A WELL FACTSHEET

Excreta, flies and trachoma

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This factsheet presents evidence on the relationship between the common eye-seeking fly ***musca sorbens****, the eye disease trachoma and the role that environmental health factors (including habitat, climate and sanitation) play in its transmission.*

Introduction

Trachoma is an infectious disease caused by *Chlamydia trachomatis* – a micro-organism which spreads through contact with eye discharge from the infected person and through transmission by eye-seeking flies. Trachoma affects about 84 million people of whom about 8 million are visually impaired and repeated infection, if untreated, can lead to blindness. Trachoma is the leading cause of preventable blindness and continues to be a major problem in many of the poorest and most remote rural areas of Africa, Asia, Central and South America. Active disease is most common in pre-school children with prevalence rates as high as 60-90%. It often strikes the most vulnerable members of communities--women and children, with adult women at much greater risk of developing the blinding complication of trachoma than are adult men. The key environmental risk factors are water shortage, flies, poor hygiene conditions, and crowded households (WHO 2006).

The eye-seeking fly *Musca Sorbens*

Adult *Musca sorbens* feed directly from people or on food gathered by people. They lay their eggs on the faeces of people (and their domestic livestock) and they rest at night on the walls of human structures. The close affinity of *Musca sorbens* to man, coupled with aggressive feeding on substances (ocular and nasal discharges) that may contain *Chlamydia trachomatis* by females, allow it to be a mechanical vector of trachoma.

Musca sorbens is a complex species with three members currently being recognised, namely, *M. sorbens*, *M. biseta* (Afrotropical and both referred to as the Bazaar fly) and *M. vetustissima* (Asian / Australasian referred to as the Australian bush fly) (Pont 1991). *M. sorbens* is frequently referred to as though it is a single species; in what follows *M. sorbens* refers to the two African species, rather than the specific single species.

Relationship to man

The species is known to be domestic and is commonly referred to as being synanthropic, meaning living in close proximity to man. There is evidence that the closeness with man is such that these flies can be termed euanthropic, in that they have co-evolved with man and are not only adapted to an environment which is shaped by human activity, but are reliant on humans to provide a suitable habitat. The species almost certainly co-evolved with man in Africa and followed human expansion across the world, limited in its range only by its trophic requirements. *Musca sorbens* did not follow the human migration into the new world, (probably being unable to follow its hosts over the transient northern land bridges) and is absent from the Americas. This is likely why flies have not been linked with trachoma transmission in risk factor studies from Brazil and Mexico (Taylor et al. 1985; Luna et al. 1992).

How many flies does a fly produce?

The theoretical ability for population growth in *M. sorbens* is mind bogglingly large. At a constant 28°C one adult female emerging on August 1st could have 17.8 million progeny by mid-October. Thankfully, this does not happen; the population is limited by predators, parasites, disease, and most importantly the availability of larval media. If a suitable medium exists where *M. sorbens* lives, we can presume that *M. sorbens* will find it and breed in it.

Breeding in excreta

Investigations into the preferred breeding media of *M. sorbens* conclude that human faeces available on the ground, but not in the full sun, are the preferred breeding media of *M. sorbens*. (Zimin 1948; Hafez and Attia 1958c; Peffly 1953). A study from The Gambia (Emerson et al. 2001) looked at the productivity in terms of numbers of flies per hundred grams of faeces and also the quality of the flies as measured by their head-widths (bigger is better in the insect world, it equates to greater longevity and fecundity). Human faeces produced the most, and the biggest flies. The study compared the distribution of head-widths of flies caught from eyes with those emerging from human and other animal faeces. The mean head-width of the flies from human faeces was similar to those caught from eyes, whilst the flies from all other breeding media were significantly smaller. We can reasonably speculate that it is the presence of *M. sorbens* and human faeces that is associated with trachoma transmission.

Although human faeces are clearly the preferred larval medium, a gravid female *M. sorbens* will lay her eggs on the next best thing, if human faeces are not available. Young *M. sorbens* have been reported emerging from pig, dog, milk-fed calf and cattle faeces in addition to that of humans (Zimin 1948; Hafez and Attia 1958c; Emerson et al. 2001) *Musca sorbens* flies have not been reported from horse, camel, donkey, sheep, goat or poultry faeces when tested (Peffly 1953; Emerson et al. 2001).

Environmental factors and *Musca Sorbens*

Temperature

The duration of development from egg to adult is temperature dependent, with lower temperatures increasing development time and there being absolute values below and above which development does not take place (Hafez and Attia 1958a; Hafez and Attia 1958c). At ambient temperatures below 16°C and above 40°C development of *M. sorbens* is very slow. At a constant 28°C development from egg to adult took 8.4 days; this was similar to field conditions in the The Gambia (Emerson et al. 2001). Adult activity is also temperature dependent. No published data exist demonstrating this, but anecdotally adult *Musca sorbens* in cages died at 40°C and above. At 35°C and above, fly-to-eye contact is greatly decreased with the flies being seen resting at the top of walls where they are shaded by eaves, indoors or on the underside of leaves.

There is a marked increase in *Musca sorbens*feeding activity in the relative cool of the African morning and early evening (Emerson et al. 2000). Anecdotally, the greatest concentrations of *Musca sorbens* are usually coupled with the greatest concentration of people in tropical Afgrica, irrespective of the temperature. "Clouds" of flies are commonly seen around the faces of children in densely populated villages in The Gambia, Tanzania, Kenya, Ethiopia, Sudan, Mali, Niger, Ghana and Morocco across the Berbers. Fewer flies are seen with some of the nomadic people or those living in really low population areas, such as the Kalahari and the Sahel. However, in all probability *M. sorbens* is quite likely to continue to transmit trachoma (and be bothersome) during the African hot seasons where temperatures creep beyond 45°C. During these hot times the flies pester their hosts in the shade.

Inside or outside the house?

In the Gambia there was statistically no difference in fly-eye contact inside or outside a house, (Emerson et al. 2000) although in Ethiopia it was found that there were fewer indoors (unpublished data). The Ethiopian data did not record temperatures but it is likely that the apparently inconsistent findings are actually linked to temperature - in the relatively cool Ethiopian highlands there is no reason for *M. sorbens* to go into the shade.

Rainfall

Moisture is probably the most important factor in what makes faeces a suitable breeding medium; in very dry environments human faeces desiccate rapidly and the larvae developing within them die or migrate out of them. Assuming that there is no loss of nutritional value through the desiccation process, if water is added to the stool, it may become a suitable breeding media again, and will be utilized. This may explain the conflicting reports of seasonal variation in the density of adult *M. sorbens*. No data exist on life expectancy of adult flies, but it would be reasonable to assume that flies will live longer when humidity is higher, which may also be a contributing factor.

Seasonality

The population of *M. sorbens* does not change by orders of magnitude like that of the common house fly *M. domestica* in the wet and dry seasons (Emerson et al. 1999; Emerson et al. 2000; Emerson 2004). The balance of the evidence suggests that the adult *M. sorbens* population is limited by the availability of quality human faeces as a breeding media, and the prime development of 'quality' in the human faeces is the moisture content. In some places this varies with season.

Altitude

Data from Ethiopia (Alemayehu et al. 2005) shows that at altitudes above 3,000m the prevalence of signs of trachoma is greatly reduced from the lower altitudes; this is consistent with the absence of *M. sorbens* flies at the higher altitudes. Collections of eye-seeking flies at different altitudes found that the catches of *M. sorbens* are basically zero above 3,000m. Realistically, there are few places in the world where people routinely live above 3,000m that are also trachoma-endemic.

Musca sorbens does not breed in latrine pits

Human faeces in pit latrines do not appear to be a suitable breeding material. In a year-long longitudinal study of 16 sentinel latrines in The Gambia (Emerson 2005, only 65 *M. sorbens* were ever caught emerging from latrine drop holes (from 192 catches). Of these 65 there was a disproportionate number of females, which is not consistent with the 1:1 ratio of males to females always reported from breeding experiments. It is suspected that most, if not all, of these 65 were accidental captures of females attracted to the latrine by the odour. Quite why *M. sorbens* fails to breed in pit latrines is open to conjecture. It is possible that that females are attracted into the latrines and lay their eggs there, but the larvae are out-competed by the larvae of Calliphorid flies which may compete better for oxygen in the moist conditions – and also eat anything that doesn't get out of their way, possibly including the *M. sorbens* larvae.

It is therefore all the more important to strive for isolation and containment of human excreta in sanitary latrines.

Do other flies contribute to Trachoma?

In experiments gathering flies directly from the eyes of children conducted in The Gambia, Tanzania and Ethiopia, only *Musca sorbens* and *Musca domestica* (the common housefly) have been caught (Emerson et al. 1999; Emerson et al. 2000; Emerson 2004; Hafez and Attia 1958b; West (in press); Alemayehu (unpublished data). *Musca domestica* cannot be excluded as a potential vector of trachoma; however, its broad feeding and ranging habits make the possible vectorial capacity low to absent. For a fly to act as mechanical vector it must first pick up the bacteria from an infected eye or nasal discharge and then transfer them to an uninfected eye before the bacteria are either dislodged in flight, killed by desiccation or ultra violet light exposure, remove by the fly as it grooms itself or stick to something else. Since *M domestica* is attracted to a broad range of substrates, and is not specifically attracted to eyes, the likelihood that any bacteria picked up will be transferred to a new host is rather small. This is not to say that *M. domestica* never plays a role in trachoma transmission; when it is very abundant and crawling over everything, it may be of transient importance.

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