Blowfly strike: biology, epidemiology and control

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Blowfly strike is one of the most unpleasant yet familiar annual problems that sheep farmers need to deal with. Strike causes significant welfare problems for sheep and costs for farmers in terms of both time and money. The development of good prevention strategies is an important opportunity for sheep veterinarians to engage with their clients; this requires a clear understanding of the scope of the problem and the challenge it presents. This article explains the biology of the blowfly, the risk factors and how to control strike. It also considers the costs involved in managing this problem.

Biology of blowflies and sheep strike

In most of the UK, the main species of blowfly that infests sheep is the common greenbottle, *Lucilia sericata*. In the north and west of the country, there may be an increase in the numbers of secondary fly species also present, predominantly *Lucilia caesar* and *Protophormia terraenovae* (Morris and Titchener 1997).

Adult female *Lucilia* flies deposit batches of about 200 eggs in the wool (Wall 1993). After hatching from the egg, first stage larvae migrate down the wool fibres to the skin. The larvae moult twice during their development. Feeding is assisted by proteolytic enzymes, which initiate external digestion of the host's tissue and, in the second and third stage larvae, also by mouth hooks which abrade the skin surface, rapidly leading to skin damage. Mature third stage larvae cease feeding and enter a dispersal (wandering) phase, in which they drop from the host and migrate, before pupating in the soil, before adult emergence (Fig 1). At skin surface temperatures, eggs hatch after 12 to 24 hours and the larvae feed for about three days before dispersing (Wall and others 1992). It is this high rate of development on the host that accounts for the fact that apparently clean sheep seen one day may be heavily infested one or two days later and which therefore necessitates daily flock inspection.

The blowfly strike problem is very widespread in the UK; it affects more than 75 per cent of farms, where an average of 1.5 per cent of ewes and 3 per cent of lambs may be struck in an average year, despite the use of prophylaxis by most farmers (French and others 1992, Bisdorff and others 2006). The economic cost of flystrike to the UK sheep industry is considerable as it includes mortality, production losses, hide and wool damage, treatment and control costs, as well as the time and labour involved in the frequent inspection of flocks.

Most strikes occur in the anal-perineum area (breech), but strike to the neck, shoulders, back and withers (body) is also important. The larvae from a single oviposition may produce few overt clinical signs and are often difficult to detect (Fig 2). Significant clinical damage results from the fact that, once initiated, an infestation of feeding larvae creates a powerful odour which attracts other gravid females, and multiple oviposition can then occur rapidly with high numbers of larvae present. When infested by large numbers of larvae, sheep experience increases in temperature and respiratory rate accompanied by a loss of weight and appetite, anaemia and chronic ammonia toxaemia, leading to depression followed by death, if left untreated.

Risk factors for blowfly strike

The incidence of strike is determined by two groups of factors: those that influence sheep susceptibility and those that affect fly abundance (Box 1). However, it is often difficult to disentangle the various individual factors that act together to influence the overall pattern of risk and of strike incidence, particularly because different risk factors affect the position on the body – breech, body or foot (Fig 3), the age class of animal (lamb or ewe), or the time of year when it occurs. Furthermore, the importance of the various risk factors will change dynamically over time.

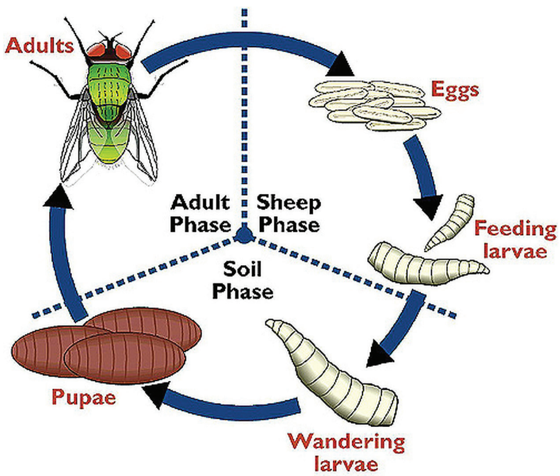

Fig 1: Life cycle of *Lucilia sericata*, the main species of blowfly that infests sheep

Fig 2: Blowfly strike can be hard to detect; however, larvae may be seen, as in this case of fly strike showing fully fed third stage larvae

Fig 3: *Lucilia* maggots in the interdigital space of a foot with foot rot (Photograph: Emily Reeves)

Physical conformation

Sheep susceptibility to strike is affected by a wide range of physical attributes. The condition of the fleece and its capacity to retain moisture, the degree of skin folding in the breech and the formation of the vulva may all be important. Wool length and quality have been identified as major risk factors. In general, sheep breeds with a more open fleece would be expected to have lower humidity at the skin surface, to dry more rapidly and hence to have a lower susceptibility to strike. The relationship between strike and wool length may, however, be difficult to identify because it is frequently confounded by factors such as faecal soiling (French and Morgan 1996).

Shearing was shown to be associated with a 95 per cent reduction in the risk of ewe strike by *L sericata*, and again this was considered to be largely the result of reduced humidity in the fleece of the shorn animal (Broughan and Wall 2007a). The presence and length of a tail have also been recognised as important risk factors for strike; strike incidence was shown to be over five times higher in lambs where the tail had not been removed, compared to docked lambs (French and others 1994).

Faecal soiling

Faecal soiling (Fig 4) has been recognised as a primary risk factor for breech strike (French and Morgan 1996, Broughan and Wall 2007b). The odour of a faecally soiled fleece attracts gravid blowflies to oviposit and this area provides a warm, humid environment for the blowfly larvae to develop. The degree of faecal soiling in the breech region of the lamb is affected by at least two groups of factors: those that affect the consistency of the faeces, and those which encourage its accumulation in the breech region, such as fleece length. Faecal consistency appears to be the most important cause of faecal soiling; lambs with watery faeces have been found to be 8.5 times more likely to be struck than lambs with solid faeces (French and Morgan 1996). The importance of gastrointestinal nematodes in relation to faecal soiling and its effect on breech strike has been clearly demonstrated (Broughan and Wall 2007b).

Box 1: Factors affecting the risk of strike

Strike risk is increased by:
- Warm weather
- High humidity (summer rain)
- Undocked tails (in lowland flocks)
- Faecal soiling (daggy sheep)
- Lowland flocks
- High blowfly numbers
- Foot rot
- Head wounds in rams
- Thick fleeced breeds
- Lack of preventive insecticide use

Strike risk can be reduced by:
- Good parasitic worm control
- Tail docking (in lowland flocks)
- Dagging & crutching
- Foot rot control
- Shearing
- Frequent flock inspection, especially at high risk times
- Appropriate insecticide use

Weather

Weather conditions are known to have a major multifactorial influence on the incidence of strike. The activity and oviposition rates of adult blowflies are strongly related to temperature and humidity (Pitts and Wall 2004). The survival of first stage larvae in the fleece is also increased at humidities above 65 per cent. Fleece humidity is, in turn, largely determined by ambient humidity, rainfall and fleece length (Wall and others 2001). In the UK, a strong relationship between the incidence of total blowfly strike and mean weekly temperature has been demonstrated (French and others 1995). However, the relationship is complex. The distribution of strikes in lambs has been found to change over time, with breech strikes predominating in May, June and July, and body strikes occurring increasingly later in the season (Broughan and Wall 2007a). In the latter study, the incidence of lamb breech strikes was not significantly associated with weather conditions, and appeared to be more strongly determined by patterns of faecal soiling (Broughan and Wall 2007a). In contrast, the incidence of strike on the body was significantly associated with higher blowfly abundance, higher rainfall and higher maximum temperatures.

Fly abundance

Significant relationships between fly abundance and strike incidence have been demonstrated (Broughan and Wall 2007a). However, again, the relationship is complex and interacts with a wide range of the other factors which affect susceptibility. Under highly seasonal northern European conditions, at the start of the summer, relatively low *L sericata* abundance may be the main factor limiting

Fig 4: This Suffolk ram lamb has extensive faecal soiling and so is at increased risk of breech strike at a risk time of year

Fig 5: This Swaledale lamb has been 'dagged' around the breech and had fly repellent applied

strike incidence (Smith and Wall 1998) and oviposition will occur only on the most highly susceptible animals, which are those that are most heavily faecally soiled. During the summer, as fly abundance increases, ewes are sheared which reduces their susceptibility. However, for lambs, their wool grows, increasing susceptibility, and they begin to scour as they ingest increasingly large nematode burdens. Hence, the high fly challenge is focused increasingly on lambs and the incidence of both breech and body strikes increases.

Strike control

Since the incidence of ovine cutaneous myiasis is determined largely by two factors – the number of susceptible sheep and the number of flies available to oviposit – to control fly strike two strategies can be considered. These are reducing sheep susceptibility and reducing fly abundance to a level that significantly reduces blowfly strike challenge. These strategies are not necessarily mutually exclusive.

Mechanical control

Reductions in sheep susceptibility may be effected first by reducing the suitability of the fleece for oviposition and larval survival. At its simplest, this may be effected by maintaining established breeds of sheep with more open, hairy or self-shedding coats. The reduction in susceptibility to strike may also be brought about by mechanical means. Dagging (Fig 5), the removal of faecally soiled wool, and crutching, the regular shearing of wool from around the breech, may both reduce susceptibility to strike by eliminating suitable oviposition sites. Similarly, strike susceptibility is reduced in ewes following annual shearing. Surgical practices, such as tail docking, will also reduce the incidence of strike (French and others 1994).

Chemical control

Blowfly strike is currently controlled primarily through the prophylactic and therapeutic use of neurotoxic insecticides (Bates 2004, Bisdorf and Wall 2008). These include the organophosphate diazinon and the pyrethroids high cis-cypermethrin, alpha-cypermethrin and deltamethrin (Table 1). Of increasing importance over recent decades, however, are the insect growth regulators (IGRs) cyromazine and dicyclanil. Other IGRs, such as diflubenzuron, are not available for blowfly control in the UK. IGRs are arthropod-specific compounds that interfere with cuticle formation and chitin synthesis and thus disrupt the larval moulting process. On IGR-treated sheep, egg batches are still deposited, eggs hatch and first stage larvae start to feed, but then they die as they reach their first moult. Hence, while they can provide effective strike prevention, IGRs are not an effective treatment for established strikes (Graf 1993).

Cyromazine has been shown to provide a 90 per cent reduction in strike in lambs for up to nine weeks and an 80 per cent reduction between 10 to 12 weeks in England (Lonsdale and others 2000), although it is becoming less available in the UK. Dicyclanil, has in vitro activity against dipteran larvae more than 10-fold higher than cyromazine, and can provide substantially longer protection against flystrike, depending on its formulation (Graf 1993, Schmid and others 1999) and due, in part, to the oily vehicle that binds it to wool grease. A 100 per cent reduction in blowfly strike for up to 16 weeks after application was recorded in the Netherlands after sheep were treated with dicyclanil (Schmid and others 1999); even 22 weeks after application, the number of strikes in a dicyclanil-treated flock were reduced by 89 per cent (Lonsdale and others 2000). Anecdotally, farmers complain that these products do not give the duration of protection in the field, but generally in such cases pharmacovigilance investigations indicate poor application of product and/or periods of particularly prolonged summer rain. Indeed, it is worth considering the EMEA guidelines (EMEA 2002) which only require ectoparasites given to sheep to have 90 per cent efficacy (other than for *Psoroptes ovis* where 100 per cent efficacy is required). This means that, even under controlled field efficacy trials, it is always possible for a sheep to be struck within the protective period stated on the data sheet.

Although increasing numbers of farmers use IGRs (40 per cent in 2003 [Bisdorf and Wall 2008]), for strike control there are still large numbers that use synthetic pyrethroids (SP) (35 per cent in 2003) and even a proportion

Table 1: Products available in the UK for the prevention of fly strike (also showing the duration of their activity preventing headfly and other ectoparasites)

Trade name	Active ingredient	Blowfly prevention	Headfly prevention	Lice	Scab	Ticks	Meat withdrawal
Vetrazin (Novartis)	6% cyromazine	10 weeks	Insect growth regulator (disrupts larval development); not effective against other ectoparasites; prevention only against blowfly, not treatment.				28 days
Clik (Novartis)	5% dicyclanil	16 weeks	Insect growth regulator (disrupts larval development); not effective against other ectoparasites; prevention only against blowfly, not treatment.				40 days
Clikzin (Novartis)	1.25% dicyclanil	8 weeks	Insect growth regulator (disrupts larval development); not effective against other ectoparasites; prevention only against blowfly, not treatment.				7 days
Dysect (Zoetis)	Alpha-cypermethrin 12.5 mg/ml Pour on	8 to 10 weeks	6 weeks	Best off-shears or at least less than 30 days since shearing	No	8 to 12 weeks	28 days
Crovect (Novartis) Ectofly (Bimeda)	High cis-cypermethrin 12.5 mg/ml Pour-on	6 to 8 weeks	3 weeks	Best off-shears or at least less than 30 days since shearing	No	6 to 8 weeks	8 days
Spotinor (Norbrook) Spot On (Zoetis)	Deltamethrin 10 mg/ml	No prevention; treatment only	Possibly 2 weeks but not mentioned on data sheet; 4 to 6 weeks in cattle	Best off-shears or at least less than 30 days since shearing	No	4 to 6 weeks	35 days
Osmonds Gold Fleece (Bimeda) Paracide 62 (Animax)	Diazinon dip	8 to 10 weeks	Little residual protection	Good	3 weeks if fleece is more than 1 cm	4 weeks (possibly 8 weeks in ewes, 2 to 3 weeks in lambs)	49 days 70 days

that summer-dip in organophosphate (12 per cent in 2003) despite increasing public and legislative concern for operator and environmental safety.

To date, no resistance in *L sericata* populations in the UK, to any insecticides, has been formally recorded despite anecdotal farmer reports of maggots that have appeared to survive direct application of synthetic pyrethroid. It is likely that there are sufficient reservoir populations of flies to minimise this risk.

Trapping

Despite the relatively high rates of reproduction achieved by species of *Lucilia*, odour-baited catching devices for the control of blowfly strike may make an effective contribution to strike control. In early studies, carrion-baited targets were used to suppress fly populations (Smith and Wall 1998). More recently, non-return insecticide-free sticky-traps for *L sericata* baited with rehydrated freeze-dried liver were shown to reduce the incidence of strike for ewes and lambs on farms in south west England to a fifth of that seen in untreated the control flocks (Broughan and Wall 2006). Simulation modelling has suggested that, in seasonal environments, early deployment of traps at a time of year when fly densities are low may be the most effective approach to their use.

Making a home-made trap is a relatively simple procedure, using two 2-litre plastic drinks bottles, one clear and one brown (Fig 6). A 1 cm^2 hole is cut in the lid of the brown bottle and three cross-shaped cuts are made equally spaced around this bottle, about 4 cm above the base. Each cut of the cross should be 1.5 cm long and the triangular flaps pushed inwards. A bait of chopped offal is poked through these holes to lie at the bottom of the brown bottle. The base is cut off the clear bottle so that the top can be fixed over the top of the brown bottle and fastened with tape. Flies enter the brown bottle through the cross-shaped holes, attracted by the bait (which must be kept moist). They leave through the hole in the lid, to be trapped in the clear bottle. Trapped flies can be emptied through the lid of the clear bottle. Due to the later emergence of *L sericata* compared to *L caesar* and the similar appearance

Fig 6: A home-made trap for blowflies is easy to make, using two 2-litre plastic drinks bottles, one clear and one brown. Offal is placed in the bottom of the brown bottle and cross cuts are made to allow the flies in. The flies will be trapped in the top clear bottle, from which they can be easily disposed of

Box 2: Predicting the start of the blowfly season

Predicting the start of the blowfly season is a relatively straightforward procedure using a max-min thermometer. Place the thermometer outside, away from the shelter of buildings. Each day starting in January, add together the daily maximum and minimum temperature, divide by two and subtract nine. Add together all the positive daily totals. The date on which they reach 150 should give a sufficiently accurate prediction of the start of the blowfly season and indicate the need to consider taking preventive measures.

of other common flies, it is not advisable to use traps to predict the start of the blowfly risk period (Box 2).

Cost of control

The cost of control strategies can be assessed using a simple spreadsheet model – for example, for a farm with 250 ewes, lambing in March, with an output of 1.5 live lambs per ewe. For this analysis, it is assumed that the death rate for struck animals is 5 per cent and the total cost of a breeding replacement ewe is £200 per animal (after factoring in vaccinations, transport, etc). The average loss per lamb that dies from strike is assumed to be £80. Given that struck animals need to be located, caught and then treated, it is assumed that the labour cost to handle each struck animal is £10 and the treatment cost is £0.50. There is a lack of published data on the costs of production losses due to blowfly strike; in this model, it was estimated that struck lambs might suffer a £10 production loss, although no figure was put on the ewe loss of production. Hence, the costs of clinical cases are likely to be conservative estimates of the actual costs.

Using published data on strike risk and fly abundance patterns in the UK, with no prophylactic treatment applied, in a moderate risk area, this flock might expect 19 ewe strikes with one death and 23 lamb strikes with two deaths over the entire season. Hence, the costs of not treating are £200 and £160 for ewe and lamb deaths, respectively, £437 for labour and reactive treatment and £230 in lamb production losses, giving a total cost of £1027.

We can then simulate the impact of different treatment products, applied at different times (Table 2). Product A is assumed to give 16 weeks protection and product B gives eight weeks' protection. It is assumed that indicative costs of treatment for ewes/lambs respectively for product A are £1.25/£0.90 and for B are either £0.90/£0.70 or £0.60/£0.30, in the latter case depending on whether an IGR or SP is used.

Even with the longer-acting treatment applied to ewes off shears (strategies 2 and 3), some ewe strikes are to be expected because animals will be struck either before shearing or in some cases late in the season when the product is no longer effective. Lamb treatments have a particularly significant effect on strike and cost reduction (strategies 3, 4, 5, and 6). The most cost-effective approach highlighted in this analysis (strategy 5) is to treat ewes at the start of the season (usually May) before shearing with the short-acting product and then treat the lambs in May with the longer-acting product. Following this strategy, it would be expected that there would be only nine ewe strikes (most later in the season) and two lamb strikes, with no deaths. For the most part, ewes post-shearing are protected by their shorter fleece, but to minimise strike over the course of the year, a second ewe treatment (strategy 6) could be added after shearing, and this would be particularly important if the weather was warm and wet going into autumn, as might be expected to become more common (discussed below). Minor changes in the precise figures used for treatment costs or expected losses make little difference to the relative rank order of the cost of the different treatment strategies. Clearly, while financial costs are informative, there are also significant welfare considerations to be factored into any treatment decisions.

This compelling financial analysis, together with the evidence showing a reduction in clinical cases following an early ewe treatment (Walters and Wall 2012), suggests that far more farmers should adopt this strategy rather than waiting until cases of strike are spotted. It is worth discussing a suitable product for the treatment of fully-fleeced ewes. There is potentially a residue and efficacy issue with applying a synthetic pyrethroid pour-on to a long fleece, which makes it preferable to use the shorter duration IGR. This is a very safe product which is fully licenced to use pre-shearing, although it is advisable to ensure that it is applied at least eight weeks in advance as some people develop an itchy rash when handling treated sheep.

Table 2: Comparative costs of treatment, losses and labour required under different strike prevention strategies in a moderate strike risk area, with the predicted numbers of lambs and ewes struck and expected deaths. Costs are for IGR treatment or, in parenthesis, where a replacement SP product B is used

Treatment strategy	Cost (£)	Number of struck ewes	Number of struck lambs	Number of ewe deaths	Number of lamb deaths
(1) No treatment	1027	19	23	1	2
(2) Treatment A ewes only (off shears), no lamb treatment	1028	7	24	0	2
(3) Treatment A both ewes (off shears) and lambs (May)	764	7	2	0	0
(4) Treatment A lambs (May), no ewe treatment	778	19	2	1	0
(5) Treatment B ewes (pre-shear), treatment A lambs (May)	698 (623)	9	2	0	0
(6) Treatment B ewes pre-shear and then treatment A after shear, treatment A lambs (May)	958 (883)	4	2	0	0

IGR Insect growth regulators, SP Synthetic pyrethroids

Fig 7: Two lambs treated for breech strike by the usual method of clipping away wool around the struck area and the direct application of a synthetic pyrethroid. It is not hard to see how strike causes a considerable growth check in growing lambs

Future for blowfly strike

Sheep susceptibility, fly abundance and fly activity are, as described above, all strongly influenced by weather conditions. Hence, strike incidence would be expected to be highly sensitive to even relatively small changes in climate. In temperate environments, the range of elevated temperatures predicted by current climate change scenarios are likely to result in elongated blowfly seasons with earlier spring emergence and a higher cumulative incidence of strike leading ultimately, as is already seen in some parts of Australia, to the year-round presence of blowflies (Rose and Wall 2011). Strike risk is also likely to increase for sheep grazed at higher altitudes and higher latitudes, where lower temperatures currently offer protection from challenge. The combination of warm, wet winter conditions and fully-fleeced wet sheep, could potentially lead to very significant increases in the incidence of myiasis.

Conclusion

Sheep farmers adopt a range of approaches to the type and timing of the management used for the control of blowfly strike, the rational basis for which is often not well evaluated. Selection of the most appropriate blowfly management strategy, particularly in relation to insecticide application, is important because it will help to minimise disease incidence relative to cost, while also helping to reduce the potential for insecticide resistance development. In seasonal environments, where fly abundance increases after a period of overwintering, strategic, early season treatment may be important because it reduces the fly population at its lowest point and because this has an effect which persists beyond the residual activity of the treatment, particularly if the entire at-risk population is treated (Wall and Else 2011). This is because treatment of both lambs and ewes simultaneously removes all the available oviposition sites, resulting in a substantial reduction in the *Lucilia* population, thereby lowering fly challenge for a period after the direct protective effect of the insecticide has ended until the fly population can recover.

Blowfly strike has high welfare and financial costs to the sheep industry (Fig 7). Consequently, it is an important issue that demands close engagement between sheep veterinarians and shepherds. Equally important is the close collaboration between sheep veterinarians and researchers so that the impact of different treatment strategies and the use of integrated management might be assessed alongside detailed understanding of seasonal changes in risk, patterns of sheep susceptibility and strike epidemiology.

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