ADVANCED PEST SOLUTIONS Limited

In Collaboration with Texol Technical Solutions Plc, Dundee

F I N A L   P R O J E C T   R E P O R T

Midge Management, Gulating, Norway

Contact details

Address:	**Advanced Pest Solutions Ltd.** **Institute of Cell Biology** **University of Edinburgh** **Darwin Building** **Kings Buildings** **Edinburgh EH9 3JR**
Contact:	**Dr Alison Blackwell**
Tel:	**0131 651 3328**
Fax:	**0870 458 3844**
E-Mail:	**ablackwell@advancedpestsolutions.co.uk**
Web Site:	**www.advancedpestsolutions.co.uk**

November 2005

ADVANCED PEST SOLUTIONS Ltd

G U L A T I N G F I N A L P R O J E C T R E P O R T

PROJECT SUMMARY

A trapping programme using Midgeater and Midg-it traps (manufactured by Texol Technical Solutions) was implemented at the Gulating site in late June 2005. Traps were monitored over an approximate twelve-week period, during which time 15 traps caught over 19 million midges. All insects caught belonged to a single species (*Culicoides impunctatus*), although it is likely that others were also present but not identified.

A preliminary study of midge breeding grounds identified a number of sites and these data are discussed in relation to the prevailing wind direction and its influence on midge activity and differences in trap catches over the site.

An attempt to create a barrier around the central stage area appeared to be successful, although it is likely that the exposed nature of the centre, together with recent drainage activities also contributed to the reduced number of midges in this area.

Initial observations on the population structure and the influence of climate on the midge populations suggested a similar situation to that which exists in Scotland, although further studies would be required to strengthen these conclusions.

1 PROJECT BACKGROUND

1.1 Background

The Problem

Gulating in Western Norway is the most renowned of all the assembly sites in the ancient Norwegian empire. During 2005 it was again to function as meeting-place and court. To mark the site of the Gulating, sculptures have been erected and an outdoor arena formed, providing a beautiful natural setting for performances of theatre, dance and music.

The site has been unattended for many years and large populations of *Culicoides* spp. biting midges have become established, presenting a significant, potential nuisance to visitors to the site.

The Target

Culicoides spp. biting midges have a worldwide distribution, with over 1,000 named species. In certain areas they are significant vectors of diseases of veterinary importance (e.g. bluetongue virus, African horse sickness virus and EHD virus of deer). They are most renowned, however, as representing a significant 'nuisance' factor and barrier to outdoor activities and industry. In the temperate, northern hemisphere this is a seasonal event, with adult midges being on the wing for approximately 4-5 months, from late spring–to-early autumn. During this time the female midge requires a bloodmeal to mature and lay her eggs (although 'autogenous' species will lay a first egg batch without needing to take a bloodmeal). Females undergo a complex sequence of host-seeking behaviour, incorporating odour, visual and taste cues. Within the female midge, the rate of egg development is largely temperature dependent; in the laboratory this can be completed in 2 days, whereas in northern Europe 5-7 days is a more realistic time period, with a single female midge laying 2-3 egg batches during her lifetime, depending on survival rates. Usually, a species will undergo 2-3 generations during a season, with a number of species (often up to 20) co-existing at any one time/in any one place. Outside of the adult midge season, midges remain in the final (fourth) instar stage in the soil, living as omnivores on decaying plant and animal matter.

Although adult midges can be carried by the wind some distances, generally, they do not fly far from their breeding sites. Hence, these areas can be key targets to site midge traps, particularly to attract the first-emerging insects (hence reducing the reproductive potential of the midge population).

Management through attractant-based traps

Whilst midges cannot be effectively eliminated without having substantial, adverse effects on the environment, manipulating the behaviour of the insects can attain a significant degree of management.

Attractant-based traps effectively mimic a potential bloodmeal-host of a hungry female midge, through the use of a series of cues (primarily odour and heat) which are associated with the normal (usually mammalian) bloodmeal host. Whilst the traps attract midges, used effectively and with sensible positioning, over time they can distract the insects away from a populated area and begin to reduce the overall midge population. Detailed knowledge of the pest insect's population structure is ideally required, since it is important to trap those insects emerging at the beginning of the season, so reducing the reproductive potential of both the first and second breeding cycles. Traps will not remove midges over-night; they are most effective when used constantly, throughout a season.

1.2 Project Objectives

The aims of this study were:

- to determine the efficacy of propane-powered biting insect traps ('Midgeater' and 'Midg-it') regarding the reduction and management of *Culicoides* spp. biting midges in Gulating, Western Norway;
- to investigate an experimental barrier of traps around Gulating's central 'stage' area;
- to carry out a preliminary estimate of midge breeding (and hence emergence) sites;
- to make an initial assessment of the population structure and *Culicoides* species complex at Gulating;
- to carry out a preliminary investigation of the effect of a variety of meteorological factors on midge activity.

The aims were to be met by a site visit in June 2005, the establishment of a trapping pogramme and subsequent monitoring of this programme.

1.3 Project Partners

Advanced Pest Solutions Ltd. ('APS')

Advanced Pest Solutions Ltd. (APS) is a start-up company from the University of Edinburgh, currently supported by the 'Edinburgh Pre-Incubation Scheme' (EPIS), funded by the University of Edinburgh, Scottish Enterprise and the European Regional Development Fund (ERDF). The company (based in the Institute of Cell Biology, University of Edinburgh) focuses on the development and implementation of solutions to pest and disease problems associated with man in a range of market sectors (including agricultural-, household and medical/veterinary sectors), meeting growing demands by governments, industry and the public for more environmentally-friendly methods of control. The Founder and Managing Director of APS is Dr Alison Blackwell, who has recently completed a prestigious Royal Society of Edinburgh 'Enterprise Fellowship' and who previously was in academia for 14 years; she is author of more than 60 peer-reviewed papers on biting insect behaviour, physiology and ecology and several book chapters. She is a recognized expert on biting midge biology, particularly in Scotland.

Texol Technical Solutions Plc

Texol Technical Solutions has designed and manufactured the 'Midgeater' range of biting insect traps, launching the Midgeater® in 2003 and the Midg-it® in 2005. A management and employee-owned company, Texol has been around since 1998. Now employing around 190 people and with a turnover of over £13m, Texol specializes in providing technical engineering and manufacturing solutions in a number of markets from gas generation to security and petrol pumps. Midgeater/Midg-it is one of the product ranges provided by Texol, and the product is now used in a number of countries throughout the world, as well as a significant tool in midge control within the UK. More information can be found about the company through its website (www.texol.co.uk).

2 EXPERIMENTAL APPROACH

A visit was made to the Gulating site in late June 2005 (F Leighton (Texol) and A Blackwell (APS)), during which time a midge-trapping programme was established and a monitoring programme suggested. In addition, a limited amount of larval sampling was carried out.

2.1 Traps

Unlike other propane-fuelled insect traps, the Midgeater traps have been designed specifically to catch midges; they are not simply mosquito traps re-branded for UK sale. The small size of midges, together with the high densities in which they occur have both been taken into account during the design process to produce a highly effective and reliable trap, which is also able to withstand a variety of weather. After initial ignition, the trap uses a flameless catalytic process to produce carbon dioxide (the primary midge activator and attractant) from propane gas. Before being emitted from the machine, the produced carbon dioxide is passed over a bait based on a natural midge attractant (octenol), which has a synergistic effect with carbon dioxide, resulting in greater midge attraction. Using thermoelectric materials, heat energy from the catalytic process is used to generate electricity that powers the trap's suction fan, drawing the insects into a net when they approach the machine. Once switched on the machine runs continuously.

Key aspects of the Midgeater range of traps include:

- they have been designed specifically for biting midges;
- they require no mains electricity supply;
- they use no pesticides;
- they are low-maintenance, with the only routine maintenance required being changing the collecting bag when it is full and changing the cylinder when empty (approximately every 3-4 weeks), at which time the additional bait is also changed;
- safety and security: the traps are CE-marked and use a flameless catalytic process.

2.2 Trap Positions

Initially, 15 traps were positioned around the stage area, using nine Midgeater traps, mainly behind the stones and six Midg-it traps, on the northerly, steep bank above the stage. The positions were chosen from a preliminary visual inspection of the terrain, in relation to potential midge breeding and resting grounds. Trap 9 (Midgeater) was placed in the centre of the ring, with the aim of acting as a control, monitoring insect flight inside of the ring of traps. This trap, however, was moved (27 July), along with trap 15 in an attempt to reduce the biting activity towards the jetty area. The trap positions are shown in Figure 1.

2.3 Monitoring and Reporting

Trap catches were collected on a 2-4 day basis from 28 June – 14 September 2005. Catches (in terms of weight) were emailed to APS for analysis. The local support provided by Toril Rysjedal Bygnes was critical to this stage; catches were reliably assessed on a regular basis, allowing up-to-date feedback on trap performance.

2.4 Midge Larval Sampling

Midge larvae live in the water films of soil, 5-10 cm below the soil surface. To form a preliminary assessment of midge breeding grounds in relation to trap position, small soil samples were taken from each of the original trap sites (3 samples from each site). These were transported to Edinburgh, where the samples were dried in a series of Tullgren funnels in the laboratory. This allowed the extraction and subsequent identification of soil organisms, including *Culicoides* spp. biting midge larvae. Species identification was possible from the larval pigmentation and head capsule characteristics.

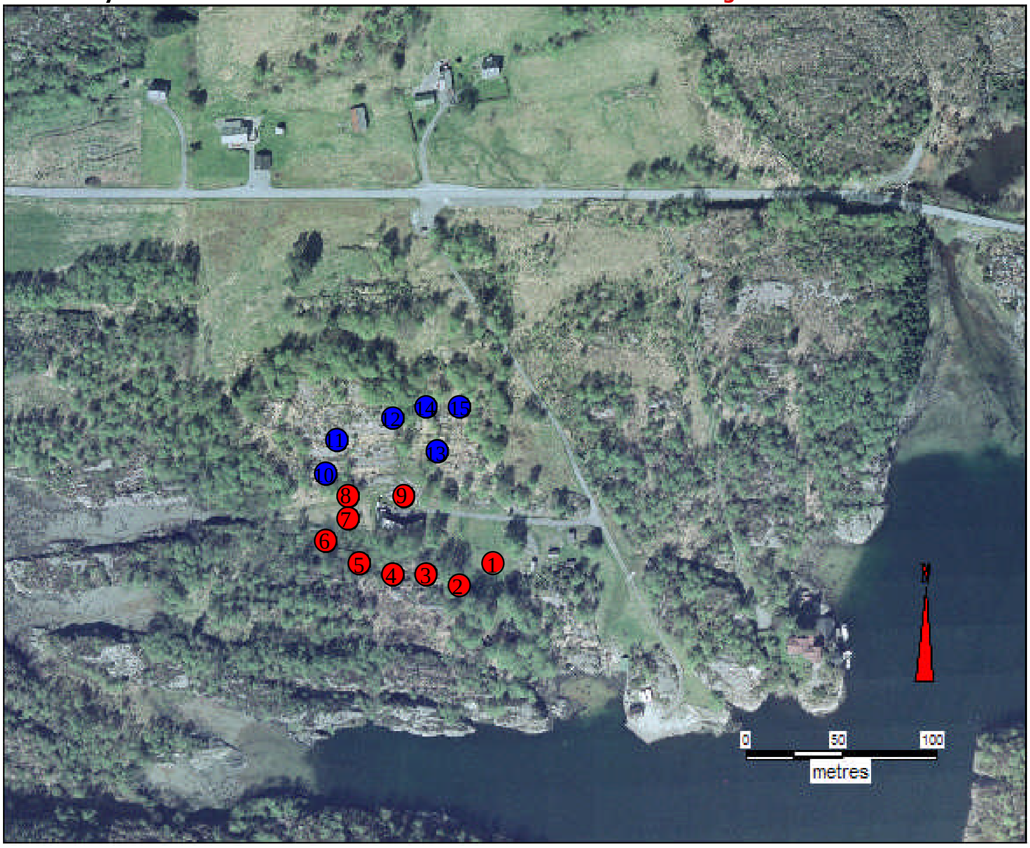
Tullgren funnel unit

Culicoides biting midge larva

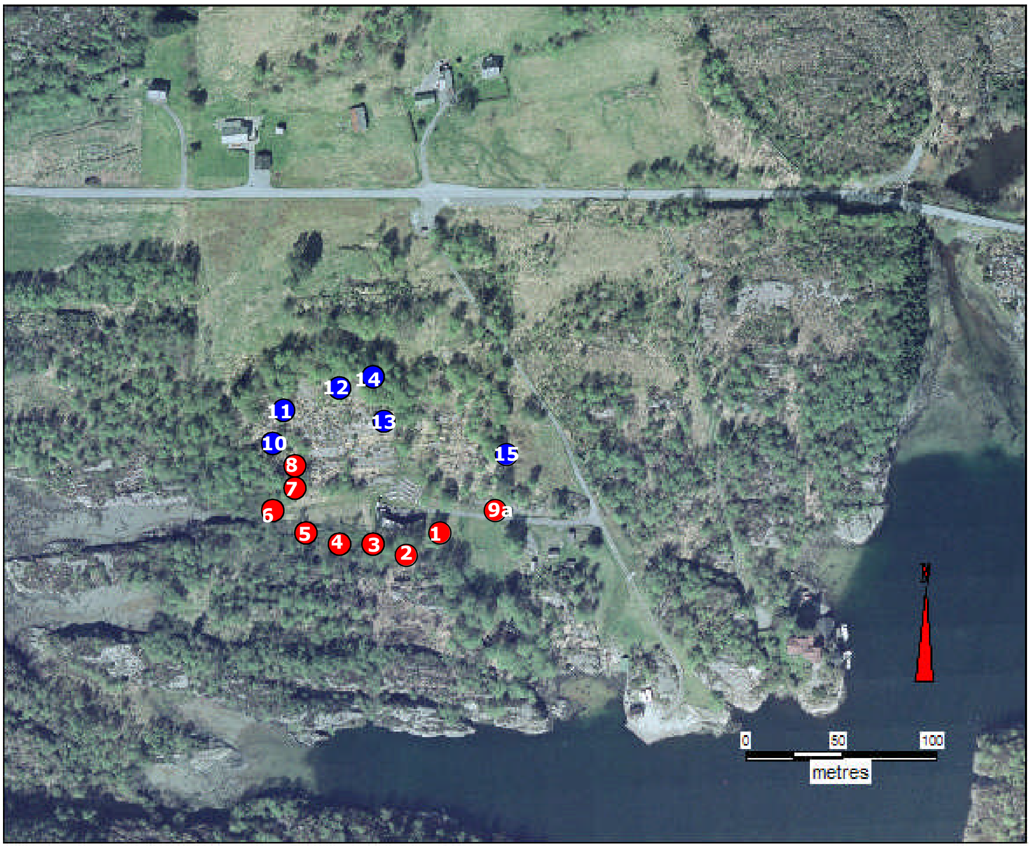
Midge Trap Positions, Gulating 2005

Blue: Midg-its
Red: Midgeaters

28 June - 24 July 2005



From 27 July 2005



3 RESULTS

3.1 Trap performance

Midgeater vs Midg-it

A total of approximately 19 million midges were collected in all of the traps during the 12-week trapping period. Approximately 12 million of this total was collected in the Midgeater traps. There were, however more Midgeaters (9) than Midg-it traps (6) and when the mean catches were compared there was no significant difference between the trap types (Figures 2a & b).

Individual trap performance

Cumulative trap catches for the individual traps (Figure 3a) and mean catches for each trap (or position for traps 9 and 15 which were moved mid-way through the trial) (Figure 3b) indicated difference between the trapping sites. In particularly, there were significant catch increases in those traps above which were moved position, with 9 and 15 being moved towards the jetty area. The highest catches were at sites 3, 6, 8, 9a and 15a, with significantly lower catches (indicated by * in the figure) being recorded at sites 9, 10 and 15.

Barrier effect

It is difficult to determine whether or not a true barrier effect was achieved. Certainly, trap 9 in its original position caught very few insects. It is impossible to tell, however, whether or not this was due to a reduction of insects reaching this area (i.e. that a barrier had been created by the remaining traps) or that the exposed nature and significant drainage in this area had reduced its suitability for midges. Certainly, reports from the site's opening event suggested that very few midges were actually noticed within the central area surrounded by traps and that the biting nuisance was significantly greater outside of this area.

3.2 Midge Breeding Grounds

The numbers of larvae extracted were very small (0-5 per sample). All were *Culicoides impunctatus.* When the data are examined, however, it is clear that the highest numbers were located in the areas initially recognised as potential midge-breeding grounds, above the centre of the site (positions 10 – 15), (Figure 4).

3.3 Midge Population Structure

Daily midge counts over an entire season, including an assessment of sex ratio and female physiological condition are required for an accurate prediction of species seasonality. From the existing data, the main species present was *Culicoides impunctatus* (also the most dominant species of approximately 40 occurring in Scotland). There was an apparently bimodal pattern of activity, suggesting at least two generations occurring during the 2005 season (Figure 5).

3.4 Influence of Climate on Midge Activity

The above pattern of activity will be significantly altered by local climate. Data were provided from a site 30km from Gulating. Accepting that these will not directly relate to the conditions at Gulating, trends from the data can be seen, with low temperatures, high rainfall and high winds coinciding with reduced catches (Figures 6a-c).

Figure 2a. Gulating 2005: Total Midge Catch

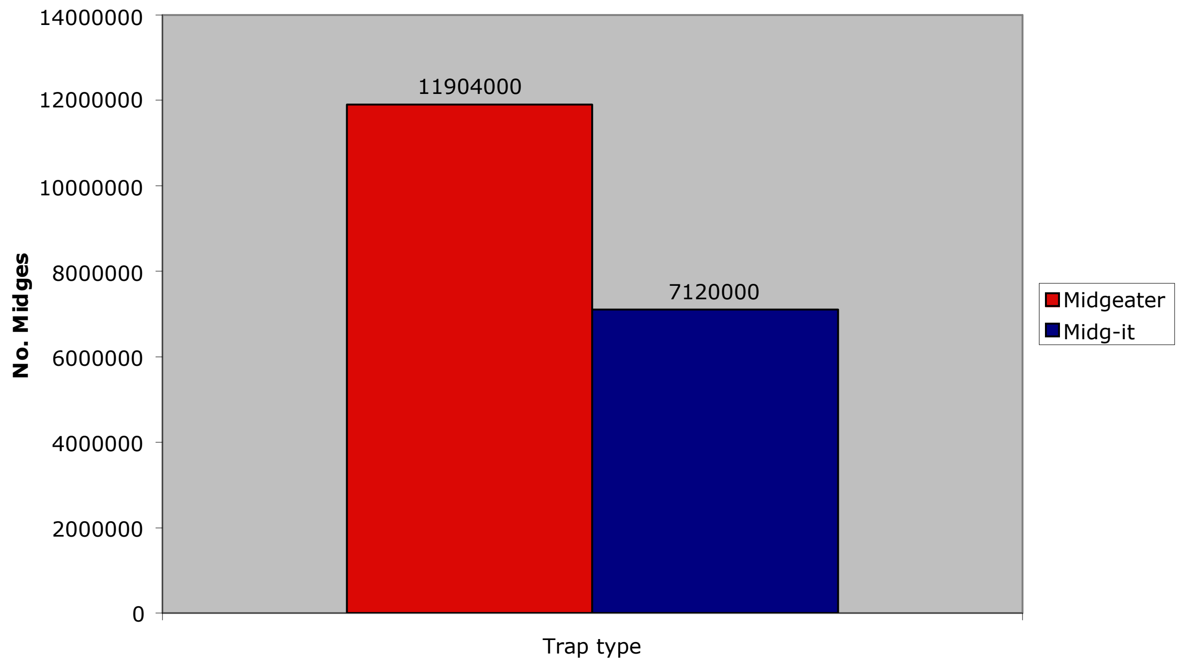
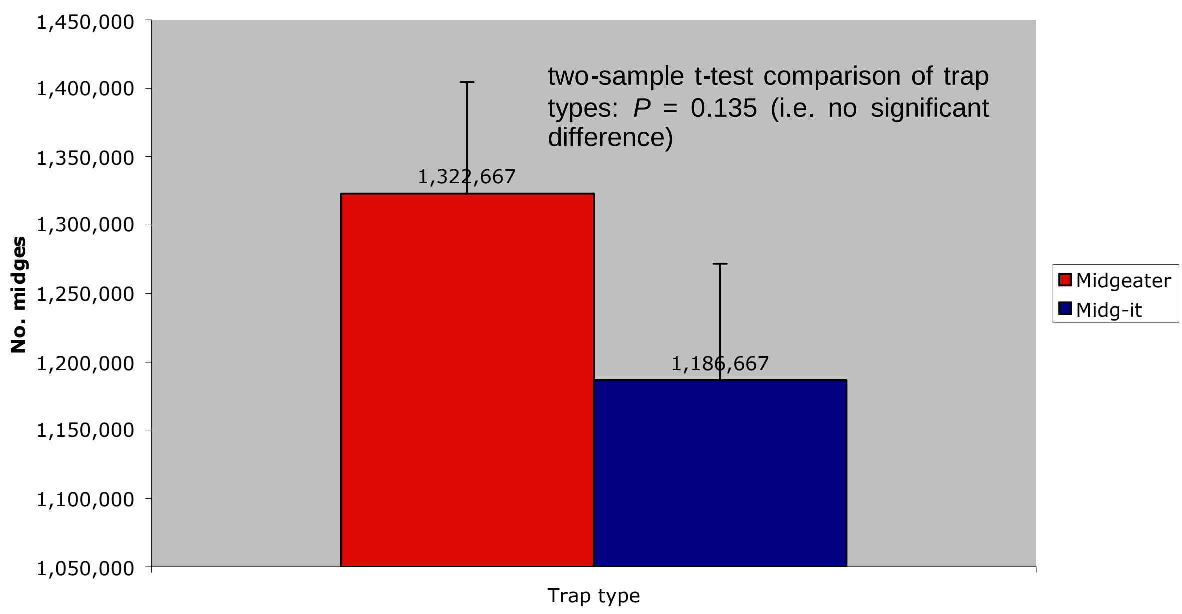
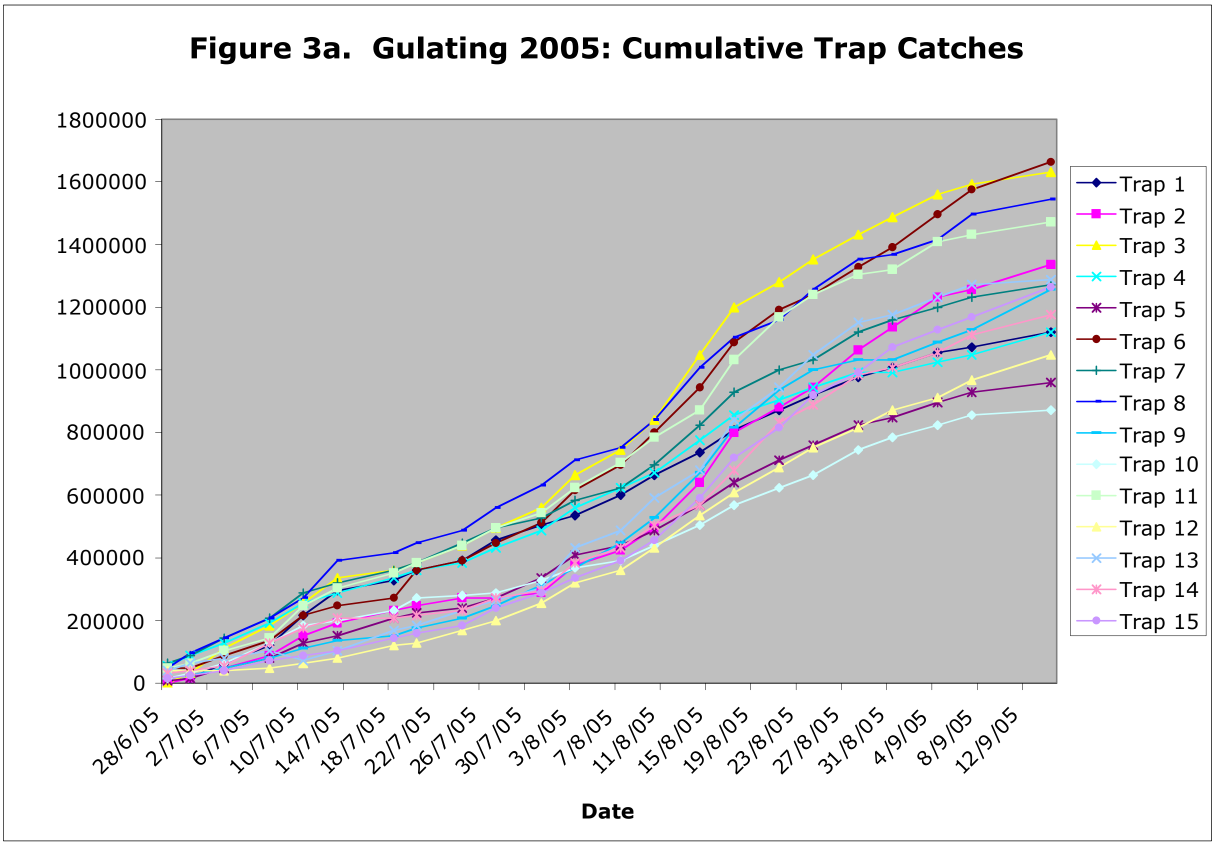
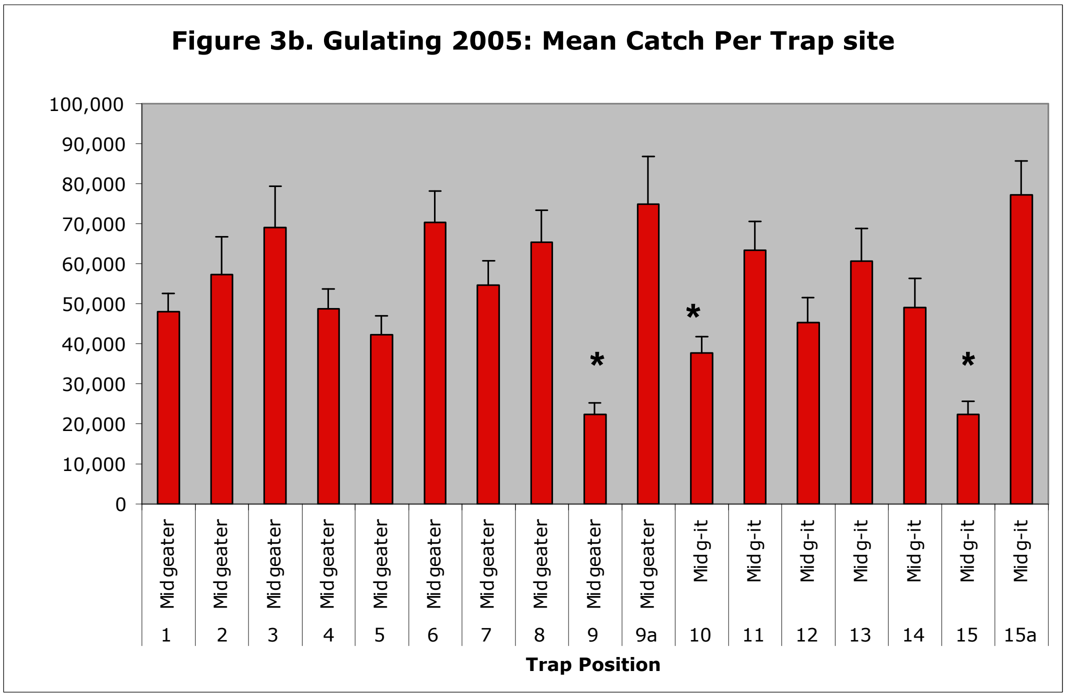


Figure 2b. Gulating 2005: Mean Total Midge Catch







*: significantly lower catches than remaining traps ($P < 0.05$)

Figure 4. Gulating 2005: Midge Larvae at Trap Positions 1-15

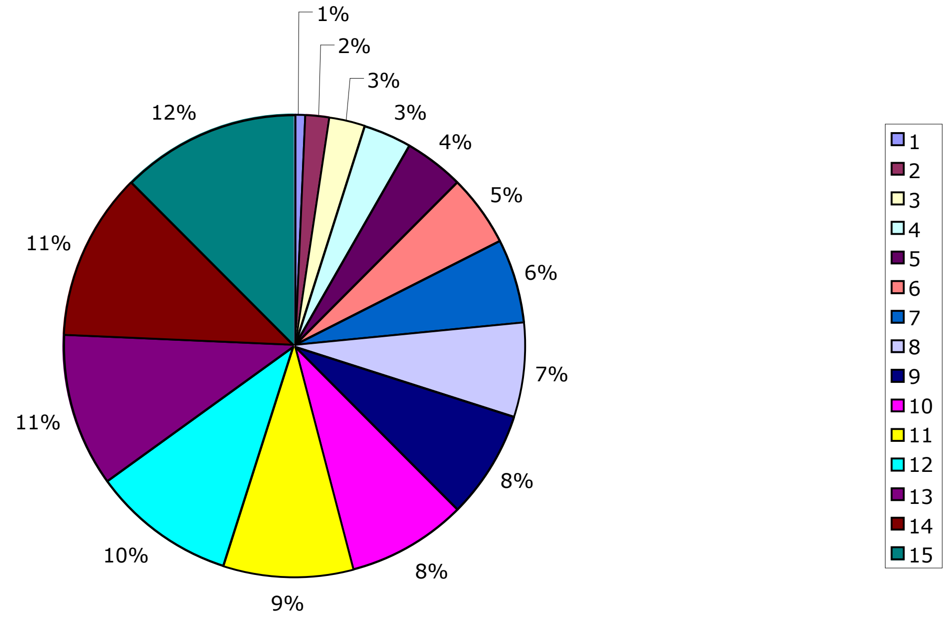
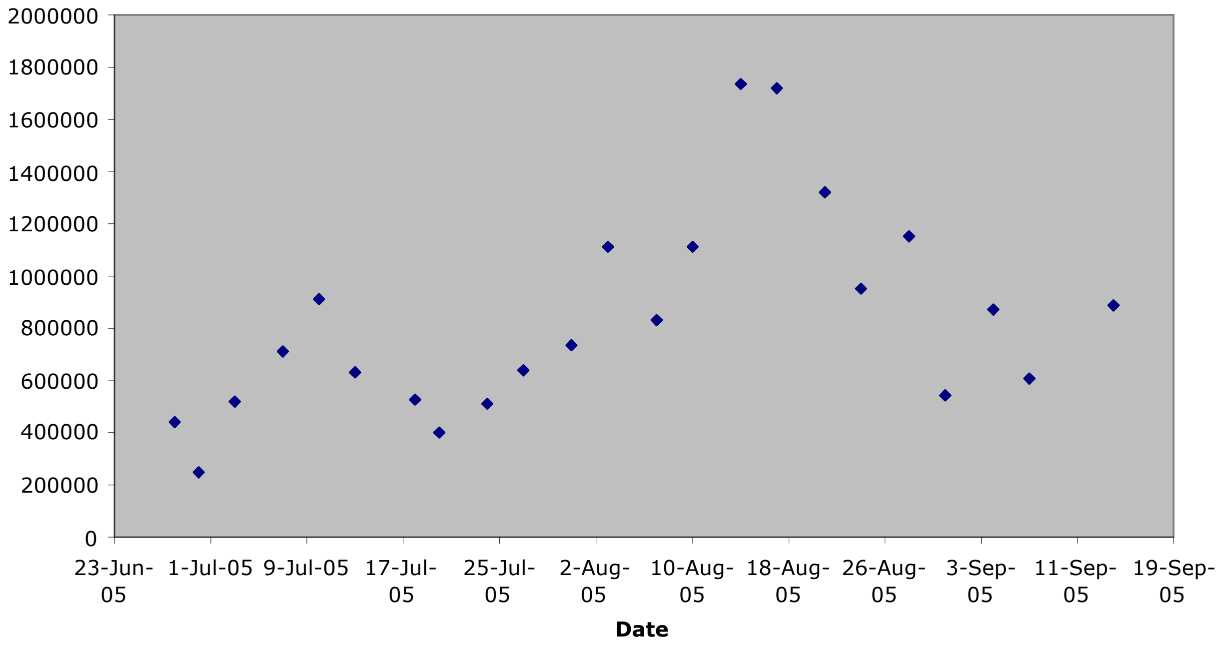


Figure 5. Gulating 2005: Midge Population Structure



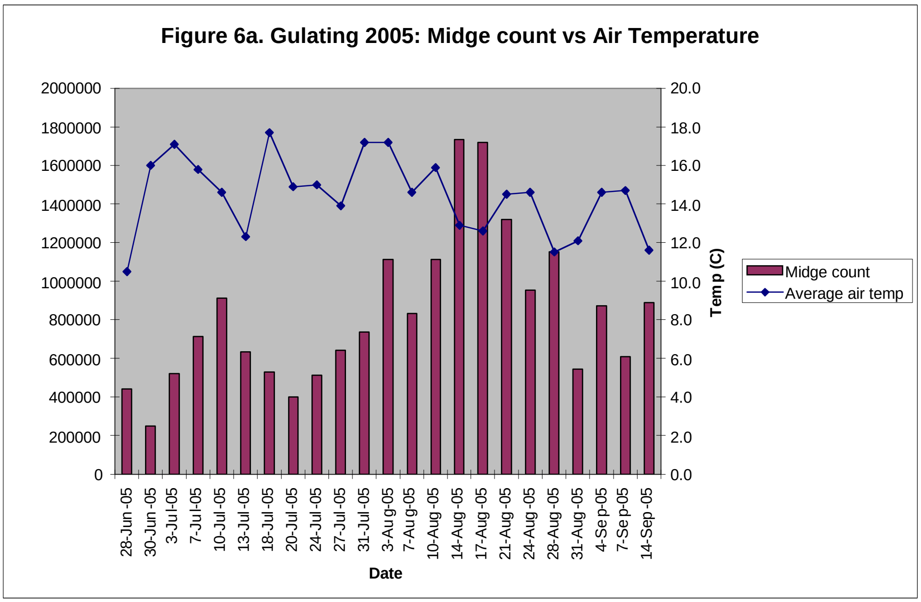


Figure 6a. Gulating 2005: Midge count vs Air Temperature
Temp (C)
Date
Midge count
Average air temp

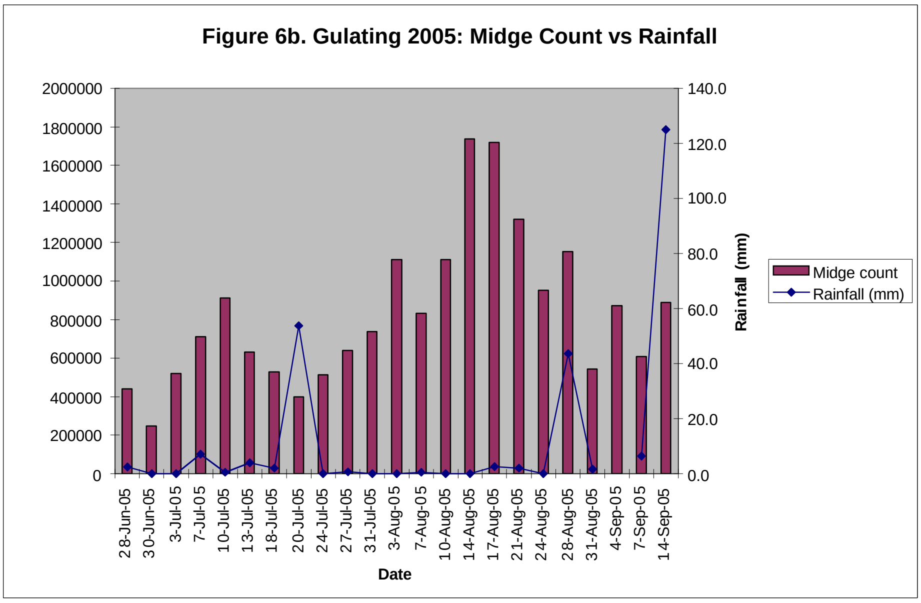


Figure 6b. Gulating 2005: Midge Count vs Rainfall
Rainfall (mm)
Date
Midge count
Rainfall (mm)

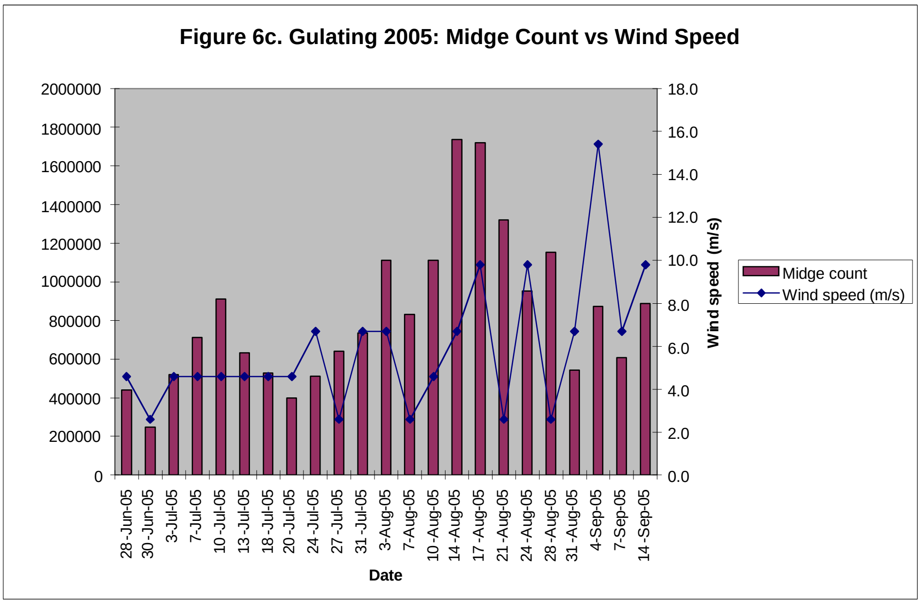


Figure 6c. Gulating 2005: Midge Count vs Wind Speed
Wind speed (m/s)
Date
Midge count
Wind speed (m/s)

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Project Success

This was the first introduction into Norway of traps designed specifically for biting midges. Over a twelve-week period, over 19 million midges were caught in 15 different traps. Anecdotal reports suggested that the situation was far improved compared to previous years, with very few reports of significant midge attacks. Clearly, the construction work at the site involved significant habitat modification, which may have contributed to this effect but it is also clear that the Midgeater and Midg-it traps were very effective and over time, have the potential to significantly impact on the biting midge population within the area. A key point to note is the importance of local assistance throughout the project (provided by Toril Rysjedal Bygnes). In addition to monitoring the traps throughout the project (resulting in rapid feedback on trap performance), the local contacts and introductions that this assistance made possible, were extremely valuable.

4.2 Trap and Site Comparison

The current data cannot be used to make direct comparisons between the two trap types; for this, trap positions would need to be rotated on a regular basis to combat any positional-based bias. The results indicate that there was no significant difference in the Midgeater and Midg-it catches, which would agree with previous test data from Scotland. The Midg-it trap is extremely well suited to more exposed, inaccessible area, where a more portable trap, sitting close to the ground is required. In this respect, it a highly suitable partner to the larger Midgeater.

Regarding trap site, with the exception of site 15a, the largest catches were made behind the stones, at the southerly edge of the site. Oddly, the greatest numbers of midge larvae were recovered from above the steep slope, behind traps 10-15 (original positions). This may reflect the normal prevailing wind, or it may have been that the full extent of the midge breeding activity was not recorded. Certainly, the terrain around and behind traps 1-8 visually appeared highly suitable for midge breeding.

4.3 Midge Population Structure and the Influence of Climate

With a similar terrain and climate to western Scotland, it was perhaps not surprising that the main species at Gulating was *Culicoides impunctatus* and that the population structure appeared similar. In Scotland this species undergoes at least two and often three generations, with an approximate generation period of 6 weeks. It is very likely that additional species, particularly in the same grouping as *C. impunctatus* were present within the Gulating test site, although it usual for a degree of temporal separation to occur (i.e. some species will be early season ones, whereas others will occur only towards the end of the season).

4.4 Further Work

Midge trapping, 2006

The present data has provided the groundwork for the implementation of a trapping programme in 2006, identifying areas of high midge activity. To maximise the success of the traps they should be positioned prior to the season commencing, in readiness to catch the first emerging insects. However, it should be noted that males usually emerge before the females and will not be attracted to the host-odour based traps. For their collection more traditional light-suction traps could be deployed. As with 2005, trap catches should be monitored on a regular basis and the traps positions experimented with as required.

Potential further investigations

The Gulating study has significantly raised the profile of biting midges in Norway and made both the public and industry aware of the measures that can be taken to reduce the impact of these insects on outdoor activities. Commercially, the study has identified a good opportunity for the application of midge traps, although there are a number of areas that would benefit from further investigation.

The real key to identifying areas where midges are likely to be a problem is still to identify their breeding grounds and be able to understand how these areas relate to the local climate and species activity patterns. There is considerable scope within Norway to significantly improve the current knowledge base regarding *Culicoides* biting midges and to be able to apply this information to enhanced levels of insect management. Over a decade of ecological and behavioural data has contributed to the current situation in Scotland. This has included detailed knowledge of midge host-preference data and host-seeking behaviour[1,2,3], knowledge of the midge population structure within Scotland[4], the distribution of midge larvae[5], adult midge activity patterns[6] and how these all interact and contribute to potential management programmes[7]. Commercial applications such as the Midgeater and Midg-it traps have benefited from this knowledge, in addition to the high level of design and engineering skills of their manufacturer. Other applications include the detailed analysis of midge breeding activity to allow the placement of midge traps; for example, APS has recently constructed a map of 'midge risk' for a new, £50 million leisure resort in Scotland for direct application in the deployment of midge traps and most recently, has launched a 'midge forecasting' technology to act as an additional tool in midge-management programmes, as well as a marketing tool for businesses involved in midge control (a demonstration is available at www.midgeforecast.co.uk).

Finally, the programmes identified above are equally suited to mosquitoes and given the nuisance problems caused by a number of mosquito species in Norway, a future project investigating the application of odour-based traps for mosquito control should be considered.

Appendix I: Information Sources

1. Blackwell, A., Mordue (Luntz), A.J. & Mordue, W. (1994b) Identification of bloodmeals of the Scottish biting midge, *Culicoides impunctatus*, by indirect enzyme linked immunosorbent assay (ELISA). *Medical and Veterinary Entomology,* 8, 20-24.
2. Blackwell, A., Brown, M. & Mordue, W. (1995) The use of an enhanced ELISA method for the identification of *Culicoides* bloodmeals in host-preference studies. *Medical and Veterinary Entomology,* 9, 14-218.
3. Blackwell, A., Dyer, C., Mordue (Luntz), A.J., Wadhams, L.J. & Mordue, W. (1996) The role of 1-octen-3-ol as a host-odour attractant for the biting midge, *Culicoides impunctatus* Goetghebuer and interactions of 1-octen-3-ol with a volatile pheromone produced by parous female midges. *Physiological Entomology,* 21, 15-19.
4. Blackwell, A., Mordue (Luntz), A.J., Young M.R. & Mordue, W. (1992a) Bivoltinism, survival rates and reproductive characteristics of the Scottish biting midge, *Culicoides impunctatus* (Diptera: Ceratopogonidae) in Scotland. *Bulletin of Entomolical Research,* 82, 299-306.
5. Blackwell, A., Boag, B., Gordon, S.C., Lock, K.A. & Marshall, B. (1999) The spatial distribution of *Culicoides impunctatus* biting midge larvae. *Medical and Veterinary Entomol*ogy, 13, 362-371.
6. Blackwell, A. (1997b) Diel flight periodicity of the biting midge *Culicoides impunctatus* and the effects of meteorological conditions. *Medical & Veterinary Entomology*, 11, 361-367.
7. Blackwell, A. (2001) Recent advances on the ecology and behaviour of *Culicoides* spp. in Scotland and the prospects for control. *Veterinary Bulletin*, **71** 1-8.