Biology of sheep lice (*Bovicola ovis*)

Peter James
Department of Primary Industries and Fisheries, Queensland

A key element in designing efficient property-specific IPM control programs is a good knowledge of the biology of the target pest. This note provides a summary of the key elements of the biology of sheep lice.

The sheep body louse is a pale yellow insect 1.5–2 mm long with brown transverse stripes on the abdomen and a broad, red-brown head (see Figure 1). It is a chewing louse and feeds on skin scurf, lipid and sweat gland secretions, superficial skin cells and skin bacteria (Sinclair *et al*. 1989). Males are smaller than females and have more pointed abdomens.

Figure 1. Sheep lice females, male, nymphs and egg.

Sheep are also host to three other species of lice. These are sucking lice which feed on blood, appear bluish in colour and have long thin heads. The face louse, *Linognathus ovillus*, occurs mainly on or close to the face and the foot louse, *Linognathus pedalis,* is found on the legs and on the scrotum in rams. *Linognathus africanus*, which can also infest sheep, has been reported from goats, although not sheep, in Australia (O'Callaghan *et al.* 1989). Goat chewing lice, *Bovicola caprae* have been found on sheep paddocked together with goats, but do not appear to breed on sheep (O'Callaghan *et al.* 1988).

Production loss from lice

Infestation with sheep lice can reduce clean wool cut by up to 1 kg per head (Wilkinson *et al.* 1982, Niven and Pritchard 1985). Lice also cause fleeces to become cotted and yellow with reduced yield and increased losses during processing. In New Zealand, sheep lice have been shown to cause a defect in sheep leather known as cockle (Heath *et al.* 1995b). This is manifest as multiple, sometimes discoloured lumps which are visible after processing. Infestation with *B. ovis* does not affect fibre diameter or cause reduction in body weight.

Life cycle

Egg: Females cement individual eggs to wool fibres, most within 12 mm of the skin. For egg laying to occur the temperature must be in the range 35–40°C and a fibre of suitable diameter must be available. A detailed description of the egg laying behaviour of *B. ovis* is given by Murray (1957). Mated and unmated *B. ovis* females deposit approximately the same number of eggs, but unlike cattle lice (*B. bovis*) which can reproduce without mating, *B. ovis* eggs will not hatch if mating has not taken place.

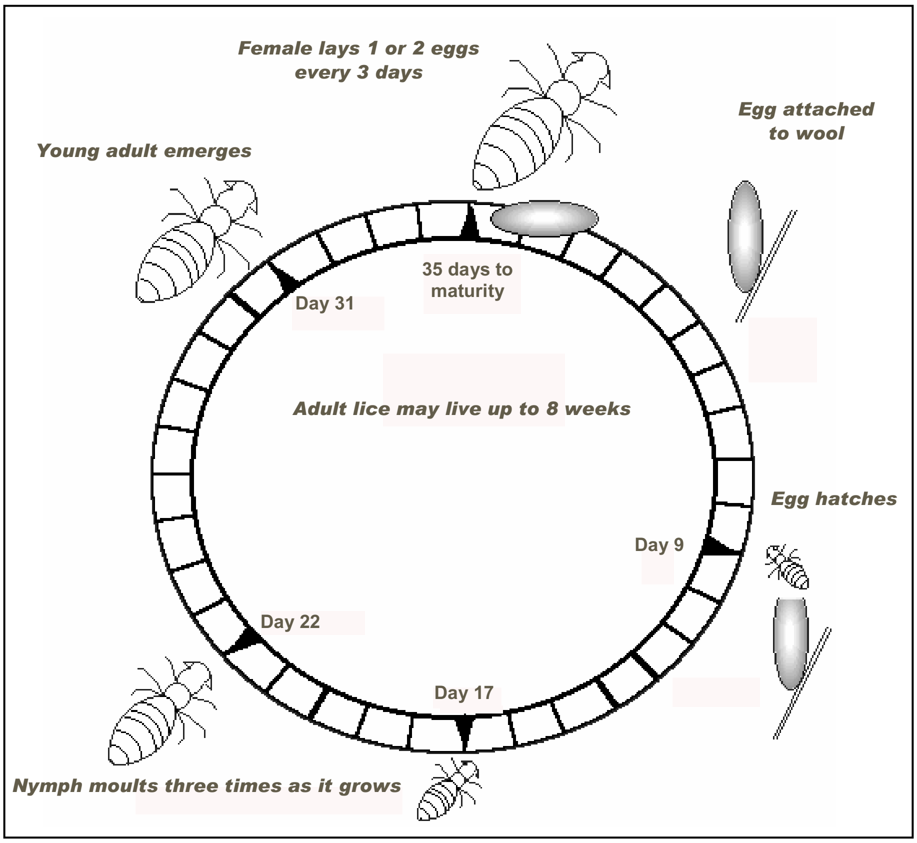

Figure 2. Life cycle of sheep lice.

The eggs are translucent and difficult to see in the fleece. Development occurs only at temperatures between 30°C and 39°C and the incubation period is generally between 9 and 11 days. Temperatures of greater than 45°C will rapidly kill eggs. When eggs were held at room temperature (18–20°C) and then incubated at 32°C and 70% relative humidity, no eggs kept for more than five days hatched and even one day's exposure markedly reduced hatch rate (Murray 1960). Hatching of eggs that are already well advanced in their development is less affected by temperature. Humidity between 7% and 92% has little effect on eggs, but humidity above 92%, as can occur in the fleece after heavy rainfall, prevents hatching. Hopkins and Chamberlain (1972) found that 86% of eggs hatched and 72% developed to adults in laboratory colonies maintained at 35.5–38.5°C and 68% relative humidity.

Nymph: There are three nymphal stages, pale yellow in colour and similar in appearance to the adults except that there are no transverse stripes on the abdomen (Figure 1). The time for the three stages on sheep is approximately 7, 5 and 9 days although observations from colony studies suggest that this may vary. Scott (1952) found that newly hatched nymphs could not be reared through to adults at temperatures below 35°C or above 39.5°C regardless of humidity. Murray (1962) found that immersion for only one hour, as could occur during heavy rainfall, was fatal when followed by 90% humidity for more than 7.5 h but that immersion in water for 4 to 6 hours was required to kill most nymphal and adult lice if they were kept at low relative humidity afterwards.

Adult: Female lice will mate within a few hours of moulting to adults, but do not begin to lay eggs until they are 3–4 days old. Females lay eggs at a maximum rate of about two eggs every three days. Below 37°C eggs do not develop in the female and above 42.5°C no eggs are laid (Murray 1960). There are approximately equal numbers of males and females and the length of a complete life cycle from egg to egg is 34–36 days under normal conditions. Studies with laboratory colonies showed an average adult lifespan of 28 days for females (maximum = 53 days) and 49 days for males (maximum = 74 days) (Hopkins and Chamberlain 1972). The optimum temperature for rearing sheep lice in the laboratory is 36–37°C, which is the approximate skin temperature of sheep under most conditions.

Spread of lice between sheep

Lice move to the surface of the fleece when it is shaded and warm. Transfer between animals occurs when sheep are in close contact. The rate at which transfer occurs will depend on the following factors:

Wool length – Transfer occurs more quickly when sheep have short wool than when the wool is longer. Significant spread can occur in counting out pens after shearing.

Amount of close contact between sheep – Management practices that increase the amount of close contact between sheep, such as frequent mustering or yarding and hand feeding, will increase the opportunity for lice to spread.

Time and strength of the stimulus for lice to move to the fleece surface – If the surface of the fleece is warm and shaded it only takes minutes for lice to be found in the tip wool. If these conditions persist for extended periods more lice will move to the fleece surface and greater numbers of lice can transfer between sheep. Substantial spread can be expected when sheep are held tightly together in sheds or yards.

Weather condition – If ambient temperatures are low most lice will remain near the skin and transfer is unlikely. It is also unlikely that much spread will occur when the surface of the fleece is wet or when the tip of the fleece is very hot from solar radiation.

Density of lice on infested sheep – Greater numbers of lice will find their way to the fleece surface if a sheep is heavily infested and transfer is more likely to occur when another sheep is contacted. If a sheep has only a light infestation it may take many contacts for transfer to take place.

Chemical treatment – Residual chemical from blowfly or louse treatments, if present in sufficient concentration, will kill lice which transfer. Some chemicals may also have a repellent effect on lice.

Sources of infestation

By far the most important source of new infestations is other infested sheep. The two main ways in which a property becomes infested are from sheep which are purchased or brought in from other properties (don't overlook rams) and from stray sheep. Stray sheep may be sheep from other flocks which have entered a mob, or sheep which have strayed, come into contact with other lousy sheep and returned to the mob.

Spread of lice between mobs in adjacent paddocks does not occur readily if sheep do not get through fences. In a South Australian study it was not until 64 weeks after the introduction of two lousy sheep to a clean mob that lice spread to sheep in an adjacent paddock (Cleland *et al.* 1989). However, one can imagine scenarios in which spread across fences occurs more quickly than this, for example where sheep camps in adjacent paddocks are close to each other or where sheep share a common watering point and may come into contact while drinking. Wool caught on fencelines is unlikely to be a source of infestation as most lice drop out of this wool within a few hours (Crawford *et al.* 2001).

Failure to eradicate lice at a previous treatment is also a major reason for infestations. Lice are extremely difficult to detect when in low numbers and when only a few lice survive, it may be many months after treatment before lice become apparent (see below).

Lice are obligate parasites and most die within a week when separated from sheep. However, survival away from sheep for up to 29 days has been recorded (Crawford *et al*. 2001). Although there is a chance of sheep coming into contact with lice in contaminated handling facilities, the number of new infestations beginning from this source is probably low. Lice readily transfer to shearers' moccasins and clothing during shearing and spread between sheds by this means is possible. Microwaving each moccasin in a plastic bag for five minutes will kill all lice (Crawford *et al.* 2001). Sheep lice can also breed on goats (Hallam 1985) but in practical terms goats are unlikely to be important in causing new infestations in sheep.

Build-up in louse numbers

Increase in louse numbers is a function of both transfer between sheep and subsequent build-up in numbers on individual sheep once an infestation has established. Figure 3 shows a typical pattern of increase in numbers of lice in a mob following the introduction of a lousy sheep. In the early stages of an infestation lice numbers increase very slowly and it may take many months for the infestation to become obvious. If the source of the infestation is a sheep where lice were not eradicated by a chemical treatment, spread of the lice over the sheep and to other animals would be delayed until the residual action of the insecticide wore off. It is easily possible to imagine scenarios where the effects of shearing, environmental factors or residual chemical from a previous treatment could prevent a new infestation from being detected for more than 12 months from the initial infective contact.

Once the majority of sheep in the mob have contracted lice, numbers can start to build up very rapidly and substantial wool losses can result if the flock is not treated.

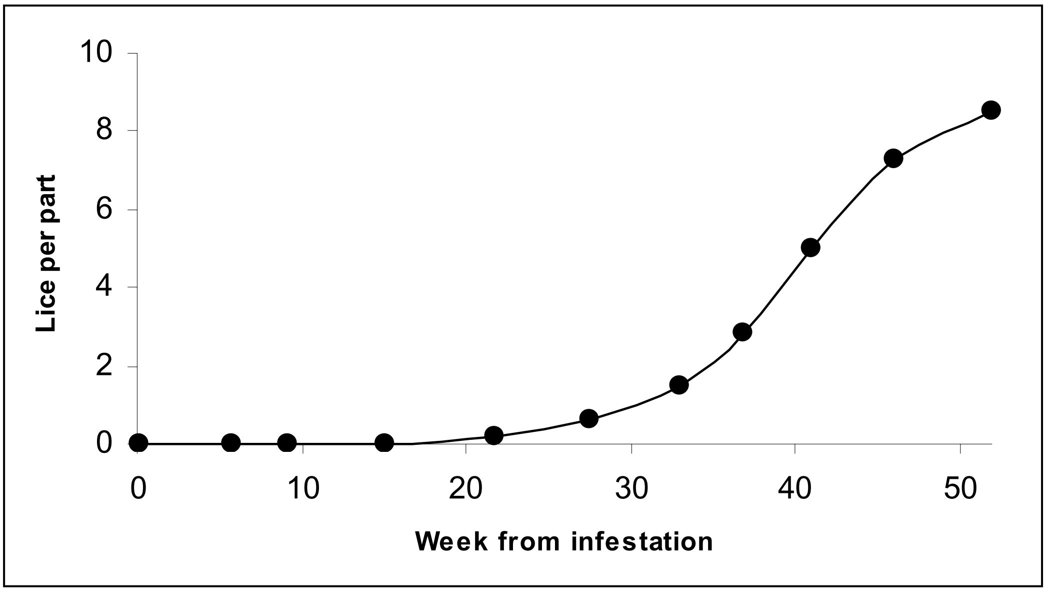

Figure 3. Typical pattern of lice build-up in a mob following contact with a lousy sheep.

A seasonal pattern in louse numbers is often reported with lice building up in winter and spring and declining in summer. This pattern is seen in spring shorn flocks where shearing directly reduces numbers of lice and exposes the remainder of the population to high temperatures and high levels of solar radiation in summer. If sheep are not shorn in spring, louse populations may continue to build up despite high summer temperatures (Wilkinson *et al*. 1982, Niven and Pritchard 1985). James *et al.* (1988) reported cyclic declines in louse numbers which were not associated with shearing, high temperatures or high levels of solar radiation, suggesting that other factors may also be involved in some flocks.

Spatial distribution of lice on sheep

Lice can be found on most woolled areas of sheep although they are rare on the belly and don't appear to breed there. They are not evenly spread but have a clumped or aggregated distribution. At most times of the year densities of lice are highest along the sides and on the back of sheep. Significant numbers of lice can also be found on the head at times, underlining the importance of thorough coverage when dipping sheep or applying backliners. Shearing removes 30–50% of lice and causes further mortality by exposing the remaining population to environmental factors, but also alters the distribution of lice.

After shearing a greater proportion of the population are found at sites on lower body regions such as under the neck, lower flanks and upper legs and in areas where the wool has not been closely shorn (James *et al.* 1999). It is therefore particularly important that effective concentrations of insecticide are applied to these regions to gain good effect from post-shearing treatments and to prevent the development of resistance. When sheep are not thoroughly treated, lice may be confined to untreated areas or areas of low lousicide concentration. Once the residual effects of the chemical wane the lice can spread over the remainder of the body and to other sheep.

When inspecting sheep for lice, at most times of the year greatest attention should be paid to the sides and back of the sheep. However, soon after shearing inspections should also include the neck and lower body regions and areas where longer wool has been left. It should be noted that the chance of detecting lice in the early stages of an infestation is very low. For example, for a sheep with 10 lice, the probability of detecting the infestation by inspecting 10 parts is less than 5%. Even with 40 parts the probability is less than 20% (James *et al.* 2002). If this sheep is running in a mob with many other louse free sheep the chance of both choosing the infested sheep and then finding lice on it once it is selected is extremely low indeed. However, rubbing is a powerful indicator of infestation and choosing a sheep with rubbed fleece greatly increases the likelihood of detection (James *et al*. 2007).

Under most conditions more than 70% of nymphs and 60% of adults are found within 6 mm of the skin surface. However, when the fleece is shaded and warm lice will move up to the fleece tip. All instars of lice can be found in the tip wool at times, but most are adults or third instar nymphs (Murray 1968).

Factors affecting louse numbers

Time from infestation – Usually a sheep becomes infested by transfer of one or a few lice during contact with another infested sheep. Increase in lice numbers occurs very slowly in the early stages of an infestation and it can take many months for numbers to build up to levels where lice are easily found.

Shearing – Shearing directly removes 30–50% of lice and many more die subsequently because of exposure to environmental influences. Louse numbers are lowest 30 to 60 days after shearing.

Temperature – Optimum temperature for *B. ovis* is between 37°C and 39°C. Environmental conditions which subject lice to temperatures outside of this range reduce louse reproduction. Exposure to 48°C for 60 min., 50°C for 30 min. or 55°C for 5 min. kills all nymphal and adult stages of lice and most eggs (Murray 1968).

Solar radiation – High solar radiation can cause temperature gradients in the fleece from 70°C at the fleece tip to 45°C near the skin within 5 to 10 minutes of exposure. This has severe effects on louse populations, especially if the wool is short. Murray (1968) suggests that significant mortalities may also be caused by rapid reversal of temperature gradients in the fleece as sheep walk from shade into sunlight. Lice become disoriented, stranded in the distal part of the fleece, and are killed as lethal temperatures develop.

Rainfall – If the fleece remains saturated for more than six hours many nymphs and adults can drown and hatching of eggs is inhibited. Reductions in louse numbers in excess of 90% following a thunderstorm have been demonstrated (Murray 1963).

Sheep susceptibility to lice – Susceptibility is affected by the following factors (James *et al.* 1998):

> *Breed*: There are large differences between breeds in susceptibility. Merinos appear to be more susceptible than many other breeds.
>
> *Differences among sheep within breed*: Individual sheep also vary in susceptibility. Some sheep do not become infested despite repeated challenge.
>
> *Age*: Lambs are more susceptible to lice than older sheep. This emphasises the need to avoid running untreated lambs together with recently treated ewes.
>
> *Sheep health and nutrition*: Heaviest infestations of lice are found on lambs with low growth rates and sheep under stress from poor nutrition or disease.

Sheep response to lice

Lice stimulate a number of responses in sheep. First, they cause pruritic behaviour (rubbing, biting and scratching). This is a major reason for reduction in wool cut and quality. There is a clear relationship between rubbing and lice, particularly in the early stages of an infestation (James and Moon 1988). Sheep begin to rub at very low louse levels, well before lice can be readily found by direct inspection (James *et al*. 2007). However, when sheep have been infested for some time the relationship is not as strong. It is likely in long standing infestations on individual sheep that immune responsiveness is a more important determinant of the amount of rubbing than numbers of lice per se. Other factors such as grass seeds, itchmite, and fleece rot can cause rubbing (Johnson et al. 1993) and for this reason diagnosis of louse infestation should not be made on the basis of rubbing alone. Definitive diagnosis requires the detection of lice.

Lice also cause an increase in the amount of scurf (dandruff like material) on the skin, thickening of the uncornified epidermis, the stratum corneum and the surface lipid layer of the skin and a number of other skin changes (Britt *et al*. 1986, Heath *et al.* 1995a). As cells from the surface layers of the skin and lipid are major components of the louse diet, this may provide an enhanced feeding environment for lice.

There is now good evidence that sheep lice stimulate an immune response in sheep, despite their surface feeding habit. This is manifest in hypersensitive (allergic) skin response, increase in serum antibodies and cellular responses (Bany *et al.* 1995, James and Moon 1998, James *et al.* 1998). Hypersensitive response is important in the development of cockle and almost certainly plays an important part in stimulating rubbing, biting and scratching. There is also evidence that immune response may be involved in regulating louse numbers and may underlie differences amongst sheep in susceptibility to lice (James 1999, James *et al.* 2002). Impaired immune response may explain the greater susceptibility to lice of animals in poor condition or under stress.

References

Bany, J., Pfeffer, A. and Phegan, M.D. (1995). Comparison of local and systemic responsiveness of lymphocytes *in vitro* to *Bovicola ovis* antigen and concanavalin A in *B. ovis*-infested and naive lambs. *International Journal for Parasitology* **25**: 1499-1504.

Britt, A.G., Cotton, C.L., Pitman, I.H. and Sinclair, A.N. (1986). Effects of the sheep-chewing louse (*Damalinia ovis*) on the epidermis of the Australian Merino. *Australian Journal of Biological Science* **39**: 137-143.

Cleland, P.C., Dobson, K.J. and Meade, R.J. (1989). Rate of spread of sheep lice (*Damalinia ovis*) and their effects on wool quality. *Australian Veterinary Journal* **66**: 298-299.

Crawford, S., James, P.J. and Maddocks, S. (2001). Survival away from sheep and alternative methods of transmission of sheep lice (*Bovicola ovis*). *Veterinary Parasitology* **94**: 205-216.

Hallam, G.J. (1985). Transmission of *Damalinia ovis* and *Damalinia caprae* between sheep and goats. *Australian Veterinary Journal* **62**: 344-45.

Heath, A.C.G., Cole, D.J., Bishop, D.M., Pfeffer, A., Cooper, S.M. and Risdon, P. (1995a). Preliminary investigations into the aetiology and treatment of cockle, a sheep pelt defect. *Veterinary Parasitology* **56**: 239-254.

Heath, A.C.G., Cooper, S.M., Cole, D.J. and Bishop, D.M. (1995b). Evidence for the role of the sheep biting-louse *Bovicola ovis* in producing cockle, a sheep pelt defect. *Veterinary Parasitology* **59**: 53-58.

Hopkins, D.E. and Chamberlain, W.F. (1972). Sheep biting louse: Notes on the biology of lice reared off the host. *Annals of the Entomological Society of America* **65**: 1182-1183.

James, P.J. (1999). Do sheep regulate the size of their mallophagan louse populations? *International Journal for Parasitology* **29**: 869-875.

James, P.J., Bartholomaeus, F.W. and Karlsson, L.J.E. (2007). Temporal relationship between infestation with lice (*Bovicola ovis* Schrank) and the development of pruritic behaviour and fleece derangement in sheep. *Veterinary Parasitology* **149**: 251-257.

James, P.J., Carmichael, I.H., Pfeffer, A., Martin, R.R. and O'Callaghan, M.G. (2002a). Variation among Merino sheep in susceptibility to lice (*Bovicola ovis*) and association with susceptibility to trichostrongylid gastrointestinal parasites. *Veterinary Parasitology* **103**: 355-365.

James P.J., Garrett, J.A. and Moon, R.D. (2002b). Sensitivity of two stage sampling to detect sheep biting lice (*Bovicola ovis*) in infested flocks. *Veterinary Parasitology* **103**: 157-166.

James, P.J. and Moon, R.D. (1999). Spatial distribution and spread of sheep biting lice, *Bovicola ovis*, from point infestations. *Veterinary Parasitology* **81**: 323-339.

James, P.J., Moon, R.D. and Brown, D.R. (1998). Seasonal dynamics and variation among sheep in densities of the sheep biting louse, *Bovicola ovis*. *International Journal for Parasitology* **28**: 283-292.

James, P.J. and Moon, R.D. (1998). Pruritis and dermal response to insect antigens in sheep infested with *Bovicola ovis*. *International Journal for Parasitology* **28**: 419-427.

James, P.J., Moon, R.D. and Ragsdale, D.W. (1998). Skin surface antibodies and their associations with sheep biting lice, *Bovicola ovis*, on experimentally infested sheep. *Medical and Veterinary Entomology* **12**: 276-283.

Johnson P.W., Boray, J.C., Plant, J.W. and Blunt, S.C. (1993). Prevalence of the causes of fleece derangement among sheep flocks in New South Wales. *Australian Veterinary Journal* **70**: 220-224.

Murray, M.D. (1957). The distribution of the eggs of mammalian lice on their hosts: II. Analysis of the oviposition behavior of *Damalinia ovis* (L.). *Australian Journal of Zoology* **5**: 19-29.

Murray, M.D. (1960). The ecology of lice on sheep: II. The influence of temperature and humidity on the development and hatching of the eggs of *Damalinia ovis* (L.). *Australian Journal of Zoology* **8**: 357-362.

Murray, M.D. (1963). The ecology of lice on sheep: V. Influence of heavy rain on populations of *Damalinia ovis*. *Australian Journal of Zoology* **11**: 173-182.

Murray, M.D. (1968). Ecology of lice on sheep: VI. The influence of shearing and solar radiation on populations and transmission of *Damalinia ovis*. *Australian Journal of Zoology* **16**: 725-738.

Niven, D.R. and Pritchard, D.A. (1985). Effects of control of the sheep body louse (*Damalinia ovis*) on wool production and quality. *Australian Journal of Experimental Agriculture* **25**: 27-31.

O'Callaghan, M.G., Moore, E. and Langman, M. (1988). *Damalinia caprae* infestations on sheep. *Australian Veterinary Journal* **65**: 66.

O'Callaghan, M.G., Beveridge, I., Barton, M.A., McEwan, D.R. and Roberts, F.H.S. (1989). Recognition of the sucking louse *Linognathus africanus* on goats. *Australian Veterinary Journal* **66**: 228-229.

Scott, Marion T. (1952). Observations on the bionomics of the sheep body louse (*Damalinia ovis*). *Australian Journal of Agricultural Research* **3**: 60-67.

Sinclair, A.N., Butler, R.W. and Picton, J. (1989). Feeding of the chewing louse *Damalinia ovis* (Shrank) (Phthiraptera:Trichodectidae) on sheep. *Veterinary Parasitology* **30**: 233-251.

Wilkinson, F.C., de Chaneet, G.C. and Beetson, B.R. (1982). Growth of populations of lice, *Damalinia ovis*, on sheep and their effects on production and processing performance of wool. *Veterinary Parasitology* **9**: 243-252.