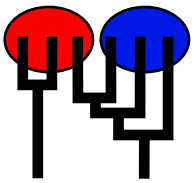
# *Example: Microsatellite data set*

MIGRATION RATE AND POPULATION SIZE ESTIMATION
using the coalescent and maximum likelihood or Bayesian inference
Migrate-n version 2.5.1
Program started at Thu Jul 10 07:52:44 2008
Program finished at Thu Jul 10 07:53:20 2008



## *Options*

| | | |
|---|---|---|
| Datatype: | | Microsatellite data [Brownian motion] |
| Missing data: | | not included |
| Random number seed: | (with internal timer) | 1598441029 |

Start parameters:

Theta values were generated from the FST-calculation

M values were generated from the FST-calculation

Connection type matrix:
where m = average (average over a group of Thetas or M,
s = symmetric M, S = symmetric 4Nm, 0 = zero, and not estimated,
* = free to vary, Thetas are on diagonal

| Population | 1 | 2 |
|---|---|---|
| 1 population__num | * | * |
| 2 population__num | * | * |

Order of parameters:

| | | |
|---|---|---|
| 1 | $\Theta_1$ | <displayed> |
| 2 | $\Theta_2$ | <displayed> |
| 3 | $M_{2->1}$ | <displayed> |
| 4 | $M_{1->2}$ | <displayed> |

Mutation rate among loci: Mutation rate is constant for all loci

Analysis strategy: Bayesian inference

Proposal distributions for parameter

| Parameter | Proposal |
|---|---|

Theta Slice sampling
M Slice sampling

Prior distribution for parameter

| Parameter | Prior | Minimum | Mean* | Maximum | Delta | Bins |
|---|---|---|---|---|---|---|
| Theta | Exponential | 0.000000 | 1.000000 | 10.000000 | - | 200 |
| M | Exponential | 0.000000 | 10.000000 | 1000.000000 | - | 200 |

Markov chain settings: Long chain
Number of chains 1
Recorded steps [a] 1600
Increment (record every x step [b] 2
Number of concurrent chains (replicates) [c] 2
Visited (sampled) parameter values [a*b*c] 6400
Number of discard trees per chain (burn-in) 130

Multiple Markov chains:
Static heating scheme 4 chains with temperatures
5.00 3.67 2.33 1.00
Swapping interval is 1

Print options:
Data file: infile.msat
Output file: outfile-bayes
Posterior distribution raw histogram file: bayesfile
Print data: No
Print genealogies [only some for some data type]: None

# *Data summary*

Datatype: Microsatellite data
Number of loci: 10

| Population | Locus | Gene copies data | (missing) |
|---|---|---|---|
| 1 population__number___0 | 1 | 50 | (0) |
| | 2 | 50 | (0) |
| | 3 | 50 | (0) |
| | 4 | 50 | (0) |
| | 5 | 50 | (0) |
| | 6 | 50 | (0) |
| | 7 | 50 | (0) |
| | 8 | 50 | (0) |
| | 9 | 50 | (0) |
| | 10 | 50 | (0) |
| 2 population__number___1 | 1 | 42 | (0) |
| | 2 | 42 | (0) |
| | 3 | 42 | (0) |
| | 4 | 42 | (0) |
| | 5 | 42 | (0) |
| | 6 | 42 | (0) |
| | 7 | 42 | (0) |
| | 8 | 42 | (0) |
| | 9 | 42 | (0) |
| | 10 | 42 | (0) |
| Total of all populations | 1 | 92 | (0) |
| | 2 | 92 | (0) |
| | 3 | 92 | (0) |
| | 4 | 92 | (0) |
| | 5 | 92 | (0) |
| | 6 | 92 | (0) |
| | 7 | 92 | (0) |
| | 8 | 92 | (0) |
| | 9 | 92 | (0) |
| | 10 | 92 | (0) |

# *Allele frequency spectra*

Locus 1

| Allele | Pop1 | Pop2 | All |
|---|---|---|---|
| 16 | 0.220 | 0.167 | 0.193 |
| 19 | 0.040 | 0.071 | 0.056 |
| 18 | 0.060 | 0.119 | 0.090 |
| 15 | 0.220 | 0.024 | 0.122 |
| 21 | 0.020 | 0.167 | 0.093 |
| 23 | 0.020 | 0.119 | 0.070 |
| 17 | 0.280 | 0.095 | 0.188 |
| 22 | 0.060 | 0.119 | 0.090 |
| 25 | 0.060 | 0.024 | 0.042 |
| 24 | 0.020 | 0.000 | 0.010 |
| 26 | 0.000 | 0.024 | 0.012 |
| 27 | 0.000 | 0.048 | 0.024 |
| 29 | 0.000 | 0.024 | 0.012 |

Locus 2

| Allele | Pop1 | Pop2 | All |
|---|---|---|---|
| 16 | 0.520 | 0.571 | 0.546 |
| 19 | 0.040 | 0.000 | 0.020 |
| 18 | 0.220 | 0.119 | 0.170 |
| 17 | 0.160 | 0.167 | 0.163 |
| 15 | 0.020 | 0.000 | 0.010 |
| 21 | 0.020 | 0.071 | 0.046 |
| 20 | 0.020 | 0.024 | 0.022 |
| 22 | 0.000 | 0.048 | 0.024 |

Locus 3

| Allele | Pop1 | Pop2 | All |
|---|---|---|---|
| 19 | 0.240 | 0.262 | 0.251 |
| 20 | 0.280 | 0.476 | 0.378 |
| 18 | 0.080 | 0.095 | 0.088 |
| 21 | 0.280 | 0.119 | 0.200 |
| 22 | 0.120 | 0.048 | 0.084 |

Locus 4

| Allele | Pop1 | Pop2 | All |
|---|---|---|---|
| 16 | 0.080 | 0.071 | 0.076 |
| 24 | 0.180 | 0.024 | 0.102 |

| Allele | Pop1 | Pop2 | All |
|---|---|---|---|
| 15 | 0.020 | 0.048 | 0.034 |
| 25 | 0.160 | 0.167 | 0.163 |
| 14 | 0.020 | 0.048 | 0.034 |
| 19 | 0.100 | 0.143 | 0.121 |
| 12 | 0.060 | 0.000 | 0.030 |
| 20 | 0.080 | 0.190 | 0.135 |
| 23 | 0.060 | 0.119 | 0.090 |
| 28 | 0.020 | 0.000 | 0.010 |
| 22 | 0.060 | 0.024 | 0.042 |
| 21 | 0.160 | 0.119 | 0.140 |
| 13 | 0.000 | 0.024 | 0.012 |
| 26 | 0.000 | 0.024 | 0.012 |

Locus 5

| Allele | Pop1 | Pop2 | All |
|---|---|---|---|
| 20 | 0.400 | 0.524 | 0.462 |
| 21 | 0.420 | 0.357 | 0.389 |
| 19 | 0.180 | 0.119 | 0.150 |

Locus 6

| Allele | Pop1 | Pop2 | All |
|---|---|---|---|
| 19 | 0.060 | 0.000 | 0.030 |
| 20 | 0.100 | 0.024 | 0.062 |
| 18 | 0.300 | 0.214 | 0.257 |
| 22 | 0.200 | 0.119 | 0.160 |
| 21 | 0.120 | 0.476 | 0.298 |
| 16 | 0.060 | 0.000 | 0.030 |
| 24 | 0.160 | 0.048 | 0.104 |
| 17 | 0.000 | 0.119 | 0.060 |

Locus 7

| Allele | Pop1 | Pop2 | All |
|---|---|---|---|
| 23 | 0.040 | 0.238 | 0.139 |
| 20 | 0.660 | 0.143 | 0.401 |
| 22 | 0.180 | 0.190 | 0.185 |
| 21 | 0.100 | 0.333 | 0.217 |
| 19 | 0.020 | 0.095 | 0.058 |

Locus 8

| Allele | Pop1 | Pop2 | All |
|---|---|---|---|
| 19 | 0.520 | 0.524 | 0.522 |
| 17 | 0.040 | 0.048 | 0.044 |

| Allele | Pop1 | Pop2 | All |
|---|---|---|---|
| 18 | 0.100 | 0.071 | 0.086 |
| 20 | 0.140 | 0.190 | 0.165 |
| 16 | 0.080 | 0.000 | 0.040 |
| 22 | 0.100 | 0.048 | 0.074 |
| 15 | 0.020 | 0.048 | 0.034 |
| 23 | 0.000 | 0.071 | 0.036 |

Locus 9

| Allele | Pop1 | Pop2 | All |
|---|---|---|---|
| 24 | 0.080 | 0.024 | 0.052 |
| 19 | 0.300 | 0.429 | 0.364 |
| 20 | 0.300 | 0.167 | 0.233 |
| 23 | 0.180 | 0.143 | 0.161 |
| 22 | 0.080 | 0.024 | 0.052 |
| 18 | 0.020 | 0.071 | 0.046 |
| 21 | 0.040 | 0.095 | 0.068 |
| 25 | 0.000 | 0.048 | 0.024 |

Locus 10

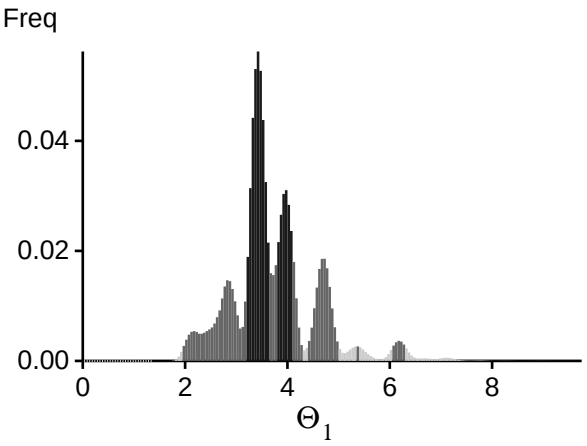
| Allele | Pop1 | Pop2 | All |
|---|---|---|---|
| 22 | 0.100 | 0.214 | 0.157 |
| 20 | 0.440 | 0.214 | 0.327 |
| 23 | 0.080 | 0.167 | 0.123 |
| 24 | 0.020 | 0.000 | 0.010 |
| 19 | 0.160 | 0.167 | 0.163 |
| 21 | 0.060 | 0.048 | 0.054 |
| 18 | 0.080 | 0.000 | 0.040 |
| 15 | 0.020 | 0.071 | 0.046 |
| 17 | 0.040 | 0.048 | 0.044 |
| 25 | 0.000 | 0.071 | 0.036 |

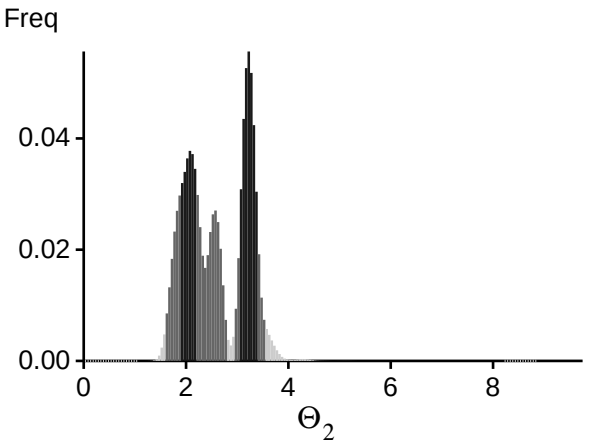
# *Bayesian Analysis: Posterior distribution table*

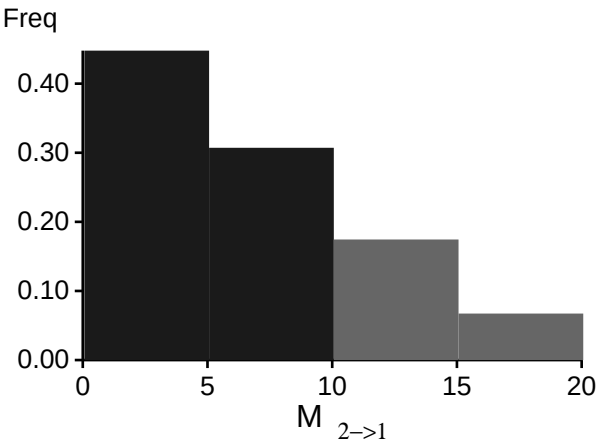
| Locus | Parameter | 2.5% | 25.0% | Mode | 75.0% | 97.5% | Median | Mean |
|---|---|---|---|---|---|---|---|---|
| 1 | $\Theta_1$ | 1.40000 | 3.35000 | 4.32500 | 4.80000 | 5.05000 | 4.52500 | 5.26478 |
| 1 | $\Theta_2$ | 7.20000 | 8.20000 | 9.77500 | 10.00000 | 10.00000 | 8.27500 | 7.04778 |
| 1 | $M_{2->1}$ | 0.000 | 0.000 | 2.500 | 10.000 | 20.000 | 12.500 | 4.223 |
| 1 | $M_{1->2}$ | 0.000 | 0.000 | 7.500 | 15.000 | 25.000 | 17.500 | 8.524 |
| 2 | $\Theta_1$ | 1.45000 | 2.80000 | 3.42500 | 4.25000 | 5.80000 | 3.57500 | 3.64177 |
| 2 | $\Theta_2$ | 1.35000 | 4.50000 | 4.87500 | 5.05000 | 5.60000 | 4.32500 | 5.14776 |
| 2 | $M_{2->1}$ | 0.000 | 0.000 | 2.500 | 10.000 | 20.000 | 12.500 | 4.927 |
| 2 | $M_{1->2}$ | 0.000 | 0.000 | 2.500 | 15.000 | 25.000 | 17.500 | 7.918 |
| 3 | $\Theta_1$ | 4.35000 | 4.45000 | 4.62500 | 5.35000 | 6.65000 | 5.17500 | 5.46904 |
| 3 | $\Theta_2$ | 1.15000 | 2.30000 | 2.62500 | 3.30000 | 4.15000 | 2.82500 | 2.78699 |
| 3 | $M_{2->1}$ | 0.000 | 0.000 | 2.500 | 10.000 | 20.000 | 12.500 | 4.114 |
| 3 | $M_{1->2}$ | 0.000 | 0.000 | 2.500 | 10.000 | 25.000 | 12.500 | 7.319 |
| 4 | $\Theta_1$ | 7.40000 | 8.45000 | 9.82500 | 10.00000 | 10.00000 | 8.57500 | 7.16454 |
| 4 | $\Theta_2$ | 4.55000 | 8.85000 | 9.07500 | 9.50000 | 10.00000 | 6.47500 | 6.14968 |
| 4 | $M_{2->1}$ | 0.000 | 0.000 | 2.500 | 10.000 | 20.000 | 12.500 | 4.626 |
| 4 | $M_{1->2}$ | 0.000 | 0.000 | 2.500 | 10.000 | 25.000 | 12.500 | 7.299 |
| 5 | $\Theta_1$ | 1.20000 | 1.45000 | 1.67500 | 3.25000 | 3.65000 | 3.17500 | 4.31662 |
| 5 | $\Theta_2$ | 1.00000 | 2.80000 | 3.17500 | 3.45000 | 4.70000 | 3.02500 | 3.22268 |
| 5 | $M_{2->1}$ | 0.000 | 0.000 | 2.500 | 10.000 | 25.000 | 12.500 | 5.894 |
| 5 | $M_{1->2}$ | 0.000 | 0.000 | 2.500 | 10.000 | 25.000 | 12.500 | 6.565 |
| 6 | $\Theta_1$ | 1.75000 | 3.70000 | 4.72500 | 5.25000 | 7.50000 | 4.77500 | 4.73794 |
| 6 | $\Theta_2$ | 1.30000 | 1.55000 | 1.97500 | 3.50000 | 5.45000 | 4.22500 | 5.06340 |
| 6 | $M_{2->1}$ | 0.000 | 0.000 | 2.500 | 10.000 | 25.000 | 12.500 | 5.596 |
| 6 | $M_{1->2}$ | 0.000 | 0.000 | 2.500 | 10.000 | 25.000 | 12.500 | 5.391 |
| 7 | $\Theta_1$ | 2.70000 | 4.90000 | 5.27500 | 5.60000 | 7.95000 | 5.37500 | 5.26686 |
| 7 | $\Theta_2$ | 0.90000 | 1.95000 | 2.57500 | 3.75000 | 7.30000 | 3.92500 | 4.12347 |
| 7 | $M_{2->1}$ | 0.000 | 0.000 | 2.500 | 10.000 | 20.000 | 12.500 | 3.821 |
| 7 | $M_{1->2}$ | 0.000 | 0.000 | 2.500 | 10.000 | 25.000 | 12.500 | 6.167 |
| 8 | $\Theta_1$ | 3.25000 | 4.40000 | 5.22500 | 6.30000 | 6.40000 | 5.87500 | 6.04024 |
| 8 | $\Theta_2$ | 0.95000 | 3.50000 | 4.52500 | 5.40000 | 6.95000 | 4.37500 | 4.28143 |
| 8 | $M_{2->1}$ | 0.000 | 0.000 | 2.500 | 10.000 | 20.000 | 12.500 | 3.651 |
| 8 | $M_{1->2}$ | 0.000 | 0.000 | 2.500 | 15.000 | 25.000 | 17.500 | 6.847 |

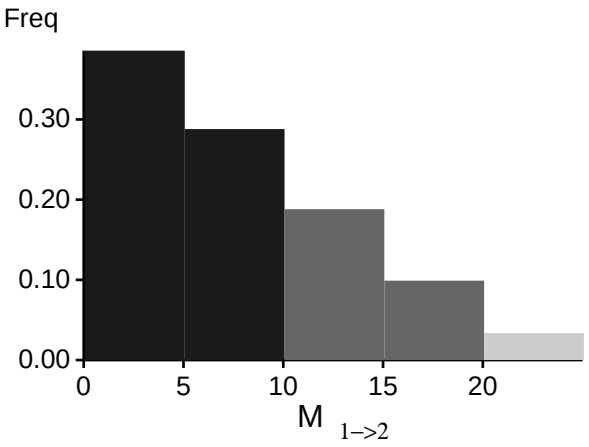
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 9 | $\Theta_1$ | 4.25000 | 6.75000 | 7.37500 | 7.95000 | 8.95000 | 6.12500 | 5.79059 |
| 9 | $\Theta_2$ | 1.05000 | 2.90000 | 3.87500 | 4.50000 | 7.30000 | 3.97500 | 4.40128 |
| 9 | $M_{2->1}$ | 0.000 | 0.000 | 2.500 | 10.000 | 20.000 | 12.500 | 3.734 |
| 9 | $M_{1->2}$ | 0.000 | 0.000 | 2.500 | 15.000 | 25.000 | 17.500 | 7.946 |
| 10 | $\Theta_1$ | 7.75000 | 8.35000 | 9.12500 | 10.00000 | 10.00000 | 7.02500 | 6.62277 |
| 10 | $\Theta_2$ | 7.00000 | 8.50000 | 9.67500 | 10.00000 | 10.00000 | 8.17500 | 6.96102 |
| 10 | $M_{2->1}$ | 0.000 | 0.000 | 2.500 | 10.000 | 20.000 | 12.500 | 4.413 |
| 10 | $M_{1->2}$ | 0.000 | 0.000 | 7.500 | 15.000 | 30.000 | 17.500 | 10.138 |
| All | $\Theta_1$ | 1.90000 | 3.15000 | 3.42500 | 3.65000 | 4.30000 | 3.62500 | 3.73939 |
| All | $\Theta_2$ | 2.90000 | 3.00000 | 3.22500 | 3.40000 | 3.55000 | 2.62500 | 2.61171 |
| All | $M_{2->1}$ | 0.000 | 0.000 | 2.500 | 10.000 | 20.000 | 12.500 | 2.752 |
| All | $M_{1->2}$ | 0.000 | 0.000 | 2.500 | 10.000 | 20.000 | 12.500 | 4.842 |

## *Bayesian Analysis: Posterior distribution over all loci*



## *Log-Probability of the data given the model (marginal likelihood)*

Use this value for Bayes factor calculations:
BF = Exp[ ln(Prob(D | thisModel) - ln( Prob( D | otherModel)
shows the support for thisModel]

| Method | ln(Prob(D\|Model)) | Notes |
|---|---|---|
| Thermodynamic integration | -11105.469570 | (1) |
| Harmonic mean | -171797.952118 | (1) |

(1 and 2) is an approximation to the marginal likelihood, make sure the program run long enough!
(1) and (2) should give a similar result, (2) is considered more
crude than (1), but (1) needs heating with several well-spaced chains,

## *Acceptance ratios for all parameters and the genealogies*

| Parameter | Accepted changes | Ratio |
|---|---|---|
| $\Theta_1$ | 8245/8245 | 1.00000 |
| $\Theta_2$ | 8202/8202 | 1.00000 |
| $M_{2->1}$ | 8219/8219 | 1.00000 |
| $M_{1->2}$ | 8362/8362 | 1.00000 |
| Genealogies | 11457/32296 | 0.35475 |

## *MCMC-Autocorrelation and Effective MCMC Sample Size*

| Parameter | Autocorrelation | Effective Sampe Size |
|---|---|---|
| $\Theta_1$ | 0.96005 | 656.75 |
| $\Theta_2$ | 0.94780 | 865.53 |
| $M_{2->1}$ | 0.90610 | 1583.93 |
| $M_{1->2}$ | 0.90364 | 1653.89 |
| Ln[Prob(D\|G)] | 0.98468 | 249.13 |