# Data sources for the Anopheles-model package

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The main source for vector bionomics data is the MAP repository, documented by Massey et al. (1).

## Additional data

Substantial additional data were included in a supplementary database. This includes publications that are not included in the MAP repository, because they did not meet one or other inclusion criterion. These include some very old, and some very recent publications (2-26). A considerable number of additional publications included relate to *An. albimanus* for which there is a substantial literature poorly represented in the MAP repository. The additional data also comprise measures (especially the sac rate, and biting rhythms see below) which were not routinely extracted by Massey et al. (1).

## Post processing

Most of the entomological parameters can be extracted from the format used by MAP, but additional issues arise with:

### Biting rhythms

African data on biting rhythms have recently been compiled by Sherrard-Smith(27). There is no comprehensive database of the biting rhythms for non-African sites, though the MAP files can be searched for publications containing biting rhythms. Biting rhythms were extracted from a convenience sample of publications giving rhythms for a subset of vectors of particular interest (13, 20, 22, 24, 28-33). This is by no means a comprehensive collection of the data that are out there.

### Duration of host-seeking

The duration of host-seeking is estimated from the sac rate where ((using the notation of (34), as described by (4) in (35) and applied also in (24, 35-39). (This ignores the possibility that the mosquitoes might rest for more than 48 hours before oviposition). The duration of host seeking is available only for only a small subset of taxa.

The duration of the gonotrophic cycle is the sum of that of the host-seeking and resting period. Some publications report estimates of the duration of the gonotrophic cycle from either:

1. Mark-recapture(25, 40-48)
2. Cross-correlations in time of biting densities (49)

There are also some publications reporting gonotrophic cycle length where the method used is unclear (50-53). It may be that these estimates really consider only the resting period.

### Duration of resting period

The duration of the resting period can be estimated as follows:

1. Keeping fed mosquitoes to see how long it takes for them to lay eggs (as recommended by WHO(54)). This was carried out by (18, 26, 43, 47, 55-61).
2. The ratio of fed:gravid resting mosquitoes is available for 106 studies in the MAP database for which the fed:gravid ratio is available, corresponding to 30 different Anopheles taxa. Kulkarni et al (2006)(62) and Tchuinkum et al(63) have used the fed:gravid ratio from resting mosquitoes to roughly estimate the duration of the resting period. The Kulkarni et al (2006)(62) analysis gave values of 1:1.4 (low altitude) and 1:4.5 (high altitude) for *An. arabiensis* in Tanzania, translating these into estimates of 2-3 days and 5-6 days.

The logic of the fed:gravid approach is best explained in Tchuinkum et al(63). Assuming negligible mortality while resting and that a whole annual cycle is representatively sampled), the proportion f = fed/(total-unfed), the duration of the cycle should be = 1/f. If we assume daily survival while resting of p<1, and is an integer then:

which is equivalent to:

We can consider the extreme case of assuming all the mortality is at the resting stage, and use this to estimate p from the parous rate, as: . This this leads to an equation for as a function of the parous rate and f:

Feeding in some ‘reasonable’ numbers into this, we get:

|  |  |  |  |
| --- | --- | --- | --- |
|  | M |  |  |
| 0.6 | 0.8 | 1.67 | 1.75 |
| 0.5 | 0.8 | 2.00 | 2.12 |
| 0.4 | 0.8 | 2.50 | 2.68 |
| 0.3 | 0.8 | 3.33 | 3.61 |
| 0.2 | 0.8 | 5.00 | 5.47 |
| 0.1 | 0.8 | 10.00 | 11.05 |
| 0.6 | 0.6 | 1.67 | 1.86 |
| 0.5 | 0.6 | 2.00 | 2.29 |
| 0.4 | 0.6 | 2.50 | 2.93 |
| 0.3 | 0.6 | 3.33 | 4.00 |
| 0.2 | 0.6 | 5.00 | 6.13 |
| 0.1 | 0.6 | 10.00 | 12.51 |

This suggests that could be a reasonable estimate of the duration of the resting period (applicable even if the parous rate has not been determined). The average duration of the full oviposition cycle is then estimated by:

The inputs to the Anopheles package should thus be and (with the constraint that ). Values of the former are obtained either as a temperature-dependent function (various publications have estimated this), or as . Where the sac rate ( is available, can be determined from the above equation. takes real values, but the model is discrete time, with one-day time steps. Effectively this means that we are simulating a Poisson mixture of discrete values (this is broadly supported by published distributions for (58)).

### Estimates of the proportions of mosquitoes resting indoors

The proportions of mosquitoes resting indoors is usually estimated using experimental huts, where exophilic mosquitoes are caught in exit traps. This parameter is relevant for the parameterisation of models of IRS. Publications in the MAP database(1) with exit trap data are (64-67)

### Estimates of the human blood index

The human blood index (χ) is required for estimating the availability of human hosts relative to animals, and is usually estimated by testing blood-fed mosquitoes for human antigens or DNA. Some SE Asia studies (of places where bovines represent the major alternative host to humans) report the ratio of numbers of mosquitoes captured on humans:buffaloes (or carabao). This value coded RHB (human:bovine ratio) has been extracted from several of the SE Asian studies and is included in the additional datasets. It can be used to provide estimates of . Alternatively, if there is a good estimate of χ for some vector species in a site, the estimates for the other species can be obtained by regression analysis of the values of RHB.

## Parameterisation of interventions

Interventions are parameterised by their effects on the input parameter vector:

### Insecticide Treated Nets

The effects of ITNs are parameterised in terms of effectiveness in reducing the availability of humans, , and both pre- and post-prandial killing of mosquitoes and respectively. The effects are based on estimates from experimental hut studies(68). The decay of these effects over time, in terms of attrition, use, physical and chemical integrity is parameterised using the data of PMI net durability studies (7 countries, 8 net types, 23 combinations in all), and also Morgan et al(69)

### Indoor Residual Spraying (IRS)

IRS is also parameterised in terms of reducing the availability of humans, and killing of mosquitoes. 12 different parameterisations (for different insecticide x vector species combinations) are included in the database(70-74).

Following references not sure where they belong:

(75)

(76)

(77)

#### Data used by Swiss TPH in parameterising entomological models

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Data sources available |  |  |
|  | Swiss TPH publication explaining the paramerisation | Africa | S.E.Asia and Oceania | Americas |
| Mosquito bionomics in the absence of intervention | | | | |
| Human blood index | (78) | (1) | (1) (79, 80), (81) (42) (5, 9)(Schultz, 1993) | (1, 19, 73, 82) |
| Biting rhythm | (78) | (27) | (13, 28-32). | (20, 22, 24, 33, 78) |
| Indoor resting | (78) | (1) |  | (20, 22, 23, 83) |
| Parous rate (or survival per cycle) | (78) | (1) | (9, 42, 79)(Hii et al., 1990)(Chiang et al., 1991)(Catangui, 1971)(Torres et al., 1997) | (25, 84) |
| Duration of Resting period | (78) | (1, 46-49, 55-59, 61-63) | (40, 44, 45, 60)(Chiang et al., 1991)(Catangui, 1985) | (18, 25, 26, 43, 47) |
| Duration of host seeking | (34) | (35-38) | (39, 41, 42)(Charlwood et al., 2016)(Catangui, 1971) | (24) |
| Proportion indoor biting | (78) | (1) | (79-81) |  |
| Duration of larval development | (Manuela’s paper on larviciding?) |  | (Catangui, 1985)(Phasomkusolsil et al., 2013) |  |
| Survival of eggs to emergence | (Manuela’s paper on larviciding?) |  | (Phasomkusolsil et al., 2013)(Kanda et al., 1981) |  |
| Number of eggs laid by ovipositing female | (Manuela’s paper on larviciding?) |  | (Kanda et al., 1981)  (Salazar, 1989) |  |
| Models of intervention effects | | | | |  |  | (Salazar, 1989) |
| Effects of LLINs (including PBO nets) on blood feeding and mortality | (85) | (86-98) | (16) | (99) |
| Decay of LLIN effects over time | In prep | PMI studies(attrition, physical and chemical decay for 8 net types in 7 countries); (69) | - | - |
| Availability of hosts to mosquitoes and insecticidal effects of LLINs as functions of insecticide content, holed area, and resistance status | (68, 78) | (68) | - | - |
| IRS effects in reducing human availability and killing of mosquitoes | (78) | (70-74) | - | (78) |

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