

The competitors of *Anopheles gambiae s.l.*

What are the likely consequences for interacting competitors of *Anopheles gambiae* reduction in local ecosystems?

Competition during the larval life-stage

Mosquito larval and pupal stages are restricted to the water bodies in which they hatched; it is here that competition is most likely. Competition can only occur when a resource is in limited supply, for example, space, food, or mates. There are many studies of competition both within and between *Anopheles* species in larval habitats. Many of these have taken place in simplified mesocosms (outdoor experimental system that examines the natural environment under controlled conditions) and have less-variable environmental conditions than are met with in nature; this can limit the realism of their extrapolation. During the adult life stage there is little evidence of competitive interactions, other than for mating opportunity.

Within-species (intraspecific) competition can limit local abundance of that species, but between-species (interspecific) competition can limit abundance of other species co-occurring in the habitat. '**Competitive displacement**' happens when one species with any competitive advantage over another is able to dominate that habitat. In other words, its strength as a competitor restricts or displaces other species. If a species is reduced in numbers, then other species that have previously been displaced may increase in number; this is '**competitive release**'.



Inferences from mosquito control interventions

Many mosquito control programmes have been successful and give evidence of the effects of reduced competition from a focal species.

- In early 20th Century Italian mosquito control, the malaria vector *An. labranchiae* was largely replaced by the zoophilic (preference of animals as a source of food) *An. hispaniola*. This shift in balance was not permanent; over the following 35 years, the number of sites occupied by *An. labranchiae* rose again
- In the 1950s and 1960s, Indoor Residual Spraying (IRS) with dieldrin to control malaria in southern Kenya and northern Tanzania led to the virtual disappearance of the vector *An. funestus*. Two other anopheline species, *An. rivulorum* and *An. parensis* rose in numbers, possibly as a result of reduced larval competition.
- A marked decline of the *An. gambiae s.s.* population in response to an Insecticide Treated Net (ITN) programme was noted in western Kenya. Competitive release may have occurred in the larval habitat and contributed to a species shift towards *An. arabiensis*.

- After elimination of *An. darlingi* and malaria in the Demerara River Estuary of Guyana (by DDT spraying), the human population grew rapidly, and land use activities switched from livestock to more profitable rice farming. The removal of livestock from the landscape, however, caused the formerly zoophilic (preference of animals as a source of food) *An. aquasalis* to switch its feeding from livestock to humans. Here a locally present species was ecologically flexible in response to change in the environment.

Competition within the species complex: *Anopheles gambiae sensu lato*

The larvae of the three principal malaria vectors *An. gambiae*, *An. coluzzii* and *An. arabiensis* are often found in the same habitats, e.g. man-made holes, roadside ditches, transient puddles and footprints. Differences in survival and development of these species at different temperatures may help explain adult distribution in much of Africa. The typically small breeding sites of *An. gambiae* can support very high larval densities and intense intra- and interspecific competition. Relative competitive ability in *An. gambiae s.l.* species has implications for species distribution and aquatic habitat colonisation. Faster development time in temporary aquatic habitats is a trait of major importance enabling reduced exposure to negative effects such as desiccation, predation risk, cannibalism, pathogens and flushing due to rainfall.

- *An. arabiensis* is considered to be better adapted to dry, hot conditions, whereas *An. gambiae* is the superior competitor in wetter field conditions.
- Mixed-species rearing can reduce survival of *An. arabiensis*, but not *An. gambiae*. Limited food might impose more competition on the larger *An. arabiensis* than on *An. gambiae*.
- Semi-field studies of wild mosquitoes indicated that *An. gambiae* larvae are superior competitors to *An. coluzzii*. The reverse was true in insectary-sourced and laboratory-

trials, which suggests caution in extrapolating results of laboratory competition studies to field populations. Faster development of *An. gambiae* than of *An. coluzzii* in the field has also been reported.

Competition with other dipteran groups

Interspecific competition with other co-occurring Diptera (the order of insects that contains mosquitoes and other flies) could lead to population-level effects. In a semi-field situation, the mosquito *Culex quinquefasciatus* can affect adult size, sex ratio and speed of development in *An. gambiae s.s.*:

- The sex ratio of both *An. gambiae s.s.* and *Cx. quinquefasciatus* was male-biased when raised with only individuals of the same species; when mixed with the other species, the reverse was true.
- For both species, more pupae and adults emerged earlier when raised with only individuals from the same species than in cohabitation. Increased larval density when raised with only individuals of the same species or when mixed with the other species did not affect survival.
- Wing-length (a proxy for overall body size), host seeking ability and fecundity of female mosquitoes was reduced in *An. gambiae s.s.* by this inter-specific competition. Smaller female malaria vectors feed more frequently and may need two feeds before their first oviposition and this may influence transmission.
- In co-habitation, niche partitioning which reduces competition, was seen; *Cx. quinquefasciatus* fed on lower micro layer surfaces while *An. gambiae s.s.* fed on upper surface micro layers.

Glossary

Diptera: The order of insects that contains mosquitoes and other flies.

Interspecific competition: Competition for a limited resource between individuals of different species.

Intraspecific competition: Competition for a limited resource between individuals of the same species.

Selected references:

Collins *et al.* (2018), Effects of removal or reduced density of the malaria mosquito, *Anopheles gambiae s.l.*, on interacting predators and competitors in local ecosystems, *Medical and Veterinary Entomology*

Gimonneau, G. *et al.* (2014) 'Larval competition between *An. coluzzii* and *An. gambiae* in insectary and semi-field conditions in Burkina Faso', *Acta Tropica*