

According to Fisher (1972) precipitating antibodies can be detected in the sera of sheep and cattle (Fisher, 1983) infested with *P. ovis*. These antibodies can be detected by agar-jel methods. The development of the ELIZA test (Enzyme- linked immunosorbent assay) revolutionized the ability to detect serum antibody activity to psoroptic mite antigens (Fisher & Wilson, 1977; Fisher, 1983; O'Brien, 1992b). This method makes it possible to detect early pre-clinical infestations of sheep scab, and the development of the disease is mirrored

in the antibody response (O'Brien, 1992b). At present diagnosis of sheep scab mainly depends upon clinical assessment, case history and microscopic examinations of wool and skin scrapings for mites.

The results from the present study confirm that sheep scab changes the blood biochemistry and haematology of sheep, which are heavily infested with sheep scab mites, but more reliable methods such as the ELIZA test, are required for the early detection of sheep scab. In the eradication campaign against sheep scab it can be proven worthwhile to pursue further studies in the relationship between ovine immune response and pathology, in particular the effect of *P. ovis* on antibody production.

Chapter 4

The effect of *Psoroptes ovis* on the body mass of sheep

Introduction

Psoroptes ovis infestation is an obvious intense irritation and infested sheep nibble at the discoloured patches and scratch themselves continually (Tarry, 1974). The affected sheep become very restless and spend much time and energy in attempts to alleviate the discomfort (Hudman, 1962). Apart from the welfare issue, sheep scab can have significant economic effects within the flock, with a considerable reduction in fleece and leather quality, reduced conception rates (Bates, 1996a), poor lamb growth (Kirkwood, 1980) and in extreme cases, fatalities (Bates, 1996a). In general there seems to be ignorance on the part of farmers as to the effect of *P. ovis* infestation on the body mass of sheep. One of the difficulties in eradicating *P. ovis* is the difficulty to convince a farmer of the economic importance of sheep scab (Kirkwood, 1980).

Several researchers (Brownlie & Harrison, 1960; Alva-Valdes, Wallace, Foster, Ericsson & Wooden, 1986) have examined the effects of sarcoptic mange on the productivity of pigs. The same was done on beef cattle (Fisher & Wright, 1981; Cole & Guillot, 1987) but, apart

from the work done by Kirkwood (1980), very little information is available on the effect of *P. ovis* on the body mass of sheep. Cargill & Dobson (1979) studied the development and effect of *Sarcoptes scabiei* var *suis* infestations in growing pigs. The authors found that the mean growth rates were depressed from 9.2 to 12.5 per cent and concluded that the effect of sarcoptic mites on the performance of the pigs was highly significant in terms of the loss of production. Alva-Valdes, *et al.*, (1986) found that *Sarcoptes scabiei* var *suis* depressed the weight gain of pigs by 5.5%. According to Arends, Stansilaw & Gerdon (1990) the lactating performance of sows was significantly influenced by sarcoptic mange infestation, and the litter weights from ivermectin-treated sows were 4.14 kg heavier than those from untreated sows. Cole & Guillot (1987) determined the effect of *P. ovis* on the energy metabolism of heifers. The authors found that the infested calves had a significantly lower daily gain compared to the control calves, and *P. ovis* infestation increased the maintenance energy requirements of the calves by >50%.

It is thus evident from the literature that mites can have a profound effect on the body mass of their hosts. The specific objective of this study was to determine the effect of *P. ovis* on the body mass of Merino and Dorper sheep, respectively.

Material and Methods

In order to determine the effect of sheep scab on the body mass of two sheep breeds, 10 healthy, year-old Merino and 10 healthy, year-old Dorper sheep were purchased from farms in the Fauresmith district in the Orange Free State, during September 1997. On arrival all the sheep were tagged for identification, weighed on an electronic scale (to the nearest 0.1 kg), and the data recorded. Subsequently, the Merino and Dorper sheep were separately

housed in two camps (± 1 ha) with natural pasture for approximately three weeks. During this three-week period both groups of sheep were fed on 200 – 250g maintenance pills per sheep per day (obtained from Senwesco, Viljoenskroon, South Africa) and 720g alfalfa per sheep per day, with water supplied *ad libitum*.

After this three-week period (early in October 1997) all the sheep were weighed again and the data recorded. Subsequently, five Merinos and five Dorper sheep were randomly selected from the two groups, and used as control animals. The remaining five Merino and five Dorper sheep were each infested with 30 ovigerous females, two males and two attachment pairs. The mites were collected from donor sheep as described previously (Chapter 3). The sheep were each infested by parting the fleece and placing the mites close to the skin with a brush. The control sheep and the two groups of infested sheep were separately housed in quarantine camps (±1 ha) with natural pasture and fed on a daily ration of alfalfa and maintenance pills as described above.

The infested sheep were closely observed on a weekly basis for the development of sub-clinical signs of sheep scab, and were individually examined on a fortnightly basis for the presence of sheep scab lesions. The lesion size of each sheep was assessed as described in Chapter 5.

In order to determine the effect of sheep scab on the mean body mass change of Merino and Dorper sheep, both the infested and control sheep were weighed again at three and six weeks after infestation and subsequently on a fortnightly basis for the duration of the assessment period (16 weeks). On each recording date the sheep were individually placed onto an electronic sheep scale and the body mass of each sheep was recorded. On each of the recording dates the uninfested control sheep were weighed first to prevent possible cross infestation. For each of the recording dates the mean body mass of each group was

calculated. The percentage loss or gain in mean body mass of the infested groups and control sheep, respectively, was calculated. At the end of the assessment period each of the infested sheep was treated with a single subcutaneous injection of 1,5-ml Dectomax ® (obtained from Pfizer Animal Health Division (Pty), Ltd., South Africa).

The mean body masses of each recording from the different groups were statistically analyzed by a one-way analysis of variance (ANOVA). To determine if there was a significant difference in mean body mass between the two control groups and the two infested groups, the data were compared by an ANOVA followed by a multiple comparison test (Tukey). To determine if there was a significant difference in the body mass of the Merino and the Dorper sheep at the recorded intervals, a t-test was performed on the mean body mass of each group. A computer program PRISM™ from GraphPad, Statistical Software, Inc., was used for the analysis and the graphical presentation of the data.

Results

Merino sheep

On arrival the mean body mass of the Merino sheep was 28.48 kg. On the day of infestation (approximately three weeks later) the mean body mass of the Merino sheep had increased to 29.99 kg. One week after infestation the Merino sheep displayed the first sub-clinical signs of sheep scab. All the infested Merino sheep developed positive scab lesions and the disease followed the normal course. At two weeks post infestation the Merino sheep had a mean lesion size of 1 cm^2. At eight weeks post infestation the lesions of the Merino sheep expanded to an average of 342.22 cm^2, with a moist periphery containing large numbers of mites (Chapter 5). Twelve weeks after placement of the mites on the sheep the scab

extended over almost the entire body of the infested Merino sheep (average 7056.8 cm^2) and the wool had become ragged and stained. The sheep were visibly irritated and continuously scratched themselves in an attempt to alleviate the discomfort. At the termination date (16 weeks post infestation) large parts of the body were devoid of wool, and the Merino sheep were clearly very weak.

The mean body mass of the control Merino sheep continued to increase during the course of the experiment from 29.64 kg to 33.08-kg (Fig. 4.1). The infested Merino sheep on the other hand showed a steady decrease in their mean body mass from 27.32 kg to 20.92 kg. After 12 weeks of infestation the control Merino sheep gained a mean 4.16 kg, compared to the 0.92 kg of the infested Merino sheep. At the end of the assessment period (16 weeks) the control Merino sheep had gained a mean 3.44 kg which represents an 11.60% increase in body mass, compared to the mean body mass decrease of 6.4 kg of the infested Merino sheep which represents a 23.43 % decrease in body mass.

A t-test indicated that no significant difference ($p=0.2402$) in the mean body mass of the control Merino sheep and the mite infested Merino sheep occurred at the start of the experiment. The first significant difference ($p=0.0072$) in mean body mass between the control Merino sheep and the infested Merino sheep occurred at 12 weeks post infestation. A t-test indicated that there was a highly significant difference ($p<0.0001$) in mean body mass between the control Merino sheep and the infested Merino sheep at 16 weeks post infestation (Fig. 4.1).

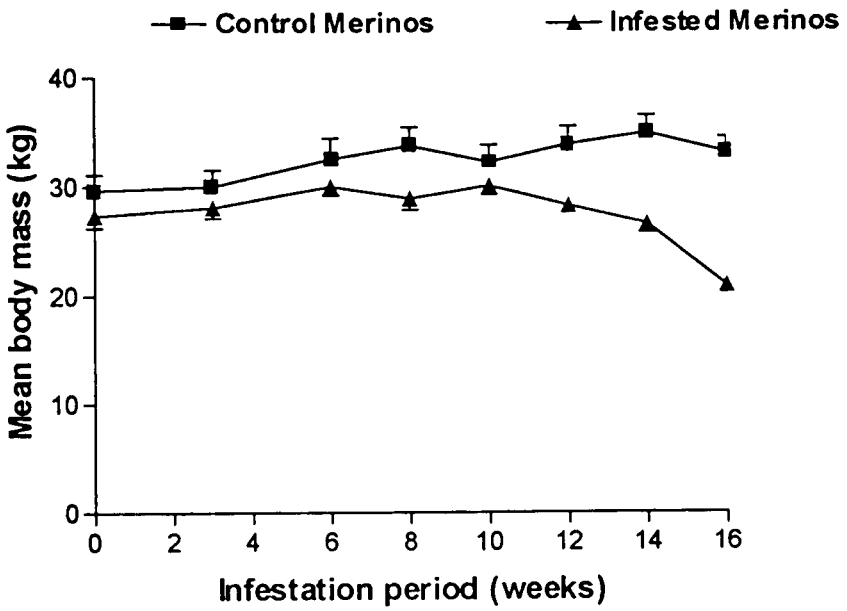


Figure 4.1: Graph indicating the change in mean body mass of uninfested control and *Psoroptes ovis* infested Merino sheep during a 16 week period. Bars indicate standard deviation.

Dorper sheep

On arrival the mean body mass of the Dorper sheep was 28.97 kg and had increased to 31.16kg on the day of infestation approximately three weeks later. Although all the Dorper sheep initially developed scab, three of the Dorper sheep lost their original lesions and had to be re-infested during week four. At two weeks post infestation the Dorper sheep had a mean lesion size of 0.46 cm^2. The mean lesion size of the Dorper sheep was 59 cm^2 and 149 cm^2 at eight and twelve weeks post infestation, respectively. At eight weeks the Dorper sheep displayed signs of uneasiness and irritation, and pieces of wool were visible in their

teeth. At the end of the assessment period (16 weeks) an insignificant amount of wool loss occurred and the sheep were still very strong and appeared to be healthy.

The infested Dorper sheep showed an increase in mean body mass from 30.16 kg to 34.72 kg. The mean body mass of the control Dorper sheep increased from 32.16 kg to 38.04 kg (Fig. 4.2). The mean body mass of the infested Dorper sheep had increased over the 16 week period by 4.56 kg (15.11%) compared to the 5.88 kg (18.28%) of the control Dorper sheep. A t-test indicated that there was no significant difference ($p>0.005$) in the mean body mass of the two groups of Dorpers sheep at any of the recorded intervals.

Table 4.1: A summary of a multiple comparison test (Tukey) to compare the differences in mean body mass between *Psoroptes ovis* infested and uninfested control Dorper and Merino sheep over a 16 week period.
(s = significant ($p\leq0.05$); * = non-significant)

Group	Groups codes	A	B	C	D
A (Infested Merino sheep)	A	*	S	S	S
B (Control Merino sheep)	B		*	S	S
C (Infested Dorper sheep)	C			*	*
D (Control Dorper sheep)	D				*

An ANOVA test revealed that a highly significant difference occurred between the Merino sheep and Dorper sheep ($p = 0.0001$). A multiple comparison test (Tukey) indicated that there was a significant difference in mean body mass between the infested Merinos and the control Merino sheep, but no significant difference in mean body mass between the infested Dorper and the control Dorper sheep (Table 4.1).

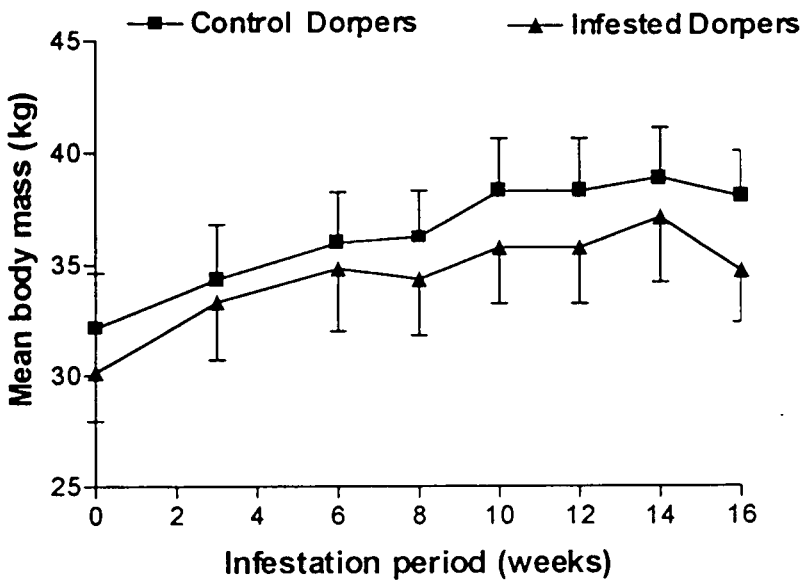


Figure 4.2: Graph indicating the change in mean body mass of uninfested control Dorper sheep and *Psoroptes ovis* infested Dorper sheep during a 16 week period. Bars indicate the standard deviation.

Discussion

The obvious intense irritation experienced by the infested Merino sheep during the course of the experiment clearly influenced their ability to consume food. It was noted that whilst being fed the Merino sheep would frequently interrupt feeding to bite and scratch. This must potentially have a severe effect on the amount of feed actually taken in and hamper the ability to compete for food. According to Babcock & Black (1933) it appears that the detrimental effect of scabies upon sheep is not only due to the time consumed in responding to the irritation. It is mainly due to changes in the skin which, depending upon the severity of the case, hinder the sheep in its functions. During the early stages of the disease the body mass of the infested Merino sheep increased, but as the lesion size increased the sheep were subjected to elevated levels of discomfort and a possible increase in energy output.

During the advanced stages of the disease the individual ability of the Merino sheep to compete for food decreased. Cargill & Dobson (1979) suggested that a self-imposed reduction in food intake observed in pigs infested with *Sarcoptes* mange mites might lead to the decreased ability of pigs to resist chronic infestation. Nelson, Bell, Clifford & Keirans (1977) stated that toxins in the oral secretions of external parasites cause anorexia in the host that is severe enough to ensure insufficient food consumption. Cole & Guillot (1987) found that calves infested with *P. ovis* showed a trend towards a decreased digestibility similar to that noted in calves during cold stress. Cold stress appears to increase the rate of passage through the digestive tract, mediated by an increased secretion of thyroxin. Hair loss and a damaged integument reduce thermal insulation and increase the effect of cold stress. Calves with severe *P. ovis* infestation may have difficulty in consuming sufficient amounts of feed to meet maintenance energy requirements and therefore may be highly susceptible to

hypothermia (Cole & Guillot, 1987). It can be assumed that similar effects will be experienced in sheep infested with *P. ovis*.

The amount of food that the sheep received in the period before infestation was sufficient to increase the body mass of the Merino sheep by a mean of 1.51 kg and the body mass of the Dorper sheep by a mean of 2.19 kg, respectively. Apart from this, both the control groups showed a steady increase in body mass during the 16-week study period. This implies that the decrease in body mass experienced by the infested sheep was due to the disease and strongly suggests that *P. ovis* infestation does play a significant role in depressing the weight gain in sheep artificially infested with this mite.

The lesion development of the Dorper sheep was significantly slower compared to that of the Merino sheep (Chapter 5), but despite this the negative effect of *P. ovis* infestation on the body mass of Dorper sheep was still apparent.

According to Arends, *et al.*, (1990) some parasitic mite infestations require time to develop to a level high enough to influence an animal's performance. Significant weight differences in the Merino sheep were experienced at 12 weeks post infestation, which corresponds with the peak lesion development (Chapter 5). The results are concurrent with Fisher & Wright (1981) who indicated that it requires an extended period of 12 weeks or more for the full impact of mange infestation in pigs to be reached. Although Cargill & Dobson (1979) mentioned that the degree of pruritus, and not the extent of the lesions, was closely related to changes in the growth rate of pigs infested with *Sarcoptes scabiei*, Cole & Guillot (1987) found that the reduction in daily gain in heifers is not observed until the infestation covers >15% of a calf's body. A 10% increase in body surface infested with *P. ovis* increases the maintenance requirements of heifers by 0.5 mcal per day (Cole & Guillot, 1987). It can be

assumed that the maintenance energy requirements of sheep will also be influenced by *P. ovis* infestation.

The economic impact of sheep scab should be a major motivation for the eradication of this disease from South African sheep. An avarage 23.43% loss in body mass due to sheep scab in 100 adult slaughtered Merino sheep (between 19 – 21 kg) valued at R10.00 per kg could mean a loss of nearly R 5000, 00. Apart from the loss due to a marked decrease in body mass, additional loss in reduced fleece weight, approximately 5 – 8 kg wool for an adult Merino sheep (Vivier, pers. comm. 1998), and quality is also an important factor. The costs involved in prophylactic treatment and eradication campaigns must also be taken into account and will increase the economic importance of *P. ovis.*

Sheep scab spreads so successfully and has remained a major problem because it is not always apparent, and farmers introduce sheep that appear normal and free of disease into their flocks (Pretorius, pers. comm. 1998). Difficulty in the complete muster or gathering of sheep for treatment against sheep scab can be one of the main reasons for the failure to eradicate the disease from South African flocks (Kitshof, pers. comm. 1998). Although currently approved acaricides are fully effective for the control of sheep scab, problems arise because of improper treatment management, which unfortunately, frequently occurs (Chapter 8). If flock owners could realize how important it is to treat sheep before introduction into a flock, and apply the correct acaricide at the recommended dosage it would make a major contribution towards the successful eradication of the disease.

Several other effects of *P. ovis* infestation on sheep should be investigated to fully understand the economic impact of the disease. These include the energy metabolism of lactating ewes and growing lambs as well as the relationship between production loss and the intensity of the hypersensitivity reaction.

Chapter 5

The role of sheep breed and season in lesion growth

Introduction

It is known that *Psoroptes ovis* possesses long, sharp, barbed chelicerae, capable of piercing and scraping the skin of its host. However, the sheep scab lesion itself is not the direct result of the mite feeding, but it is in fact a form of allergic dermatitis (due to the mite excreta) characterised by a type I hypersensitivity reaction. The mite exploits this allergic reaction, and the heat and humidity produced by the inflammation forms the microclimate that is required for mite survival (Bates, 1996).

Early scab lesions are difficult to detect, due to the mites adjusting to the new host and the host responding to the mites. A lesion two to three days old appears as a small papule about 5 mm in diameter (Soulsby, 1982). As the scab mites multiply on the skin of the sheep, new lesions spread around the original one, and the disease can progress very rapidly over the entire body of the sheep. A dry crust forms in the centre of the lesion, while the scab mites are usually found in the moist inflamed advancing margin of the lesion. The crusts finally lift with any fleece that the sheep has not already rubbed off. Some scab cases can be completely different from "text book" cases. Wool loss does not always occur, pruritus varies with individual sheep and can be from nil to severe. Within a single flock there will

be animals with disease in a range of growth phases, where the numbers of infested animals can vary from one or two in the early days of infestation, to the whole flock as the disease takes hold. Furthermore, veterinary officers must be aware that the sheep with the largest lesion is not necessarily the index case that introduced the disease into the flock (Bates, 1997).

Several factors, including fleece length, the time of year and breed of sheep can have a profound effect on scab symptomatology (Bates, 1997). Shilston (1915) reported that shearing was found to distinctly suppress the disease, and in some cases apparent recovery followed. Mites infesting short wool sheep are exposed to sunlight, low humidity and extremes of heat and thus may be very slow to colonise (Guillot & Cole, 1984; Bates, 1997). Although sheep scab has for many years been regarded as a winter disease (Downing, 1936; Spence, 1949), several authors (Sweatman, 1958a; Blachut, Roberts & Meleney, 1972; Kirkwood, 1983) reported that mites could survive the hot summer months. The differences in climate between South Africa and the Northern Hemisphere, where most of the research has been done in this regard, stressed the importance of establishing if the adverse climatic conditions in South Africa would influence the lesion development of *P. ovis* on its host.

Surveys conducted in the Free State province of South Africa have shown that the symptoms of the disease are not as apparent in Dorper compared to Merino sheep (L.C. Marais, pers. comm. 1997). The Dorper sheep is typically South African; a mixed breed developed from crossings between Black-headed Persian and Dorset Horn breeds. Dorper sheep produce a short, course, hairy wool of little value. It was hypothesized that due to this phenomenon Dorper sheep may be important in spreading the disease. The objective of this study was to conduct comparative studies on the rate of sheep scab lesion growth on Merino and Dorper sheep during winter and summer months.

Material and Methods

Infestation methodology and assessment

In order to determine possible differences in lesion growth between sheep breeds, 10 Merino and 10 Dorper sheep were each infested with *P. ovis* mites during the beginning of April 1996. The sheep were all 7-8 months old and of the same sex (wethers). The infestation methodology followed was to use a heavily infested donor Merino sheep and to transfer skin scrapings to the uninfested animals. Scrapings (1 x 1 cm) were made on the periphery of an actively expanding lesion with the aid of a scalpel blade. Each sheep was subsequently infected on three places on the dorsal aspect namely the withers, middle of the back and between the ileac crests. The specific procedure was to place a scraping on the withers of alternatively a Merino and Dorper sheep, followed by the middle of the back and so forth. The procedure was followed until scrapings were placed on the three selected body areas of all the sheep. The scrapings were placed directly onto the skin and disturbance was prevented by an elastic band twisted around the fleece above the receiving area.

The Dorper and Merino sheep were allowed to graze in separate quarantine camps (± 1 ha) with natural grazing. Maintenance pills (obtained from Senwesco, Viljoenskroon, South Africa) were provided twice a week as supplementary feed. The lesion growth was assessed fortnightly over a six-week period. Each sheep was placed on a table and the body was carefully examined for the presence of lesions. When located the position of the lesion was recorded, and the length and width of each lesion measured to the nearest mm. In order to get an approximation of the surface of each lesion area the two recorded dimensions were multiplied. The different values for each sheep on the different recording days were added to obtain the total surface area covered by the scab lesions.

The experiment was repeated during April of 1997 but this time only five, each of 10-11 month-old Merino and Dorper sheep were used. The sheep were initially infested as previously described (Chapter 3), with 10 ovigerous females placed on the withers, followed one week later by 22 mites (different developmental stages) also placed on the withers. All the mites that were used in the infestations were collected from a heavily infested donor Merino sheep. The sheep were placed in separate quarantine camps as before. Lesion formation and surface area were recorded over an eight week period, at fortnightly intervals, as described previously.

In order to determine lesion growth during summer, five, year-old Merino and five year-old Dorper sheep were infested during middle October 1997 with 30 ovigerous females, two males and two attachment pairs, collected from a donor Merino sheep (Chapter 3). The sheep were placed in separate quarantine camps as before and lesion growth quantified as previously described on a fortnightly basis over an eight week period.

Climatic data

Rainfall and temperature data (daily minimum and maximum) for Bloemfontein were obtained from the national weather bureau in Pretoria.

Statistical analysis

In order to determine possible significant differences in the lesion sizes between Dorper and Merino sheep unpaired t-tests were performed for each recording day. Possible differences between lesion growth on Dorper and Merino sheep for a specific season were determined by calculating the total area under the curve (AUC) which depicts the relationship between lesion size and time. The different AUC values for Dorper and Merino sheep were subsequently compared by means of an unpaired t-test. A significance level of $p< 0.05$ was

used throughout. A computer program PRISM 2.01 from GraphPad, Statistical Software, Inc., was used for the analysis and the graphical presentation of the data.

Results

During the winter of 1996 the mean lesion size (cm^2) on the Merino sheep increased from 59.91 cm^2 at two weeks post infestation to 2700 cm^2 at six weeks post infestation. The mean lesion size on the Dorper sheep increased from 17.57 cm^2 at two weeks post infestation to 561.7 cm^2 at six weeks post infestation (Table 5.1). The differences in mean lesion size between Merino and Dorper sheep were significant for each of the recording days (Table 5.1). Comparisons of the AUC values for Merino and Dorper sheep indicated that the values for Merino sheep were significantly ($p< 0.0001$) greater. The relationship between lesion size over time for Merino and Dorper sheep is represented by an exponential equation ($y=c^{kx}$) (Fig. 5.1).

The mean lesion size (cm^2) for the Merino sheep during the winter of 1997 increased from 17.10 cm^2 to 2615 cm^2. On Dorper sheep the lesion size increased from 3.1 to 148.7 cm^2. For each of the assessment dates the mean lesion size was significantly greater on Merino compared to Dorper sheep (Table 5.1). The AUC comparisons also indicated significant ($p=0.0143$) differences between Merino and Dorper sheep. The relationship of lesion growth over time is graphically presented in Figure 5.2.

During the summer assessment of 1997 the lesion size on the Merino sheep expanded from 1.0 cm^2 at two weeks post infestation to 342.2 cm^2 at eight weeks post infestation, compared

to the lesion size of 0.406 cm^2 and 59.0 cm^2, respectively, recorded at two and eight weeks post infestation on the Dorper sheep (Table 5.1). The mean lesion size for Merino and Dorper sheep differed significantly for each of the assessment periods, except for eight weeks post infestation (Table 5.1). The relationship between lesion growth over time is graphically presented in Figure 5.3. Even though an exponential equation was suggested as a best fit curve, more data points over a wider range would have given a better fit to the equation for the summer 1997 period. A comparison of the AUC values for Merino and Dorper sheep indicated that the differences were not significant.

The daily maximum and minimum temperatures during (April-beginning May) 1996 varied between 14.4 – 26.4 °C and 0.7 – 12.7 °C, respectively. For the winter (mid April to mid June) assessment period during 1997 the corresponding values varied between 10.8 – 25.2 °C and -4.9 – 10.2 °C, respectively. The maximum and minimum daily temperatures for the summer (mid October to mid December) assessment period during 1997 ranged between 16.5 – 37.2 °C and 1.3 – 17.7 °C, respectively. The temperature fluctuations during the various assessment periods are graphically presented in Figures 5.4 to 5.6. The total rainfall recorded during the 1996 observation period was 60.7 mm. For the 1997 winter and summer assessment periods a total rainfall of 56.6 and 19.9 mm, respectively, was recorded by the national weather bureau.

Table 5.1: The mean lesion size (cm^2) recorded on Merino and Dorper sheep during various assessment periods and the results of an unpaired t-test comparing the values recorded on the two sheep breeds.

Year	**Post infestation (weeks)**	**Mean±SEM Merino sheep (cm^2)**	**Mean±SEM Dorper sheep (cm^2)**	**P-value**	**N (Merinos)**	**N (Dorper)**
1996 (Winter)	+2	59.91±11.35	17.57±5.77	0.0038	10	10
	+4	446.1±58.96	219.1±64.47	0.0182	10	10
	+6	2700±302.2	561.7±145.1	<0.0001	10	10
1997(Winter)	+2	17.10±3.407	3.1±0.8682	0.0041	5	5
	+4	222.8±53.68	28.2±6.045	0.0070	5	5
	+6	938.3±279	78.00±23.42	0.0153	5	5
	+8	2615±921.6	148.7±50.96	0.0283	5	5
1997(Summer)	+2	1.0±0.071	0.406±0.2425	0.0466	5	5
	+4	20.2±6.484	1.8±1.114	0.0233	5	5
	+6	190.4±71.28	7.0±2.025	0.0330	5	5
	+8	342.2±240.3	59.0±27.67	0.2753	5	5

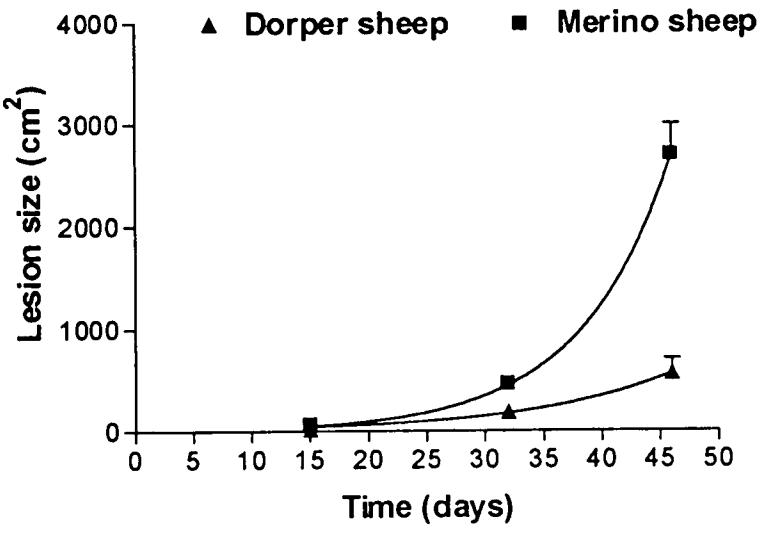


Figure 5.1: The relationship between lesion size (cm^2) and post infestation time of *Psoroptes ovis* infested Merino and Dorper sheep during the winter of 1996. The regression equation for Merino sheep is $y = 7.408^{0.1282x}$ and for Dorper sheep $y=12.22^{0.0833x}$, respectively, where y = lesion size in cm^2, x = time (days). The bars indicate the standard errors.

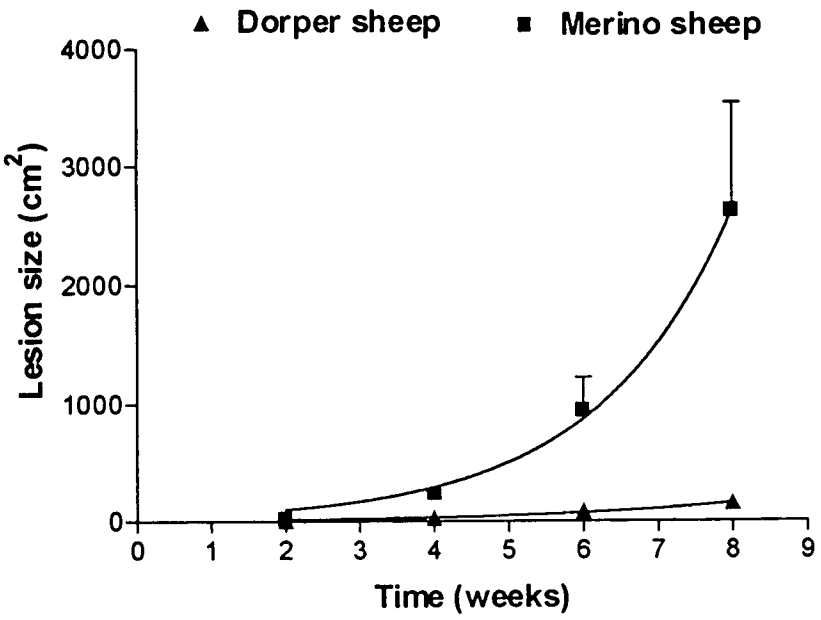


Figure 5.2: The relationship between lesion size (cm^2) and post infestation time of *Psoroptes ovis* infested Merino and Dorper sheep during the winter of 1997. The regression equation for Merino sheep is $y = 31.52^{0.5529x}$ and for Dorper sheep $y=6.391^{0.3955x}$, respectively, where y = lesion size in cm^2, x = time (days). The bars indicate the standard errors.

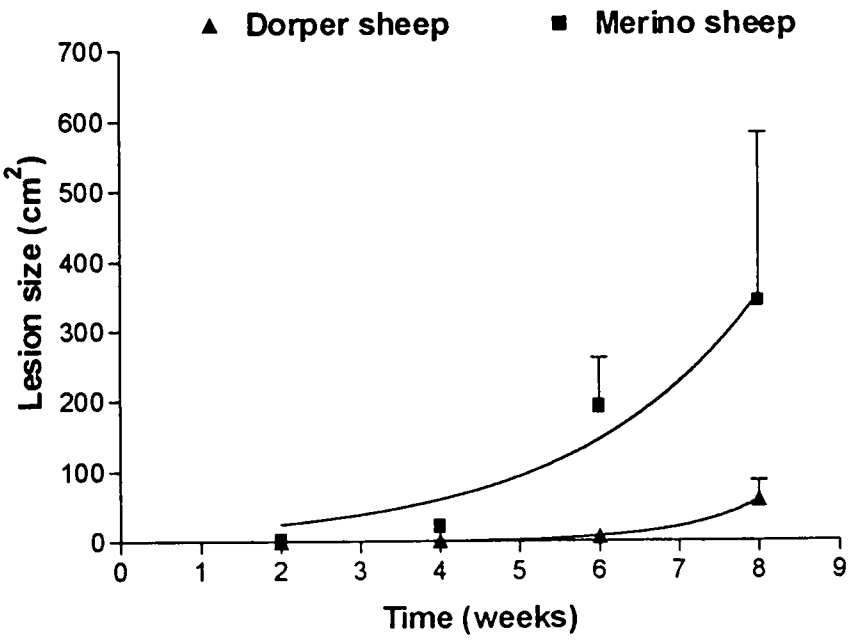


Figure 5.3: The relationship between lesion size (cm^2) and post infestation time of *Psoroptes ovis* infested Merino and Dorper sheep during the summer of 1997. The regression equation for Merino sheep is $y = 10.22^{0.442x}$ and for Dorper sheep $y=0.207^{0.994x}$, respectively, where y = lesion size in cm^2, x = time (days). The bars indicate the standard errors.

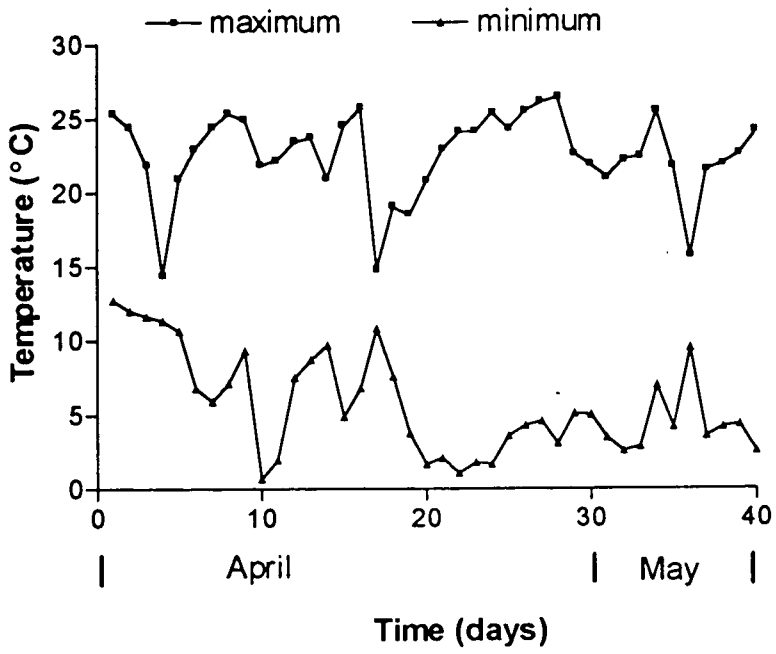


Figure 5.4: The daily minimum and maximum temperatures (Bloemfontein) during April – May 1996.

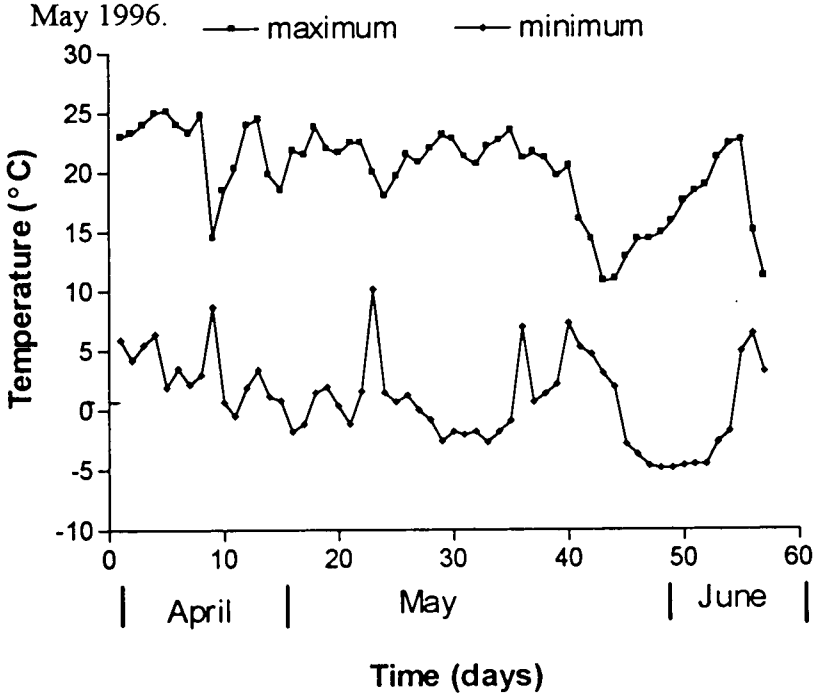


Figure 5.5: The daily minimum and maximum temperatures (Bloemfontein) during middle April to middle June 1997.

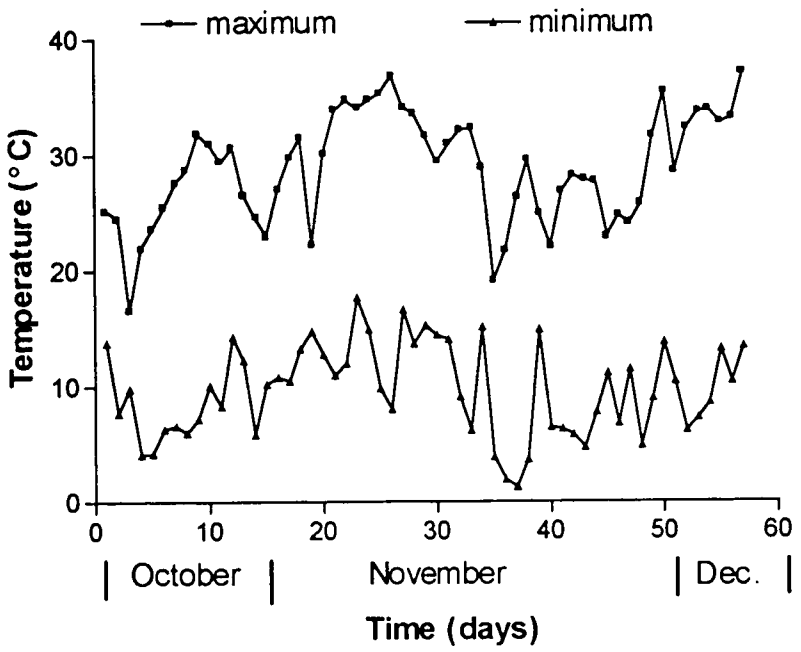


Figure 5.6: The daily minimum and maximum temperatures (Bloemfontein) during middle October to middle December 1997.

Discussion

The experiments conducted during the colder months (April-May) of 1996 and (April-June) 1997, respectively, illustrated marked differences between lesion growth in Merino and Dorper sheep. During 1996 the mean surface area covered by the lesions was 4.8 times greater in Merino sheep compared to Dorper sheep. For 1997 this value was 17.7. These profound differences in scab symptomatology between sheep breeds was also reported by

Bates (1997), who observed that lowland breeds, with a high density of wool follicles per cm^2, are extremely efficient in sustaining the disease microclimate. Hill breeds, on the other hand, have a low density of wool follicles per cm^2 resulting in a more open fleece and as such are inefficient in forming the disease microclimate.

Bates (1997) described six phases of sheep scab on sheep artificially infested with *P. ovis*. According to him low scab mite numbers and small lesions characterize the lag phase. This is followed by a rapid growth phase, where a rapid increase in scab mite numbers occur, and the lesions spread. The plateau phase, where equilibrium takes place is followed by the decline phase. During this phase lesion growth slows down, or stops completely. The regressive phase follows the decline phase and in this stage it is possible that the scab mites can die out and the animals can recover completely, without treatment. During the cryptic phase it is also possible that previously infested sheep may appear clinically normal but mites can still be found in the external auditory canal or the infra-orbital fossae (Bates, 1996b).

Results from the present study clearly indicate a more extended lag phase in the Dorper compared to the Merino sheep. Intraspecific differences, however, occur and cursory observations have indicated that the scab symptomatology is more pronounced in Dorper sheep with a high wool to hair ratio. Another factor that may also influence the manifestation of scab lesions on Dorper and Merino sheep is differences in grooming behavior. The shorter hair fiber and less dense fleece in Dorper sheep will allow for the more effective removal of scab mites through biting and scratching. The long fibers and dense fleece in Merino sheep will cause grooming to be rather ineffective.

The Merino sheep used in this study were unshorn. According to Bates (1997) long fleece can mat together forming a suitable microclimate for scab mites to rapidly colonize and

hence the lag phase will be reduced compared to sheep with shorter wool or those with a low density of wool fibers. The results of the present study have also shown that growth of the sheep scab lesions was markedly depressed during the summer assessment period (October-December). During the winter (1997) assessment period the mean lesion size on Merino compared to Dorper sheep was 17.6 times greater. During the summer recording time this difference was only 5.8 times. Irrespective of the fact that the sheep were infested with more ovigerous females during the summer (1997), the mean lesion sizes eight weeks post infestation were only 0.13 of that recorded during the winter on Merino sheep. For the Dorper sheep this value was 0.40.

Although sheep scab was previously believed to be a winter disease only, the present results indicated that sheep scab could occur in South Africa on both Merino and Dorper sheep during winter and summer. The increased rainfall and decreased temperature recorded during the winter assessment period compared to the summer assessment period suggest that both temperature and rainfall influence lesion growth of sheep scab. It has, however, been shown (Sweatman, 1958a; Blachut, *et al.*, 1972; Guillot, 1981a) that although the overall parasite population was greater on sheep and cattle during the winter than the summer, there was no evidence to suggest that climatic influences altered the ratios of the various developmental stages. There was also no evidence of diapause. It was also previously believed that scabies mites migrate to cryptic sites (ears, infra-orbital fossae, inguinal fossae and crutch) during the summer (Downing, 1936; Spence, 1949; Roberts, Blachut & Meleney, 1971). Scab mites have, however, been shown to migrate to cryptic sites more often during winter than summer and mainly in animals covered with extensive lesions (Kirkwood, 1985).

Differences in the magnitude of seasonal variations in populations of sheep scab mites may also be related to strain differences. Certain highly pathogenic strains withstand population

reduction more successfully than others do during summer months. These aggressive strains also survived longer than non-virulent strains on sheep held in individual isolation (Roberts & Meleney, 1971). Variations in mite virulence between different strains of *P. ovis* have also been reported by Bates (1997). Some strains may cause a slow growth of lesions in which the sheep is covered in 8 to 10 months, with little or no symptoms. Other strains may cause an acute growth of lesions in which a sheep may be covered within 4 to 5 weeks accompanied by a high degree of irritation (Bates, 1997). Virulent strains have also been shown to be more resistant to acaricides compared to non-virulent strains (Roberts & Meleney, 1971; Bates, 1997b).

Except for the above mentioned factors, namely breed of sheep, season and mite virulence, other factors can also influence the rate at which lesions grow. These include age of the sheep, fleece length, individual susceptibility (Guillot, 1981; Pruett, Guillot & Fisher, 1986) previous exposure to *P. ovis*, resistance to acaricides, numbers of mites in the challenge and the position of the lesion (Bates, 1997). The multi-factorial nature and variability of sheep scab therefore makes the age determination of sheep scab lesions in the field very difficult. From a sheep scab control perspective the slow growth of lesions and the sub-clinical nature of sheep scab on Dorper sheep, make detection very difficult. Producers breed Dorper sheep for their meat and there is a lively trade with a high frequency of movement between farms and districts. Due to the fact that sheep scab in many Dorper sheep may be non apparent, it is possible that they are the main carriers of the disease into non-infested flocks or areas and as such should receive special attention.

Chapter 6

Host specificity and rate of spread within a flock

Introduction

The persistence of sheep scab in the prolonged absence of sheep led many to believe that sheep scab mites can use other animals as hosts. The practice of mixed livestock farming allows for the possibility of other hosts, besides sheep, to act as carriers of the disease (O'Brien, Gray & O'Reilly, 1994). Previous workers (Shilston, 1915; Van der Merwe, 1949; Hudman, 1962) studied inter-host transmission, but there is no agreement on the extent of inter-species spread. Meleney (1967) managed to transfer bovine *Psoroptes ovis* to rabbits. Babcock & Black (1933) were unsuccessful in transferring sheep scab mites to the bodies of Angora goats, but Van der Merwe (1949) claimed success in infecting the ears of one Boer goat with *P. ovis* from the ears of sheep.

The conflicting results obtained by previous researchers may have been due to differences in prevailing climatic conditions, husbandry and infestation methods or *P. ovis* strain differences. The elucidation of the possible transfer of *P. ovis* between different host species, and the maintenance of the mite on these hosts is clearly important in order to implement successful control strategies.

The main objectives of this phase of the study were to determine the suitability of Boer and Angora goats as hosts for *P. ovis*, and to investigate the rate of spread of *P. ovis* during different seasons, from a single infested sheep, within a flock of Merino and Dorper sheep.

Material and Methods

Goats as hosts for *Psoroptes ovis*

The specific objective of this study was to determine if Boer and Angora goats could serve as hosts for *P. ovis*. In order to ascertain this, two healthy adult Boer goats were selected from a flock and placed in quarantine on a farm near Bloemfontein, early in June 1997. The goats were fed a daily ration of alfalfa and maintenance pills, with water supplied *ad libitum*. In order to infest the Boer goats, *P. ovis* mites (Botshabelo strain) were collected from a donor sheep as described previously (Chapter 3). Each goat as well as two Merino sheep, which served as control animals, were initially infested with 15 ovigerous females, 15 males and one attachment pair. The hair / wool on the withers of the goats / sheep was parted, and the mites were placed in the parting directly on the skin and kept in place with an elastic band twisted around the hair at the placement site. One week later the goats were again infested, in a similar way, with 25 ovigerous females, 15 males, one attachment pair and two eggs. The goats were subsequently infested fortnightly with a similar number of mites on three additional occasions (Fig. 6.1). The control sheep were kept in a quarantine camp on the campus of the UOFS.

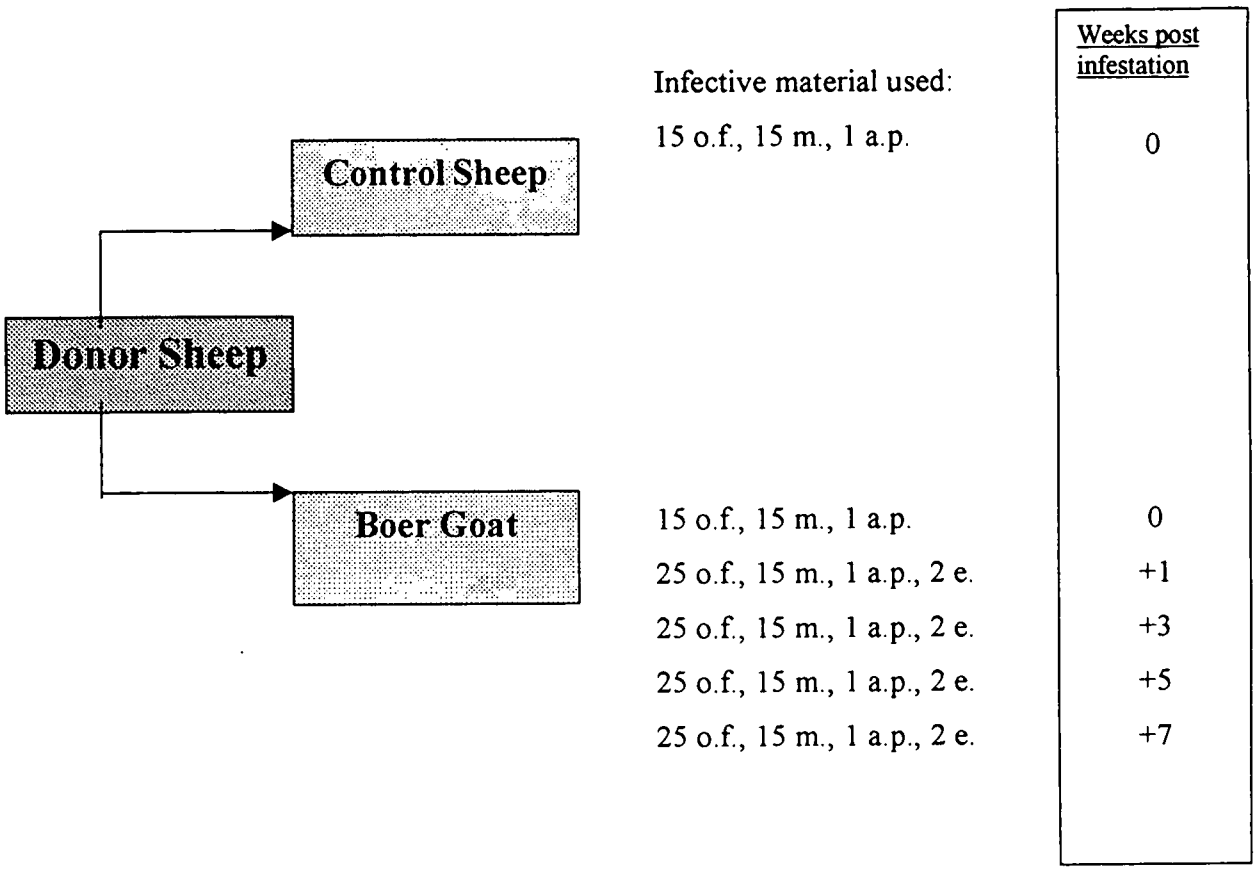


Figure 6.1: A schematic layout of the infestation schedule used to establish *P. ovis* infestations on Boer goats (o.f. = ovigerous females, m=males, a.p. = attachment pair, e = eggs).

The Boer goats and control sheep were examined one week after the initial infestation and subsequently on a fortnightly basis. The examinations were carried out by using a hand lens and consisted of the systematic search of the skin and hair of the Boer goats and sheep for the presence of live mites and / or lesions. Skin scrapes were conducted on various parts of the body, as well as in and behind the ears of the goats. Both Boer goats and control sheep were observed closely for clinical signs of sheep scab during the entire nine-week period. After the intense nine-week observation period, the observations were followed by periodic examinations at three, six and 12 months after the initial infestation.

A similar procedure was followed in an attempt to establish a *P. ovis* infestation on Angora goats. Mites were collected from the same donor sheep as for the Boer goats. Three Angora goats and two control Merino sheep were initially infested at the end of April 1997 with 19 ovigerous females, nine males and one attachment pair. The mites were placed on the withers, directly on the skin of the Angora goats and Merino sheep and kept in place as previously described. One week after the initial infestation the Angora goats were infested again and subsequently on a fortnightly basis with 25 ovigerous females, 25 males, one attachment pair and two eggs on three additional occasions (Fig. 6.2). The control sheep were infested only once.

For the duration of the assessment period (nine weeks) the different experimental groups were kept in separate quarantine enclosures (± 1 ha) on the campus of the UOFS. The Angora goats and control sheep were examined as described previously. During these examinations special attention was given to the infestation site and the areas behind and inside the ears of the Angora goats, and skin scrapes of these areas were made in order to determine if any live mites were present. The Angora goats were not subjected to follow-up examinations after the intense nine-week observational period. Neither the Boer nor the Angora goats were killed during or after the assessment period so that the infra-orbital

fossae or deep ear canal could not be investigated for the presence of scab mites, and the examinations of the ears were restricted to the pinna.

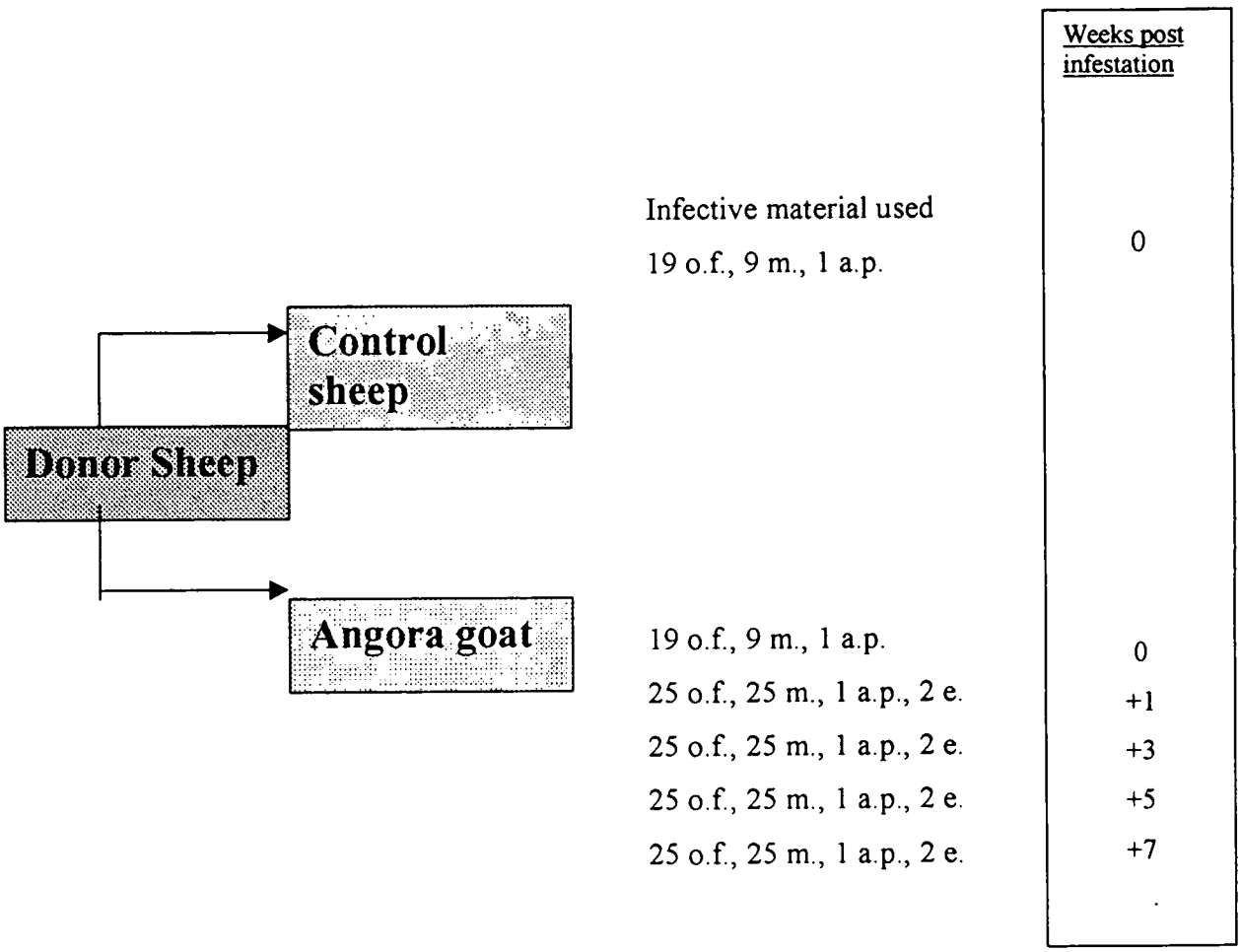


Figure 6.2: A schematic layout of the infestation schedule used to establish *P. ovis* infestations on Angora goats (o.f. = ovigerous females, m = males, a.p. = attachment pair, e = eggs).

Spread of sheep scab within a flock

The specific objective of this study was to determine the rate at which sheep scab can spread within a flock of Merino and Dorper sheep, respectively, between winter and summer months. In order to determine this 10 healthy, year-old Merino and Dorper sheep were used in this study, which was initiated during April 1997 (winter). One Merino and one Dorper sheep was selected from the group, placed in separate quarantine camps (± 1 ha) and infested with *P. ovis* by parting the wool and placing the mites on the skin of the sheep. The mites were held in position as described previously. The Merino and Dorper sheep were both individually infested with a total of 30 mites, which included 25 ovigerous females and five adult males. The nine remaining Merino and Dorper sheep were separated and pastured in two quarantine camps (± 1 ha) where natural grazing was available. Supplementary feed (alfalfa and maintenance pills) was supplied twice a week.

The infested Merino and Dorper sheep were examined three weeks after infestation for the development of sheep scab, and placed back within their respective groups. The same criteria as described in Chapter 3 were used to confirm positive lesion growth on these sheep. On a fortnightly basis the two breeds were separately herded together in a pen. Each sheep was carefully examined for the presence of live mites or active lesion development and the results were recorded. After the examination of each sheep, aprons were changed and hands were washed in order to prevent the possible mechanical spread of mites between sheep by the investigators.

Both groups of sheep were closely observed for clinical signs of sheep scab during the entire period (April – July), which extended over 14 weeks. Early in October 1997 (summer), another 10 Merino and Dorper sheep were purchased from a farm in Fauresmith. The sheep were kept in the same manner as described above. One Merino and one Dorper were again selected, infested and, after developing positive lesions (approximately three weeks) placed

back into their respective groups. In both studies (winter and summer) the time it took for sheep scab to spread to the rest of the group was recorded. The presence of a live mite, or active scab lesions was considered as a positive infestation.

Results

Goats as hosts for *Psoroptes ovis*

For the duration of the study (nine weeks), both Boer goats were individually infested five times, with a total of 115 ovigerous females, 75 males, five attachment pairs and eight eggs. The control sheep were infested only once with 15 ovigerous females, 15 males and one attachment pair. Scab lesions developed rapidly on the control sheep. One week after infestation a 1.0 cm^2 lesion had developed on each of the control sheep. Within three weeks the mean lesion size recorded for the control sheep was 21 cm^2. Close examination of both sheep revealed numerous active mites and eggs. Lesion growth progressed on the control sheep over the study period, and at seven weeks after infestation the mean lesion size was 602 cm^2, and 2300 cm^2 after nine weeks at which time both control sheep were treated with an endectocide to kill the scab mites.

Seven days after initial infestation no scab mites could be found on the bodies of either of the Boer goats. Skin scrapes behind or in the ears (pinna) and on the bodies of the Boer goats were negative. No clinical signs of sheep scab developed at any time during the observation period, and at no stage were any signs of scratching or biting due to sheep scab apparent. Follow-up examinations of the Boer goats at three months, six months and one year after initial infestation showed no development of lesion growth. No clinical signs developed, and the goats were in prime condition.

Each Angora goat was infested with a total of 119 ovigerous females, 109 males, five attachment pairs and eight eggs. The control sheep were infested only once with 19 ovigerous females, nine males and one attachment pair. One week after infestation a mean lesion size of about 1.0 cm^2 was detected on the control sheep, at the sites of deposition. At the termination of the study (nine weeks) the mean lesion size on the control sheep had expanded to 3093 cm^2.

At no stage during the observation period (nine weeks) did the Angora goats display any signs of uneasiness, scratching or any other form of sub-clinical signs that could be related to sheep scab. No mites were detected on the skin or in the hair of the Angora goats at any time during the study and no lesions could be observed after extensive examinations.

Spread of sheep scab within a flock

Winter

Two weeks after the artificially infested Merino sheep was introduced back into the flock, it had a total lesion area of 158 cm^2. None of the other Merino sheep showed any sub-clinical signs of sheep scab, nor were any lesions visible. Six weeks after the introduction of the infested sheep the first sub-clinical signs of sheep scab (scratching and biting) were apparent, although no lesions could be found. On the eighth week the artificially infested sheep's lesion covered almost half of its body, and it was very shaggy in appearance. After eight weeks scab lesions were apparent on three of the Merino sheep. At 10 ten weeks post infestation another three Merino sheep were infested, and the lesion on the artificially infested sheep had developed to 2100 cm^2, with large parts of its body devoid of wool. Two weeks later, another two sheep were positively infested, and the lesions developed rapidly

on the already infested sheep. Fourteen weeks after the introduction of the infested sheep into the flock all Merino sheep displayed visible lesions (Fig. 6.3).

Two weeks after the introduction of the artificially infested Dorper sheep into the rest of the flock, no sub-clinical signs of sheep scab were apparent on any of the other members of the flock and no visible lesions could be found. At six weeks after placement of the artificially infested sheep into the flock, some of the Dorper sheep showed sub-clinical signs, had wool in their teeth, and they scratched and rubbed against the trees but no positive lesion development or live mites could be detected during the examinations. Eight weeks after introduction all the Dorper sheep were positively infested (Fig. 6.3), and they all had substantial lesions, with an average of 40. 14 cm^2. During the study period, one of the Dorper sheep died, but its death was unrelated to the scab infestation.

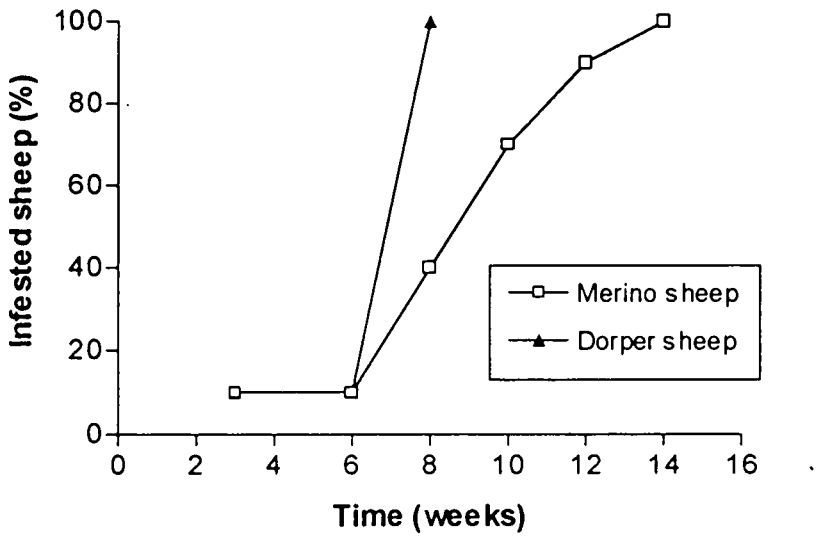


Figure 6.3: The rate at which sheep scab spread during winter within flocks of Merino and Dorper sheep, respectively, after introduction of a single, infested sheep into each flock.

Summer

Two weeks after the introduction of the artificially infested Merino sheep into the flock the artificially infested sheep's lesion had developed to 30 cm^2. The other Merino sheep showed no sub-clinical signs of sheep scab and they all appeared to be healthy. The first positively infested Merino sheep was recorded six weeks after the artificially infested sheep was introduced into the flock. At eight weeks 90% of the flock was infested and at 10 weeks all the Merino sheep were infested with mites and had actively growing lesions (Fig. 6.4)

The lesion development on the artificially infested Dorper sheep was faster than that recorded on the Merino sheep. The artificially infested Dorper sheep had a lesion of 70 cm^2 two weeks after introduction back into the flock, and at 10 weeks the lesion had developed to 1700 cm^2. Two weeks after introduction of the artificially infested sheep all the Dorper sheep appeared to be healthy, no sub-clinical signs were evident. On a single Dorper sheep a positive lesion was found six weeks after introduction of the artificially infested sheep. Although 40% of the sheep had positive lesions after eight weeks no sub-clinical signs were noted at this stage, and the Dorper sheep appeared to be healthy. Two additional sheep were found to be positively infested at 10 weeks, and all the sheep were positively infested at 12 weeks (Fig. 6.4). At 10 weeks after introduction of the artificially infested sheep into the flock the Dorper sheep showed the first signs of uneasiness and wool appeared in their teeth but prior to that no sub-clinical signs (scratching or biting) were apparent. After 14 weeks all the Dorper sheep were biting and scratching, and rubbing against the fences.

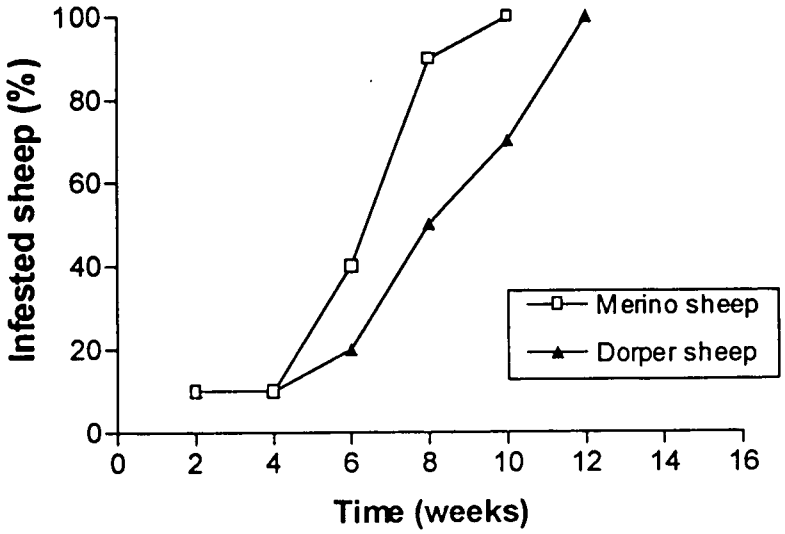


Figure 6.4: The rate at which sheep scab spread during summer within flocks of Merino and Dorper sheep, respectively, after introduction of a single, infested sheep into each flock.

Discussion

A total of five different individual artificial infestations with fairly large numbers of scab mites were conducted on both Boer and Angora goats, respectively. On the control Merino sheep one artificial infestation was sufficient to cause clinical symptoms of sheep scab. The extraordinary rate of multiplication that has been observed in the control sheep indicated that the specific mite strain had the ability to rapidly invade the entire body surface of the sheep but neither of the infestations resulted in the clinical manifestations of scab on the Boer or Angora goats. The results from this study have shown that *P. ovis* can not be successfully transmitted from the body of sheep to the body of Boer or Angora goats under the tested

conditions. The present results are in accordance to those of Babcock & Black (1933) and Hepworth & Thomas (1962).

In order to place the present results in perspective with previous investigations, it is imperative to first distinguish between the two mite species that are known to infest sheep. Sweatman (1958) postulated that two species of *Psoroptes* mites could infest sheep: *P. ovis* on the body, and *P. cuniculi* in the ears. *P. ovis* is also responsible for psoroptic mange of cattle (Wright & DeLoach, 1981; Bates, 1996), horses, rabbits (Salmon & Stiles, 1903), and Bighorn sheep (Ward, 1915; Lange, Sandoval & Meleney, 1980), but for each of these hosts there appears to be a distinct variety of the parasite (Salmon & Stiles, 1903). Apart from the ears of sheep, *P. cuniculi* also infests the ears of rabbits, horses and all breeds of goats (Littlejohn, 1968; Bates, 1992). Apart from *P. cuniculi*, the ears of goats (feral and domestic) can also be infested with the mesostigmatid mite *Railttia caprae* (Heath, Bishop & Tenquist, 1989; Bates, 1992). Ear mites (*P. cuniculi)* are found deep within the auditory canal of clinically normal sheep and are not infective to the body (Shilston, 1915; Van der Merwe, 1949; Heath, 1978; Kirkwood, 1985; Bates, 1996). Although *P. cuniculi* derived from the ears of domestic rabbits can migrate to the external auditory canal of sheep, after being placed on the withers, these mites are unable to initiate lesions at the site of challenge (Bates, 1996). According to Bates (1996) the classical body sheep scab mite (*P. ovis)* can migrate into the area of the ear canal of sheep although no actual scab lesions are caused on the pinna itself.

Due to the similar morphology of *P. ovis* and *P. cuniculi* several attempts have been made by previous investigators to transfer ear and body mites between host species to determine host specificity of both *P. ovis* and *P. cuniculi* with varying degrees of success. In South Africa Shilston (1915) found, on several occasions, that acari (*P. cuniculi)* from goat ears died quickly or disappeared when placed in the ears of sheep. Van der Merwe (1949), also

in South Africa, claimed success in transferring ear mites from sheep to goats, but failed to infect the ears of sheep with goat ear acari. Sweatman (1958), however, successfully transferred mites from the ears of goats to the ears of sheep, both artificially and by natural exposure. Williams & Williams (1978) reported that *P. cuniculi* were not transmitted from infested goats and their kids to sheep or lambs. All attempts by Bates (1991, 1992) to transfer sheep scab ear mites to the ears of goats have failed.

Morphometric studies of *P. ovis* and *P. cuniculi* indicated that no morphological or biological differences existed between these two species (Roberts & Meleney, 1971; Boyce, Elliot, Clark & Jessup, 1990). Cross mating experiments with *P. ovis* from bovine hosts and *P. cuniculi* from rabbits confirmed that these varieties are not reproductively different (Kirkwood, 1986; Wright & Fisher, 1984). Although Wright, & Fisher (1984) showed that reciprocal cross mating between the two species produced viable offspring capable of infesting rabbit ears and cattle bodies, Bates (1992) on the other hand, found that the crosses were either infertile or not infective to sheep or rabbits.

Although various strains of *P. ovis* (a body mite) appear to have become adapted to a specific host, the species is not entirely host-specific. In the USA, for example, *P. ovis* from a cow was transferred to a rabbit and then from the same rabbit to a sheep (Meleney, 1967). It is now routinely transferred between bovines and rabbits (Wright, 1982; Wright & Fisher, 1984). In Germany *P. ovis* has been transferred between sheep and cows, but infestations survived for only a short time. Studies by Kirkwood (1985) in the U.K. indicated that *P. cuniculi* from rabbits did not survive on sheep, and neither did *P. ovis* from cattle. Kemper & Peterson (1956) transferred sheep scab mites to cattle, maintained the infestation on them for four years and then successfully transferred the scabies mites back to sheep. By using British field isolates Evans & Kirkwood (1984), however, failed to establish cross

transmission of cattle scab mites to sheep or *vice versa*. There are indications that the scab mites have retained their host specificity under field conditions in Britain.

Although *P. ovis* mites have exceptionally been transmitted under experimental conditions from one host species to another (Tarry, 1974) the numerous discrepancies reported in the literature on the transfer successes of the acari to different hosts clearly indicate that different factors influence the successful manifestation of sheep scab and ear scab on different hosts. These factors include strain, climatic differences, and microclimatic differences on the body surface of the recipient host. Host specificity may be attributed to physiological differences in mite strains and to host variables such as appropriate host odour, dietary and non-dietary host chemicals and physical factors, and an efficient host immune response (Arlain, Ahmed & Vyszenski-Moher, 1988). Possible reasons for the unsuccessful manifestation of sheep scab on Boer goats and Angora goats might be attributable to the strong hair component found on goats. It has been shown that retarded lesion development occurs in sheep with a high-density hair component (Chapter 5).

Although it is speculated that *P. ovis* infest mainly the body of sheep and *P. cuniculi* the ears of sheep and goats, the exact relationship and interaction between the two strains are as yet not fully understood. The unsuitable microclimate on the Boer- and Angora goats might have had a detrimental effect on the successful manifestation of lesions, but the possibility cannot be excluded that *P. ovis* mites may live undetected for short periods of time on goats. Finally, even though the present results indicated that sheep scab was unsuccessful in the manifestation of body lesions on Boer and Angora goats, the interaction between body and ear mites should be further investigated. Where sheep and goats are herded together goats may in fact re-infest sheep that have been treated previously. An all-important factor in the eradication of sheep scab is the destruction of every mite including both *P. ovis* and *P. cuniculi*. Until it has been established if *P. ovis* would migrate to the ears of goats, survive a

period of time, and therefore would be able to re-infest sheep, care should be taken and goats should be treated together with sheep as a precautionary measure.

It has been shown that lesion development during winter and summer occurs faster in Merino sheep compared to Dorper sheep (Chapter 5). Therefore one would have expected that the rate of spread among Merino sheep would be faster during both seasons compared to Dorper sheep, but that was not the case. Sheep scab is regarded as a highly contagious disease and several factors might influence the rate at which the disease will spread within a flock. These factors include flock size, contact frequency between uninfested and infested sheep, age of flock members, sheep breed, season and husbandry methods. During the present study the flock size was relatively small and the contact frequency between individual sheep was high.

The age of sheep may also have a profound effect on the rate of spread of the disease. Under normal farming conditions flocks may consists of sheep of different age groups. Bates (1997) has shown that yearlings may manifest a more severe form of scab compared to adult ewes, and lambs may have an intense irritation and support active mites, although no definite lesions may be apparent.

Although it has been shown previously (Chapter 5) that significantly different lesion development occurs between Merino and Dorper sheep, breed had no major effect on the rate of mite transfer but only on the rate of lesion development and hence manifestation of clinical symptoms. The different rate of spread between Merino and Dorper sheep may be attributable to the differences in fleece length of the two breeds.

The rate at which sheep scab spread and the clinical symptomatology of the disease would develop over variable time intervals in different flocks. Apart from the above-mentioned factors the extent of disease infestation of the carrier sheep will also have a profound effect on the rate at which the disease spreads within a flock. During the present study positive lesions were found on other members of the flock only when the lesion size of the artificially infested sheep reached considerable proportions. Admittedly not every individual member of the flock would have had direct contact with the artificially infested sheep or at similar frequencies, and undeniably this would also have influenced the rate of spread. It has been shown that vertical migration occurs on scabby sheep with substantial lesion development (Chapter 7), but the gregarious nature of sheep ensures ample opportunities for direct contact between individual sheep, and therefore the rate of contact between sheep will inevitably influence the time required for transfer between sheep. Stockman (1910) remarked that after extended exposure to scabby sheep often only one sheep out of a large flock is regarded as positively infected with sheep scab after examination by veterinarians, which could be regarded inexplicable unless one is prepared to either question the reliability of the diagnosis or to admit that sheep scab is not as contagious as is generally believed.

The immunocompetence of individual sheep will also influence the rate of spread within a flock. If a sheep is unable to mount an allergic reaction to the mite excreta (Chapter 3) the colonization of mites will be retarded and in some cases die out completely. One should consider sheep scab as a dynamic system. It is incumbent on each and every sheep farmer to ensure that sheep scab doesn't enter his flock and cause a sheep welfare problem, nor spread from his sheep to another flock.

In view of the above-mentioned factors, it is impossible to predict the rate at which the disease will spread within a specific flock. No amount of legislation can ensure complete

eradication due to different husbandry methods, but the vigilance of sheep owners and indeed everyone with any connection with the sheep industry could prevent sheep scab from spreading. Sheep owners and farm workers must primarily take the preventative measures. Although early detection of sheep scab within a flock will not reduce the costs involve due to treatment; it would have a considerable effect on the possible production loss (Chapter 4) and will also increase treatment success.

Chapter 7

On and off-host spatial distribution

Introduction

Certain features of the epizootiology of sheep scab present unsolved problems, which are of considerable importance. So far limited success in the eradication of the disease has been achieved. The insidious nature of the disease, the seeming ease with which transmission takes place and the prevalence of the disease in certain localities are contributory factors to erroneous ideas regarding transmission mechanisms of sheep scab. Previous workers (Hertwig, 1835; Hering, 1835) observed that direct contact between sheep is the main reason for the spread of the disease, although indirect transmission mechanisms should not be excluded. Later authors have to a large extent been content to quote these statements and few attempts have been made to ascertain if indirect transmission methods are truly applicable to the recurrence of sheep scab. The scepticism of farmers regarding transmission methods, the exigency to provide information regarding transmission methods and the lack of evidence that indirect transmission could lead to sheep scab outbreaks, gave rise to this study. In order to understand the importance of indirect transmission, a sound knowledge on the spatial distribution of the mite, on and off-host, is required. The objective of this study was to conduct comparative studies on the on- and off-host spatial distribution of *P. ovis* on Merino and Dorper sheep as well as the diurnal rhythm of occurrence of mites in the proximal and distal parts of wool / hair tufts on both breeds of sheep. This chapter includes several different assessment procedures and each will be separately enunciated.

Material and Methods

Distribution of mites in wool or hair

Two heavily mite infested Merino and two scabby Dorper sheep were selected from a flock and individually confined to steel cages (1.7 x 1.2 m) for 24 hours. The Merino sheep had advanced lesions of 1700 cm^2 and 1000 cm^2, respectively, located on the withers and back of each animal. Close examination of the lesions on the Dorper sheep revealed the presence of live mites, although the sizes of the lesions on the Dorper sheep were considerably smaller, being 550 and 720 cm^2, respectively. For the duration of the study (24 hours) maintenance pills (obtained from Senwesco, Viljoenskroon, South Africa) and water was supplied *ad libitum* to the sheep. A 10 x 10-cm section of the respective scab lesions on each sheep was selected and demarcated with masking tape. At two-hourly intervals 1.5 cm^2 tufts of hair / wool were clipped close to the skin of each sheep in order to ascertain the distribution of the different instars of *P. ovis* on the fleece of Merino and Dorper sheep, respectively. Immediately after removal from the sheep each tuft was cut in half to separate the section closest to the skin (proximal) and that furthest (distal) from the skin. Each divided portion of fleece was placed in a labelled sample bottle. The contents of the bottles were subsequently digested in 10% KOH solution heated to 40 – 50°C. The digested residue was filtered through a Watman No. 5 filter paper and examined under a stereo microscope. The mean number of eggs, immature and mature mites in the residue were recorded separately and compared between Merino and Dorper sheep.

Superficial occurrence of mites

In order to determine the extent of mites occurring superficially on infested Dorper and Merino sheep, 2-cm^2 hair / wool tufts were collected from healthy sheep and placed directly onto sheep scab lesions of infested sheep. The same scab infested sheep as described above

were used during this study. Every four hours, over a period of 24 hours, three wool tufts were randomly placed on the wool or hair directly above the scab lesions of the infested Merino and Dorper sheep, respectively. After five minutes the tufts were carefully removed from each sheep and separately placed into labeled sample bottles. The wool samples were digested, filtered and examined as previously described. The mean number of mites that transferred from the two Merino and two Dorper sheep onto the wool tufts during the exposures was calculated.

Birds as possible mechanical carriers of sheep scab mites

The same scab infested sheep as described above were used to determine whether birds could potentially act as mechanical carriers of sheep scab mites. The dried feet of a cattle egret (*Bubulcus ibis*) were placed on the edges of the sheep scab lesion of each sheep in the steel cages previously described. The feet were pressed against the sheep and at the same time simulations of a bird walking on the back of the sheep were performed for five minutes. After each exposure of five minutes the feet were washed in alcohol and rinsed with water. The alcohol and water solution was filtered through a Watman No. 5 filter paper and the residue examined for the presence of mites or egg remains. The procedure was repeated 100 times on each sheep.

Occurrence of mites in soil

During June 1997 a modified Berlese type collector was used to determine if mites are present in soil collected from enclosures frequented by scab infested sheep. The Berlese type collector was slightly modified to prevent any mites from escaping. A sieve that held the soil was placed 10 cm below a 60 W bulb. The funnel connecting the sieve to a collector container was constructed with black plastic and fastened at the top of the sieve with

masking tape. The collection bottle at the end of the funnel was joined to the funnel with masking tape in order to prevent the migrating mites from escaping. The Berlese type collector is based on the principle that any mites or insects present in the soil would move away from the light source into the funnel and end up in the collector bottle. Soil samples (4-cm top layer) were randomly taken from two enclosures (± 1 ha), each enclosure housed 10 heavily scab infested sheep. Special attention was paid to areas where sheep often spent time, such as the area around the feedlot, under the trees, and the areas where sheep rested during the day. A total of 4508.08g soil was collected in the designated areas. The soil samples were subsequently placed in the modified Berlese type collector. Care was taken not to disturb the soil in the sieve in order to prevent excessive soil from spilling into the collector bottle at the end of the funnel. Clean soil was seeded with 20 mites and placed in a similarly constructed modified Berlese type collector to serve as control. The control and collected soil samples were placed in the sieve of the Berlese type collector and left undisturbed for three consecutive days under a 60 W light bulb. The experiment was repeated approximately five weeks later (July 1997). This time 1586.48g soil was collected in a similar manner as previously described. Clean soil was seeded with 10 mites and used as control.

Infective stages on vegetation

Ten severely scabby Merino sheep and nine severely scab infested Dorper sheep were housed in separate quarantine camps (± 1 ha). Once a day for one calendar month (June 1997) all visible wool / hair was collected from tree trunks and branches in order to determine if the fleece rubbed off by sheep contained any live mites. The wool / hair samples from the Merino and Dorper sheep were kept separately in labeled plastic bags. In the laboratory the wool / hair samples were weighed and subsequently digested in a 10% KOH solution. The residue was filtered through gauze with 75-µm aperture size, rinsed

with water and examined under a stereo microscope for the presence of mites or egg remains.

Results

Distribution of mites in wool or hair

The minimum, maximum and mean number of eggs and mites recorded on the different fleece sections collected from Merino and Dorper sheep are summarized in Table 7.1. A maximum of 214 eggs were found on the fleece section closest to the skin of a Merino sheep compared to the maximum of 19 eggs on the proximal part of the Dorper sheep's fleece. The maximum number of eggs collected from the distal section of wool samples from Merino sheep was 6.5 compared to 3.5 eggs for Dorper sheep (Table 7.1).

A maximum of 50.5 nymphs, 55.5 ovigerous females and 14.5 males were recorded on the skin tuft section of the Merino sheep, compared to the maximum of 8.0 nymphs, 9 ovigerous females and 5.5 males recorded on the skin tuft section of the Dorper sheep. A maximum of 15.0 nymphs, 7.5 ovigerous females and 6.0 males were recorded on the distal tuft section of the Merino sheep compared to the maximum of 2.5 nymphs, 2.5 ovigerous females and 2.0 males recorded on the distal tuft section of the Dorper sheep (Table 7.1).

The percentage of mites (males, ovigerous females and nymphs) that were found on the distal section of fleece clippings from Merino sheep varied between 1 and 46%. The highest percentage of mites on the distal tuft section of Merino sheep was recorded at 10:00 o'clock in the morning (Fig. 7.1). The percentage of mites on the distal tuft section of Dorper sheep

varied between 6 and 70%. Peaks of mites on the distal part of the Dorper tuft were observed at 6:00 and 8:00 in the morning as well as at 4 o'clock in the afternoon (Fig. 7.2).

Table 7.1: A summary of the minimum, maximum and mean number of eggs and different instars of *Psoroptes ovis* collected from the wool or hair tufts, removed from Merino and Dorper sheep, respectively. (N = wool samples).

Sheep breed	**Fleece section**	**Instar**	**Minimum**	**Maximum**	**N**	**Mean (± S.D.)**
Dorper	Proximal	Egg	0.5	19.0	13	3.231 (±4.86)
Merino	Proximal	Egg	11.0	214.0	13	103.8 (±59.12)
Dorper	Distal	Egg	0.0	3.5	13	0.7692 (±1.07)
Merino	Distal	Egg	0.0	6.5	13	2.077 (±2.18)
Dorper	Proximal	Nymph	0.0	8.0	13	2.346 (±2.73)
Merino	Proximal	Nymph	7.0	50.5	13	21.35 (±13.38)
Dorper	Distal	Nymph	0.0	2.5	13	0.769 (±0.95)
Merino	Distal	Nymph	0.0	15.0	13	1.846 (±4.14)
Dorper	Proximal	Female	0.00	9	13	2.731 (±3.44)
Merino	Proximal	Female	8.00	55.5	13	28.12 (±14.4)
Dorper	Distal	Female	0.0	2.5	13	0.8462 (±0.77)
Merino	Distal	Female	0.0	7.5	13	2.231 (±0.63)
Dorper	Proximal	Males	0.0	5.5	13	2.0 (±1.86)
Merino	Proximal	Males	1.5	14.5	13	8.115 (±3.531)
Dorper	Distal	Males	0.0	2.0	13	0.3077 (±0.56)
Merino	Distal	Males	0.0	6.0	13	0.7692 (±0.46)

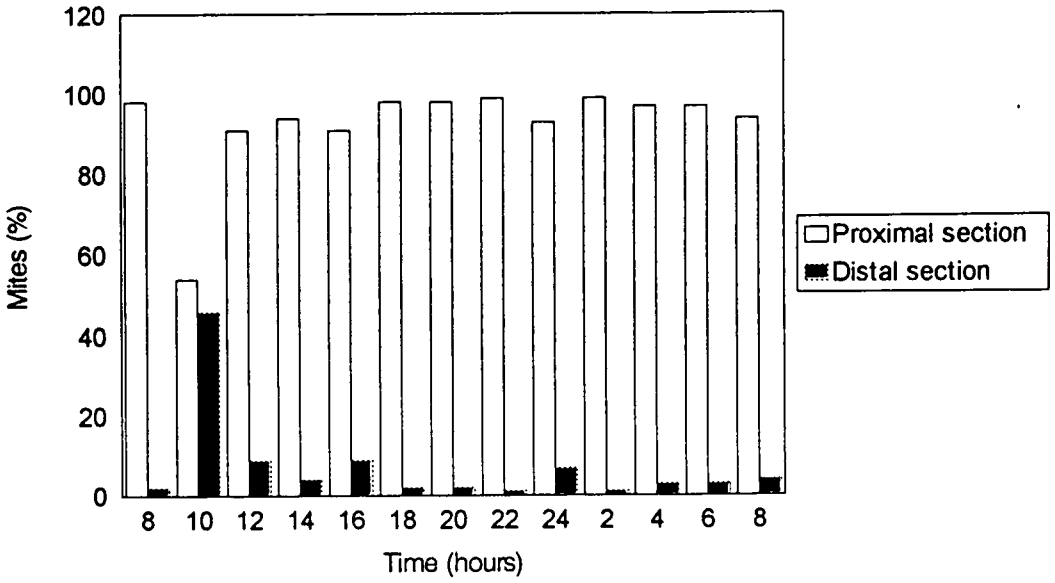


Figure 7.1: The time specific occurrence (%) of *Psoroptes ovis* (all instars) in proximal and distal fleece sections of Merino sheep.

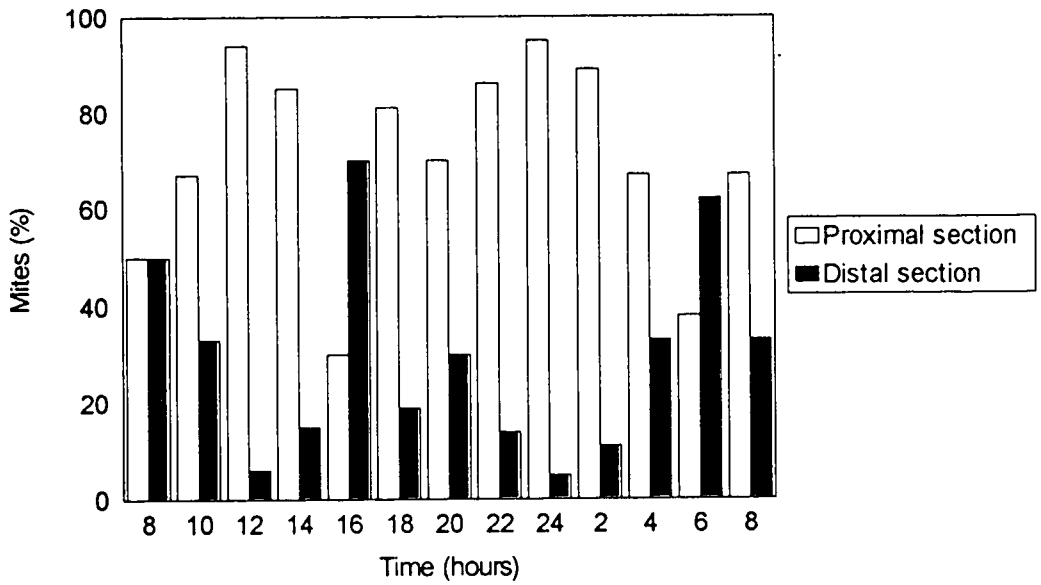


Figure 7.2: The time specific occurrence (%) of *Psoroptes ovis* (all instars) in proximal and distal fleece sections of Dorper sheep.

Superficial occurrence of mites

The results on numbers of mites that occurred superficially and were thus transferred to the tufts of wool or hair placed on the sheep are summarized in Table 7.2. A maximum of 1.5 and 0.3 adult mites transferred to the wool / hair tufts of Merino and Dorper sheep, respectively. The maximum number of immature mites that transferred from the Merino and Dorper sheep was 0.6667 and 1.667, respectively (Table 7.2).

Table 7.2: A summary of the minimum, maximum and mean number of adult and immature *Psoroptes ovis* mites that were transferred to tags of wool or hair placed on mite infested Merino and Dorper sheep during a 24 hour period. (N = wool samples)

Adult mites				
Sheep breed	**Minimum**	**Maximum**	**N**	**Mean (± S.D.)**
Merino	0.0	1.5	21	0.476 (± 0.52)
Dorper	0.0	0.3	21	0.1667 (± 0.17)
Immature mites				
Sheep breed	**Minimum**	**Maximum**	**N**	**Mean (± S.D.)**
Merino	0.0	0.6667	21	0.1429 (± 0.24)
Dorper	0.0	1.667	21	0.4286 (± 0.58)

Birds as possible mechanical carriers of sheep scab mites

Although the bird's feet were exposed extensively to the infested sheep, no mites were ever recovered from the feet afterwards. On one occasion a mite was seen to climb onto the bird's foot. However, it dropped off when the foot was moved.

Occurrence of mites in soil

In the case of the control soil samples 90% and 87%, respectively of the mites seeded in the soil were recovered in the collector bottles of the Berlese-type collector. No mites were found in any of the soil samples which were collected in the camps frequented by scab infested sheep.

Infective stages on vegetation

A total of 42.12g wool was collected from the camp that the Merino sheep frequented. In the camp frequented by Dorper sheep 134.46g hair were collected. No mites were found on any of the tufts of wool or hair.

Discussion

Large numbers of eggs and mites were recorded close to the skin of both Merino and Dorper sheep. This was predictable, as body heat is required for the hatching of eggs (Spence, 1949) and the mites are feeding on the skin secretions of the host. A considerable number of mites were, however, recorded on the distal sections of the wool / hair tufts of both Merino and Dorper sheep which would therefore increase the potential for the successful transfer of the scab mites. The differences between lesion size of the Merino and Dorper sheep clearly influenced the number of mites that migrated to the distal section of the wool / hair tufts. The number of mites that migrated to the distal section of the wool / hair tufts of Merino and Dorper sheep is not important. What is, however, very important is that migration to the distal tuft section does take place, and that this is an important transfer route of *P. ovis.*

No discerning pattern of time specific occurrence was observed on Merino sheep. On the other hand, the mites on the distal sections of the hair tufts on the Dorper sheep increased in numbers during the night and early morning. This corresponds with the time that the Dorper sheep herd together, and could increase the rate of spread between individuals of this particular breed of sheep (Chapter 6).

It should be stressed that birds should not be ignored as potential transmitters of this disease despite the results obtained during the present study. The methodology effectuated is not an accurate simulation of live birds' behaviour. It is common to find birds in the Free State walking on the backs of sheep. Birds closely associated with sheep in this manner include the cattle egret (*Bubulcus ibis*), the African pied starling (*Spreo bicolor*) and the wattled starling (*Creatophora cinerea*). In view of the fact that birds such as starlings are known to carry off loose wool from scab infested sheep the risk of spread by this means is a real one (Tarry, 1974). Further studies in this regard should be considered.

The results obtained with the examination of soil samples and wool tufts illustrated that the possibility of sheep scab using soil or wool tufts as transmission mechanisms is highly unlikely. Despite the fact that scab mites can survive short periods of time at high temperatures, Babcock and Black (1933) in Texas found that direct summer sunlight had killed scab mites within ten minutes to three hours. This could explain the absence of mites in both soil and wool samples. Hudman (1962) remarked that clean sheep seldom contract scab from infected premises and transmission is usually only through direct contact. It has been shown that scab mites can survive for extended periods of time off the host (Chapter 8) but scab mites are vulnerable to desiccation (Martin, Aitken & Stobo, 1991). Infected pens should be left unoccupied for at least 30 days as a precautionary measure (Chapter 8), but Du Toit (1924) found that treated animals can safely be placed back into infected corrals without fear of re-infestation.

A multitude of factors could be involved in the transmission of scab infestations and the complexity of host parasite relationships demonstrates the intricacies involved in diseases such as sheep scab. *P. ovis* is an obligatory parasite and its entire life cycle is completed on the host. Most tick species, on the other hand, leave their hosts during moulting and as the opportunities of reaching a new host may be infrequent, they are often able to live for several months without feeding. The gregarious habits of sheep provide adequate opportunities for direct contact between sheep and maintenance of scab under natural conditions is thus ensured. It is therefore not necessary for sheep scab mites to be able to survive for long periods off the host as is often the case with ticks.

Though mites might be able to remain alive for extended periods of time off the host (Chapter 8), the most likely danger of sheep becoming infested with sheep scab lies in direct contact between sheep. The inability to identify possible sources of infestation is undoubtedly one of the most intricate and controversial aspects of sheep scab. To ensure eradication of this disease from South African flocks, further studies in order to ascertain all possible sources of infestation, are necessary.

Chapter 8

The longevity and survival of *Psoroptes ovis* off the host

Introduction

It would be futile to attempt the eradication of an infectious disease such as sheep scab if exact information on the survival time of the parasite off the host is unknown. Several reports on the development of sheep scab on apparently healthy sheep that became infested in places where no sheep had been kept for two years, led many to believe that the mite can survive off the host for this period of time (Du Toit, 1924). Between 1835 and 1994 a considerable number of workers (Hertwig, 1835; Salmon & Stiles, 1903; Babcock & Black, 1933; Kirkwood, 1986) attempted to determine the survival time of *Psoroptes ovis* off the host. Dill (1920) stated that mites, if protected from the sun, might live for years off the host. Later O'Nualláin (1966) claimed that survival of mites off the host was only for a few days. Even today there still exists considerable confusion regarding off-host longevity of the sheep scab mite.

In order to establish realistic guidelines for the eradication of *P. ovis* from the sheep population in South Africa it is imperative to be aware of the survival time of this parasite

off the host and without the availability of any food under prevailing conditions of desiccation and temperature. Laboratory studies under controlled and quantifiable conditions are important to explain the interactions between the abiotic factors (relative humidity and temperature) and the survival of the mite. The objective of this study was to determine the off-host longevity of *P. ovis* exposed to various combinations of temperature and relative humidity. The incubation times of eggs were also investigated.

Material and Methods

Longevity of different instars

Scrapings from scab lesions were collected from a heavily infested donor sheep and separated from the wool as previously described (Chapter 3). In order to ascertain the longevity of nymphs, males and females the different instars were separated with the aid of a brush, grouped into nine groups of 10 mites each for each stage and the groups placed separately in glass vials (15 mm x 50 mm). A hole was drilled into the plastic lid of each vial and it was sealed with 75 µm gauze to allow free flow of air and prevent the mites from escaping.

Groups of nymphs, males and ovigerous females were placed at 10°C, 15°C and 25°C respectively. For each temperature three desiccators with relative humidities of 33±2%, 75±2%, and 90±2%, respectively, were used (Fig. 8.1). Saturated salt solutions ($MgCl_2$, NaCl and K_2SO_4) were used to establish different relative humidities in the different desiccators (Young, 1967). The mites were examined under a stereomicroscope every

second, third or fourth day between 11:00am and 12:00pm to determine if they were still alive. To prevent injuries through handling, the mites were not removed from the glass vials during examinations but each glass vial was individually placed under a stereomicroscope and the number of live mites in each vial was counted and recorded. In order to distinguish between live and dead mites the glass vials were briefly placed on a magnetic stirrer with a hot plate set at 35°C. The vibration in combination with the heat stimulated the mites to move. Signs of obvious dehydration, curled up legs and the complete lack of movement were considered as an indication that the mites were dead. The observations were terminated once all the mites in the glass vials were dead. The survival times and the percentages live nymphs, males and ovigerous females at the different combinations of relative humidity and temperatures on the various observation days were determined. The experiment was repeated four times.

Egg incubation period and larval longevity

Eggs were carefully collected from scab samples with the aid of a brush and divided into 18 groups of 10 eggs each. These eggs were placed in glass vials and exposed to different combinations of relative humidity and temperature (Fig. 8.1). For each temperature (10, 15 & 25°C) three different relative humidities were used. Saturated salt solutions were used to establish relative humidities of 33±2%, 75±2%, and 90±2%, respectively, as described previously. Nine groups of eggs were placed at 10°C, 15°C and 25°C and for each temperature three different relative humidities were used. The eggs were monitored every two to three days, over a 56-day period. The observations on egg incubation times were repeated another three times by using glycerol / water dilution to obtain the required relative humidities. Recordings were as before and extended over a 35-day period. The incubation time for the eggs and the subsequent survival of the larvae were recorded. The experiment was repeated four times.

In order to determine whether the different abiotic factors (temperature and relative humidity) significantly affected the survival of the instars and the incubation time of the eggs the data were subjected to a one-way ANOVA followed by Tukey's multiple comparison tests. The results on the incubation of eggs were subjected to a one-way ANOVA to determine whether the incubation time of eggs kept at different relative humidities obtained with saturated salt solutions differed significantly from eggs kept at different relative humidities obtained with glycerol. A computer program PRISM™, Version 2.01 of GraphPad Software, Inc., was used for the statistical analysis and the graphical presentation of the data.

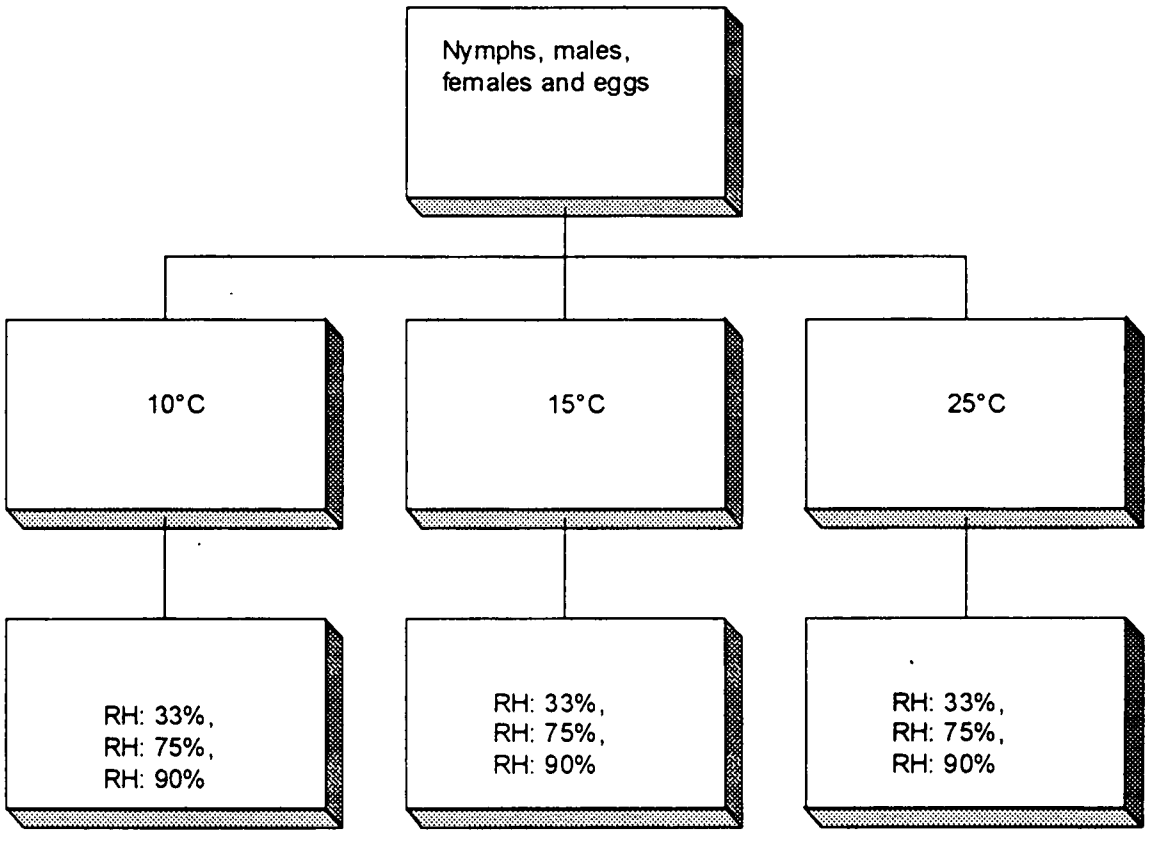


Figure 8.1: A schematic outlay of the different temperatures and relative humidities used to determine longevity of *Psoroptes ovis* instars and egg incubation times.

Longevity of ovigerous females under natural conditions

Ovigerous female mites were selected early in April 1997 from scab samples collected from a heavily infested donor sheep as described previously (Chapter 3). The ovigerous female mites were divided into 60 groups of 10 each and placed in cylindrical glass vials (30mm x 30mm). The two opposing openings of the glass vials were covered with 75 µm nylon gauze to allow free flow of air, and to prevent the mites from escaping. In 30 of the glass vials tufts of Merino sheep wool were placed together with the mites. In the other 30 glass vials mites were placed and left without wool. All 60 groups of mites were subsequently placed at the same selected site on the premises of the University of the Free State. All the glass vials containing the mites were placed on a sieve situated approximately 10 cm above ground. The sieve and glass vials were loosely covered with layers of cut dried grass to ensure ample shade for the mites. Every three to four days the mites were examined under a stereomicroscope and the number of live mites in the glass vials were recorded until all the mites were dead. The percentage live mites were calculated for each recorded interval. The survival time of the ovigerous females in the glass vials with Merino sheep wool was determined and compared to the survival time of the ovigerous females in the glass vials without wool. Rainfall and temperature data (daily minimum and maximum) during the assessment period (April 1997) for Bloemfontein were obtained from the national weather bureau in Pretoria.

Results

Longevity of different instars

The longest mean survival time recorded for nymphs was 15 days at T = 10°C and RH = 33% and 75%, and the shortest mean recorded survival time was three days at T = 25°C and RH = 33%. The longest survival times for individual nymphs were 19 days at 10°C including all three different combinations of relative humidity. The first dead mites were recorded three days after removal from the host (Table 8.1). The mean survival time decreased with increase in temperature (Fig. 8.2). At T = 25°C and RH = 33% none of the nymphs survived longer than three days after removal from the host. Survival of nymphs exposed to the various combinations of relative humidities and temperatures are graphically presented in Figures 8.3 to 8.5.

The mean survival times of the nymphs exposed to different relative humidities at 10°C differed significantly ($p < 0.05$) from the survival times of nymphs exposed to 25°C and different relative humidities. The relative humidity had no significant effect on the survival time of the nymphs at 10°C ($p = 0.683$), 15°C ($p = 0.788$), or 25°C ($p = 0.9966$).

Table 8.1: A summary of the minimum, maximum and mean (±S.D.) survival times (days) of *Psoroptes ovis* nymphs exposed to different combinations of relative humidities and temperatures

Temp (°C)	RH (%)	Mean (±S.D.) survival (days)	Minimum (days)	Maximum (days)	N
10	33	15 (±8.0)	3	19	40
10	75	15 (±8.0)	3	19	40
10	90	13 (±7.0)	3	19	40
15	33	8 (±3.8)	3	11	40
15	75	10.25 (±5.4)	3	16	40
15	90	8.8 (±4.7)	3	14	40
25	33	3 (±0.0)	3	3	40
25	75	4 (±2.0)	3	7	40
25	90	5 (±2.30)	3	7	40

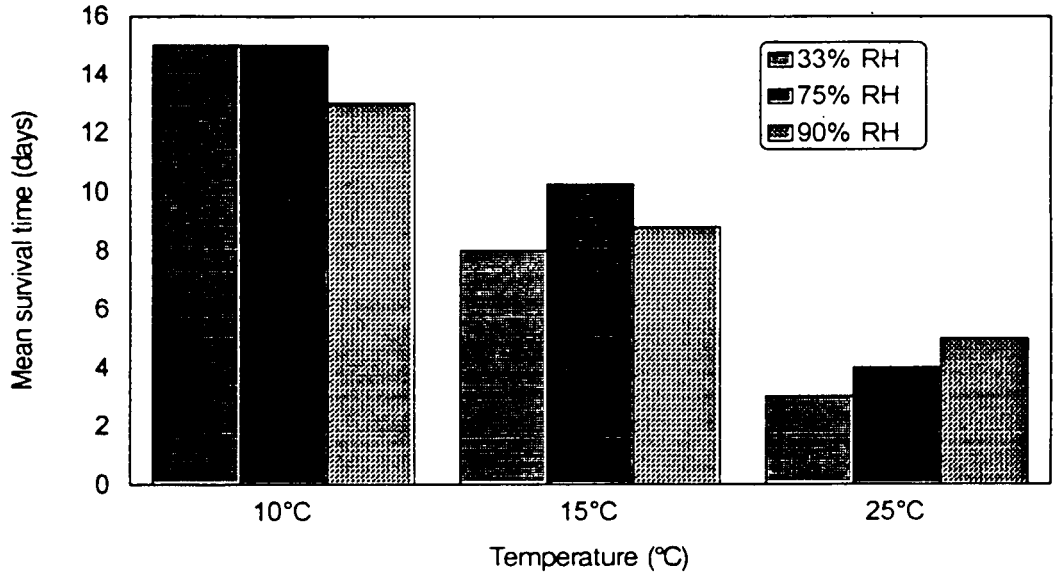


Figure 8.2: The mean survival time of *Psoroptes ovis* nymphs at different combinations of relative humidities and temperatures.

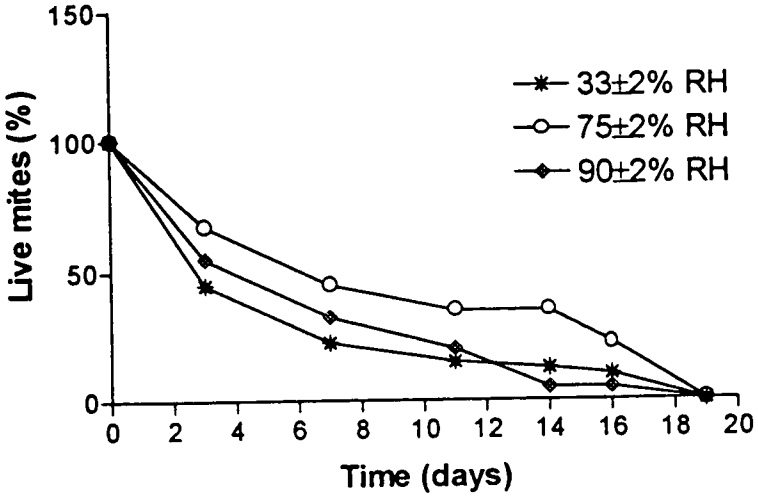


Figure 8.3: Percentage survival of *Psoroptes ovis* nymphs exposed to 10°C and different combinations of relative humidities.

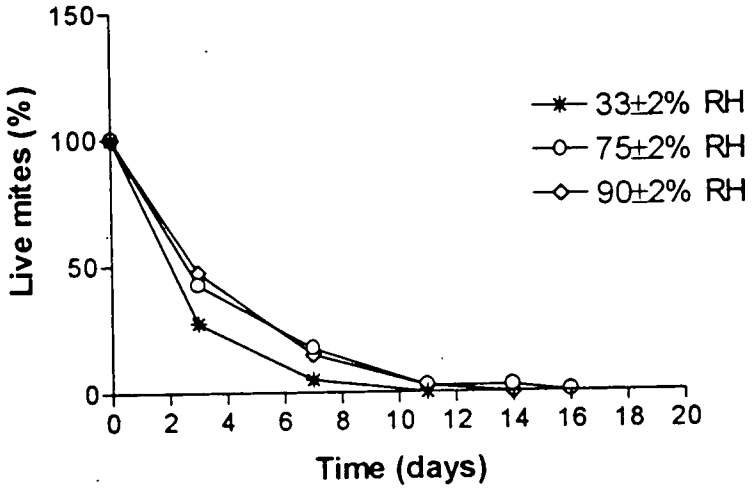


Figure 8.4: Percentage survival of *Psoroptes ovis* nymphs exposed to 15°C and different combinations of relative humidities.

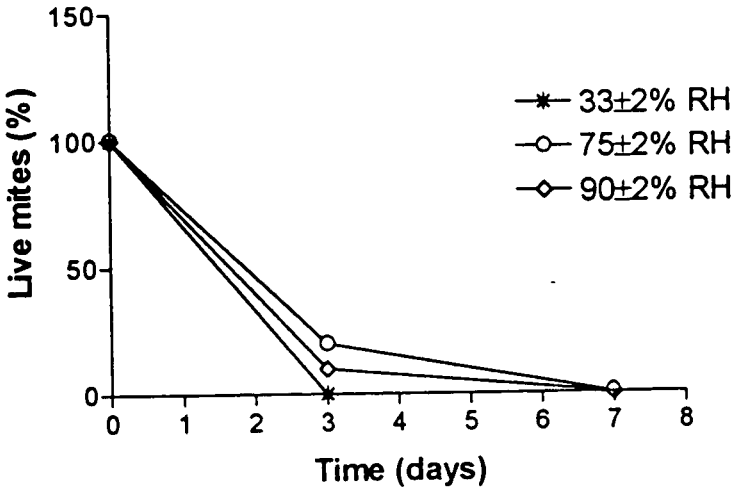


Figure 8.5: Percentage survival of *Psoroptes ovis* nymphs exposed to 25°C and different combinations of relative humidities.

The longest mean survival times recorded for the adult males were 10. 5 days at T = 10°C and RH = 75% and 90%. The longest survival time recorded for individual males was 17 days at T = 10°C and RH = 75%. The first dead males were recorded three days after removal from the host. At T = 25°C and RH = 75% none of the males survived longer than three days (Table 8.2). With an increase in temperature the survival times of the males decreased. Temperature had a significant ($p = 0.0425$) effect on the survival of the males. The relative humidity had no significant effect on the survival time of the males at 10°C ($p = 0.9063$), 15°C ($p = 0.9319$) or 25°C ($p = 0.9274$). The mean survival time of males and survival over time for mites exposed to different temperatures and relative humidities are graphically presented in Figures 8.6 to 8.9. After three days 82 % of the males were still alive at T = 10°C and RH = 33% (Fig.8 7) in comparison to 30% live mites at 25°C and RH = 33% (Fig. 8.9).

Table 8.2: A summary of the minimum, maximum and mean (±S.D.) survival times (days) of *Psoroptes ovis* males exposed to different combinations of relative humidities and temperatures.

Temp (°C)	RH (%)	Mean (±S.D.) survival (days)	Minimum (days)	Maximum (days)	N
10	33	9.75 (±4.7)	3	14	40
10	75	10.5 (±5.7)	3	17	40
10	90	10.5 (±5.2)	3	14	40
15	33	6 (±2.0)	3	7	40
15	75	8.75 (±4.8)	3	14	40
15	90	9 (±4.0)	3	11	40
25	33	5 (±2.3)	3	7	40
25	75	3 (±0.0)	3	3	40
25	90	9 (±4.0)	3	11	40

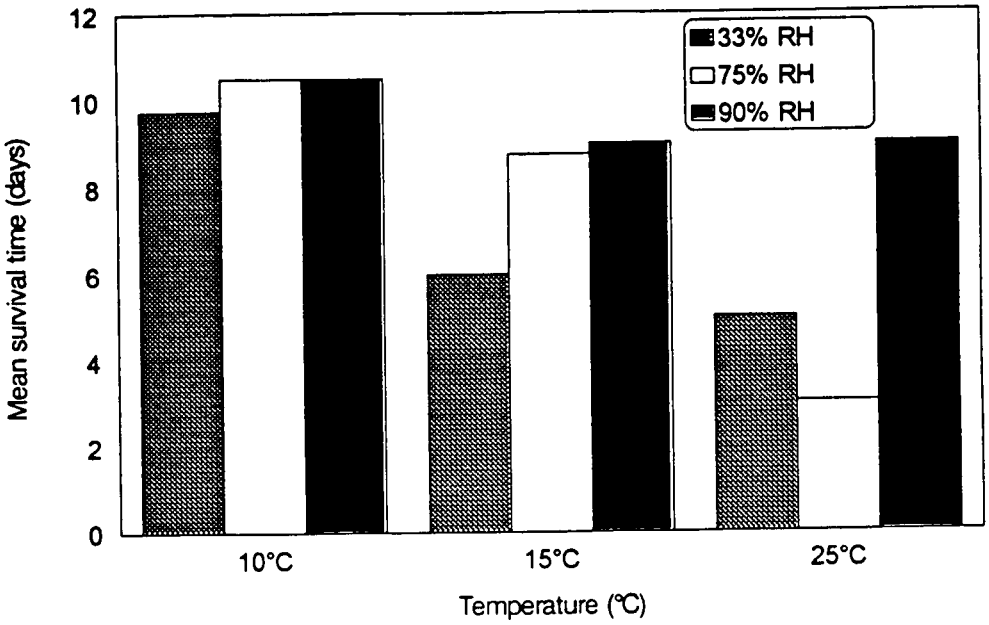


Figure 8.6: The mean survival time of *Psoroptes ovis* males at different combinations of relative humidities and temperatures.

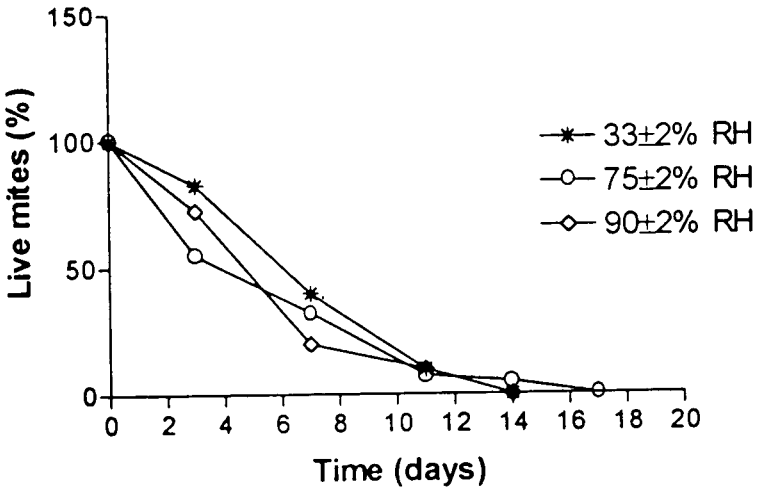


Figure 8.7: Percentage survival of *Psoroptes ovis* males exposed to 10°C and different combinations of relative humidities.

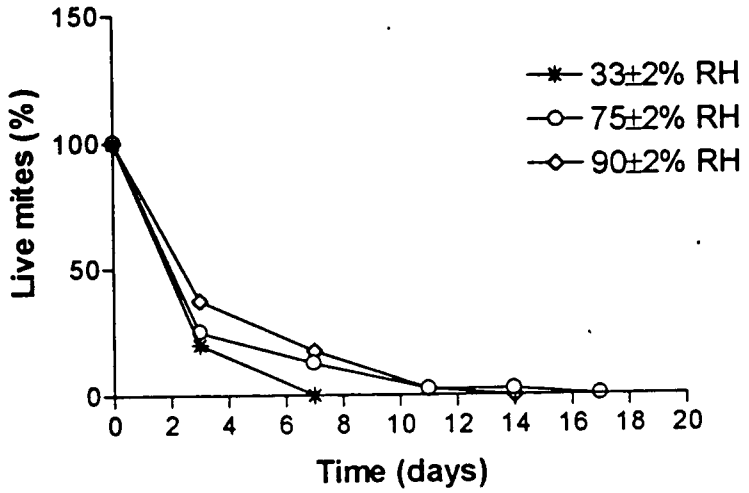


Figure 8.8: Percentage survival of *Psoroptes ovis* males exposed to 15°C and different combinations of relative humidities.

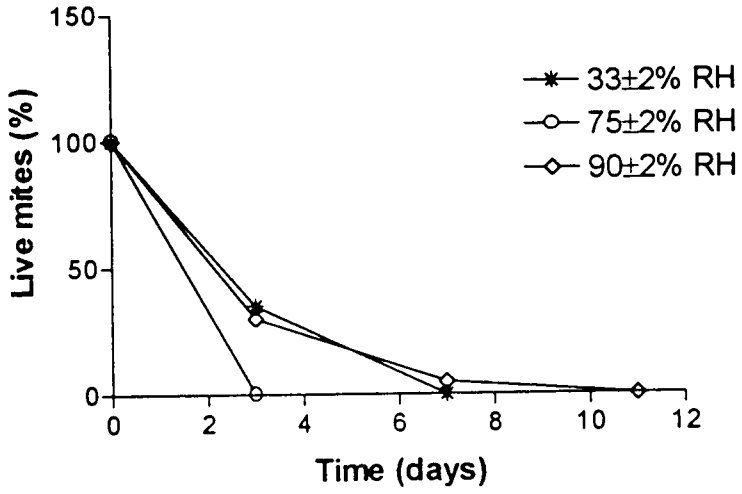


Figure 8.9: Percentage survival of *Psoroptes ovis* males exposed to 25°C and different combinations of relative humidities.

The longest mean survival period of the ovigerous females was 11.25 days recorded at T = 10°C and RH = 90%. The shortest mean survival time was four days at T = 25°C and RH = 33% and 75%. The maximum survival time of the individual mites was 14 days recorded at 10°C (all three relative humidities). At T = 25°C (RH = 90%) a maximum survival of 14 days was recorded (Table 8.3). The mean survival times of the ovigerous females decreased with an increase in temperature (Fig. 8.10). The different relative humidities had no significant effect on the survival time of the ovigerous females at 10°C ($p = 0.9747$), 15°C ($p = 0.9804$) or 25°C ($p = 0.8396$).

The survival time of the ovigerous females exposed to T = 10°C and RH = 90% differed significantly from the survival time of the mites placed at 15°C and RH = 33%. At T = 10°C and RH = 33% forty percent (Fig. 8.11) and 42,5% (T = 15°C RH = 75%), respectively, (Fig. 8.12) of the ovigerous females were still alive after three days, in comparison to the 5 % at T = 25°C and RH = 33% (Fig. 8 13).

Table 8.3: A summary of the minimum, maximum and mean (±S.D.) survival times (days) of *Psoroptes ovis* ovigerous females exposed to different combinations of relative humidities and temperatures

Temp (°C)	RH (%)	Mean (±S.D.) survival (days)	Minimum (days)	Maximum (days)	N
10	33	10.25 (±5.2)	3	14	40
10	75	9.3 (±4.6)	3	14	40
10	90	11.25 (±5.5)	3	14	40
15	33	6 (±2.0)	3	7	40
15	75	7.5 (±3.3)	3	10	40
15	90	7.5 (±3.3)	3	10	40
25	33	4 (±2.0)	3	7	40
25	75	4 (±2.0)	3	7	40
25	90	7.8 (±4.6)	3	14	40

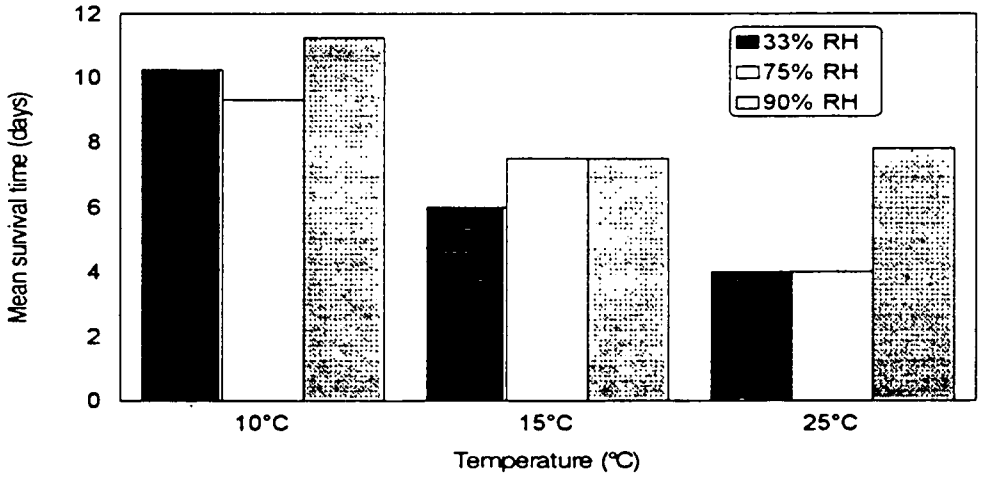


Figure 8.10: The mean survival time of *Psoroptes ovis* ovigerous females at different combinations of relative humidities and temperatures.

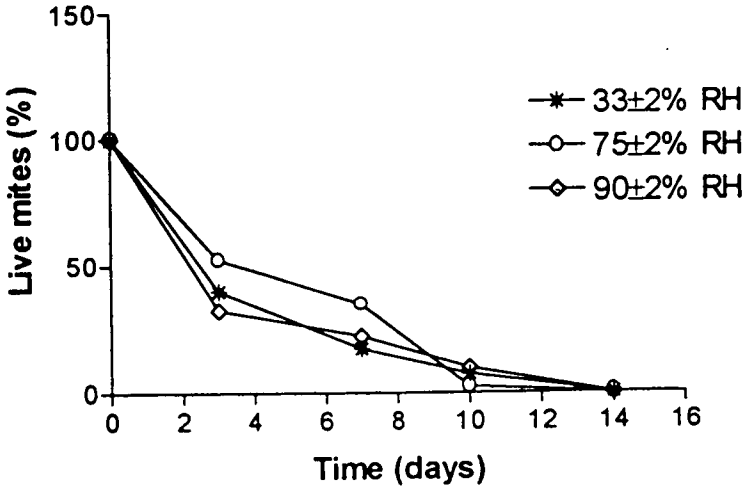


Figure 8.11: Percentage survival of *Psoroptes ovis* ovigerous females exposed to 10°C and different combinations of relative humidities.

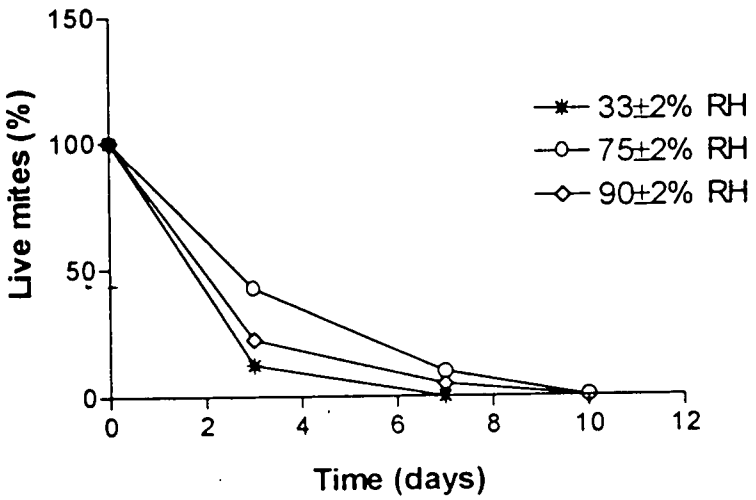


Figure 8.12: Percentage survival of *Psoroptes ovis* ovigerous females exposed to 15°C and different combinations of relative humidities.

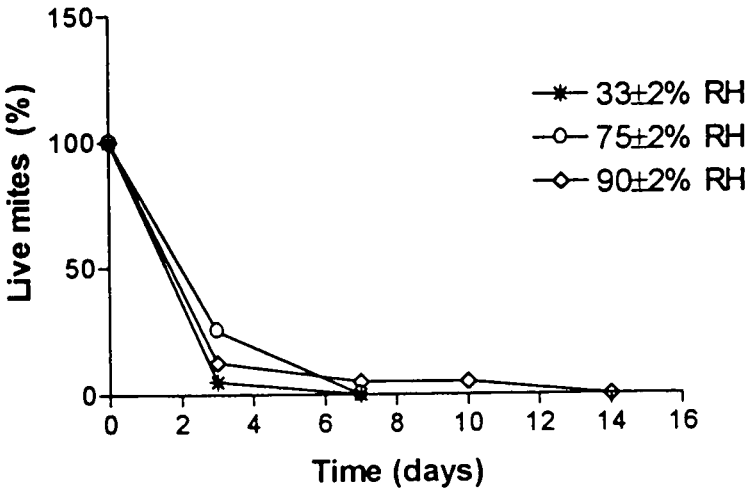


Figure 8.13: Percentage survival of *Psoroptes ovis* ovigerous females exposed to 25°C and different combinations of relative humidities.

Egg incubation period and larval longevity

There were no significant differences ($p>0.05$) between the incubation time of eggs kept at different relative humidities obtained by saturated salt solutions and those obtained by glycerol / water dilutions. The data were therefore pooled. The hatching success (%) varied between 7.14% (T = 10°C, RH = 33%) and 30% (T = 15°C, RH = 90%). The minimum time to egg incubation was three days and was at T = 15°C, and T = 25°C (RH = 90%). The longest time to egg incubation was 31 days at T = 10°C and RH = 75%. The mean egg incubation time varied from 5.9 (±2.58) to 22.14 (±6.53) days (Table 8.4). Larval longevity varied between two and 14 days. The longest mean larval longevity (9.25 days) was recorded at 10°C (RH = 90%) and the shortest (4.44 days) at 25°C (RH = 33%) (Table 8.4).

Table 8.4: Mean (±S.D.), maximum and minimum incubation times of *Psoroptes ovis* eggs and larval longevity.

Temp. (°C)	**RH (%)**	**Hatching success (%)**	**Minimum incubation (days)**	**Maximum incubation (days)**	**Mean incubation time (days) (±S.D.)**	**N**	**Minimum larvae longevity (days)**	**Maximum larvae longevity (days)**	**Mean larvae longevity (±S.D.)**
10	33	7.14	7	9	7.5 (±1.0)	70	4	11	5.75 (±3.5)
10	75	22.8	14	31	22.14 (±6.53)	70	2	10	5.71 (±2.75)
10	90	12.5	17	18	17.50 (±0.57)	70	6	14	9.25 (±3.59)
15	33	14.28	3	13	8.7 (±4.26)	70	3	11	7.33 (±3.42)
15	75	12.85	3	18	9.75 (±5.49)	70	3	12	8.12 (±3.42)
15	90	30	3	28	12.6 (±10.15)	70	2	11	5.21 (±3.15)
25	33	12.85	4	11	5.9 (±2.58)	70	3	7	4.44 (±1.33)
25	75	21.42	4	16	7.43 (±4.89)	70	2	7	4.68 (±1.95)
25	90	35.71	3	16	7.43 (±3.58)	70	2	8	5.17 (±1.82)

Longevity of ovigerous females under natural conditions

Less than half (45%) of the ovigerous female population in the glass vials without Merino wool survived for four days, compared to the 54% live females recorded at four days in the glass vials containing wool. At 15 days 2.6% females were still alive and at 17 days all the mites in the glass vials without wool were dead (Fig 8.14). In the glass vials containing wool, 4% of the ovigerous females were still alive after 15 days, but all the mites were dead at 20 days (Fig. 8. 15). There was no significant difference ($p>0.05$) in the survival of the ovigerous females in glass vials with wool and those without wool. The temperature fluctuations during the assessment period are graphically presented in Figure 8.16. A total of 35mm rain fell during the assessment period (April 1997).

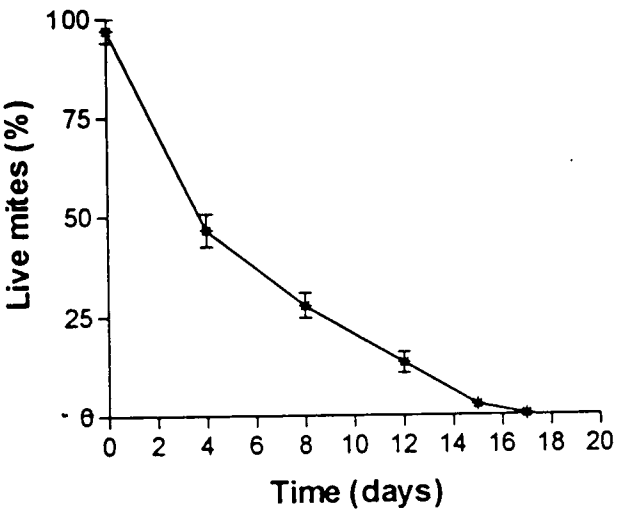


Figure 8.14: The survival of ovigerous female *Psoroptes ovis* mites in glass vails without wool exposed to naturally fluctuating conditions.

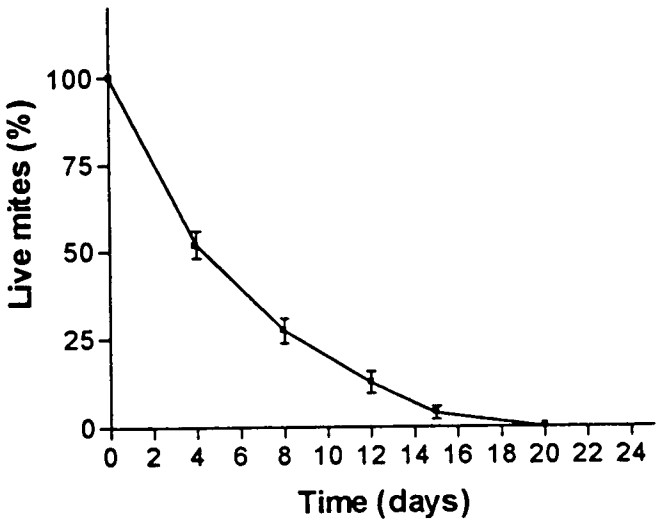


Figure 8.15: The survival of ovigerous female *Psoroptes ovis* mites in glass vails with wool exposed to naturally fluctuating conditions.

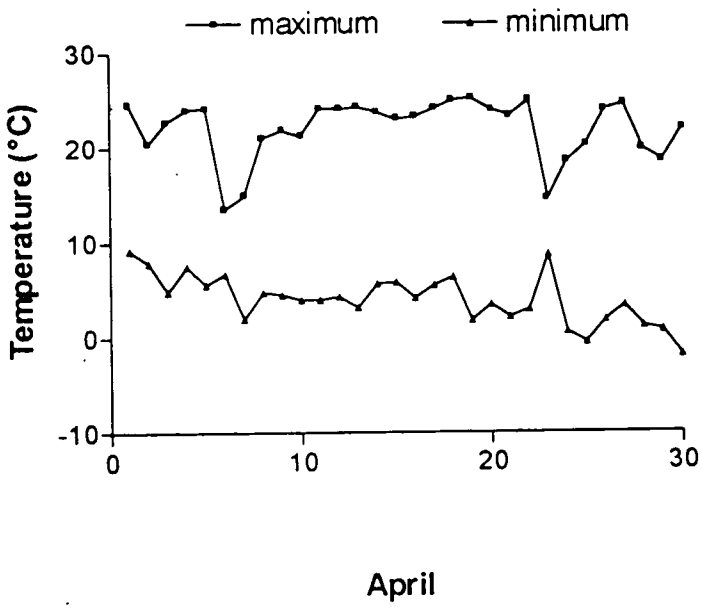


Figure 8.16: The daily minimum and maximum temperatures recorded in Bloemfontein for April 1997.

Discussion

The present study clearly indicated that high temperatures had a detrimental effect on the off-host longevity of *P. ovis*. During this study no mites survived longer than 14 days at a constant temperature of 25°C. It must, however, be borne in mind that the recorded values are just approximations since the ages of the mites collected from the scrapes are not known. Possible reasons for the shorter longevity at higher temperatures are an increased activity of scab mites at high temperatures (Chapter 7) which may result in the exhaustion of physiological reserves (Wilson, Blachut & Roberts, 1977). The rate of water exchange will also be greater at high temperatures (Needham & Teel, 1986) resulting in death due to desiccation. Babcock & Black (1933) found that the scab mite is capable of surviving a wide range of temperatures, but perished from a lack of food when removed from the host. On the other hand, Shilston (1915) stated that scab mites soon perished if exposed to either low (0°C) or high (37°C) temperatures. Wilson, *et al.*, (1977) evaluated prevailing temperature, humidity and other environmental factors on mite longevity and found that low temperatures and high humidity are conducive to mite longevity. The results from this study, however, indicated that low temperatures (10°C) favoured the survival of mites irrespective of the relative humidity. Mites of all developmental stages began to die within the first three days after removal from the host. The minimum survival time has been given as three days for the different instars, but it is most likely that some of the mites died before then. The minimum number of days that the mites survived after removal from the host is insignificant. What is, however, very important is that mites are able to survive off the host for extended periods of time.

Eggs of *P. ovis* hatched at as low a temperature as 10°C and a relative humidity of 33%. Hatching success was, however, low (23%). Since the eggs that were collected from the

scabby sheep were in different stages of embryonic development, and very likely also contained pre-larvae, it is difficult to make sound conclusions. It is possible that 10°C, and perhaps the other temperatures tested, may be too low for embryonic development, but that the few larvae that hatched were from pre-larvae. The results obtained on the larval longevity during this study are more reliable considering the fact that the ages of the larvae that hatched from the eggs were known. Whether these larvae are infective should be determined. In view of these observations on the acari themselves it is most likely that prolonged infestation in the absence of scabby sheep could be due to the eggs which retain their vitality for long periods. The present results illustrated that the eggs' ability to hatch after a month (31 days) away from the host could account for the persistence of sheep scab in South African flocks, and increase the probability of re-infestation.

The extended survival time recorded for the ovigerous females under natural conditions compared to the ovigerous females used in the laboratory studies is difficult to explain. It is possible that the glass containers used in the incubators produced an artificial atmosphere. The use of small containers (under natural conditions) with two opposing openings permitted free airflow and contributed to the proportional distribution of temperature and humidity. It is also possible that the temperature fluctuations between high and low ambient temperatures experienced during the observational period (April) contributed to the extended longevity of the ovigerous females.

Off-host survival of *P. ovis* is a very intricate study. This is clearly indicated by the numerous discrepancies in the survival times of the scab mite reported in the literature (Table 8.5). It has frequently been stated that sheep have contracted scab when placed in pens occupied by infested sheep two or even three years previously, but which have been kept closed during the interval. Since this view is held by persons who have had wide practical experience of the disease in South Africa, their opinion cannot be lightly disregarded, although it must be admitted that the evidence adduced in support of

prolonged infection of pens is not convincing (Shilston, 1915). Hertwig (1835) stated that mites separated from the host lived 17-21 days. Wilson, Blachut & Roberts (1977) found that scab mites successfully infested sheep 17 days after removal from the host. This is in accordance with results obtained by Babcock & Black (1933) and O'Brien, Gray & O'Reilly (1994a).

Table 8.5: A summary of the off-host survival times of *Psoroptes ovis* as recorded by several authors

Survival time (days)	**Reference**
17-21	Hertwig 1835
20-42	Salmon & Stiles (1903)
21	Stockman (1910)
16	Bedford (1915)
20	Shilston (1915)
17	Du Toit (1924)
1-38	Babcock & Black (1933)
17	Wilson *et al* (1977)
21-48	Kirkwood (1986)
15-18	O'Brien, Gray & O'Reilly (1994)

In Texas Babcock & Black (1933) reported that mites survived 1-38 days at 70-80°F, and found pens to be infective immediately after being vacated, but not after being vacated for one day or longer. Stockman (1910) in England reported pens to be infective after a maximum of eight days, although mites remained alive up to 21 days after removal from their host. Kirkwood (1986) also in England claimed that mites survived in exceptional cases for three weeks at normal temperatures and 48 days at 10°C. Du Toit (1924) in

South Africa illustrated in detailed examinations that pens could be safely restocked 17 days after removal of heavily infested scabby sheep. Also in South Africa Shilston (1915) reported that one female scab mite was still alive 20 days after removal from its host, but was found to be dead the next morning. Differences in experimental methodology, mite strains and humidity differences between South Africa and the Northern Hemisphere, where most of the research has been conducted, might have a significant effect on the intricate results obtained by previous workers.

Furthermore, Roberts & Meleney (1971) showed that certain mite strains could withstand adverse conditions more successfully than others could. O'Brien, *et al.*, (1994) in England found that mites removed from their host remained alive for 18 days although they could not induce infestation when replaced onto the sheep. In general O'Brien, *et al.*, (1994) found that mites were infective for a period equalling a day less than their longevity. Although the methodology of the current study differ markedly from that of O'Brien, *et al.*, (1994) it is essential to keep in mind that mite eggs constitute a potential source of infection throughout the year and attention should therefore be paid to areas that could harbour eggs.

Although *P. ovis* is an obligatory parasite and the entire life cycle occurs on the sheep the direct transmission from one sheep to another ensures successful maintenance of the disease (Chapter 7). The gregarious nature of sheep ensures ample opportunities for direct contact between individual sheep, therefore minimum opportunities for prolonged absence from the host is required. When the numbers of mites becomes excessive and the hosts are able to effectively remove scab mites and eggs through grooming behaviour the reoccurrence of sheep scab in apparently healthy flocks may be due to retarded off-host egg development and incubation.

Undoubtedly, the off-host survival of *P. ovis* and the intricacies involved in the mechanisms contributing to the mite longevity are one of the most controversial and

discrepant aspects in the biology and ecology of sheep scab mites. The fickleness of results on off-host longevity demonstrates that many factors are involved in the survival of scab mites and experimental results are not readily predictable.

Chapter 9

Sheep scab in Botshabelo, Thaba Nchu and Verkeerdevlei

Introduction

Currently, one of the pressing issues in South Africa is to upgrade the quality of life for a large portion of the population (Foster, 1984). For many years agricultural and veterinary research and aid in South Africa focussed on the needs of the commercial, predominantly white farmers. This biased situation led to the development of a huge difference in farming and production standards between the commercial farmer and the resource-poor, small-scale, predominantly black farmer (Ewang, 1995). The main objective of this study was to assess the prevalence of sheep scab in a black farming community (Botshabelo / Thaba Nchu) and to collect the necessary background information on the sheep-farming practices in these areas. The information obtained was compared to a similar assessment of the Verkeerdevlei district that includes predominantly white commercial farmers.

Material and Methods

A survey was conducted during July 1997 in the predominantly white commercial farming district of Verkeerdevlei, located 75 km northeast of Bloemfontein. During an annual meeting of farmers from the Verkeerdevlei district a field worker explained the purpose of the survey to the farmers. After the meeting a total of 22 farmers were individually interviewed by the field worker. The field worker completed the questionnaire and the answers were filled in as offered by the farmer. The survey questionnaire (Appendix 1) was divided into four sections, namely: sheep husbandry, sheep scab, ectoparasite control and resistance. These sections involved direct and multiple-choice answers and assessments. Direct questions established the locality of the livestock owner as well as the livestock numbers. Multiple choice questions were aimed at establishing the main source of income from the sheep, the extent of problems with ectoparasites as well as the extent of knowledge with regard to chemical resistance. Questions requiring assessments were used to determine the views of the livestock owner and to establish the problems experienced by the farmers with regard to sheep scab control.

In September 1998 a similar survey was conducted in two urban areas, namely Botshabelo and Thaba-Nchu in the Free State province. Botshabelo and Thaba-Nchu are located 55 and 65 km, respectively, east of Bloemfontein. A total of 28 livestock owners were interviewed in Botshabelo (n = 14) and Thaba Nchu (n = 14), with the help of a field worker and an assistant. The field worker and assistant visited the different study areas, introduced themselves to the livestock owner and explained the purpose of the questionnaire. The field worker completed the questionnaire together with the livestock owner, the assistant translated the questions when necessary and the answers were filled in as offered by the livestock owner. The number of flocks infested with sheep scab in the Botshabelo and Thaba-Nchu regions were established. With the consent of the flock owner the sheep from the individual flocks were captured in portable kraals and

systematically searched for the presence of lesions. The same criteria as described in Chapter 3 were used to confirm the presence of active lesions and / or infestation. The flock was regarded as positive for sheep scab if a single sheep with sheep scab was found. A total of four questionnaires were rejected due to inadequate information given by the livestock owner. The data obtained in the questionnaire study were processed and statistically analyzed on a personal computer. The software program Epi-Info, Version 6.03 was used. The categorical variables were statistically tested in Epi-Info with Fisher exact test and the Mantel-Haenszel chi-square test. For the continuous data the Bartlett's test and the Kruskal Wallis one-way analysis of variance test were used. Most of the data were converted to percentages or means ± standard deviations to simplify the discussion. A probability of ≤ 0.05 was considered as a significant result.

Study area

The geographical position of the Free State province in South Africa and the locations of Botshabelo, Thaba Nchu and Verkeerdevlei are indicated in Figure 9.1. The largest part of the Central Free State highveld is flat and situated at an altitude between 1200 and 1500 meters above sea level. The eastern area is higher (1500 – 1800 meters) above sea level (Mostert, Roberts, Heslinga & Coetzee, 1971), and Botshabelo and Thaba Nchu are situated in the eastern area (Dreyer, 1997). The Central Free State is a summer rainfall region. The mean annual rainfall in the east ranges from 560 to 650 mm and progressively decreases from east to west across the region. Summers in the Central Free State region are moderate to warm and the winters are cold with regular frost occurring from April to the end of September (Mostert, *et al.*, 1971). The urban natural veld around Botshabelo extends over an area of 6 000 ha (Krige, 1996). In Thaba Nchu, there is a grazing area of approximately 150 ha surrounding each village (Dreyer, 1997). Themeda-Cymbopogon grass veld (Acocks, 1975) occurs in the Verkeerdevlei and Thaba Nchu magisterial districts. Approximately 70% of the Central Free State consists of veld, with 30% under cultivation. The largest number of commercial farms is in the

425 to 1060 ha group. Fourteen percent are, however, smaller than 425 hectare and 41% are larger than 1060 ha (Mostert, *et al.*, 1971)

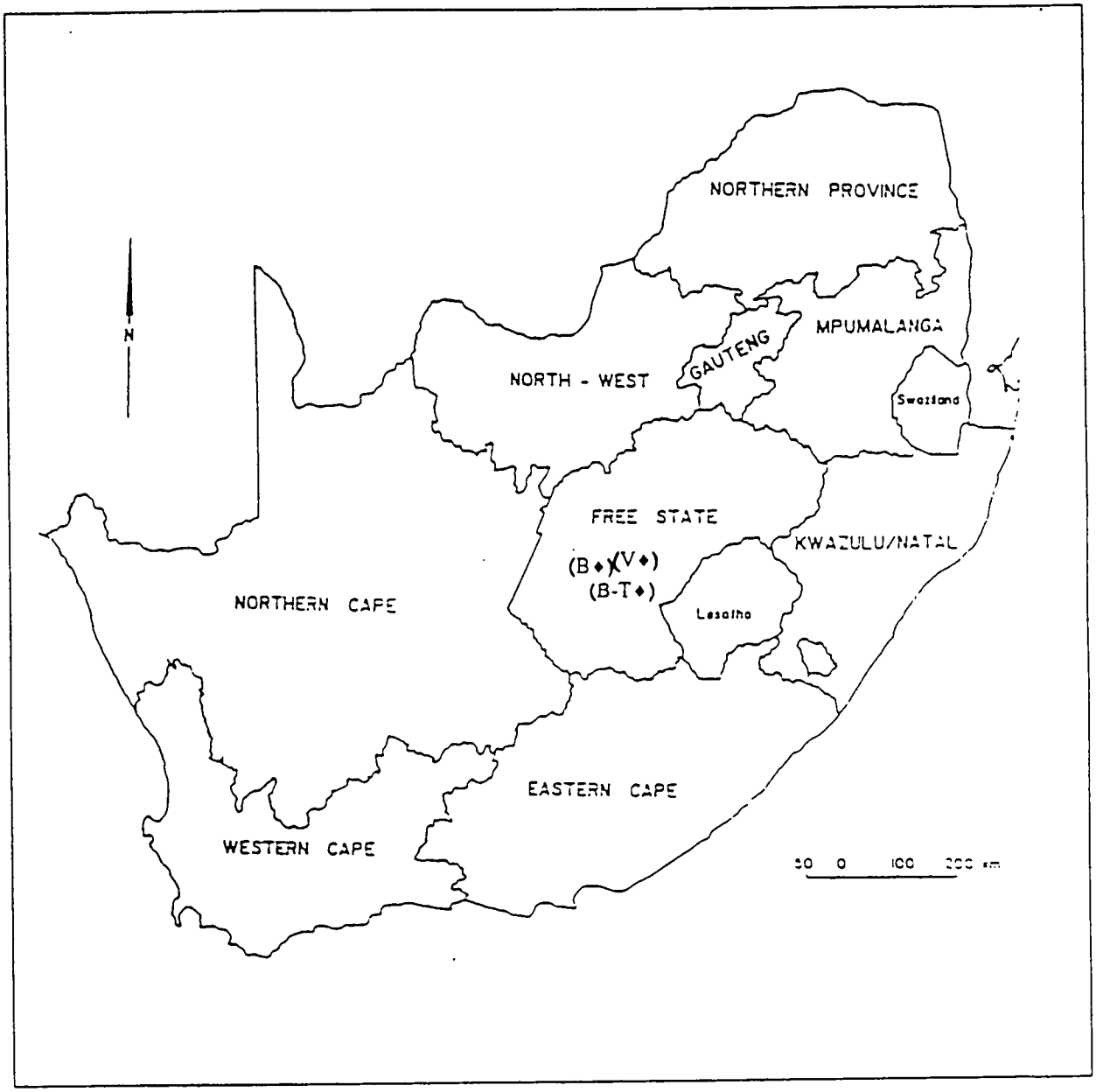


Figure 9.1: The location of the Free State province in South Africa in national context (Adapted from Krige, 1995). Bloemfontein (B), Botshabelo and Thaba Nchu (B-T) are indicated by (B◆) (B-T◆), respectively, and Verkeerdevlei is indicated by (V◆).

Results and Discussion

Sheep husbandry

In Thaba Nchu 92% of the flocks consist of Merino sheep. In Botshabelo mixed flocks with both Merino and Dorper sheep are kept. Animals in Botshabelo and Thaba Nchu are kraaled in backyards at night to limit theft, and are returned to communal or tribal pastures every morning.

In Thaba Nchu the tribal chief is traditionally the highest authority with control over the communal area of his tribe, and he allocates areas of land to different tribal wards (Jeppe, 1980). Too many farmers keep their sheep and cattle on poor quality tribal land, and in many cases the sheep are in very poor condition and are not properly taken care of (personal observation). Most of the small scale farmers farm uneconomically and allow their marketable livestock to graze too long on tribal land (Jeppe, 1980). This is probably one of the reasons for the poor agricultural productivity in this region. The stocking rate in general for small scale farming areas exceeds the present carrying capacity of the veld. Natural veld loses vigour and productivity when it is continuously and excessively defoliated, and the stability of the vegetation is sacrificed (Mostert, *et al.*, 1971). The breeding of better quality stock and the feeding thereof are virtually impossible, the maintenance of improvements is very difficult, and the irresponsible damaging of fences, watering-places, etc. remain a constant problem (Jeppe, 1980).

Farmers in the commercial farming area of Verkeerdevlei tend to sell their stock earlier and prevent uncontrolled mixing of stock, which leads to the breeding of better quality stock. A potentially higher productivity can be achieved on the commercial farms due to management systems based on the principle of rotating stock within a number of camps.

The commercial farmer is in the position to control the defoliation factor by means of moving his stock and regulating the grazing intensity (Mostert, *et al.*, 1971).

Crime and stock theft are very big problems, especially in Botshabelo (Foster, 1984). The livestock owners or hired herd boys look after the animals. There are no fences and no rotational grazing of the communal veld. The animals drink water from gravel dams or taps in backyards in both Botshabelo and Thaba Nchu, and from the "Klein Modder" River in Botshabelo (Dreyer, 1997). Livestock in the Verkeerdevlei area are kept in the veld, and rotating of the grazing is under the management of each farmer. Stock theft is a big problem especially in the areas directly adjacent to the Thaba Nchu region (Borman, pers. comm. 1997).

The results from the current survey indicated that the mean flock size in Botshabelo and Thaba Nchu, respectively, was 27.6 (range = 3 - 40) and 19.0 (range =5 - 71). The mean flock size in the Verkeerdevlei area was 2301.2 (range = 500 - 3472) (Table 9.1). Results of a livestock census conducted by Agri-Eco in 1994/1995 in Thaba Nchu indicated that the number of cattle in the area was 15 826 and the number of sheep and goats was 11 107. An aerial livestock census conducted during 1994 in Botshabelo by the Department of Agriculture and Environmental Affairs, National Government, indicated that there was an estimated number of 2 263 head of cattle, 724 sheep and 640 goats in the urban area (Dreyer, 1997).

Table 9.1: A summary of the flock sizes of farmers interviewed in the different study areas.

	Minimum	Maximum	Mean	S.D.	n
Botshabelo	3	40	27.6	23.8	11
Thaba Nchu	5	71	19.0	19.8	13
Verkeerdevlei	500	3472	2301.2	1448.2	22

None of the farmers in the Botshabelo /Thaba Nchu region keep sheep for the purpose of selling the meat. In Botshabelo 8.3%, and in Thaba Nchu 2.94% of the farmers, respectively, farm sheep only for the purpose of having fresh meat available for the family (Fig. 9.2). In contrast to this 36% of the farmers in the Verkeerdevlei district keep sheep for commercial meat production. The main reason for sheep farming in the Verkeerdevlei region is wool production, and nearly half (44%) of the farmers rely on wool for an income.

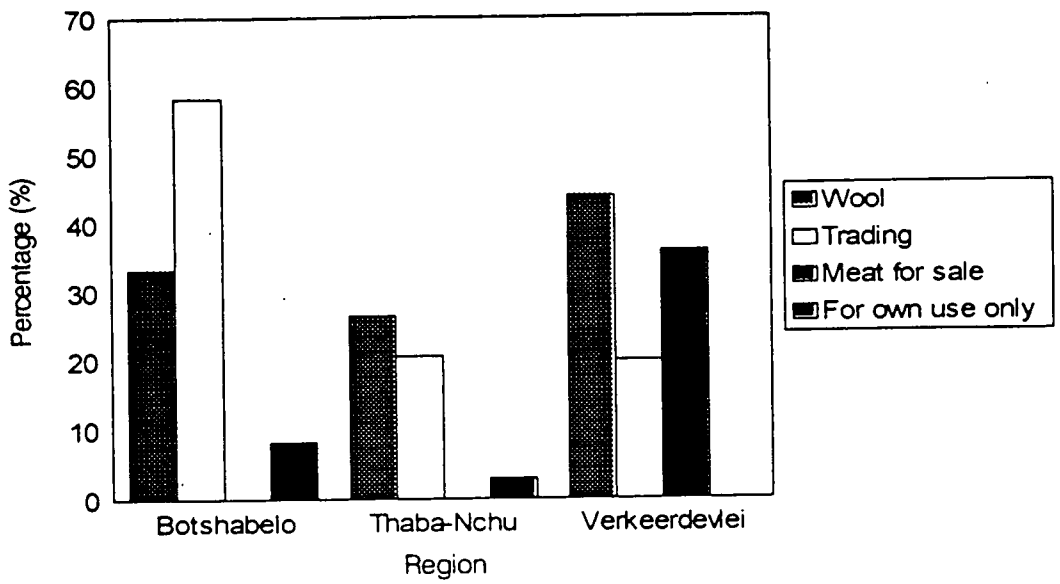


Figure 9.2: Bar graph indicating the importance of the different sources of income from sheep.

The farmers in Botshabelo and Thaba Nchu give inadequate supplementation to the livestock, resulting in poor physical condition of the livestock during the winter (Dreyer, 1997). Results from the current survey indicated that only 40% of the farmers in Botshabelo supply supplementation to their sheep, in comparison to the 92, and 95.2% of the farmers in Thaba Nchu and Verkeerdevlei areas, respectively (Fig 9.3). Although the percentage farmers in Thaba Nchu that supply supplementation to their sheep are considerably higher than those in the Botshabelo region, only 38.4% supply a combination of both alfalfa and maize, in comparison to 80% of the farmers in the Verkeerdevlei area. None of the farmers in the Botshabelo region supply salt to their sheep (Fig. 9.3). According to De Waal (1990), supplementation may increase the nutrient intake of grazing animals, as well as correct deficiencies of pastures and lead to an increase in animal production.

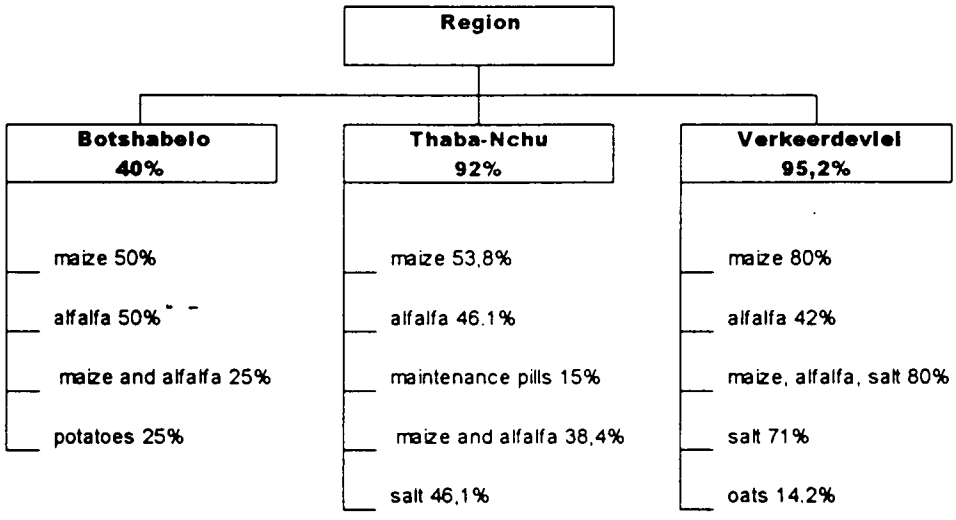


Figure 9.3: Different supplements (%) fed by farmers to their sheep in Botshabelo, Thaba Nchu and Verkeerdevlei. Forty percent, 92% and 95.2% of the farmers in Botshabelo, Thaba Nchu and Verkeerdevlei, respectively, supply supplements to their sheep.

Sheep scab

In both Botshabelo and Thaba Nchu wool forms an important part of the income of the family unit. Nearly half (44%) of the commercial farmers in Verkeerdevlei derive an income from wool. Fifty percent of the farmers in Botshabelo indicated that they personally shear their own sheep. In the Thaba Nchu region, 84.6% of the stockowners hire help to shear their sheep. Only 42.8% of the commercial farmers have their own shearing teams, and 95.4% of these farmers hire shearers from neighbouring farms. Twenty three percent of the farmers in the Thaba Nchu region shear sheep on neighbouring commercial farms. Of these farmers, 33% of their respective flocks were infested with sheep scab at the time of the survey. A small percentage (4.7%) of the Verkeerdevlei farmers shear sheep on neighbouring farms. It is therefore important to consider the possibility that sheep scab can spread between sheep during shearing periods via commuting shearers.

A small percentage of farmers (Thaba Nchu = 7.69%, Botshabelo = none and Verkeerdevlei = 9.09%) admitted to having transported scabby sheep. None of the farmers in the Verkeerdevlei district had sheep scab at the time of the survey, but one farmer reported the disease to the state veterinary officer approximately one year after the survey was done. At the time of the survey 36.36% of the interviewed farmers in Botshabelo and 38.46% of the interviewed farmers in Thaba Nchu had positive sheep scab infestation in their flocks.

A small percentage (22.2%) of farmers in Botshabelo reported the disease to the local veterinarian, but 61.5% of the farmers in Thaba Nchu indicated that they had reported the presence of sheep scab in previous years to the Veterinary officer at Agri-Eco. Sheep scab is a notifiable disease in many countries including South Africa, but the disease is rarely reported until it has reached epidemic proportions and is out of control (Kirkwood, 1986).

None of the farmers in the Botshabelo region notified their neighbours of the presence of sheep scab in their sheep. The absence of fences to separate sheep flocks in the communal grazing area allows for the rapid spread of the disease between flocks. In many cases these farmers are unaware of the law, or the clinical signs of sheep scab. In Thaba Nchu 23.07% of the farmers notified their neighbours of sheep scab in their sheep. The reason for this is the increased education campaign during 1998 from the animal health officers in the region. This can also be presented as a reason for the increased tendency (92.3%) of the farmers in the Thaba Nchu region to treat their sheep against sheep scab.

Despite the fact that the commercial farmers are more aware of the contents of the sheep scab law, only 21.7% of the commercial farmers notified their neighbours of the presence of sheep scab on their farms. It is widely accepted amongst veterinarians that commercial farmers very often do not report sheep scab outbreaks. Sheep scab is still regarded by many farmers as a disgrace, and reflects negatively on the farmer, despite the continuous appeal of state veterinarians to report the disease (Pienaar, pers. comm. 1998).

During the survey 92.3% of the farmers (n = 13) in the Thaba Nchu region and all of the farmers (n = 11) in the Botshabelo region admitted to have had sheep scab in 1997. None of the farmers (n = 22) in the Verkeerdevlei district indicated that they had sheep scab in 1997, but isolated cases of sheep scab apparently did occur amongst the interviewed commercial farmers in the period from 1973 – 1996.

Eradication of sheep scab cannot be achieved by legislation alone, but depends on the full co-operation of the farming industry. Many stockowners argue that compulsory dipping is a waste of time and money if their sheep are not infested. They forget that sheep scab is contagious. They fail to appreciate that even if only one sheep in the country is infested, it is that single sheep which must be adequately treated. The

eradication of sheep scab is still heavily dependent on the education of the flock owner (Kirkwood & Bates, 1987).

Local husbandry methods and ignorance on the part of the farmer concerning the clinical signs of sheep scab can be presented as reasons why eradication has not yet been achieved in South Africa. The infestation is not discovered until the sheep are presented for shearing, and even then neither the farm labourers nor the shearers recognize it as sheep scab.

Several factors have been identified by different state veterinarians in the Free State, as to why sheep scab has not yet been eradicated from this region. Firstly, the commercial farmers are often not aware of the true number of sheep on their farms; therefore the correct procedure for sheep scab control cannot be followed. If sheep scab is present on a farm, all the sheep on that farm must be treated to prevent the re-infestation of the flock from untreated but infested animals. According to Kitshof (pers. comm. 1998), farmers do not declare the exact number of sheep on their farms during inspections in order to save financial expenses during treatment against sheep scab. In most cases recurrence of an outbreak occurs on the same farm within a few months following treatment. Secondly, inadequate fencing of land is another reason for the recurrence of sheep scab (Scholtz, pers. comm. 1998). Fencing of land is essential to prevent sheep from wandering and this in turn prevents accidental contact with diseased sheep and so helps prevent the spread of the disease. Thirdly, political aggression towards white animal health officers of the South African State Veterinary Service is common in Thaba Nchu and Botshabelo. This reaction led to the decline in sheep scab law enforcement in these urban and peri-urban farming areas (Kitshof, pers. comm. 1998).

All the farmers (n = 46) considered sheep scab to be problem and a serious disease. All the farmers in the Botshabelo / Thaba Nchu region were aware of the fact that sheep scab can kill their sheep. The Verkeerdevlei farmers indicated that sheep scab leads to vast

financial losses due to the fact that their wool harvest is worthless if sheep scab was present on the farm. Weight loss in the sheep due to the disease and the effect of the compulsory quarantine term as determined by the law was also presented as motivations why they considered sheep scab as a serious disease.

Control of sheep ectoparasites

In Botshabelo and Thaba Nchu 61.9% of the farmers indicated that they experienced problems with external parasites of sheep (besides sheep scab), in comparison to the 77% farmers in the Verkeerdevlei area. According to 58.3% of the small-scale farmers, and 61% of the commercial farmers, the highest incidences of problems related to ectoparasite infestations occur during the summer. A small percentage (22.7%) of the commercial farmers in the Verkeerdevlei district indicated that they do not have any ectoparasite-related problems. In Thaba Nchu 38.4%, and in Botshabelo 37.5%, of the farmers indicated that they do not experience problems with external parasites.

A veterinary service provided by AGRICOR (Agri-Eco), an agricultural corporation of the previous Bophuthatswana government has been available in the Thaba Nchu region since 1978. These services were either subsidized by the government, or free of charge, and were managed by a veterinarian and nine animal health officers. These services were terminated in March 1995, due to a lack of funds. Although six of the animal health officers are still operating, they are neither allowed to treat individual animals, nor do they have any veterinary supplies. They are still responsible for education, castration, and the monitoring of disease outbreaks (Dreyer, 1997).

Botshabelo, on the other hand, was part of South Africa, and therefore not included in the previous Bophuthatswana veterinary extension region of Agri-Eco. Although Botshabelo was included in the Thaba Nchu extension region at the beginning of 1995, after South Africa's first democratic elections, it coincided with the termination of all

clinical veterinary services in Thaba Nchu (Dreyer, 1997). Veterinary services are thus still unavailable in Botshabelo.

Few of the people in the Botshabelo/Thaba Nchu region have transportation means of their own. It is therefore difficult for people living in this area to transport their sick animals to a veterinary clinic. The nearest suppliers of animal health remedies are at Tweespruit (30 km) and Bloemfontein (65 km). It is thus not surprising that 50% and 33.3% of the farmers in Thaba Nchu (Fig. 9.4) and Botshabelo region (Fig 9.5), respectively, are unable to treat their animals against ectoparasites. Commercial farmers in the Verkeerdevlei area have their own transportation, and veterinary services are thus within easy access.

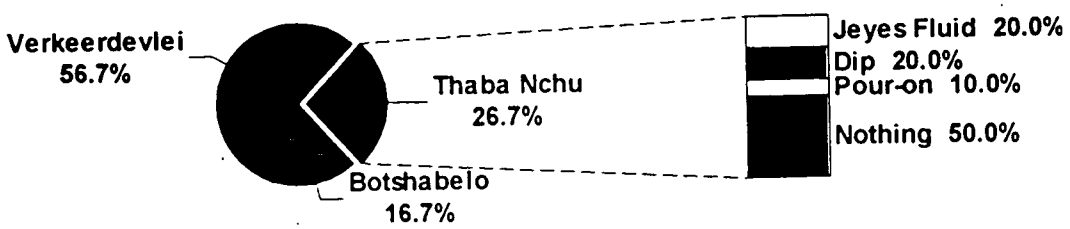


Figure 9.4: Breakdown of control methods for ectoparasites used by small-scale, predominantly black farmers in the Thaba Nchu region. Thaba Nchu represents 26.7% of the total number of livestock owners interviewed during the survey.

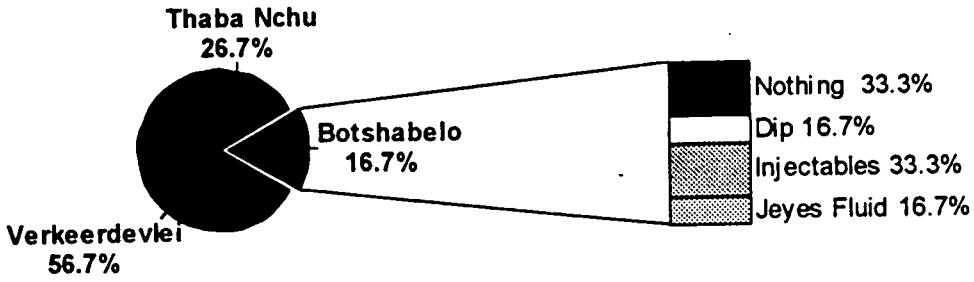


Figure 9.5: Breakdown of control methods for ectoparasites used by small-scale, predominantly black farmers in the Botshabelo region. Botshabelo represents 16.7% of the total number of livestock owners interviewed during the survey.

Significant differences (χ^2 = 24.24, $p<0.001$) occurred between the commercial farmers and the small-scale farmers in terms of the parasite control methods that they used. A very small percentage (30%) of the farmers in the Botshabelo/Thaba Nchu region (n=24) use commercial acaricides. Twenty percent of the farmers in Botshabelo, and 40% of the farmers in Thaba Nchu, indicated that they buy their animal health products at the Sen-Wes Co-op in Bloemfontein. A small percentage (20%) of the small-scale farmers in Thaba Nchu indicated that they use a household detergent, Jeyes fluid (disinfectant and cleanser, carbolic acid coefficient 4 to 6) as an acaricide. According to Dreyer (1997), Jeyes fluid is used separately or in a mixture with used engine-oil to treat scab formations on cattle. All of the Verkeerdevlei farmers indicated that they use commercially available acaricides. The farmers in the Verkeerdevlei district use injectable endectocides (68.2%), commercially available dips (9.1%) and pour-on

(22.7%) compounds (Fig. 9.6). All the farmers in the Verkeerdevlei area indicated that they buy their acaricides at the Sen-Wes Co-op in Bloemfontein.

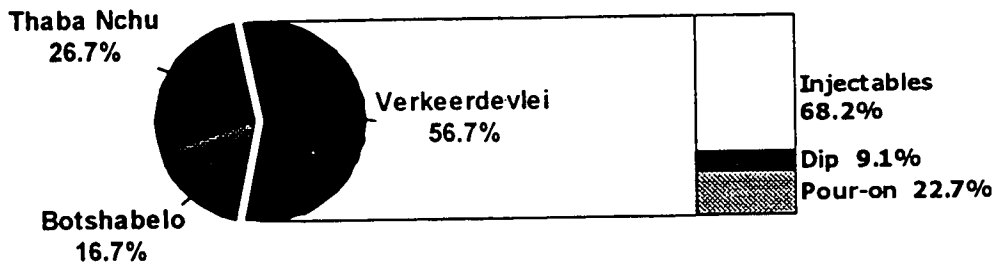


Figure 9.6: Breakdown of ectoparasiticides used by commercial, predominantly white farmers, in the Verkeerdevlei district. Verkeerdevlei represents 56.7% of the total number of livestock owners interviewed during the survey.

Resistance

Twenty three percent of the farmers in the Thaba Nchu area, 27% farmers in Botshabelo and 14.28% of the farmers interviewed in the Verkeerdevlei area admitted that they do not use acaricides at the recommended dosages. Inaccurate application of acaricides can lead to insecticide resistance. Bates (1997b) defined insecticide resistance as: "A decreased susceptibility of an ectoparasite to an insecticide (or acaricide) at

concentrations on or above a defined threshold concentration". Basically this means that if all the instructions are followed to the full and the product is still ineffective, then the parasite can be confirmed as resistant to that product. Organophosphate (OP) resistant strains of *P. ovis* were first identified in Argentina, as long ago as 1970 and since then OP resistance has spread in the U.K., primarily due to poor standards of sheep husbandry (Bates, 1997b). The exact status of chemically resistant strains in South Africa is as yet unknown, but it is possible, due to the short life cycle of *P. ovis*, that chemical resistance can develop fast (Fourie, pers. comm. 1998).

Not all the current insecticides or their methods of application are effective against the scab mite. It is therefore important that the parasite infesting the flock must be professionally identified and the correct, registered treatment administered correctly. The use of products ineffective against scab could select for sheep scab resistance (Bates, 1997b). One of the main reasons for unsuccessful eradication of sheep scab in the Free State is most probably the irresponsible application of acaricides against sheep scab. Farmers tend to treat only those sheep which shows clinical symptoms, and often at half the prescribed recommended dosage (Kitshof, pers. comm. 1998). It is thus possible and highly likely that certain strains of scab mites in South Africa may already be resistant to certain chemicals, such as organophosphates, which have been used for long periods.

Conclusions

In the present questionnaire survey, a basic understanding of the farming conditions, sheep scab prevalence and the attitudes of the farmers concerning sheep scab was sought after. Various problems concerning sheep scab control have been identified, and the absence of a properly functioning extension service has a detrimental effect on the farming communities of Botshabelo and Thaba Nchu. However, each farmer should

accept responsibility for the parasite control, improved husbandry, etc., of his own livestock.

The traditional system of communal grazing rights is in many respects detrimental to livestock farming and to other related agricultural activities. The most important disadvantages of communal grazing in areas such as Botshabelo and Thaba Nchu are the lack of production through enterprise, ties with tradition and prevailing ignorance (Jeppe, 1980). Improved agricultural planning, utilization of grazing lands and field, and the provision of a well-funded properly designed and functioning extension service would help to retain the self esteem of the small-scale livestock owners.

The failure to eradicate sheep scab has been linked to many causes, but the prevalence of the disease can be associated with husbandry methods practiced, the ineffectiveness of the control procedures, inadequate fencing on farms, and negligence. Since farmers who are experienced in sheep husbandry appear to be more aware of the problem of sheep scab, it highlights the importance of conveying the relevant information on sheep scab and its control to small scale and commercial farmers. It is possible to eradicate sheep scab, but all farmers must realize this, and that it is in their power and interest to do so.

Appendix 1

Sheep scab survey: Verkeerdevlei, Botshabelo, Thaba Nchu

1) Locality_____ (B = Botshabelo, T = Thaba Nchu, V = Verkeerdevlei)

Sheep husbandry

2) With which sheep breed do you farm?_____ (M = Merino, D = Dorper)

3) How many sheep do you have? _____

4) Which product/s of the sheep is your main source of income?_____ (1 = Wool, 2 = Meat, 3 = whole sheep)

5) Where do you keep your sheep?
(1 = in yard, 2 = in the veld, 3 = during night in yard during day in veld)

6) Do you feed your sheep any supplements?_____(Y/N)

7) If the previous answer was "Yes", please specify _____

Sheep scab

8) Have you ever had sheep scab on your sheep?_____(Y/N)

9) If previous answer was "Yes":

In what year was it recorded? _____

Did you report the disease? _____(Y/N)

To whom did you report it? _____

Did you notify your neighbours? _____(Y/N)

10) Do you consider sheep scab as a serious disease?_____(Y/N)

Please motivate your answer_____

11) Have you ever transported scabby sheep?_____(Y/N)

12) Do you shear your own sheep?_____(Y/N)

13) Do you hire shearers?_____(Y/N)

14) Do you shear sheep for other livestock owners?_____(Y/N)

15) Are your sheep currently infested with sheep scab mites?_____(Y/N)

Ectoparasite control

16) Do you have any problems with ectoparasites _____(Y/N)

17) If the previous answer was "Yes": At what time of year? _____
(1 = summer, 2 = winter, 3 = autumn, 4 = spring)

18) How do you control the ectoparasites? _____(1 = none, 2 = pour-on, 3 = dip, 4 = injection, 5 = used engine oil, 6 = jeyes fluid)

19) How often do you use control methods? (1 = with high parasite challenge, 2 = once a month, 3 = once a week, 4 = twice a year)

20) Where do you buy treatment compounds? (1 = Co-op Bloemfontein, 2 = Veterinary clinic, 3 = Supermarket Botshabelo)

Resistance

21) Do you always follow the prescribed dosage when you treat animals?
_____(Y/N)

22) Are you aware that organisms can develop chemical resistance?_____(Y/N)

General conclusion

Sheep scab is, on the brink of the year 2000, despite intense efforts to eradicate the disease, still a serious veterinary problem. Not only does it have a detrimental impact on its host, it also has an economic impact and is an impediment to sheep husbandry. Although this study has contributed to our knowledge on *P. ovis*, there are still numerous unknown facets regarding the disease that should be investigated.

The findings on the haematology and serum biochemistry studies are important components in the understanding of the disease process in scab infested sheep. This disease is a vicious one, and eradication will undoubtedly contribute to the overall well being of the host and the prosperity of stockowners. Reduced weight gain, a reduction in fleece weight and quality as well as costs related to chemical prevention and cure can amount to a considerable financial loss to the farmer and inevitably the wool and leather industry. Sheep scab causes an intense irritation to the host and it is arguable that it should be controlled and eradicated on welfare grounds alone.

It has been generally perceived that the sheep scab mite cannot survive the hot summer temperatures. In fact, the present results have shown that the mite survives equally well in both summer and winter. Considering the fact that there is still an inclination to regard sheep scab as a winter disease, the accentuation of this knowledge to all involved in the sheep industry is of the utmost importance.

Farmers introduce sheep that appear normal and free of disease into their flocks, because sheep scab is not always apparent. The reduction in reproduction rate of the mites during summer makes the detection of sheep scab lesions very difficult, but it doesn't necessarily imply that sheep scab is absent from the flock. Prophylactic measures and

early detection of sheep scab are primarily the responsibility of stockowners and farm workers.

The present results indicated that the population increase of the scab mites, which is reflected in the lesion growth rate, was higher in Merino sheep compared to Dorper sheep. In Dorper sheep the disease may in many cases be sub-clinical and farmers may not be able to identify infested sheep. This implies that sheep breed can markedly influence the course of the disease. The rate of population increase and lesion growth on other sheep breeds should also be investigated in order to ascertain their suitability as hosts for *P. ovis*. Except for sheep breed, the mite strain may also have a major effect on the course of the disease manifestation. The pathogenecity of distinct strains can fluctuate and are possibly influenced by several different factors. It is therefore important to investigate all possible influential factors. Due to the above-mentioned factors it is recommended that farmers should quarantine all purchased animals for about eight weeks and treat them with an endectocide registered for sheep scab control. A similar procedure should also be adopted for stray animals.

From the results of the limited inter-host transmission experiments in this study it seems unlikely that Boer or Angora goats can serve as suitable hosts for *P. ovis*. They, however, can potentially serve as mechanical carriers of the mites and when they frequent the same camps as *P. ovis* infested sheep should be treated together with the sheep as a precautionary measure. The difficulty to identify all possible sources of sheep scab infestation is undeniably one of the main reasons for failure to eradicate this disease. Direct contact between individual sheep is generally regarded as the main method of mite transfer, however, birds and wool or hair tufts should not be ignored as possible foci for infestation. Although the results gained during this study have failed to indicate the presence of mites in wool or hair tufts on fences and vegetation, it has been shown (Chapter 7) that mites can survive up to 19 days under certain environmental conditions. It has also been shown that eggs remain viable and can hatch up to 31 days

after removal from the host. If one takes into consideration that the larva may live an additional 14 days it is possible that eggs and the resultant larvae may be an important source of re-infestation. This aspect should be further investigated.

Sheep scab cannot be regarded as isolated cases of outbreaks. This disease involves everyone in the sheep industry, including farm workers, stockowners as well as the wool and leather industry. To accomplish eradication, co-operation between all parties involved is essential. Many possible causes of the failure to eradicate the disease from South Africa can be cited. The nature of the causes and difficulties today is the same as in 1903, but has greatly increased. Difficulties in eradicating this disease include the insufficient fencing of land, ignorance, and failure to muster or gather all sheep for treatment, ineffective treatment, speculative dealers and the illegal transport of scabby sheep. Sheep scab outbreaks can undeniably be related to the movement of sheep through speculative dealers (Borman, pers. comm. 1997) or new sheep farmers who know little about sheep. In addition to this, modern transport allows large numbers of sheep to be moved from one end of the country to the other and scabby sheep can therefore cover vast distances in one day. Stockowners frequently conceal the presence of sheep scab and treat the outbreak themselves (Kitshof, pers. comm. 1998), often in a less than adequate manner. Apprehensions about the effect of the sheep scab law, restrictions on movement of sheep, financial implications due to expensive chemicals for control and even feelings of shame are some of the reasons why farmers conceal outbreaks.

The two main prerequisites for effective control strategies against sheep scab are not always pursued by stockowners. Firstly, it is imperative to properly treat all sheep in a diseased area, but unfortunately this does not always happen. One scab-infested sheep can lead to the re-infestation of the whole flock. Secondly, chemicals for sheep scab control should be applied at the recommended dosage. It is often the case that a less than adequate dosage is given to sheep, especially in the case of injectables, which are

expensive. It is also easy to mistreat a sheep or very often some sheep are not treated at all. Depending on the breed of the sheep and the mite strain, recurrence of the disease may occur within a couple of weeks or even after many months.

To achieve eradication in South Africa the following requirements must be fulfilled:

1) The availability of efficient acaricides to all stockowners including small scale urban and peri-urban farmers;
2) The proper applications of acaricides;
3) Mustering and treatment of all sheep in the diseased area, and at the same time;
4) Maintenance of strict quarantine for treated sheep;
5) Identification of foci of infection;
6) Maintenance of good fence lines;
7) Prosecution of farmers not reporting the disease and;
8) Intensive publicity and educational campaigns in areas of chronic infestations should be initiated followed by the rigorously supervised mustering and treatment of all sheep in that area.

Future research should include a complete national epidemiological study to identify problems with regard to treatment success, treatment methodology, status of resistance to acaricides, source of infestation and cultural differences in sheep husbandry.

In conclusion, during recent years efforts to eradicate sheep scab from South Africa were unsuccessful and many veterinarians believe that the disease is out of control. At present legislation is in place, effective chemicals are available, but husbandry methods and the attitude and level of education of many farmers in South Africa make control difficult, and it seems as though eradication is unlikely. The fact remains, sheep scab is an eradicable disease, but eradication cannot be achieved by legislation alone, it depends on the full co-operation of the farming industry. Eradication is a matter of dogged determination.

Abstract

Keywords: Sheep scab, *Psoroptes ovis*, haematology, serum biochemistry, host body mass, lesion growth, mite longevity.

Sheep scab, which is caused by the mite *Psoroptes ovis*, has been and is still today an impediment to sheep husbandry in many countries throughout the world. Despite the economic impact, sheep scab remains a serious veterinary problem in South Africa. The broad objectives of this study were to determine the adverse effects of *P. ovis* on the host, with special reference to Merino and Dorper sheep, and to examine various possible foci of infestation and host specificity. Furthermore, the effects of abiotic factors (relative humidity and temperature) on the off-host survival of *P. ovis* were determined. The nature and extent of sheep scab in small scale, predominantly black farming communities, were assessed and compared to commercial predominantly white farming communities. The results revealed the following:

With the exception of neutrophils, haematological values remained within the normal range for infested Merino and Dorper sheep, during a 14 week assessment period. For both sheep breeds the albumin and globulin values were higher than the normal range during the entire 14 week observation period. Both sheep breeds displayed a slight decrease in albumin values and a slight increase in globulin values.

At the termination of a 16 week assessment period, uninfested control Merino sheep gained a mean body mass of 3.44 kg which represented a 11.60% increase in body mass, compared to the mean body mass decrease (6.4 kg) of infested Merino sheep. This represented a 23.43% decrease in body mass. The mean body mass of the infested Dorper sheep increased over the 16 week period by 4.56 kg (15.11%) compared to the 5.88 kg (18.28%) of the uninfested control Dorper sheep.

Comparative studies on the rate of sheep scab lesion development indicated that there were profound differences between sheep breed and season. During the summer assessment of 1997 the mean lesion size on the Merino sheep expanded from 1.0 cm^2 at two weeks post infestation to 342.2 cm^2 at eight weeks post infestation, compared to the mean lesion size of 0.406 cm^2 and 59.0 cm^2, respectively, recorded at two and eight weeks post infestation on the Dorper sheep. Lesion growth for both sheep breeds were greater during the winter.

Attempts to artificially infest Boer and Angora goats failed. No clinical signs of sheep scab developed on the goats during a nine week observation period.

When a single artificially infested Merino and Dorper sheep were introduced during winter into a flock of nine uninfested sheep for each breed, it took 14 and 8 weeks, respectively, before all the sheep in the flocks displayed clinical signs of sheep scab. During summer it took 10 and 12 weeks, respectively, before all sheep in the two flocks displayed clinical signs of sheep scab.

All developmental stages of the mites were found in proximal and distal parts of wool / hair tufts clipped from Merino and Dorper sheep. Immature and mature mites were readily transferred to wool / hair tufts placed onto, and later removed from infested sheep, confirming that direct contact between hosts is most probably the main means of transfer.

A maximum mean off-host survival time of 15 days (T = 10°C and RH = 33% and 75%), 10.5 days (T = 10°C and RH = 75% and 90%) and 11.25 days (T = 10°C and RH = 90%) were recorded for nymphs, males and ovigerous females, respectively. The mean egg incubation time varied from 5.9 (±2.58) to 22.14 (±6.53) days. The longest time eggs took to hatch was 31 days (T = 10°C and RH = 75%). The longest mean larval longevity

was 9.25 days (T = 10°C and RH = 90%). Under natural fluctuating conditions ovigerous females in glass vials containing Merino wool survived 20 days, compared to a maximum of 17 days of females in glass vials without Merino wool.

A survey indicated that 36.36% of the sheep flocks in Botshabelo and 38.46% in Thaba Nchu, respectively, were infested with sheep scab. This high incidence was believed to be due to factors such as communal grazing systems, ignorance on the part of the farmers and the lack of financial means to purchase effective remedies to treat their sheep flocks.

Opsomming

Skaapbrandsiek wat deur die myt *Psoroptes ovis* veroorsaak word was van die vroegste tye reeds, en is nog steeds, 'n belemmering vir die skaapboerdery bedryf. Ten spyte van die ekonomiese impak is skaapbrandsiek ook 'n ernstige veeartsenykundige probleem in Suid Afrika. Die oorhoofse doelstellings van hierdie studie was om ondersoek in te stel na die nadelige effek van *P. ovis* op die gasheer, om die moontlike infestasie bronne en ook gasheer spesifisiteit te ondersoek. Voorts is die effek van abiotiese faktore (relatiewe humiditeit en temperatuur) op die oorlewing van *P. ovis* weg van die gasheer vasgestel. Die aard en omvang van skaapbrandsiek in klein, oorwegend swart boerdery gemeenskappe was vasgestel deur fisiese ondersoek en vraelysopnames is ook gemaak en vergelyk met soortgelyke vraelysopnames in kommersiële, oorwegend wit boerdery gemeenskappe. Uit die resultate het die volgende aan die lig gekom:

Met die uitsondering van neutrofiele, was die hematologiese waardes, gedurende 'n 14 week observasie tydperk, vir beide Merino en Dorperskape binne die normale perke. Vir beide skaaprasse was die albumien and globulien waardes deurgaans, gedurende die observasie tydperk, bokant die normale vlakke. Beide skaaprasse het 'n effense afname in albumien waardes, en 'n effense toename in globulien waardes getoon.

Na afloop van 'n 16 week . waarnemingstydperk, het ongeïnfesteerde kontrole Merinoskape 'n gemiddelde liggaamsmassa toename van 3.44 kg (11.60%) getoon, vergeleke met 'n gemiddelde liggaamsmassa afname van 6.4 kg (23.43%) vir geïnfesteerde Merinoskape. Die gemiddelde liggaamsmassa van geïnfesteerde Dorperskape het toegeneem oor 'n 16 week periode met 4.56 kg (15.11%) vergeleke met die 5.88 kg (18.28%) vir die ongeïnfesteerde kontrole Dorperskape.

Vergelykende studies tussen Merino- en Dorperskape ten opsigte van die tempo van skaapbrandsiek letselontwikkeling, het aangetoon dat daar merkbare verskille in die populasie toename van *P. ovis* is. Gedurende die somer waarnemingstyperk in 1997 het die gemiddelde letselgrootte op Merinoskape toegeneem vanaf 1.0 cm^2, twee weke na infestasie, tot 342.2 cm^2 agt weke na infestasie. By Dorperskape is gemiddelde letselgroottes van 0.406 cm^2 en 59.0 cm^2, onderskeidelik, aangeteken twee en agt weke na infestasie. Letsel ontwikkeling was gedurende die winter vinniger vir beide skaaprasse.

Pogings om Boer- en Angorabokke kunsmatig met skaapbrandsiek te besmet, was onsuksesvol. Geen kliniese tekens van skaapbrandsiek het ontwikkel op enige van die twee boksoorte gedurende 'n nege weke observasietydperk nie.

Gedurende winter was alle Merinoskape positief geïnfesteer met skaapbrandsiek 14 weke nadat 'n enkele kunsmatig geïnfesteerde Merinoskaap by 'n trop van nege geplaas is. Agt weke na blootstelling (winter) was al die Dorperskape in 'n soortgelyke trop geïnfesteer. Gedurende somer het dit vir Merino- en Dorperskape 10 en 12 weke, onderskeidelik, geneem voordat al die skape in die trop kliniese simptome van skaapbrandsiek getoon het.

Alle ontwikkelingsstadiums van die myt is op die proksimale en distale wol- of haarsnitte, onderskeidelik, van Merino- of Dorperskape gevind. Volwasse asook onvolwasse myte het geredelik oorgedra na wol- en haarsnitte wat op geïnfesteerde skape geplaas is, en later weer verwyder is. Hierdie resultate bevestig die feit dat direkte kontak tussen diere moontlik die hoof metode is waarvolgens die siekte versprei.

Die langste gemiddelde oorlewings tydperk weg van die gasheer vir nimfe, mannetjies en volwasse wyfies was, 15 dae (T = 10°C en RH = 33% en 75%), 10.5 dae (T = 10°C en RH = 75% en 90%) en 11.25 dae (T = 10°C en RH = 90%), onderskeidelik. Die

gemiddelde eierontwikkelingstyd het gevarieër tussen 5.9 (±2.58) en 22.14 (±6.53) dae. Die langste aangetekende tyd vir eiers om uit te broei was 31 dae by T = 10°C en RH = 75%. Die langste gemiddelde larwale oorlewingstyd was 9.25 dae wat aangeteken is by 10°C en RH = 90%. Onder natuurlik veranderende toestande het volwasse wyfies in glasbuisies waarin Merinoskaapwol ingesluit was, oorleef vir 20 dae, vergeleke met die maksimum oorlewingstyd van 17 dae vir volwasse wyfies in glasbuisies sonder Merinowol.

'n Fisiese ondersoek van verskeie skaaptroppe het getoon dat 36.36% van die skape in Botshabelo en 38.46% in Thaba Nchu, onderskeidelik, positief met die skaapbrandsiekmyt besmet was. Hierdie hoë insidensie kan toegeskryf word aan faktore soos gemeenskaplike weidingsareas, onkunde van die boere en die gebrek aan finasieële vermoëns om effektiewe middels vir die behandeling van die skape aan te skaf.

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