

Example: Microsatellite data set

MIGRATION RATE AND POPULATION SIZE ESTIMATION

using the coalescent and maximum likelihood or Bayesian inference

Migrate-n version 3.2.7 [1793]

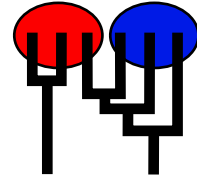
Compiled for a PARALLEL COMPUTER ARCHITECTURE

One master and 2 compute nodes are available.

Compiled for a SYMMETRIC MULTIPROCESSORS

Program started at Wed Jan 12 16:50:37 2011

Program finished at Wed Jan 12 16:50:38 2011



Options

Datatype:

Microsatellite data [Brownian motion]

Missing data:

not included

Inheritance scalers in use for Thetas: 1.00 1.00

1.00 1.00 1.00 1.00 1.00

1.00 1.00 1.00

[Each Theta uses the (true) inheritance scalar of the first locus as a reference]

Random number seed:

(from parmfile)

1407071073

Start parameters:

Theta values were generated

from the FST-calculation

M values were generated

from guessed values

M-matrix:

- 1.0,

1.0, -

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	Θ_1	<displayed>
2	Θ_2	<displayed>
3	$M_{2 \rightarrow 1}$	<displayed>
4	$M_{1 \rightarrow 2}$	<displayed>

Mutation rate among loci:

Mutation rate is constant for all loci

Analysis strategy is

Maximum likelihood

Markov chain settings:

Short chain

Long chain

Number of chains	1	1
Recorded steps [a]	10	10
Increment (record every x step [b])	1	2
Visited (sampled) genealogies [a*b]	10	20

Multiple Markov chains:

Averaging over replicates

Over independent 2 replicates

Static heating scheme

4 chains with temperatures

1000000.00

3.00

1.50

1.00

Swapping interval is 1

Print options:

Data file:

infile.msat

Output file:

outfile-ml

Summary of genealogies for further run:

sumfile

Print data:

No

Print genealogies [only some for some data type]:

None

Plot log(likelihood) surface:

No

Profile likelihood:

Yes, tables and summary

Percentile method

with df=1 and for Theta and M=m/mu

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

Maximum Likelihood estimates

Population [x]	Loc.	Ln(L/L0)	Θ	M (m/mu) [+receiving population]	
			[x Ne mu]	1,+	2,+
1:population	1 1	0.010	1.1220	-	3.609
	1 2	0.435	1.0888	-	5.142
	1 A	0.825	1.0908	-	5.061
	2 1	0.161	1.4275	-	4.174
	2 2	2.716	1.4915	-	2.775
	2 A	2.655	1.4923	-	2.776
	3 1	1.387	1.5126	-	3.646
	3 2	0.833	1.4291	-	5.378
	3 A	2.482	1.5038	-	3.702
	4 1	5.867	1.4993	-	4.271
	4 2	0.914	1.3368	-	6.845
	4 A	5.192	1.4993	-	4.270
	5 1	27.045	1.3100	-	5.226
	5 2	25.904	1.3564	-	5.450
	5 A	54.141	1.3100	-	5.226
	6 1	0.104	1.3726	-	3.881
	6 2	8.479	1.5106	-	2.982
	6 A	3.481	1.5095	-	2.983
	7 1	6.302	0.9212	-	5.724
	7 2	6.398	1.3083	-	2.590
	7 A	8.941	1.2997	-	2.596
	8 1	3.109	1.2399	-	4.062
	8 2	0.280	1.4913	-	3.646
	8 A	3.153	1.2408	-	4.067
	9 1	10.032	1.5877	-	3.290
	9 2	4.871	1.3502	-	4.112
	9 A	11.190	1.5709	-	3.334
	10 1	0.036	1.3334	-	4.122
	10 2	0.055	1.1613	-	3.995
	10 A	0.246	1.2529	-	4.068
	All	85.628	1.3578	-	3.962
2:population	1 1	0.010	1.4228	4.576	-
	1 2	0.435	1.3745	3.348	-
	1 A	0.825	1.3782	3.390	-
	2 1	0.161	1.1930	5.630	-
	2 2	2.716	0.9277	7.791	-
	2 A	2.655	0.9260	7.790	-

3 1	1.387	1.2120	6.432	-
3 2	0.833	1.1558	4.439	-
3 A	2.482	1.2066	6.386	-
4 1	5.867	1.1877	5.248	-
4 2	0.914	1.2304	2.966	-
4 A	5.192	1.1890	5.255	-
5 1	27.045	1.2128	3.237	-
5 2	25.904	1.3339	4.815	-
5 A	54.141	1.2128	3.237	-
6 1	0.104	1.1490	5.877	-
6 2	8.479	0.8875	3.775	-
6 A	3.481	0.8866	3.777	-
7 1	6.302	1.4187	3.084	-
7 2	6.398	1.1560	2.964	-
7 A	8.941	1.1632	2.966	-
8 1	3.109	1.2585	4.089	-
8 2	0.280	1.1274	6.066	-
8 A	3.153	1.2571	4.069	-
9 1	10.032	1.3922	4.592	-
9 2	4.871	1.3349	4.506	-
9 A	11.190	1.3875	4.587	-
10 1	0.036	1.2601	4.599	-
10 2	0.055	1.4553	4.544	-
10 A	0.246	1.3473	4.570	-
All	85.628	1.2191	4.313	-

Comments:

The x is 1, 2, or 4 for mtDNA, haploid, or diploid data, respectively

There were 1 short chain (10 used trees out of sampled 10)

and 1 long chain (10 used trees out of sampled 20)

COMBINATION OF 2 MULTIPLE RUNS Static heating with 4 chains was active

Approximate Likelihood Ratio Tests

Legend for the likelihood ratio tables

Null-Hypothesis: your test model
is equal to
full model (the model under which the
genealogies were sampled)

Migration matrix, migration rates are
specified as M]

Log(likelihood) of test model
Log(likelihood) of full model
Likelihood ratio test value
Degrees of freedom of test
[Theta values are on the diagonal of the
Probability*
Probability**
Akaike's Information Criterion***
Number of parameters used

*) Probability under the assumption that parameters have range -Inf to Inf

**) Probability under the assumption that parameters have range 0 to Inf

***) AIC: the smaller the value the better the model
[the full model has AIC=-163.256866, num(param)=4]

H0: 1.2884 4.1375 4.1375 1.2884
= 1.3578 3.9618 4.3132 1.2191
[m, m, m, m,]

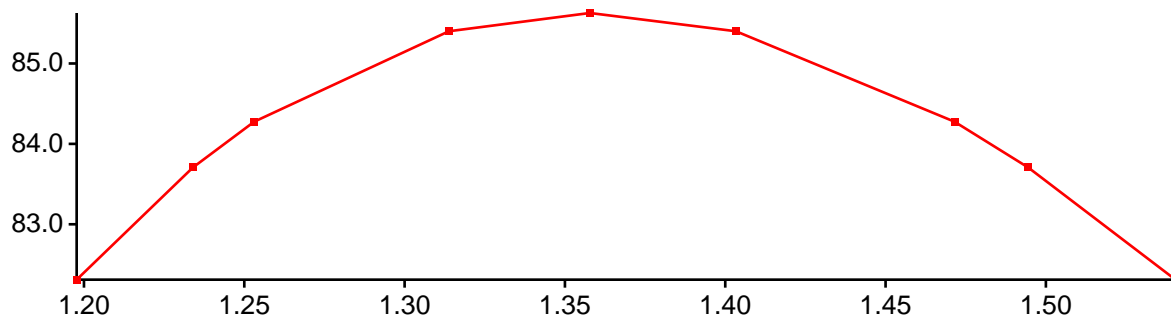
LnL(test) = 84.380030
LnL(full) = 85.628433
LRT = 2.496807
df = 4
Prob = 0.645208
Probc = 0.645208
AIC = -164.760059
num(param) = 2

Profile likelihood tables and plots

Profile likelihood table and plot for parameter Θ_1

Parameters are evaluated at percentiles using bisection method (slow, but exact).

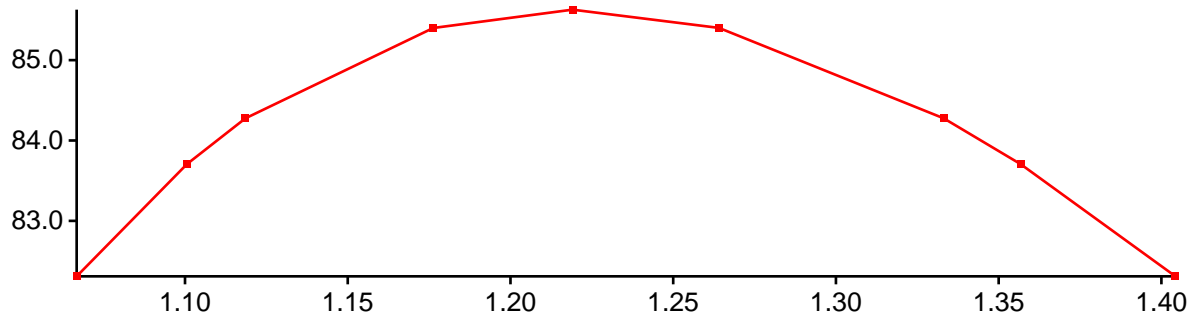
Per.	Ln(L)	Θ_1	Θ_1	Θ_2	$M_{2 \rightarrow 1}$	$M_{1 \rightarrow 2}$
0.005	82.311	1.19772	1.1977	1.2377	4.162	4.370
0.025	83.707	1.23399	1.2340	1.2323	4.109	4.353
0.050	84.276	1.25309	1.2531	1.2297	4.082	4.344
0.250	85.401	1.31382	1.3138	1.2228	4.006	4.323
MLE	85.628*	1.35779	1.3578	1.2191	3.962	4.313
0.750	85.401	1.40332	1.4033	1.2162	3.925	4.308
0.950	84.276	1.4715	1.4715	1.2130	3.884	4.305
0.975	83.707	1.49446	1.4945	1.2122	3.873	4.305
0.995	82.312	1.54037	1.5404	1.2108	3.854	4.307



Profile likelihood table and plot for parameter Θ_2

Parameters are evaluated at percentiles using bisection method (slow, but exact).

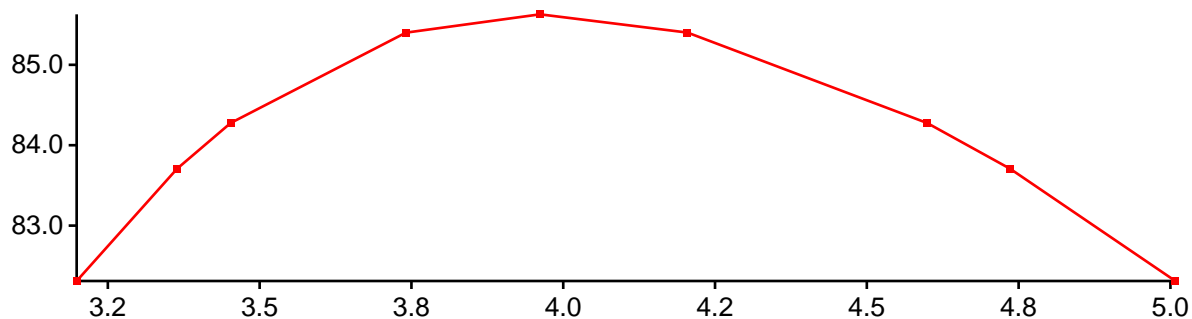
Per.	Ln(L)	Θ_2	Θ_1	Θ_2	$M_{2 \rightarrow 1}$	$M_{1 \rightarrow 2}$
0.005	82.310	1.06671	1.3670	1.0667	3.898	4.242
0.025	83.708	1.10064	1.3652	1.1006	3.910	4.254
0.050	84.276	1.11856	1.3642	1.1186	3.917	4.262
0.250	85.400	1.17627	1.3608	1.1763	3.940	4.289
MLE	85.628*	1.21906	1.3578	1.2191	3.962	4.313
0.750	85.401	1.26406	1.3541	1.2641	3.990	4.342
0.950	84.276	1.33312	1.3477	1.3331	4.042	4.391
0.975	83.707	1.35671	1.3455	1.3567	4.061	4.407
0.995	82.311	1.40428	1.3413	1.4043	4.097	4.439

Profile likelihood table and plot for parameter $M_{2 \rightarrow 1}$

Parameters are evaluated at percentiles using bisection method (slow, but exact).

Per.	Ln(L)	$M_{2 \rightarrow 1}$	Θ_1	Θ_2	$M_{2 \rightarrow 1}$	$M_{1 \rightarrow 2}$
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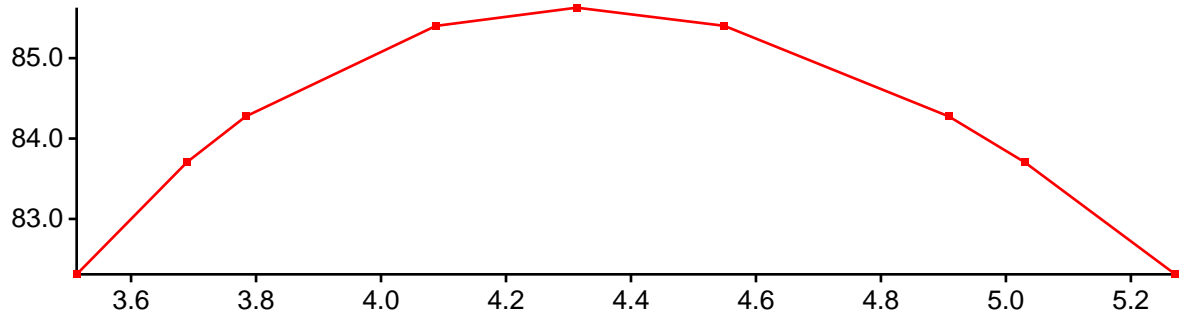
0.005	82.311	3.19865	1.3775	1.2098	3.199	4.372
0.025	83.708	3.36409	1.3741	1.2116	3.364	4.357
0.050	84.276	3.45223	1.3721	1.2124	3.452	4.350
0.250	85.400	3.74085	1.3646	1.2155	3.741	4.326
MLE	85.628*	3.96179	1.3578	1.2191	3.962	4.313
0.750	85.401	4.20462	1.3490	1.2252	4.205	4.309
0.950	84.276	4.59936	1.3343	1.2381	4.599	4.318
0.975	83.708	4.73579	1.3301	1.2422	4.736	4.319
0.995	82.311	5.00809	1.3232	1.2490	5.008	4.312

Profile likelihood table and plot for parameter $M_{1 \rightarrow 2}$

Parameters are evaluated at percentiles using bisection method (slow, but exact).

Per.	Ln(L)	$M_{1 \rightarrow 2}$	Θ_1	Θ_2	$M_{2 \rightarrow 1}$	$M_{1 \rightarrow 2}$
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0.005	82.311	3.51293	1.3584	1.2062	4.026	3.513
0.025	83.708	3.68976	1.3588	1.2083	4.011	3.690
0.050	84.275	3.78352	1.3589	1.2096	4.002	3.784
0.250	85.401	4.08769	1.3587	1.2145	3.976	4.088
MLE	85.628*	4.31324	1.3578	1.2191	3.962	4.313
0.750	85.402	4.54934	1.3558	1.2245	3.959	4.549
0.950	84.275	4.90872	1.3509	1.2339	3.979	4.909
0.975	83.707	5.02978	1.3489	1.2369	3.991	5.030
0.995	82.311	5.27112	1.3453	1.2424	4.017	5.271



Summary of profile likelihood percentiles of all parameters

Parameter	Percentiles								
	0.005	0.025	0.05	0.25	MLE	0.75	0.95	0.975	0.995
Theta_1	1.1977	1.2340	1.2531	1.3138	1.3578	1.4033	1.4715	1.4945	1.5404
Theta_2	1.0667	1.1006	1.1186	1.1763	1.2191	1.2641	1.3331	1.3567	1.4043
M_21	3.1986	3.3641	3.4522	3.7409	3.9618	4.2046	4.5994	4.7358	5.0081
M_12	3.5129	3.6898	3.7835	4.0877	4.3132	4.5493	4.9087	5.0298	5.2711