Non-Human Host Interventions

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We describe models for adding interventions targeting, or consisting of, non-human hosts. In the mathematical model for malaria in mosquitoes [1, 3], non-human hosts are described by five parameters, N_i, α_i, P_{B_i}, P_{C_i}, and P_{Di} (shown in Table 1) (with the assumption that the probability of surviving ovipositing, P_E, is independent of the host type). We note here that the calculations for initializing parameter values described in [2] is not changed by the addition of non-human host interventions.

Table 1: Description of Parameters for non-human hosts. Here, i is an index denoting the type of non-human host.

N_i:	Number of non-human hosts.
α_i:	Availability rate of each non-human host to mosquitoes. This rate includes the reduction in availability of a host due to diversion. The product, $N_i\alpha_i$ is the total availability rate of all nonhuman hosts of type i.
P_{B_i}:	Probability that a mosquito bites a nonhuman host of type i after encountering one.
P_{C_i}:	Probability that a mosquito finds a resting place after biting a nonhuman host of type i.
P_{D_i}:	Probability that a mosquito survives the resting phase after biting a nonhuman host of type i.

We model non-human host interventions using two methods:

1. Modifying existing non-human hosts
2. Adding new non-human hosts.

1 Modifying Existing Non-Human Hosts

This intervention modifies parameters of non-human hosts described in the <entomology> <vector> <anopheles> <nonHumanHosts> section of the input scenario file. These non-human hosts will have been used in the initialization routine and values will have been calculated for all five parameters described in Table 1. The intervention should be described by 5 parameters that define the change in each of non-human host parameters: [*Please rename the parameters as you see fit; and switch from a multiplier to a reduction or vice versa.*]

`increasePopulation` Multiplier that determines the increase or decrease in population size, N_i. For example, a value of 2 will double the population size; 1 will leave the population unchanged; 0.5 will halve the population size; and 0 will set the population to 0;

`reduceAvailability` Reduction in the availability rate, α_i. For example a value of 0 will result in no change; a value of 0.2 will reduce the availability to 0.8 of its initial value; and a value of 1 will set the availability to 0;

`prePrandialKillingEffect` Reduction in the pre-prandial survival probability, P_{B_i}. For example a value of 0 will result in no change; a value of 0.2 will reduce P_{B_i} to 0.8 of its initial value; and a value of 1 will set P_{B_i} to 0;

`postPrandialKillingEffect` Reduction in the post-prandial survival probability, P_{C_i}. For example a value of 0 will result in no change; a value of 0.2 will reduce P_{C_i} to 0.8 of its initial value; and a value of 1 will set P_{C_i} to 0;

`restingKillingEffect` Reduction in the survival probability of the resting period, P_{D_i}. For example a value of 0 will result in no change; a value of 0.2 will reduce P_{D_i} to 0.8 of its initial value; and a value of 1 will set P_{D_i} to 0;

as well as a deployment time and a decay function for each of these parameters. Although killing mosquitoes in any of the three stages (before feeding; after feeding; or resting) does not affect transmission, we separate the killing effects to be able to relate mosquito numbers to field data.

At the deployment time, the parameters of the non-human hosts will be altered as described in the intervention. This is applicable to interventions such as spraying livestock with insecticide and increasing or reducing the number of livestock.

2 Adding New Non-Human Hosts

This intervention adds new non-human hosts that have not been described in the `<entomology> <vector> <anopheles> <nonHumanHosts>` section of the input scenario file, and have not been used in the initialization routine. The intervention should be described by 5 parameters that fully describe the non-human host: [*Please rename the parameters as you see fit.*]

`numberHosts` The number of non-human hosts of this type;

`relativeAvailabilityHumans` The relative availability rate of one of these non-human hosts compared to one average adult human with no intervention;

`prePrandialSurvivalProbability` The probability of a mosquito surviving biting conditional on encountering this non-human host;

`postPrandialSurvivalProbability` The probability of a mosquito successfully finding a resting conditional on biting this non-human host;

`restingSurvivalProbability` The probability of a mosquito surviving the resting period conditional on finding a resting site;

as well as a deployment time and a decay function for each of these parameters. Although killing mosquitoes in any of the three stages (before feeding; after feeding; or resting) does not affect transmission, we separate the killing effects to be able to relate mosquito numbers to field data.

At the deployment time, new non-human hosts will be inserted into the population. This may be easier to implement by adding the non-human hosts with the given parameterization after the mosquito parameter calculations in the initialization phase — but setting the population size, N_i, to zero until the deployment time. This is applicable to interventions such as adding odour-baited traps or adding livestock.

References

[1] N. Chitnis, D. Hardy, and T. Smith, *A periodically-forced mathematical model for the seasonal dynamics of malaria in mosquitoes*, Bulletin of Mathematical Biology, 74 (2012), pp. 1098–1124.

[2] N. Chitnis, T. Smith, and A. Schapira, *Parameter values for transmission model.* Unpublished, Sept. 2010.

[3] N. Chitnis, T. Smith, and R. Steketee, *A mathematical model for the dynamics of malaria in mosquitoes feeding on a heterogeneous host population*, Journal of Biological Dynamics, 2 (2008), pp. 259–285.