WATER AND THE ENVIRONMENT

New App a shot in the arm for blackfly control along Orange River

A Water Research Commission (WRC)-funded research project has developed new tools to help reduce Orange River blackfly outbreaks.
Article by Sue Matthews.

During the last outbreak along the Lower Orange River in 2011, blackfly caused losses of livestock estimated at some R300 million. Lambs were particularly affected, many having been trampled to death by sheep huddling together to protect themselves from the biting insects, or prevented by their mothers from suckling. Like mosquitoes, it is only the female blackfly that bites as she needs a blood meal for egg development, and any soft and exposed skin on teats, eyes, ears and lips comes under attack. The resulting pain, together with the constant annoyance of circulating flies, inhibits feeding and mating, leading to loss of condition and reduced lambing. Secondary infection of the wounds or allergic reactions sometimes even cause the death of the animal.

The economic impact of blackfly outbreaks is not limited to livestock farming though. The irrigated agriculture and tourism sectors are also affected through lost productivity of farmworkers and visitors avoiding outdoor activities. These problems may occur anywhere along a 1 200 km stretch of the middle and lower Orange River, from Hopetown to Sendelingsdrif.

Blackfly have always been present along the Orange River, but only developed pest status after the construction of the Gariep and Vanderkloof dams in the 1970s. This is because the female flies lay their eggs close to rapids, where the larvae will be able to filter food particles from the flowing water with their retractable head fans. Releases from the dams to generate hydroelectric power and supply irrigation schemes provide a relatively constant, year-round flow of water laden with organic matter, creating ideal conditions for the larvae.

This knock-on effect first became apparent on the Vaal River – the Orange River's main tributary – following the completion of the Vaal Barrage in 1923, the Vaalharts Diversion Weir in 1936 and the Vaal Dam in 1938. Frequent blackfly outbreaks occurred after 1950, and a particularly severe one in 1963 prompted the first efforts to control blackfly populations in 1965, using DDT. That control programme was suspended two years later due to the detrimental impact of DDT on non-target species.

During the 1970s the first flow manipulation trials were conducted at the Vaalharts Diversion Weir and Vanderkloof Dam, but although successful in reducing larval numbers in the river reach immediately downstream, it was recognised by the mid-1980s that this would be an impractical method of controlling blackfly. The most effective time to cut off flows was during the winter dry season, when releases were most needed by Eskom and agricultural water users, plus the dams were too far from blackfly-affected areas lower in the catchment to fine-tune control.

Since the early 1990s, the Orange River Blackfly Control Programme has relied on spray application via helicopter of two larvicides. Vectobac® is a granule formulation of ***Bacillus thuringiensis*** subsp. ***israelensis*** (*Bti*), a soil bacterium isolated from dead mosquitoes retrieved from a stagnant pond in Israel in 1976 and now used to control mosquitoes and blackflies worldwide. It is non-toxic to humans and environmentally safe, but its effectiveness is reduced in strongly flowing, turbid rivers. Abate® – an organophosphate with the active ingredient temephos – is more suitable in these conditions, but repeated application has resulted in larval resistance, so its use has been scaled back.

Periodic spraying over an 800 km stretch of river is timed to take place before larval numbers build up to problem levels. Staff from the Department of Agriculture, Forestry and Fisheries (DAFF) offices in De Aar and Upington monitor larval densities on rocks and reeds in about a dozen sites in the river according to a 10-point scoring system developed by Dr Rob Palmer in the early 1990s. Larval densities exceeding a threshold score of 6 indicate that the river reach should be sprayed without delay. Despite these efforts, occasional outbreaks still occur – prior to the 2011 one, there was an outbreak in 2000-2001, when river levels were higher than normal.

The recently completed WRC project, conducted by Dr Nick Rivers-Moore with Dr Palmer was aimed at improving prediction of blackfly outbreaks – and hence help prevent them – by refining a Bayesian network probability model and enabling members of the public to contribute data. The latter has been achieved by developing a mobile phone application, called '***Muggies***', which is available for both iOS and Android from the Apple App Store or Google Play respectively. All the contents and features are mirrored on a website (http://muggies.org) for those who don't use smartphones or prefer to view the content on a larger screen.

The App and website allow users to upload photos or video clips of blackfly larvae on reeds and rocks in the Orange River and adjacent irrigation canals, and pinpoint their position on an interactive map. Example photos illustrating Palmer's Scoring System are provided, and users are invited to score their site if they feel confident enough to do so. There is also a four-point Fly Worry Index, ranging from 0 = no flies to 3 = extreme level of annoyance, but the accompanying instructional videos explain that this is aimed at sheep farmers. Also developed by Dr Palmer in the 1990s, 0 more specifically refers to sheep grazing and resting peacefully, while 3 describes worse-case scenarios where sheep stop grazing, lambs die and rams won't mate.

Blackfly larvae attached to reed, with a larval density score of 10 according to Palmer's Scoring System.

A text box is provided to fill in any other useful information, and users are requested to identify their economic sector – livestock, grapes, citrus, tourism, government or other. In future, it is intended that users will be able to view the collated monitoring data and predictions on blackfly outbreaks, as well as a calendar showing the spraying schedule. Local farmers have previously expressed unhappiness about not being informed by DAFF as to when spraying would occur.

Involving stakeholders in this way increases monitoring coverage and improves estimates of the time lag between high densities of larvae and outbreaks of adult blackflies. It also allows for verification and refinement of the Bayesian network outbreak probability model, the development of which formed the main component of the research project.

A Bayesian network, also known as a belief network, is a type of probabilistic graphical model that can be used to build models from data and/or expert opinion. It essentially consists of multiple cause-and-effect relationships, and is an ideal tool for representing relationships among variables, even if the relationships involve uncertainty, unpredictability or imprecision.

Dr Rivers-Moore explains that each monitoring data record will be added to the existing Bayesian network as a case file.

"The more cases you've got, the stronger your cause-and-effect relationships are, so in theory the accuracy of your predictions gets better," he says.

An earlier version of the model was developed by Dr Rivers-Moore in a previous WRC pilot project, and focused mainly on the effect of flow volume. The current version included temperature and turbidity as additional variables, because temperature is known to be a major factor in determining the size and duration of blackfly larvae and pupae, while different species are understood to have particular turbidity preferences.

The model revision involved collating and analysing existing monitoring data – including longer term flow data from various gauging weirs along the Orange River – as well as collecting new data at 14 monitoring sites along a 600 km stretch of river downstream of Vanderkloof Dam. At each of these sites, loggers were installed to record temperature on an hourly basis, turbidity data was collected weekly using a clarity tube, and four sampling trips spread over a year were undertaken to assess seasonal changes in the relative abundance of different blackfly species.

Incorporating all this additional data in the model revealed that turbidity, which is influenced by both flow volume and temperature, is a key driver triggering switches in blackfly species populations. At high turbidity ***Simulium chutteri*** and ***Simulium damnosum*** – the species that account for most of the pest problems – are more likely to occur. However, an increase in water clarity, typically associated with reduced flows, favours other species that are not regarded as major pests. This is due to differences in the structure of the larvae's filter-feeding fans, which affect their ability to capture food particles and withstand strong flows. The blackfly species switch is accompanied by an increase in benthic algae, and a crusting on rocks that appears to be a mix of diatoms and calcium carbonate.

The model also showed a negative correlation between *S. chutteri* and *S. damnosum*, indicating that only one of these species dominates at any one time at a site, with the other species largely competitively excluded.

"I suspect what naturally would have happened in the past is that the system would have periodically had lower flows, when water clarity would have increased, algae would have come in and non-pest species would have dominated," says Dr Rivers-Moore. "Then conditions would have built up again to favour 'chutteri' and 'damnosum' – with whatever got there first, colonising successfully – so there would have been a constant patch dynamics scenario. But with post-impoundment flow regulation, those kind of resets occur four times less frequently, so now it's just 'chutteri' and 'damnosum' constantly."

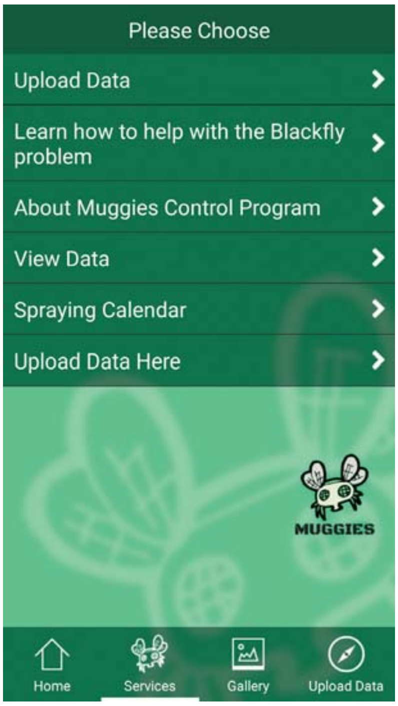
Cooler water temperatures during autumn and winter have the effect of reducing the number of generations of blackfly, but favouring large larvae that develop into more fecund adult females, increasing the potential for blackfly outbreaks in spring.

"The top two sites, Douglas and Prieska, are colder than the rest, so the larvae there would get much fatter," notes Dr Rivers-Moore. "Douglas is close to the Vanderkloof Dam, so you hardly get any blackfly there because they're flushed out by the hydroelectric flow releases, whereas Prieska has less flow variability and good reed growth, so that's one of the real problem sites."

"The control programme has improved the situation a lot from what it was, there's been good research by various people along the way – much of it funded by the WRC – and DAFF has done good work with their monitoring."

A larval density score of 6 indicates that larvicide spraying should be conducted without delay.

Project leader, Dr Nick Rivers-Moore, with MSc students, Sashin Naidoo and Esther Ndou, conducting fieldwork for the blackfly research project.



The Muggies App for smartphones allows users to learn more about the blackfly problem and the associated control programme, and to upload and view data such as photos, location and larval density scores. All the content can also be accessed via the website, http://muggies.org

He adds that he has heard horror stories of what larval populations were like in the 1980s, before the blackfly control programme began.

"The control programme has improved the situation a lot from what it was, there's been good research by various people along the way – much of it funded by the WRC – and DAFF has done good work with their monitoring. The purpose of this project was to try to put it all under one umbrella, which I think it has done in terms of developing a predictive framework for blackfly outbreaks, but the issue now is who's going to take it up."

Dr Rivers-Morore explains that there is a cost involved in hosting the Muggies website and App, and somebody would need to be kept on a retainer to respond to queries, collate the data, update the model, audit it to see if the predictions are agreeing with the monitoring, and liaise with the farmers about whether the outbreaks are being contained. Because of the uncertainty around a sustainable source of funding, the tools have not been widely promoted as yet, although an article about them was published in the ***Landbouweekblad*** in September.

Clearly, involving stakeholders in data collection to address a problem that directly affects them is a worthwhile citizen science initiative, while the model outputs would be useful for improved planning of control efforts. If you can help with sponsorship, contact Dr Rivers-Moore by emailing muggiescontrol@gmail.com.