## 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 were obtained from some 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 (2-17).

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

### Gonotrophic cycle length

Part of the MAP database is the results of studies of gonotrophic cycle length. There seem to be various methods for estimating cycle length in the papers in this collection. These are:

1. Keeping fed mosquitoes to see how long it takes for them to lay eggs (as recommended by WHO(18)). This was carried out by (19-29)
2. Mark-recapture(23, 27, 30-37)
3. Cross-correlations in time of biting densities (38)
4. There are also some publications where I can’t easily find a .pdf so I don’t know what method was used (39-41) or where the method is not described (42)
5. Sac rate (as described in (43) and applied also in (43-48)
6. Kulkarni et al (2006)(49) and Tchuinkum et al(50) have used the fed:gravid ratio from resting mosquitoes to roughly estimate the duration of the cycle. The Kulkarni et al (2006)(49) 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.

If the use of the fed:gravid ratio is valid, then of course there are far more data out there that could be used so it would be possible to obtain estimates of gonotrophic cycle length for many more situations. There are 106 studies in the MAP database for which the fed:gravid ratio is available, corresponding to 30 different Anopheles taxa. Only 22 taxa have gonotrophic cycle lengths estimated by other methods.

The logic of the fed:gravid approach is best explained in Tchuinkum et al(50). 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 u = 1/f. This ignores mortality of resting mosquitoes, but if we assume daily survival while resting of p<1, and u 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 u 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 even assigning all the mortality to the resting stage doesn’t make much difference, and so could be a reasonable estimate of the duration of the cycle (applicable even if the parous rate has not been determined). However this ignores the phenomenon of delay before attempting to refeed, which forms the basis of your formula for the use of the sac rate (as described in (43) where we proposed (using the notation of (51)). Conversely the use of the sac rate ignores the possibility that the mosquitoes might rest for more than 48 hours before oviposition.

This is resolved by treating the duration of the resting stage as a separate quantity () (47) that can be estimated as . 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. Alternatively it is obtained from any of methods a-d.

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 (22)).

### Estimates of the proportions of mosquitoes resting indoors

Publications with exit trap data (according to MAP)

Mnzava, A.E., Rwegoshora, R.T., Wilkes, T.J., Tanner, M. and Curtis, C.F. (1995). Anopheles arabiensis and An. gambiae chromosomal inversion polymorphism, feeding and resting behaviour in relation to insecticide house-spraying in Tanzania. Medical and Veterinary Entomology, 9(3):316-24 7548951

Sreehari, U., Razdan, R.K., Mittal, P.K., Ansari, M.A., Rizvi, M.M. and Dash, A.P. (2007). Impact of Olyset nets on malaria transmission in India. Journal of Vector Borne Diseases, 44(2):137-44 17722868

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Sachs, P., Diaz Rodriguez, G.A., Briceno, I., King, R., Achee, N.L. and Grieco, J.P. (2013). Comparison of experimental hut entrance and exit behavior between Anopheles darlingi from the Cayo District, Belize, and Zungarococha, Peru. Journal of the American Mosquito Control Association, 29(4):319-327 24551964

### Biting rhythms

African data on biting rhythms have recently been compiled by Sherrard-Smith. 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, 48, 52-59). This is by no means a comprehensive collection of the data that are out there.

### Additional data

Substantial additional data were included in a supplementary database, in particular for *An. albimanus* (24, 29, 37, 48, 58-62)

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