FITTING DYNAMIC ENERGY BUDGET MODELS: PARAMETER COVARIATION

I have done some initial simulation recovery experiments, and I want to explore the results of those efforts here. Note that the correlations among parameters for the four different parameter sets that have been fitted can be found in "Correlation_among_parameters.pdf". In this file, I am exploring the second parameter set, where the correlations were very clear.

I begin by looking at all of the estimated values for the fitted parameters, plotted as pairwise scatterplots to look for obvious correlations between the estimates. I focus only on those parameter sets where the log-likelihood was within 20 units of the minimum log-likelihood (note that subplex had not converged for *any* of these parameter sets - yikes). Points colored red are within 5 log-likelihood units of the minimum. I will focus my attention initially on the energy allocation parameters, and show the energy ingestion parameters and initial condition parameters next. Note that ν is on the logarithmic scale.

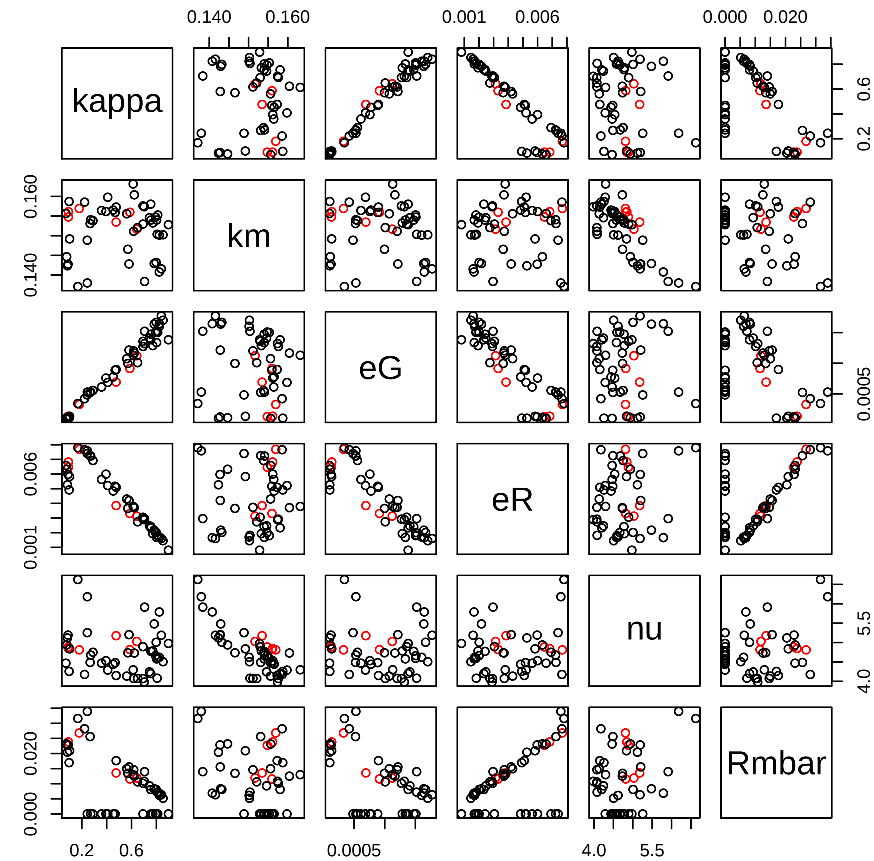
These show considerable correlation among the parameters. For example, the estimate of the energy requirement for maturation $\bar{R_m}$ is positively correlated with the estimate of the cost of reproduction ϵ_R, and the cost of growth ϵ_G is negatively correlated with the somatic maintenance rate k_m. This correlation is unsurprising, given that the DEB model, like all biological models, is overparameterized. Morever, the energy budget creates constraints that may allow parameters to trade-off against one another, producing similar growth trajectories. It may be that, although individual parameters cannot be well-estimated, certain parameter combinations can be, and the model can be reparameterized in terms of these estimable *compound* parameters.

One big, important difference between the previous parameter set and this one is the fact that ν is now reasonably well-estimated. The range of ν estimates is 1.9 to 3.98. The difference is that the truth was 1.8, rather than 18.1. So if ν is small, the likelihood surface may not be flat for increasing ν, as it seemed to be before.

The ingestion parameters are, on the whole, badly identified. Maximum surface-area specific assimilation rate p_{am} and half-saturation constant F_h have to be plotted on the log scale to visualize all of the variation. There appears to be a strong positive correlation between p_{am} and F_h, and between p_{am} and e_A.

Given that the ingestion parameters seem to be difficult to estimate, a problem that is unsurprising given that we are only considering data at a single food level, I will focus my attention on the energy allocation parameters only.

Let's first look at the estimates for each parameter by creating a histogram of the ratio of the estimates to the true value - a histogram with peak at, or near, unity inidicates

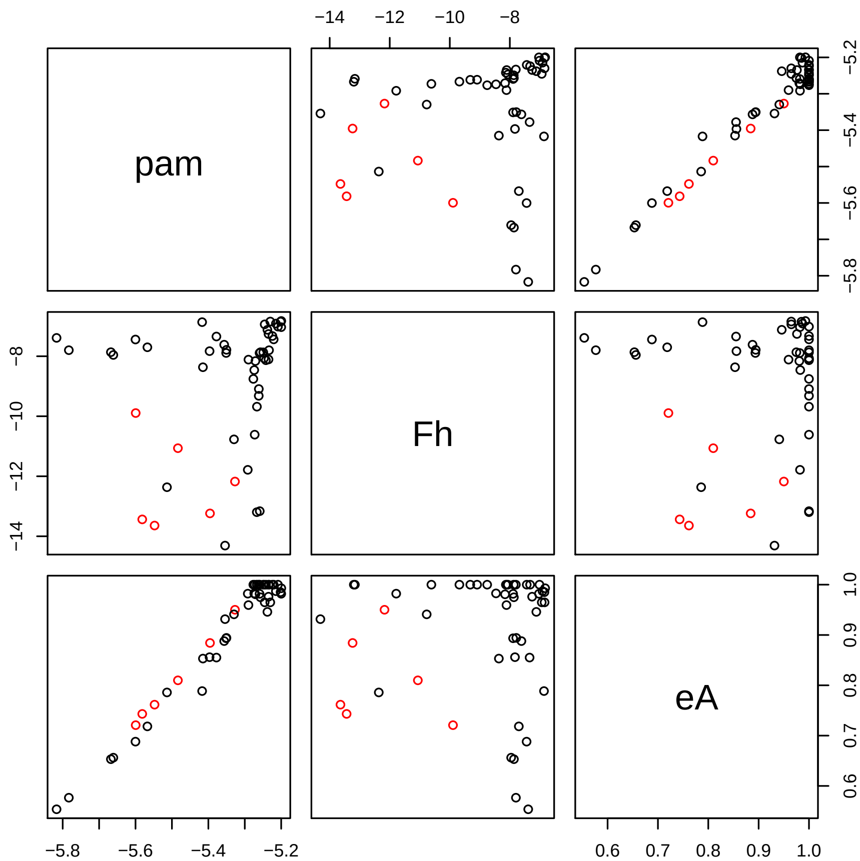


that the parameter was well-estimated. The red line indicates the truth, the blue line indicates the mean parameter estimate, and the green line the median estimate. This will allow us to focus our attention on only those parameters that might need to be looked as ratios or products with other parameters.

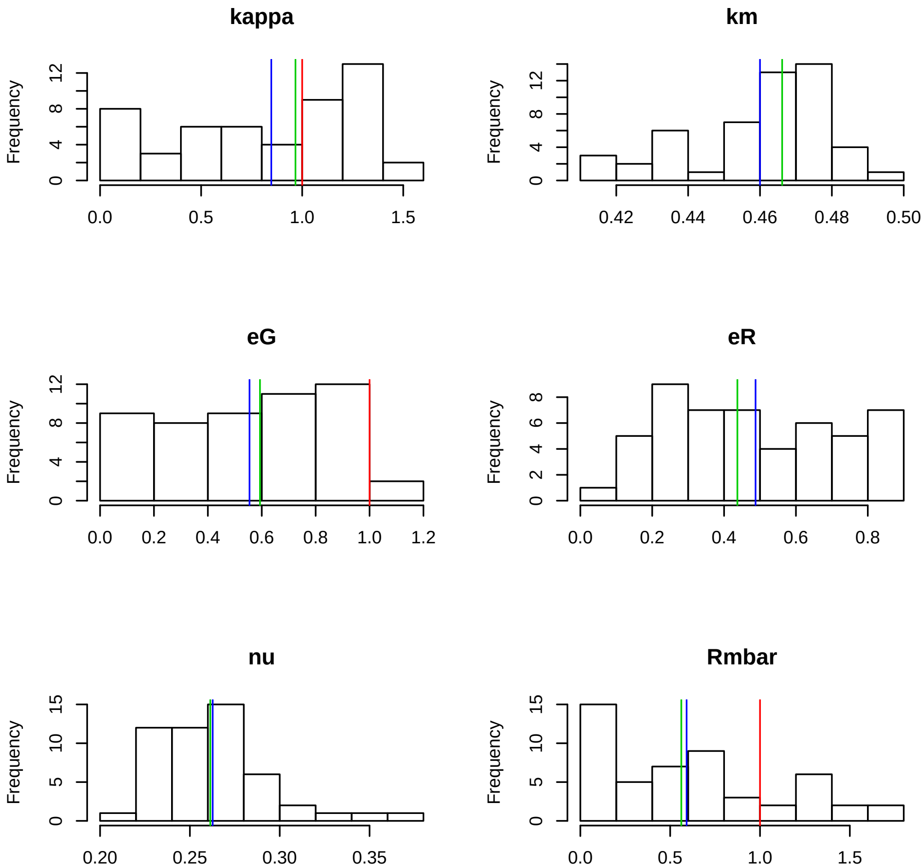
None of the parameters are particularly well-estimated. This differs a bit from my analysis of the first parameter set, where some of the parameters were reasonably well-estimated. In particular, the means of the different parameter estimates were close to the truth. Not so much here.

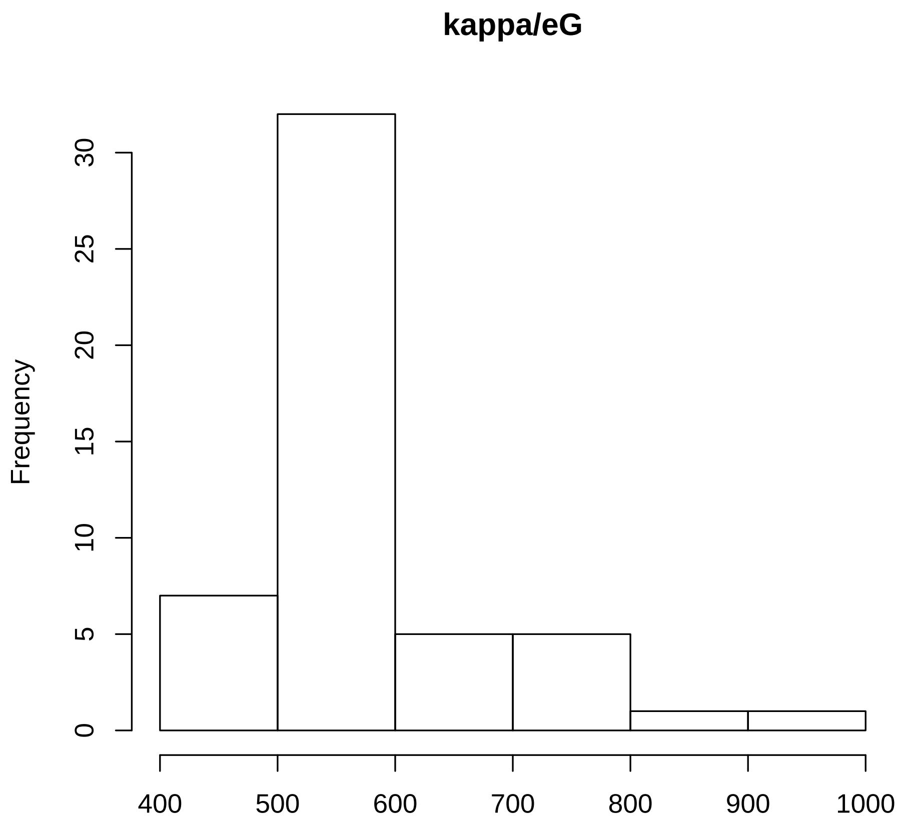
Again, I am interested in how well parameter combinations are estimated. For example, the parameter combination κ/ϵ_G appears in our DEB equations. Is this parameter combination well estimated, even if κ and ϵ_G are not? No. The true value of κ/ϵ_G does not even show up on this histogram - not a single estimate was even in the right ballpark.

All of this is making me wonder whether it might not be better to combine more than two parameters at the same time. In particular, I wonder if the non-dimensionalized parameters that Bill and I were playing around with might not be well-estimated too.



DEB theory makes use of a number of compound parameters - are any of these well-estimated?


kappa
Frequency
0.0
0.5
1.0
1.5
km
0.42
0.44
0.46
0.48
0.50
eG
0.0
0.2
0.4
0.6
0.8
1.0
1.2
eR
nu
0.20
0.25
0.30
0.35
Rmbar


kappa/eG
Frequency
0
5
10
15
20
25
30
400
500
600
700
800
900
1000

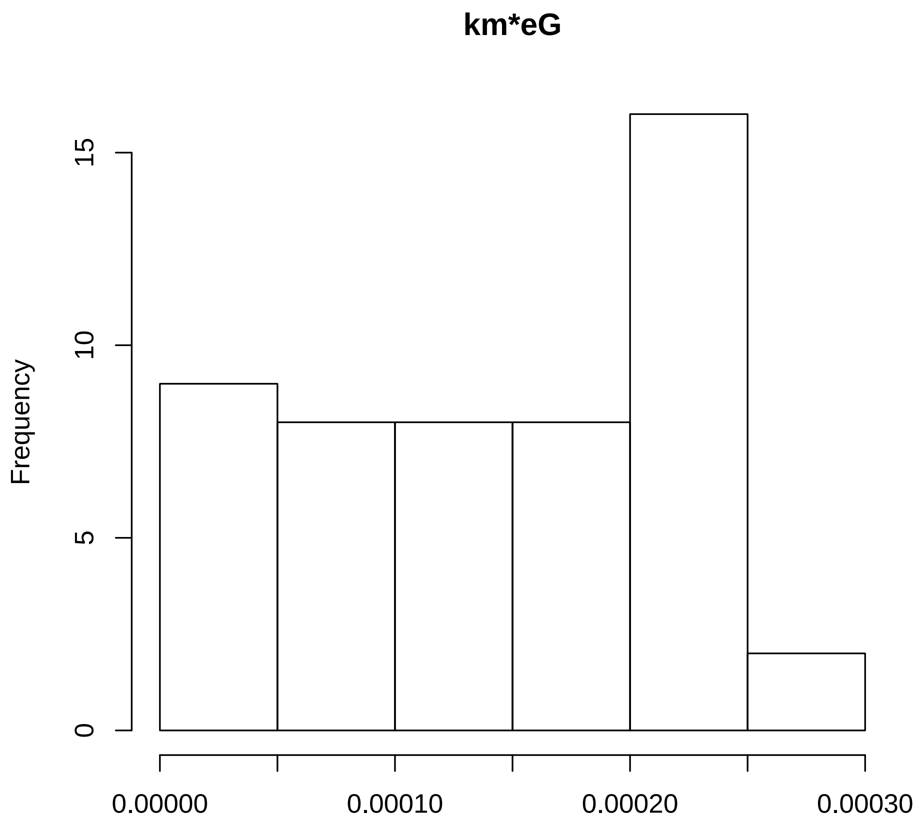


Figure 1. Another parameter combination that was well-estimated in the fitting of the first parameter set, but is not well-estimated now, is $k_m \epsilon_G$.

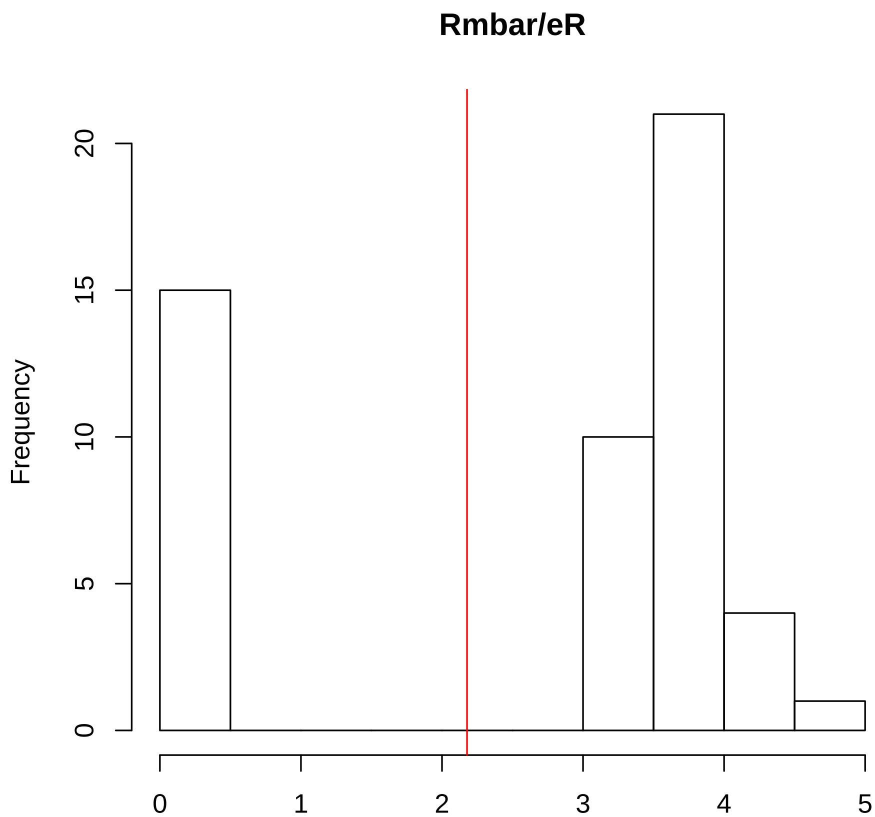


FIGURE 2. The ratio $\bar{R_m}/e_R$ was also previously well-estimated, and now, not so much.

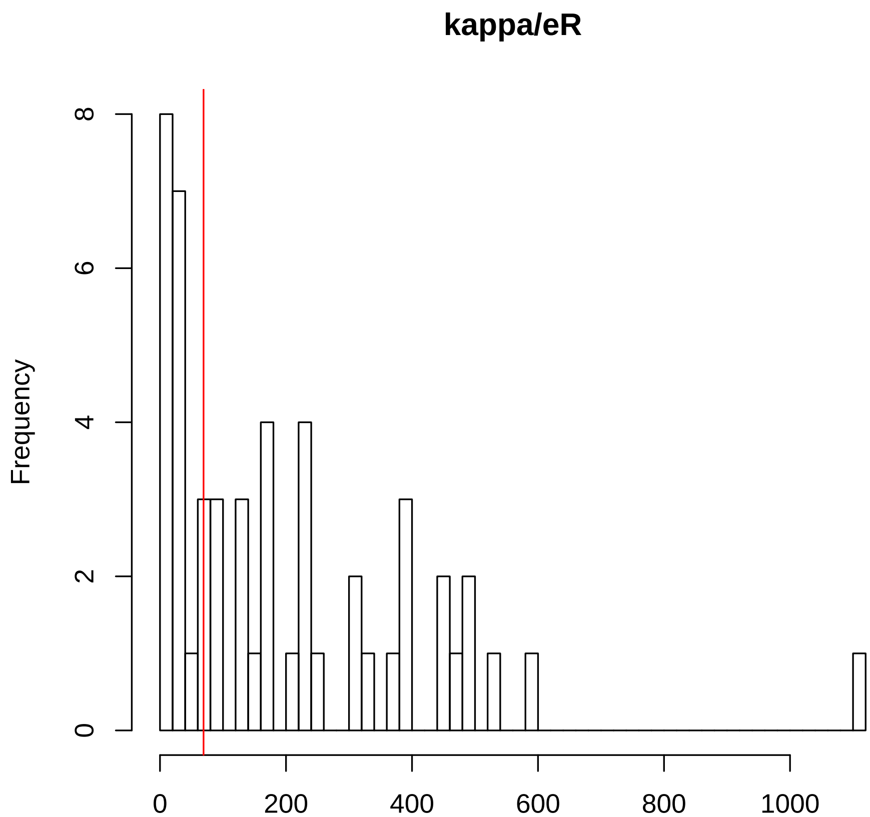


FIGURE 3. κ/ϵ_R is actually pretty well-estimated.

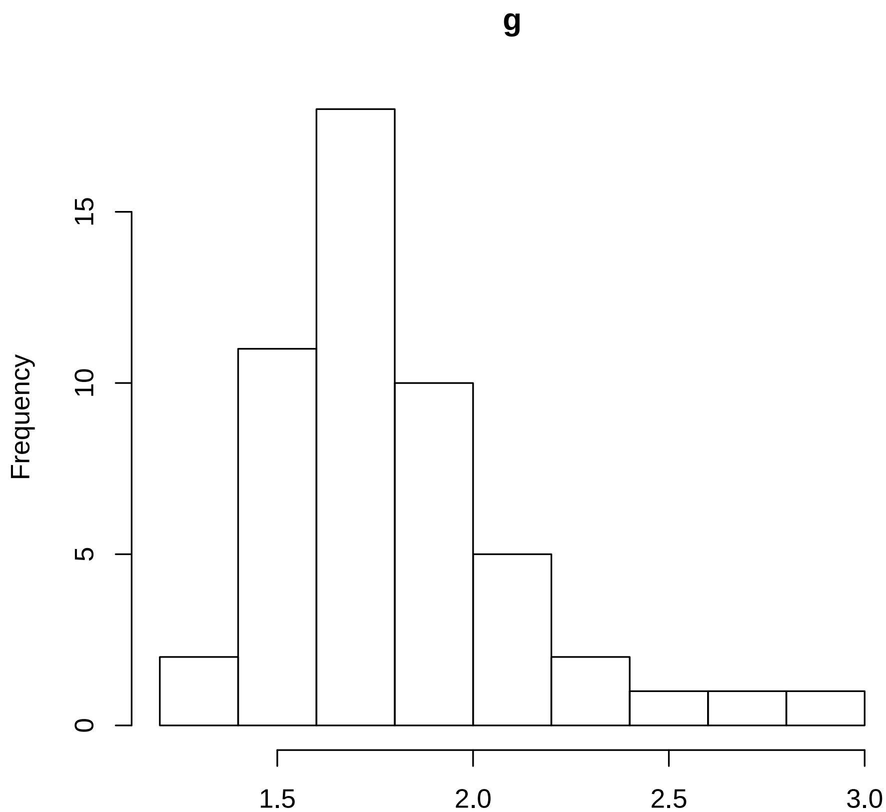


FIGURE 4. Estimates of the DEB compound parameter $g = \frac{\epsilon_G \nu}{\kappa p_{am}}$, the energy investment ratio.

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> hist(res[,'pam']/res[,'nu'],
+      main='Em', xlab='')
> abline(v=true.pars['pam']/true.pars['nu'],col=2)
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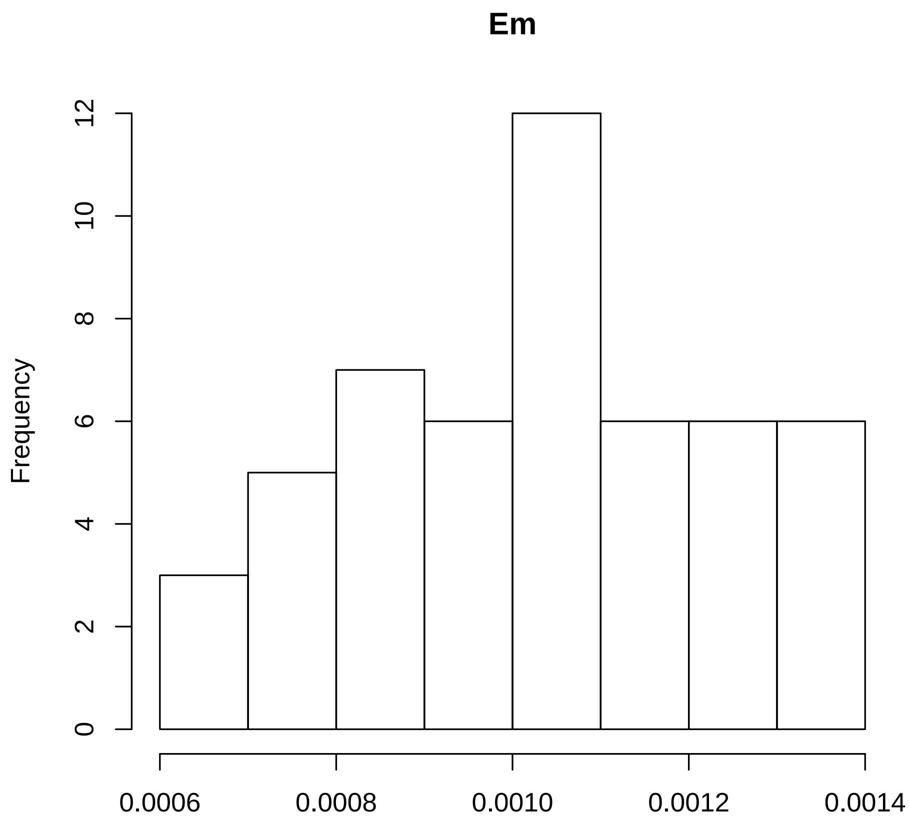

FIGURE 5. Estimates of the DEB compound parameter $E_m = p_{am}/\nu$, the maximum reserve density. I'm beginning to wonder if the parameter set used to generate the observed data is different from the one saved in "true_parameters.rda", given that the parameters seem to be converging to something, just not the truth.

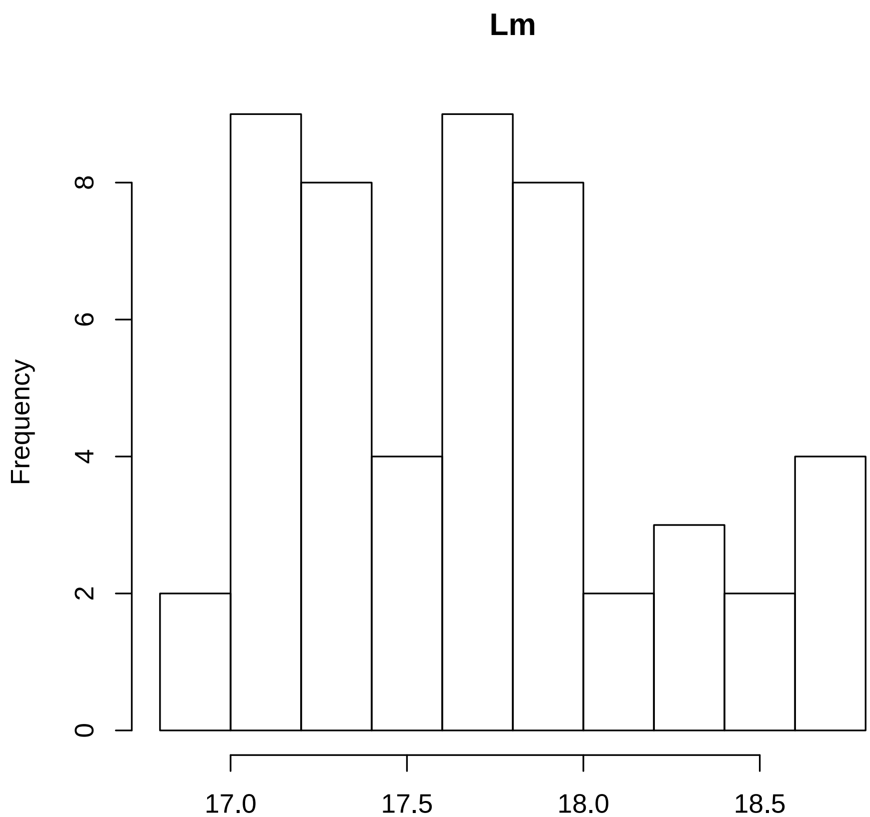

FIGURE 6. Estimates of the DEB compound parameter $L_m = \frac{\kappa p_{am}}{k_m \epsilon_G}$, the maximum length. The truth doesn't even show up on the histogram.