

# Two fake Swiss 'towns'

POPULATION SIZE, MIGRATION, DIVERGENCE, ASSIGNMENT, HISTORY

Bayesian inference using the structured coalescent

Migrate-n version 4.2.7 [April-1-2016]

Using Intel AVX (Advanced Vector Extensions)

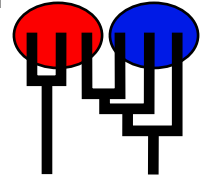
Compiled for PARALLEL computer architectures

One master and 4 compute nodes are available.

Compiled for a SYMMETRIC multiprocessors (Grandcentral)

Program started at Wed Jul 6 12:12:30 2016

Program finished at Wed Jul 6 12:54:13 2016



## Options

Inheritance scalers in use for Thetas:

All loci use an inheritance scaler of 1.0

[The locus with a scaler of 1.0 used as reference]

Random number seed: (with internal timer) 401562519

Start parameters:

Theta values were generated Using a percent value of the prior

M values were generated Using a percent value of the prior

Connection matrix:

m = average (average over a group of Thetas or M,

s = symmetric migration M, S = symmetric 4Nm,

0 = zero, and not estimated,

\* = migration free to vary, Thetas are on diagonal

d = row population split off column population, D = split and then migration

Population	1	2
1 Ascona	*	D
2 Brissago	0	*

Order of parameters:

1  $\Theta_1$  <displayed>

2	$\Theta_2$	<displayed>
3	$M_{2 \rightarrow 1}$	<displayed>
4	$\Delta_{2 \rightarrow 1}$	<displayed>
5	$\sigma_{2 \rightarrow 1}$	<displayed>

Mutation rate among loci:

Mutation rate is constant for all loci

Analysis strategy:

Bayesian inference

Proposal distributions for parameter

Parameter	Proposal
Theta	Metropolis sampling
M	Metropolis sampling

Prior distribution for parameter

Parameter	Prior	Minimum	Mean*	Maximum	Delta	Bins
Theta	Gamma	0.000000	0.010000	0.100000	0.010000	1500
Theta	Gamma	0.000000	0.010000	0.100000	0.010000	1500
M	Gamma	0.000000	500.000000	5000.000000	500.000000	1500
M	Gamma	0.000000	500.000000	5000.000000	500.000000	1500
Splittime mean	Gamma	0.000000	0.100000	1.000000	0.100000	1500
Splittime std	Gamma	0.000000	1.000000	10.000000	1.000000	1500

Markov chain settings:

Long chain

Number of chains	1
Recorded steps [a]	5000
Increment (record every x step [b])	200
Number of concurrent chains (replicates) [c]	10
Visited (sampled) parameter values [a*b*c]	10000000
Number of discard trees per chain (burn-in)	5000

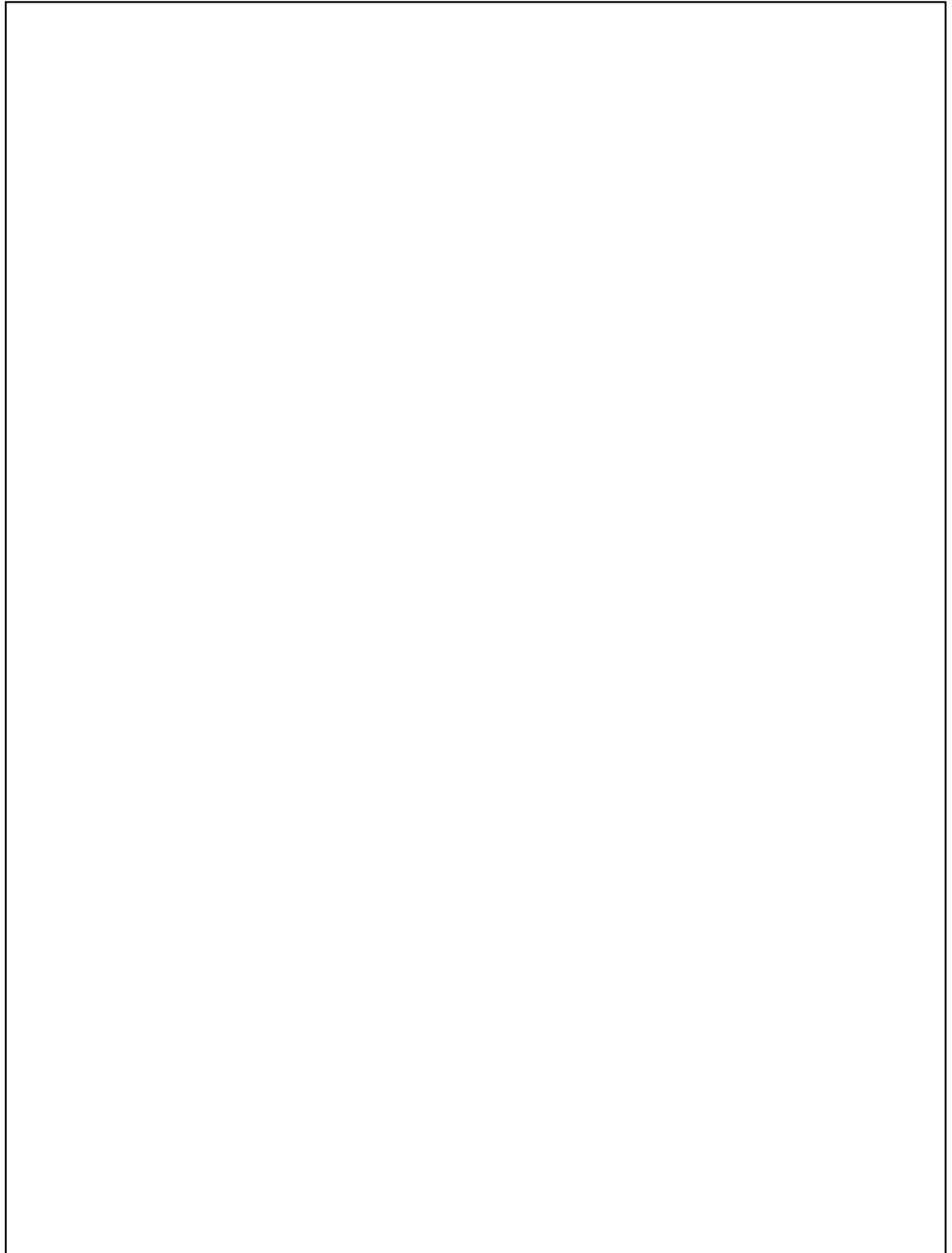
Multiple Markov chains:

Static heating scheme

1000000.00	4 chains with temperatures
3.00	1.50
1.00	
Swapping interval is 1	

Print options:

Data file:	infile
Haplotyping is turned on:	NO
Output file:	outfile_xB0x
Posterior distribution raw histogram file:	bayesfile
Raw data from the MCMC run:	bayesallfile.gz
Print data:	No
Print genealogies [only some for some data type]:	None



## Data summary

Data file: infile  
 Datatype: Haplotype data  
 Number of loci: 5

### Mutationmodel:

Locus	Sublocus	Mutationmodel	Mutationmodel parameters
1	1	Felsenstein 84	[Bf:0.24 0.26 0.27 0.22, t/t ratio=2.000]
2	1	Felsenstein 84	[Bf:0.25 0.24 0.26 0.25, t/t ratio=2.000]
3	1	Felsenstein 84	[Bf:0.25 0.24 0.25 0.26, t/t ratio=2.000]
4	1	Felsenstein 84	[Bf:0.26 0.24 0.23 0.27, t/t ratio=2.000]
5	1	Felsenstein 84	[Bf:0.25 0.24 0.27 0.24, t/t ratio=2.000]

### Sites per locus

Locus	Sites
1	1000
2	1000
3	1000
4	1000
5	1000

### Site rate variation and probabilities:

Locus	Sublocus	Region type	Rate of change	Probability	Patch size
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1	1	1	1.000	1.000	1.000
2	1	1	1.000	1.000	1.000
3	1	1	1.000	1.000	1.000
4	1	1	1.000	1.000	1.000
5	1	1	1.000	1.000	1.000

Population	Locus	Gene copies data (missing)
1 Ascona	1	10
	2	10
	3	10
	4	10
	5	10
2 Brissago	1	10
	2	10
	3	10
	4	10

	5	10	
Total of all populations	1	20	(0)
	2	20	(0)
	3	20	(0)
	4	20	(0)
	5	20	(0)

## *Bayesian Analysis: Posterior distribution table*

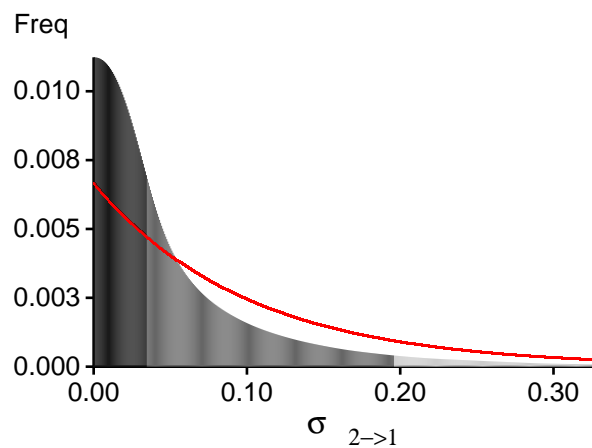
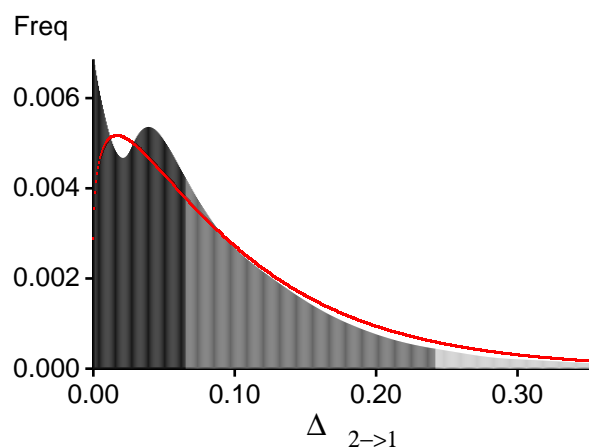
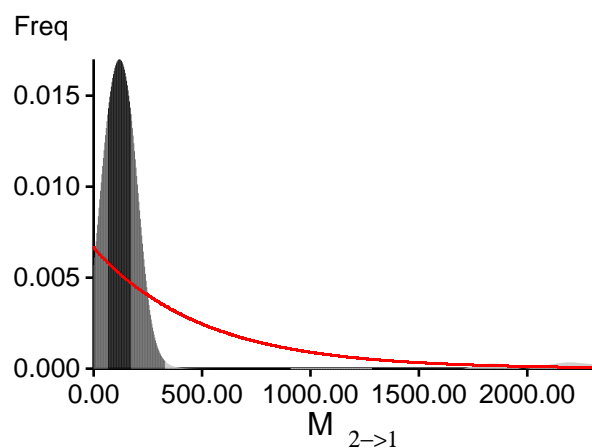
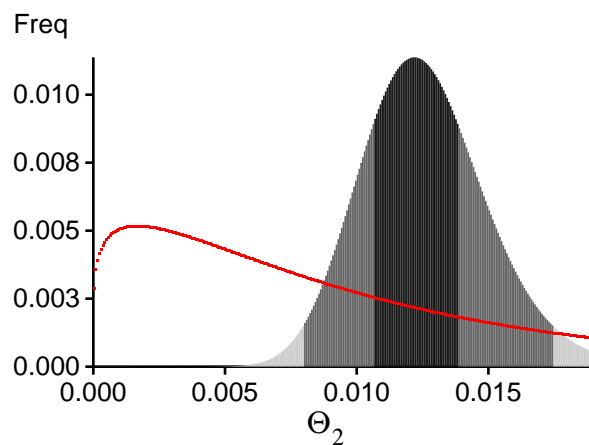
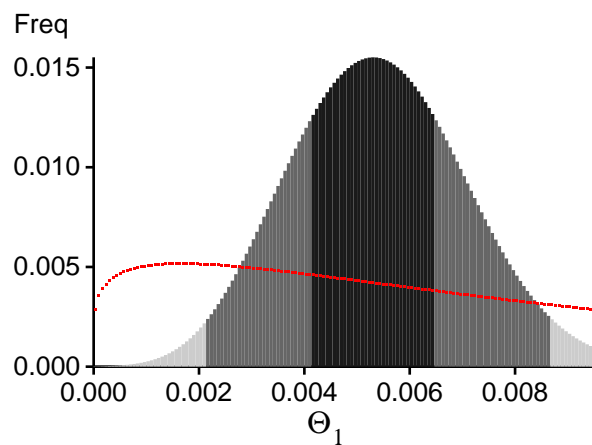
Locus	Parameter	2.5%	25.0%	Mode	75.0%	97.5%	Median	Mean
1	$\Theta_1$	0.00280	0.00587	0.00677	0.00760	0.01207	0.00757	0.00802
1	$\Theta_2$	0.00027	0.00313	0.00497	0.00693	0.01160	0.00557	0.00583
1	$M_{2 \rightarrow 1}$	0.000	0.000	1.667	63.333	193.333	65.000	48.037
1	$D_{2 \rightarrow 1}$	0.00000	0.00000	0.02833	0.06333	0.24067	0.06367	0.08383
1	$S_{2 \rightarrow 1}$	0.00000	0.00000	0.00333	0.32000	1.98667	0.32333	0.53776
2	$\Theta_1$	0.00013	0.00307	0.00490	0.00687	0.01167	0.00550	0.00581
2	$\Theta_2$	0.00273	0.00507	0.00717	0.00960	0.01340	0.00803	0.00844
2	$M_{2 \rightarrow 1}$	0.000	0.000	55.000	116.667	323.333	118.333	109.352
2	$D_{2 \rightarrow 1}$	0.00000	0.00000	0.03033	0.06933	0.06933	0.07767	0.10029
2	$S_{2 \rightarrow 1}$	0.00000	0.00000	0.00333	0.69333	2.89333	0.69667	0.99385
3	$\Theta_1$	0.00000	0.00253	0.00450	0.00660	0.01227	0.00530	0.00573
3	$\Theta_2$	0.00840	0.01127	0.01470	0.01873	0.02400	0.01590	0.01654
3	$M_{2 \rightarrow 1}$	126.667	223.333	381.667	590.000	786.667	488.333	541.822
3	$D_{2 \rightarrow 1}$	0.00733	0.00733	0.03033	0.05467	0.05467	0.07767	0.10063
3	$S_{2 \rightarrow 1}$	0.00000	0.00000	0.00333	0.70000	2.87333	0.70333	1.00120
4	$\Theta_1$	0.00000	0.00193	0.00350	0.00513	0.00880	0.00397	0.00409
4	$\Theta_2$	0.00707	0.01360	0.01490	0.01633	0.02967	0.01670	0.01755
4	$M_{2 \rightarrow 1}$	0.000	0.000	1.667	86.667	246.667	88.333	69.022
4	$D_{2 \rightarrow 1}$	0.00733	0.00733	0.03033	0.05467	0.05467	0.07833	0.10114
4	$S_{2 \rightarrow 1}$	0.00000	0.00000	0.00333	0.69333	2.85333	0.69667	0.98368
5	$\Theta_1$	0.00000	0.00340	0.00583	0.00893	0.01900	0.00743	0.00854
5	$\Theta_2$	0.00733	0.00993	0.01257	0.01553	0.01987	0.01357	0.01403
5	$M_{2 \rightarrow 1}$	196.667	416.667	628.333	903.333	1406.667	765.000	836.909
5	$D_{2 \rightarrow 1}$	0.00000	0.00000	0.02900	0.07600	0.27533	0.07633	0.09931
5	$S_{2 \rightarrow 1}$	0.00000	0.00000	0.00333	0.69333	2.83333	0.69667	0.98597
All	$\Theta_1$	0.00207	0.00407	0.00530	0.00647	0.00867	0.00543	0.00542
All	$\Theta_2$	0.00793	0.01060	0.01217	0.01387	0.01747	0.01250	0.01259
All	$M_{2 \rightarrow 1}$	0.000	63.333	118.333	173.333	330.000	131.667	210.959
All	$D_{2 \rightarrow 1}$	0.00000	0.00000	0.00033	0.06533	0.24200	0.06567	0.09015
All	$S_{2 \rightarrow 1}$	0.00000	0.00000	0.00333	0.34667	1.96000	0.35000	0.56142

Citation suggestions:

Beerli P., 2006. Comparison of Bayesian and maximum-likelihood inference of population genetic parameters.  
Bioinformatics 22:341-345

Beerli P., 2009. How to use MIGRATE or why are Markov chain Monte Carlo programs difficult to use?  
In Population Genetics for Animal Conservation, G. Bertorelle, M. W. Bruford, H. C. Hauffe, A. Rizzoli,  
and C. Vernesi, eds., vol. 17 of Conservation Biology, Cambridge University Press, Cambridge UK, pp. 42-79.

# *Bayesian Analysis: Posterior distribution over all loci*





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

Use this value for Bayes factor calculations:

$BF = \text{Exp}[\ln(\text{Prob}(D \mid \text{thisModel}) - \ln(\text{Prob}(D \mid \text{otherModel}))]$

or as  $LBF = 2 (\ln(\text{Prob}(D \mid \text{thisModel}) - \ln(\text{Prob}(D \mid \text{otherModel})))$

shows the support for thisModel]

Locus	Raw thermodynamic score(1a)	Bezier approximation score(1b)	Harmonic mean(2)
1	-1958.75	-1811.96	-1800.88
2	-1932.04	-1803.41	-1796.87
3	-2091.79	-1912.06	-1897.39
4	-2607.11	-2200.38	-2143.42
5	-2137.10	-1911.95	-1888.00
All	-10745.60	-9658.59	-9545.38

(1a, 1b and 2) are approximations to the marginal likelihood, make sure that the program run long enough!

(1a, 1b) and (2) should give similar results, in principle.

But (2) is overestimating the likelihood, it is presented for historical reasons and should not be used

(1a, 1b) needs heating with chains that span a temperature range of 1.0 to at least 100,000.

(1b) is using a Bezier-curve to get better approximations for runs with low number of heated chains

[Scaling factor = -18.826367]

Citation suggestions:

Beerli P. and M. Palczewski, 2010. Unified framework to evaluate panmixia and migration direction among multiple sampling locations, *Genetics*, 185: 313-326.

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

Parameter	Accepted changes	Ratio
$\Theta_1$	1949217/4997000	0.39008
$\Theta_2$	1576576/4998047	0.31544
$M_{2 \rightarrow 1}$	1587949/4999228	0.31764
$\Delta_{2 \rightarrow 1}$	4818588/4998212	0.96406
$\sigma_{2 \rightarrow 1}$	4484484/5001129	0.89669
Genealogies	3577216/25006384	0.14305

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

Parameter	Autocorrelation	Effective Sample Size
$\Theta_1$	0.15192	259268.91
$\Theta_2$	0.13923	261710.10
$M_{2 \rightarrow 1}$	0.19948	228042.09
$\Delta_{2 \rightarrow 1}$	0.00313	346716.42
$\sigma_{2 \rightarrow 1}$	0.02429	330295.30
$\text{Ln}[\text{Prob}(D G)]$	0.34954	167613.48

## *Potential Problems*

This section reports potential problems with your run, but such reporting is often not very accurate. With many parameters in a multilocus analysis, it is very common that some parameters for some loci will not be very informative, triggering suggestions (for example to increase the prior range) that are not sensible. This suggestion tool will improve with time, therefore do not blindly follow its suggestions. If some parameters are flagged, inspect the tables carefully and judge whether an action is required. For example, if you run a Bayesian inference with sequence data, for macroscopic species there is rarely the need to increase the prior for Theta beyond 0.1; but if you use microsatellites it is rather common that your prior distribution for Theta should have a range from 0.0 to 100 or more. With many populations (>3) it is also very common that some migration routes are estimated poorly because the data contains little or no information for that route. Increasing the range will not help in such situations, reducing number of parameters may help in such situations.

No warning was recorded during the run