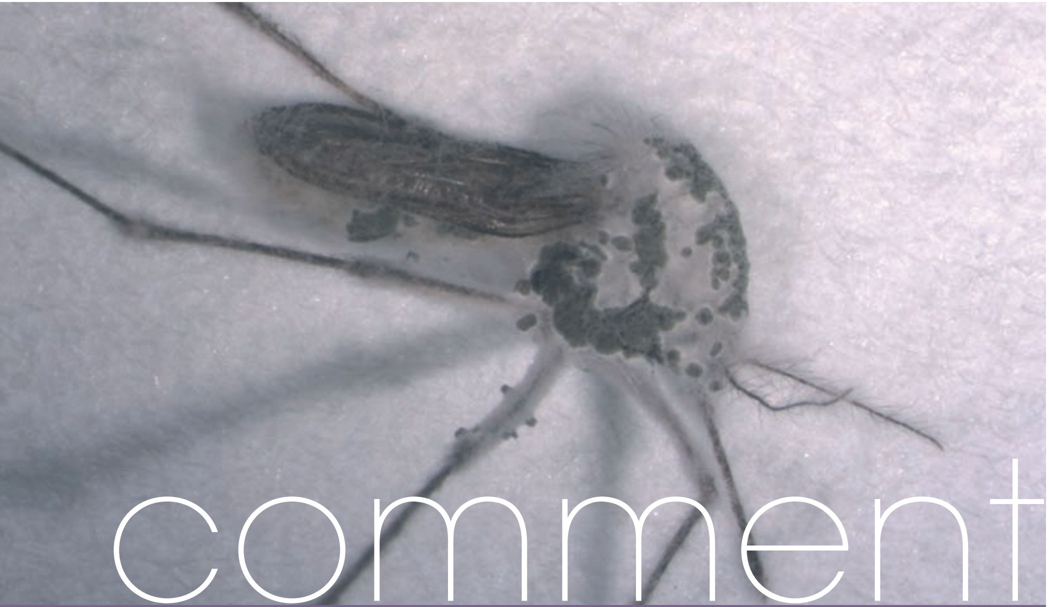

comment

Fungi as biological controls of insect disease vectors

As our climate changes, the threat from insect-borne disease may increase in the more temperate parts of the world. **Nancy Beckage** and **Anita Gordillo** discuss how, in the future, fungi may be used to control these insect vectors.

Entomopathogenic fungi have been exploited as agents for biological control of insect pests for decades. Two highly effective fungal pathogens are *Metarhizium anisopliae* and *Beauvaria bassiana*. The spores (conidia) come into contact with the insect body surface, germinate on the cuticle and move into the haemocoel, where the fungal hyphae proliferate. The host is killed due to production of toxins by the fungi. Strains have evolved to become host-specific, killing closely related species with minimal effects on non-target insects. Given appropriate conditions (temperature, humidity), the insect cadaver becomes encased in fungal spores as they erupt from the host, producing more conidia with potential to infect other individuals.

While several strains of *M. anisopliae* and *B. bassiana* have been employed as biological controls of insect pests in crop protection (e.g. 'Green Muscle' programme in Africa), their potential for controlling adult mosquito vectors of disease has only recently undergone evaluation. Implementation of *M. anisopliae* and *B. bassiana* in controlling adult *Anopheles gambiae* mosquitoes to reduce rates of transmission of malaria in Africa was described in 2005 (see Further reading). While microbial pathogens are widely used to control populations of mosquito larvae, they are not easily used for *A. gambiae*. The larvicide *Bacillus thuringiensis israeliensis* must be ingested to induce its mosquitocidal activity; *A. gambiae* develops rapidly as larvae in small pools of water following rainfall, thus making well-timed distribution of the pathogen difficult. Since physical contact of conidia with the mosquito cuticle is all that is necessary for infection, using *M. anisopliae* or *B. bassiana* as adulticides can be directed at the mosquitoes prior to their reproductive stage to reduce the number of potential offspring and the number of females that can potentially serve as disease vectors. Adult mosquito longevity decreases by >50% following infection, and female fecundity and egg production are significantly reduced within 48 h until the mosquito dies. Adult blood-feeding activity is also suppressed during this time frame, further contributing to a dramatic reduction in vector competence and decreased rates of disease transmission. *M. anisopliae* is also an effective biological control agent against other mosquito species such as *Culex quinquefasciatus*, *Aedes aegypti* and *Aedes albopictus*, which collectively are responsible for the spread of encephalitis viruses, West Nile Virus, filariasis, dengue fever and yellow fever.

▲ A *Culex quinquefasciatus* adult, a few days post-mortem, treated with the fungus *Metarhizium anisopliae*. *Anita Gordillo*

Fungal efficacy is dependent upon the conidial concentration used to infect the mosquito, exposure time, medium in which they are administered and substrate to which the fungi are applied. The applications used thus far have used substrates on which the mosquitoes can be found resting following a blood meal, but targeting newly emerged adults prior to their initiation of blood feeding would be optimal to get the most significant reduction in disease transmission rates. Because of the multiple attributes of infection by these fungi that reduce the vector's ability to transmit disease, using fungi in biological control of adult stages of mosquitoes represents a new option in our vector management toolkit.

Current methods to control adult mosquitoes in impoverished countries are limited to indoor applications of residual chemical insecticides, or bednets treated with synthetic pyrethroids. Intensive use of pesticides globally since the introduction of DDT in the 1940s has resulted in major problems with development of vector resistance to insecticides, environmental pollution and adverse effects on non-targeted species. Moreover, changing rainfall patterns and increased temperatures associated with global warming are predicted to expand the range of many insect vectors that are currently confined to the tropics and subtropics, including the vectors of malaria, dengue and yellow fever. Global health burden will assuredly increase as a result of predicted changes in climate and environmental factors that favour the successful reproduction of insect vectors and the expansion of their ranges.

Genetically modified *M. anisopliae* expressing insect-specific toxins further enhances their virulence to mosquitoes, but their utilization in field-based mosquito control is controversial due to public concern regarding genetically modified organisms and regulatory issues. Regardless, the use of entomopathogenic fungi to control populations of adult mosquitoes clearly offers significant promise as a novel biologically based strategy to be integrated with other control measures to reduce global rates of vector-borne disease transmission.

Anita R. Gordillo & **Nancy E. Beckage**
Departments of Entomology & Cell Biology and Neuroscience, 382 Entomology Building, University of California-Riverside, CA 92521, USA (t +1 951 827 3521; f +1 951 827 3087; e nancy.beckage@ucr.edu)

Further reading

Blanford, S. & others (2005). *Science* 308, 1638–1641.

Scholte, E.J. & others (2005). *Science* 308, 1641–1642 / *J Insect Sci* 4, 19.

Scholte, E.J. & others (2007). *Acta Trop* 102, 151–158.

Wang, C. & St Leger, R.J. (2007). *Nat Biotechnol* 25, 1455–1456.

www.scienceinafrica.co.za/Green_Muscle.htm