Culicoides

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DISTRIBUTION

With the exception of Antarctica and New Zealand, Culicoides midges are found on virtually all large landmasses ranging from the tropics to the tundra. The most important Culicoides vectors of orbiviruses include C. imicola in Africa, C. sonorensis in North America, C. insinicus in South and Central America, C. wadai, C. brevitaris, C. actoni in Australia, C. fulvus, C. schultzei in Asia, C. imicola. C. pulicaris and C. obsoletus in Europe.

Worldwide distribution of the major Culicoides vectors.

Geographical and seasonal abundance of livestock-associated Culicoides species in South Africa

Over the last 35 years more than 112 Culicoides species were identified in South Africa. Following the initial work of du Toit 1941 the first identification key for South African Culicoides species was compiled by O.G.H. Fiedler in 1951. He recorded 22 species, of which one (C. onderstepoortensis) was described for the first time, from South Africa. In 1971 C. imicola was shown to be the most abundant livestock Culicoides species in the Onderstepoort area of South Africa. The results of subsequent studies showed C. imicola to be the most abundant livestock- associated Culicoides species in the summer rainfall area of
Arthropod vectors → Culicoides

South Africa, especially in the warm, frost-free summer rainfall areas of the country. *Culicoides imicola* is relatively uncommon in warm/dry and cool/wet areas and therefore cannot be regarded as the only vector of orbiviruses in South Africa. The most abundant species in the latter areas were members of the *C. schultzei* group and *C. zuluensis*.

A seven year study on the seasonal abundance of *C. imicola* at the ARC-Onderstepoort Veterinary Institute showed a drop in adult numbers during sustained rainy periods followed by a sharp increase in populations during the drier periods that followed. A three year light trap survey indicated adults of *Culicoides* species, and especially *C. imicola*, to be present throughout the year in frost-free areas of the country and that breeding takes place throughout the winter in these areas. In the most parts of South Africa *Culicoides* numbers reach a peak in late summer and drop sharply after the first frost. Low numbers of adult *Culicoides* midges during the winter months may not only be due to low temperatures but also to lower winter rainfall. Relatively large *Culicoides* collections can be made during winter in the winter rainfall areas. No seasonal fluctuation of the dominant species in most summer rainfall areas was found.

*Culicoides imicola* was absent in light trap collections made in the sheep farming area in the Karoo region of South Africa which is endemic for BT. This suggested that other livestock- associated *Culicoides* species may play a role in the epidemiology of the disease. *Culicoides imicola* is uncommon in the colder high-lying BT endemic areas of South Africa where *C. bolitinos* was found to be the most abundant *Culicoides* species. *Culicoides bolitinos* was also shown to be abundant at some locations in the winter rainfall region of the Western Cape Province, and the dominant *Culicoides* species, in the absence of *C. imicola*, in the sandy dunefields adjoining Port Elizabeth in the Eastern Cape Province. The absence of *C. imicola* at Port Elizabeth and in light trap collections made at Struisbaai and Alexanderbay on the southern and western coastline were attributed to the sandiness of the soil. Limited records suggest that *C. bolitinos* is most probably also widespread in most parts of Africa but, unlike *C. imicola*, is not known to occur outside the Afrotropical Region.

Some of the abundant and more widely distributed *Culicoides* species have a limited host preference and will thus be less important as potential vectors of orbiviruses. According to these surveys, the more abundant and widespread species, which have the greatest potential as arbovirus vectors, are *C. imicola*, the *C. schultzei* group, *C. zuluensis*, *C. pycnostictus*, *C. leucostictus*, *C. bedfordi*, *C. magnus*, *C. ravirus*, *C. gulbenkiani*, *C. similis* and *C. bolitinos*. 
Predicted abundance of *C. imicola* in southern Africa based on the 2-variable model combining minimum LST and minimum NDVI. Values are the predicted annual mean light-trap catch of the vector.

**CONTROL**

Integrated control methodologies comprises chemical, biological and environmental procedures used jointly or sequentially against a background of an exhaustive ecological understanding of the selected target pest or vector, so as to maximise efficacy, and be fully acceptable from the health and environmental standpoints.
Integrated control

The most important control measure is the protection of animals from contact with *Culicoides* midges. Recommended measures to prevent diseases associated with *Culicoides* midges include vaccination, stabling at night, meshing of stables, and application of insect repellents both to the animal and its stable environment. Around livestock *Culicoides* midges can occur in remarkable high numbers especially on warmer nights and during periods of excessive rainfall. At such times more than 1 000 000 blood seeking *C. imicola* females can be captured in a single light-trap and if the estimate is correct that this may represent less than 1% of the number of midges active on a particular night, clearly illustrates the intensity of attacks that must on occasion be endured nightly by exposed animals. It is impossible to eradicate such numbers of *Culicoides* and so, in Africa specifically, the first line of defense against *Culicoides*-borne orbiviruses must remain vaccination.

**Vaccination**

A potential problem with commercially available AH5V and BTV vaccines is that as live attenuated preparations they induce a low viraemia in some vaccinated animals, and so may infect vector *Culicoides*. Because of this fairly scarce possibility many countries, especially those outside of Africa, prohibit the use of live attenuated vaccines. In addition there is the fear that *Culicoides* may ingest vaccine viruses from vaccinated animals and after reversion to virulence on passage through the vector, these viruses may be transmitted in the field. Another concern is that these vaccine viruses may re-assort with wild type viruses, and so lead to the possible creation of new strains of virus with different virulence characteristics.

**Housing livestock in screened buildings**

Although it is known that stabled horses are relative safe from infection with AH5V very little is known about the factors that either attract or repel *Culicoides* species and there are no clear directives regarding the definition of a safe stable. Results, generated in Europe, indicate that *C. imicola* and other *Culicoides* species will enter stables and that under certain environmental conditions the number of *C. imicola* collected inside a stable can exceed the numbers collected on the outside. This tendency seems to be linked to environmental temperature and will increase towards the onset of winter.

**Treating of either resting sites, such as animal housing, or host animals with insecticides**

The chemical control of adult biting midges by direct treatment of livestock with pesticides is not practical under extensive farming conditions, but it may be justifiable for valuable animals such as racehorses whose immunity to *Culicoides*-transmitted diseases (AHS and EE) is in doubt.

Many pyrethroid insecticides are effective against Diptera, and, depending on the formulation used, have a reasonably long residual effect. Sprays can be used weekly while in cattle insecticide-impregnated eartags may be effective for four to six weeks, or even as long as 10 weeks against *Culicoides* midges. In Australia it has been found that, after Hereford cattle had been given a single subcutaneous injection of Ivermectin at a dose of 200 mcg/kg, the mean mortality of engorged *Culicoides* females 48 hours after feeding was 99% for 10 days after treatment. An adverse effect is
Arthropod vectors → *Culicoides*

the impact of Ivermectin on the dung beetle fauna so important for sanitation. A study in North America reported very limited success against *C. sonorensis* following application of 5% permethrin or 27% pirimiphos-methyl to the dorsum of calves. Engorged *Culicoides* females that exhibited sublethal intoxication, recovered and subsequently produced matured batches of eggs of normal size. However, a belly spray of 0.2% permethrin substantially reduced numbers of engorged females, and lowered engorgement levels 3 and 7 days post-treatment, but by day 10 little effect was noted. The chemical control of *Culicoides* adults merit additional research, especially in Africa where attacks rates are very high. In bioassay determinations of the efficacy of permethrins against *C. sonorensis* it was shown that midges were able to feed, and thus potentially transmit pathogens, before being incapacitated.

**Environmental interventions to remove larval breeding sites or the application of insecticides and pathogens to habitats where larvae develop**

The elimination of the larval habitat of *C. imicola*, has received no attention in Africa perhaps because little success has been achieved with other species of *Culicoides* elsewhere in the world. Under restricted situations it may be feasible to reduce *Culicoides* adult numbers by treatment of their breeding sites with compounds such as Temephos. However, as regards *C. imicola* its explosive increase in numbers, and its rapid radiation over large areas as soils become suitably moist under continuous rains, would make the widespread application of Temephos not only expensive but impracticable.

Increasing concerns of the impact of chemicals on the environment resulted in a decline in the number of agents available for livestock pest management. Reliance on only a few active ingredients may create problems with insecticide resistance.

**The use of repellents or host kairomones to lure and kill adult midges**

Different modes of action have been proposed for repellents, namely

- inhibition of response to an otherwise attractive signal;
- switching of the sensory message from attraction to repulsion;
- activation of a receptor system that controls a competing behaviour;
- activation of a noxious odour receptor; and
- activation of different receptor types simultaneously causing loss of the specific signal for host location.

The ideal insect repellent would repel multiple species of biting arthropods, remain effective for at least eight hours, cause no irritation to the skin or mucous membranes, cause no systemic toxicity, be resistant to abrasion and rub-off, and be greaseless and odourless. Assessment of efficacy of repellents applied to host animals against *Culicoides* species and especially *C. imicola* is hampered by their relatively small size and their nocturnal activity which make direct observation difficult.

In recent study in South Africa utilizing light traps and repellent impregnated polyester netting, repellency has been assessed by comparison of the numbers of *Culicoides* midges caught in the light traps over a period of time. These studies concluded that N, N-diethyl-3-methylbenzamide DEET and a mixture of organic fatty acids C8910 [15% (w/w) mixture of octanoic, nonanoic and
Arthropod vectors → *Culicoides*

decanoic acids in light mineral oil] had a significant repellent effect against *Culicoides* species, including *C. imicola*, for all catches made from after sunset to before sunrise, when applied to polyester mesh as tested with a down-draught suction light trap. No significant repellent effect against *Culicoides* was found for the citronella oil or the α-cyano-cypermethrin.

**Decoy hosts**

Under certain conditions the presence of cattle near sheep may serve to reduce the level of BT infection in the sheep, apparently because the vector *Culicoides* prefer to feed on the cattle. The presence of decoy hosts can, however, increased the animal biomass on a farm which translates into increased feeding opportunities for *Culicoides* midges. It would seem thus inevitable that their population levels will rise in accord, which, devolves into increased virus transmission risk.

Smoking of stables is a farmers remedy applied in an effort to repel midges, however, light traps that have been operated in the palls of smoke have still yielded enormous catches of *Culicoides* midges, with these catches as large as any made at smokeless stables.

Research to assess and improve the efficacy of control methods is required and, in the longer term, efforts should be made to develop better bait systems for monitoring, and possibly controlling, midges. For all these studies we need better methods to analyse the ecology and behaviour of midges in the field. The paucity of control options and basic knowledge provide a warning that we must be better prepared for the emergence of midge-borne diseases.

**Strategies to protect animals from *Culicoides* midges when transporting animals**

- Treating animals with chemical repellents prior to and during transportation;
- Loading, transporting and unloading animals at times of low vector activity (i.e. bright sunshine, low temperature);
- Ensuring that vehicles do not stop en route during dawn or dusk, or overnight, unless the animals are held behind insect proof netting;
- Darkening the interior of the vehicle, for example by covering the roof and/or sides of vehicles with shade cloth;
- Surveillance for vectors at common stopping and offloading points to gain information on seasonal variations; and
- Using historical or modeling information to identify low risk ports and transport routes.