

## Appendix S3: WinBUGS code and information about priors

Here, we describe the reasons for using an informative prior on  $\eta_s$  for the Cor assumption. For the Cor datasets, the shape parameter of the upscaled density distribution,  $\eta_D$  is small (appendix S2, table 2). Examining equation (4) in the main text reveals that a small value of  $\eta_D$  will lead to a small value of  $k$ . As the  $\eta_D$  values in the Cor datasets are sufficiently small to account for most of the aggregation in the burden data, corresponding estimates of  $\eta_s$  will tend to be large. However, the effect of  $\eta_s$  on  $k$  vanishes as it becomes large, so that further increases in  $\eta_s$  have essentially no effect on model fit. Though the Cor datasets support values of  $\eta_s$  that are larger than those of  $\eta_D$ , there is little information available to pin down a specific value. The half-Cauchy prior exerts a slight pull on  $\eta_s$  towards the origin, stopping it from wandering around at arbitrarily large values.

For all of the Cor datasets except TX 1999 Cor, the scale parameter,  $\sigma$ , of the half-Cauchy prior was 25 [1]. For TX 1999 Cor, a stronger half-Cauchy prior on  $\eta_s$  ( $\sigma = 15$ ) was necessary to ensure convergence. For all uniform prior densities we checked that the ranges chosen for the priors were not influencing the results.

The following listing shows the WinBugs code, including specification of the priors, used to fit the model to the burden data,  $B$ , and upscaled larval density data,  $D$ .

```
model
{

#Loop over observed burdens
for(i in 1:NB)
{

#Upscaled tick density component, D, of the accumulation model
vdInv[i] <- 1/vd
dd[i] ~ dgamma(nd, vdInv[i])

#Susceptibility component, S, of the accumulation model
vsInv[i] <- 1/vs
ss[i] ~ dgamma(ns, vsInv[i])

#The rate parameter of the Poisson is the product of the accumulation
#model components
lambda[i] <- dd[i] * ss[i]

#The burden data are then distributed as a Poisson with this
#rate parameter
B[i] ~ dpois(lambda[i])
}

#The upscaled tick density data fit to the gamma
for(i in 1:ND)
{
vdInv[NB+ i] <- 1/vd
D[i] ~ dgamma(nd, vdInv[NB + i])
}
```

```

### Prior distributions for the four model parameters

#Uniform prior on nu_S
vs ~ dunif(0.001, 250)

#Uniform prior eta_S for the Rnd datasets
#ns ~ dunif(0.01, 200)

#Half Cauchy prior on eta_S for the Cor datasets
#Scale parameter is 25, so precision of xiNs = 1/25^2 = 0.0016
xiNs ~ dnorm(0, 0.0016)I(0.01,)
chSqNs ~ dgamma(0.5,0.5)
ns <- xiNs/sqrt(chSqNs)

#Uniform priors on eta_D and nu_D
nd ~ dunif(0.01, 60)
vd ~ dunif(0.001, 20)

}

```

## References

- [1] Gelman A (2006) Prior distributions for variance parameters in hierarchical models. *Bayesian Analysis* 1: 515–533.