

Table S1: **Pairwise  $F_{ST}$  values**. Non-significant values are in italic and grey-colored.

	LF Aa	LF Hem	LF Beth	LF Bre	LF Ris	LF Oir	LP Aa	LP Hem	LP Bet	LP Bre	LP Ris
LF Hem	<i>0.000</i>										
LF Beth	<i>0.002</i>	<i>0.001</i>									
LF Bre	<i>0.000</i>	<i>0.000</i>	<i>0.003</i>								
LF Ris	<i>0.000</i>	<i>0.000</i>	<i>0.001</i>	<i>0.003</i>							
LF Oir	<i>0.000</i>	<i>0.003</i>	<i>0.011</i>	<i>0.006</i>	<i>0.003</i>						
LP Aa	0.084	0.090	0.079	0.090	0.088	0.090					
LP Hem	0.079	0.077	0.088	0.083	0.071	0.066	0.102				
LP Bet	<i>0.022</i>	<i>0.025</i>	<i>0.028</i>	0.027	0.032	<i>0.020</i>	0.115	0.090			
LP Bre	0.099	0.116	0.135	0.091	0.102	0.087	0.192	0.189	0.088		
LP Ris	0.033	0.035	0.050	0.034	0.033	0.030	0.121	0.103	0.055	0.097	
LP Oir	0.040	0.048	0.044	0.044	0.046	0.028	0.075	0.087	0.040	0.087	0.063

Table S2: **Confidence measure in model selection** inferred from 1000 pseudo observed dataset

River	Focal scenario	Type II error					
		Type I error	SI	IM	AM	SC	PAN
<b>AA</b>	I	0.435	-	0.071	0.478	0.077	0.194
	IM	0.404	0.048	-	0.078	0.685	0.427
	AM	0.522	0.352	0.071	-	0.049	0
	SC	0.811	0.035	0.071	0.051	-	0.049
	PAN	1	0	0.071	0	0	-
<b>BET</b>	I	0.989	-	0.007	0.012	0.005	0
	IM	0.326	0.027	-	0.049	0.763	0.975
	AM	0.988	0.573	0.007	-	0.106	0
	SC	0.897	0.387	0.007	0.298	-	0.106
	PAN	0.975	0.002	0.007	0	0.023	-
<b>BRE</b>	I	0.73	-	0.098	0.109	0.087	0
	IM	0.698	0.086	-	0.186	0.253	0.015
	AM	0.891	0.107	0.098	-	0.058	0
	SC	0.4	0.537	0.098	0.614	-	0.058
	PAN	0.741	0	0.098	0	0.002	-
<b>HEM</b>	I	0.632	-	0.107	0.17	0.076	0
	IM	0.744	0.151	-	0.354	0.337	0.941
	AM	0.83	0.37	0.107	-	0.051	0
	SC	0.464	0.111	0.107	0.294	-	0.051
	PAN	1	0	0.107	0	0	-
<b>OIR</b>	I	0.885	-	0.02	0.058	0.003	0
	IM	0.742	0.236	-	0.263	0.226	0.062
	AM	0.942	0.491	0.02	-	0.0119	0
	SC	0.925	0.119	0.02	0.169	-	0.019
	PAN	0.16	0.039	0.02	0.04	0.677	-
<b>RIS</b>	I	0.876	-	0.041	0.115	0.051	0
	IM	0.868	0.2	-	0.328	0.151	0.01
	AM	0.885	0.647	0.041	-	0.026	0
	SC	0.698	0.029	0.041	0.095	-	0.026
	PAN	0.011	0	0.016	0.041	0.047	-

Table S3: Confidence measure in model selection inferred from 1000 pseudo observed dataset by pairs for the strict isolation (SI) model and panmictic (PAN) model.

		Type I error						Type II error					
Focal model		AA	BET	BRE	HEM	OIR	RIS	AA	BET	BRE	HEM	OIR	RIS
SI versus	IM	0	0	0	0	0	0	0	0.092	0.031	0.087	0.037	0.066
	AM	0.337	0.949	0.078	0.283	0.745	0.98	0.609	0.103	0.881	0.7	0.214	0.046
	SC	0	0	0	0	0	0	0	0.068	0.029	0.073	0.023	0.05
	PAN	0	0.001	0	0	0.01	0.004	0	0	0	0	0.106	0

		Type I error						Type II error					
Focal model		AA	BET	BRE	HEM	OIR	RIS	AA	BET	BRE	HEM	OIR	RIS
PAN versus	IM	0	0	0	0.002	0	0	0.005	0.023	0	0	0.009	0.027
	AM	0	0	0	0.001	0	0	0.001	0.01	0	0	0.095	0.022
	SC	0	0	0	0	0	0	0	0	0	0	0	0
	SI	0	0	0	0	0	0	0	0.001	0	0	0.01	0.004

**Table S4: Estimation of variable importance from random-forest analyses**  
 Estimation is performed pairwise for computational tractability.  
 For each pairwise comparison, the three most discriminatory variables are in bold.

Summary Stat	MODEL											Average
	lvsAM	lvsIM	lvsSC	lvsPAN	AmvsIM	Scvs AM	AmvsPAN	SCvsIM	ImvsPAN	PANvsIM	ScvsPAN	
mean He pop1*	<b>76.64</b>	31.58	30.98	18.37	35.76	38.31	19.66	24.23	37.28	37.28	38.94	32.62
var He pop1	55.06	26.87	25.24	12.90	24.56	27.62	10.53	19.00	27.76	27.76	27.45	23.35
mean He pop2*	45.32	27.99	29.70	19.03	38.88	40.61	21.76	18.55	46.75	46.75	48.50	37.16
var He pop2	37.46	21.60	22.84	13.88	33.64	35.13	13.10	17.17	29.06	29.06	28.48	25.33
mean He total	58.42	<b>48.69</b>	<b>48.79</b>	17.88	<b>67.61</b>	<b>66.55</b>	24.14	25.90	42.59	42.59	45.80	41.26
var He total	42.27	35.04	32.25	16.30	32.66	36.05	12.12	20.94	28.28	28.28	28.18	25.64
mean Ar pop1	<b>90.18</b>	27.56	28.04	13.33	35.17	36.22	13.05	25.68	30.79	30.79	26.85	27.23
var Ar pop1	49.78	23.27	22.09	10.40	36.39	38.03	14.59	19.10	25.36	25.36	25.48	24.66
mean Ar pop2	57.54	25.95	25.37	13.16	34.15	31.60	15.00	28.02	22.31	22.31	22.68	23.65
var Ar pop2	46.81	25.68	22.56	10.06	36.83	35.89	8.23	23.40	16.03	16.03	18.05	19.61
mean Ar total	56.41	38.12	44.20	14.32	43.63	52.08	16.48	23.71	27.01	27.01	24.98	28.54
var Ar total	61.87	21.91	22.81	11.07	31.53	35.19	11.97	19.85	23.42	23.42	25.35	23.20
mean R pop1	47.75	30.25	30.34	8.61	37.93	39.47	10.77	21.22	21.85	21.85	20.81	22.66
var R pop1	57.89	41.89	42.03	7.08	43.97	47.00	9.64	27.19	18.67	18.67	18.13	23.22
mean R pop2	59.87	27.06	32.17	11.53	26.88	32.14	12.87	27.23	26.38	26.38	23.35	24.72
var R pop2	69.44	36.76	46.21	9.39	39.87	46.10	9.37	23.71	21.94	21.94	18.44	23.58
mean R total	44.62	27.08	28.98	11.01	32.01	35.34	11.42	17.09	22.67	22.67	22.07	21.88
var R total	46.63	21.70	21.47	7.86	30.13	29.35	9.54	21.86	19.34	19.34	16.84	19.38
var GW pop1	<b>94.41</b>	39.08	43.83	11.70	37.76	37.70	11.88	22.05	28.71	28.71	28.28	26.22
mean GW pop1	50.64	25.46	20.65	9.07	37.06	38.73	6.98	12.90	13.26	13.26	16.00	16.85
var GW pop2	64.23	31.60	37.27	12.00	31.62	37.62	12.35	25.52	26.56	26.56	25.91	25.75
mean GW pop2	43.42	26.60	21.40	7.83	40.62	38.83	7.77	8.55	15.02	15.02	14.02	16.54
var GW total	59.44	31.61	31.51	9.88	35.88	38.19	10.89	20.88	26.82	26.82	27.07	25.11
mean GW total	39.53	24.50	22.06	6.14	38.91	34.47	5.46	18.77	12.46	12.46	13.00	16.10
mean GST	65.74	<b>62.09</b>	<b>66.67</b>	<b>34.69</b>	<b>80.61</b>	<b>85.93</b>	<b>57.28</b>	<b>34.11</b>	<b>84.59</b>	<b>84.59</b>	<b>84.41</b>	<b>71.82</b>
var GST	37.25	37.52	38.70	27.29	51.50	50.54	40.93	<b>30.75</b>	<b>104.78</b>	<b>104.78</b>	<b>107.81</b>	<b>73.27</b>
mean deltam <sup>2</sup>	71.55	<b>74.59</b>	<b>72.38</b>	<b>52.09</b>	<b>76.51</b>	<b>76.05</b>	<b>61.36</b>	<b>33.14</b>	<b>103.26</b>	<b>103.26</b>	<b>98.59</b>	<b>79.28</b>
var deltam <sup>2</sup>	60.48	43.46	44.62	<b>41.85</b>	47.22	48.70	<b>45.17</b>	23.59	57.10	57.10	60.18	48.64

\*Pop 1 = *Lampetra fluviatilis* population

\*Pop 2 = *Lampetra planeri* population

Table S5: **Robustness of summary statistics computation under the two best models (IM and SC).** Estimation based on 10 00 dataset drawn from the posterior distribution of the parameters. Summary statistics that deviate significantly from the observed distribution are in bold.

Statistics	IM					SC					PAN
	AA	BET	BRE	HEM	RIS	AA	BET	BRE	HEM	RIS	OIR
mean_He_pop1	0.9915	0.9912	0.997	0.9888	1	1	1	1	0.9485	0.9994	1
<b>var_He_pop1</b>	<b>4.00E-004</b>	<b>2.00E-004</b>	<b>0.002</b>	<b>4.00E-004</b>	<b>0</b>	<b>0</b>	<b>1.00E-004</b>	<b>0</b>	<b>0.0089</b>	<b>0</b>	1
mean_He_pop2	0.8836	0.9962	0.962	0.8489	1	0.948	1	1	0.8033	0.9859	1
<b>var_He_pop2</b>	<b>0.0471</b>	<b>1.00E-004</b>	<b>0.01</b>	<b>0.0156</b>	<b>6.00E-004</b>	<b>0.033</b>	<b>0</b>	<b>0</b>	<b>0.0451</b>	<b>0.0316</b>	1
mean_He_total	0.9539	0.9984	0.999	0.9752	1	0.997	1	1	0.9111	0.9995	1
<b>var_He_total</b>	<b>0.0011</b>	<b>0</b>	<b>0.002</b>	<b>1.00E-004</b>	<b>0</b>	<b>0.01</b>	<b>0</b>	<b>0</b>	<b>0.011</b>	<b>0</b>	1
mean_A_pop1	0.9909	0.9912	0.999	0.9889	1	1	1	1	0.9491	0.9994	1
<b>var_A_pop1</b>	<b>4.00E-004</b>	<b>5.00E-004</b>	<b>0.001</b>	<b>4.00E-004</b>	<b>0</b>	<b>0</b>	<b>1.00E-004</b>	<b>0</b>	<b>0.0097</b>	<b>0</b>	1
mean_A_pop2	0.887	0.9962	0.967	0.8542	1	0.962	1	1	0.8079	0.9864	1
<b>var_A_pop2</b>	<b>0.0384</b>	<b>1.00E-004</b>	<b>0.01</b>	<b>0.0132</b>	<b>7.00E-004</b>	<b>0.031</b>	<b>0</b>	<b>0</b>	<b>0.0405</b>	<b>0.0342</b>	1
mean_A_total	0.9549	0.9984	0.999	0.9765	1	0.997	1	1	0.9128	0.9995	1
<b>var_A_total</b>	<b>0.0011</b>	<b>0</b>	<b>0.002</b>	<b>0</b>	<b>0</b>	<b>0.01</b>	<b>0</b>	<b>0</b>	<b>0.0103</b>	<b>0</b>	1
mean_Ar_pop1	0.9928	0.9906	1	0.9978	1	1	1	1	0.9776	0.9999	1
var_Ar_pop1	0.2832	0.3585	0.435	0.2961	0.4841	0.598	0.4826	0.732	0.2514	0.6358	<b>0</b>
mean_Ar_pop2	0.9075	0.9962	0.934	0.9931	1	0.999	1	1	0.8948	0.99	1
var_Ar_pop2	0.6802	0.4688	<b>0.045</b>	0.3868	0.5767	0.882	0.4959	0.352	0.4541	0.6036	<b>0</b>
mean_Ar_total	0.9909	0.9999	0.98	0.9982	1	1	1	0.999	0.9849	0.9991	1
var_Ar_total	0.3833	0.4709	0.109	0.4236	0.6422	0.629	0.569	0.376	0.3807	0.6889	<b>0</b>
mean_V_pop1	0.9926	0.9906	1	0.9978	1	1	1	1	0.9767	0.9999	1
var_V_pop1	0.2701	0.3257	0.439	0.2796	0.4769	0.586	0.4457	0.736	0.2421	0.6298	<b>0</b>
mean_V_pop2	0.9057	0.996	0.928	0.9924	1	0.999	1	1	0.8929	0.9895	1
var_V_pop2	0.6692	0.4395	<b>0.044</b>	0.3845	0.5762	0.874	0.458	0.341	0.4504	0.6036	<b>0</b>
mean_V_total	0.9909	0.9999	0.979	0.9981	1	1	1	0.999	0.9845	0.9987	1
var_V_total	0.3747	0.4431	0.109	0.4195	0.638	0.621	0.5385	0.377	0.3764	0.6837	<b>0</b>
mean_R_pop1	0.9785	0.9916	1	0.9916	1	0.999	1	1	0.9508	0.9999	1
var_R_pop1	0.8185	0.9522	0.989	0.8252	0.9995	0.916	0.9818	1	0.7275	0.9991	1
mean_R_pop2	0.974	0.9997	0.164	0.9702	0.9999	1	1	0.713	0.8687	0.9832	1
var_R_pop2	0.9956	0.9867	<b>0.006</b>	0.6688	0.962	1	0.9954	0.249	0.5827	0.9346	1
mean_R_total	0.9874	1	0.441	0.9884	1	1	1	0.848	0.9425	0.9988	<b>0</b>
var_R_total	0.8553	0.9729	0.108	0.8635	0.9782	0.934	0.9892	0.635	0.787	0.967	<b>0</b>
mean_GW_pop1	0.4724	<b>0.0458</b>	0.075	0.5732	<b>4.00E-004</b>	0.513	<b>0.0192</b>	<b>0.009</b>	0.6205	<b>0.003</b>	<b>0</b>
var_GW_pop1	0.783	0.6298	0.954	0.8314	0.6711	0.83	0.6003	0.921	0.8376	0.7077	<b>0</b>
mean_GW_pop2	<b>0.0285</b>	<b>0.0242</b>	0.99	<b>0.0197</b>	0.2775	<b>0.002</b>	<b>0.0055</b>	0.901	0.0849	0.2945	<b>0</b>
var_GW_pop2	0.9567	0.5846	0.182	<b>0</b>	0.462	0.967	0.5361	0.216	<b>0.012</b>	0.4693	1
mean_GW_total	0.4408	<b>0.0326</b>	1	0.7969	0.0809	0.456	<b>0.0119</b>	0.975	0.8305	0.0972	1
var_GW_total	0.7364	0.6681	0.907	0.9359	0.2853	0.794	0.6458	0.852	0.9416	0.2726	<b>0</b>
mean_GST	0.2031	0.3586	0.546	0.5067	0.7748	0.191	0.2718	0.015	0.3924	0.6114	<b>0</b>
<b>var_GST</b>	0.0845	<b>0.0245</b>	0.76	0.2878	0.2154	0.046	<b>0.0045</b>	<b>0.091</b>	0.3036	0.2239	1
mean_deltamu2	0.9328	0.9917	0.117	0.8329	0.979	0.976	0.9969	0.181	0.7456	0.9464	1
var_deltamu2	0.9387	0.9883	0.17	0.6931	0.9705	0.979	0.9944	0.243	0.6096	0.9378	1

**Table S6: Untransformed Estimates of demographic parameters under the model of ongoing migration (IM) and secondary contact (SC) in each river.**  $\Theta=4*N_{ref}*\mu$  with  $\mu$  the mutation rate. Lf = *lampetra fluviatilis*, Lp = *Lampetra planeri*. \* the PAN model is controlled by a single parameter the effective population size of the single population (made of both Lf and Lp backgrounds).

River	Model	$\theta_{Lf}$	$\theta_{Lp}$	$\theta_{Ancestral}$ population	M=4Nref*m Lp to Lf	M=4Nref*m from Lf to Lp	Tsplit/(4Nref)	Tsc/(4Nref)
		med [95HPD]	med [95HPD]	med [95HPD]	med [95HPD]	med [95HPD]	med [95HPD]	med [95HPD]
<b>AA</b>	IM	1.31[0.93-.2.02]	0.41[0.29-0.68]	2.29 [2.26-2.35.]	10 [7.0-12.6]	11.9 [10.9-12.8]	13.4 [12.3-14.1]	
	SC	1.48 [0.76-.2.55]	0.39 [0.27-0.62]	1.85 [1.60-2.11]	8.82 [8.10-9.98]	12.67 [11.8-13.25]	9.56 [8.40-11.5]	4.46 [3.07-5.40]
<b>BET</b>	IM	1.62 [1.26-2.35]	0.94 [0.43-1.54]	1.65 [1.50-1.78]	11.75 [10.96-12.72]	13.92 [13.02-14.93]	1.49 [1.21-1.71]	
	SC	1.93 [1.28-2.63]	0.94 [0.57-1.42]	1.16 [1.03-1.30]	9.44 [8.03-10.86]	13.28 [12.78-14.98]	16.14 [13.28-19.82]	8.23 [5.80-10.64]
<b>BRE</b>	IM	1.02 [0.44-2.45]	0.31 [0.12-0.79]	1.36 [0.44-2.37]	1.50 [0.39—6.06]	7.98 [2.43-15.49]	13.73 [4.99-22.69]	
	SC	1.61 [0.91-2.72]	0.74 [0.22-1.50]	1.44 [0.32-2.62]	6.68 [1.77-16.35]	9.88 [2.79-18.18]	13.48 [7.04-22.32]	1.02 [0.19-.6.23]
<b>HEM</b>	IM	1.00 [0.71-.194]	0.19 [0.13-0.31]	2.60 [2.48-2.70]	8.12 [6.73-10.75]	16.92 [15.74-17.68]	12.01 [9.56-13.50]	
	SC	0.86 [0.66-1.28]	0.35 [0.08-0.88]	1.68 [1.50-1.88]	12.45 [11.13-13.64]	9.67 [7.83-11.72]	13.93 [11.57-16.44]	4.97 [4.27-5.50]
<b>RIS</b>	IM	0.84 [0.60-1.54]	0.62 [0.50-0.88]	0.84 [0.77-0.93]	8.52 [5.90-11.96]	9.83 [7.24-12.55]	9.85 [9.09-10.47]	
	SC	1.36 [0.84-2.32]	0.64 [0.39-1.03]	1.01 [0.66-1.52]	14.45 [13.42-15.45]	14.78 [14.36-15.23]	11.31 [8.43-16.02]	4.56 [2.13-7.59]
<b>OIR</b>	PAN*	2.05 [1.94-2.18]						

**Figure S1: Curves of out-of-bag errors rates and Estimation of variable importance for each population pairs.**

Data based on one random forest, each composed of 1,000 trees obtained from a trained set of 50,000 simulated predictor variables (summary statistics). The response variable is the demographic model.

Each page corresponds to a different river:

(A) AA

(B) BET

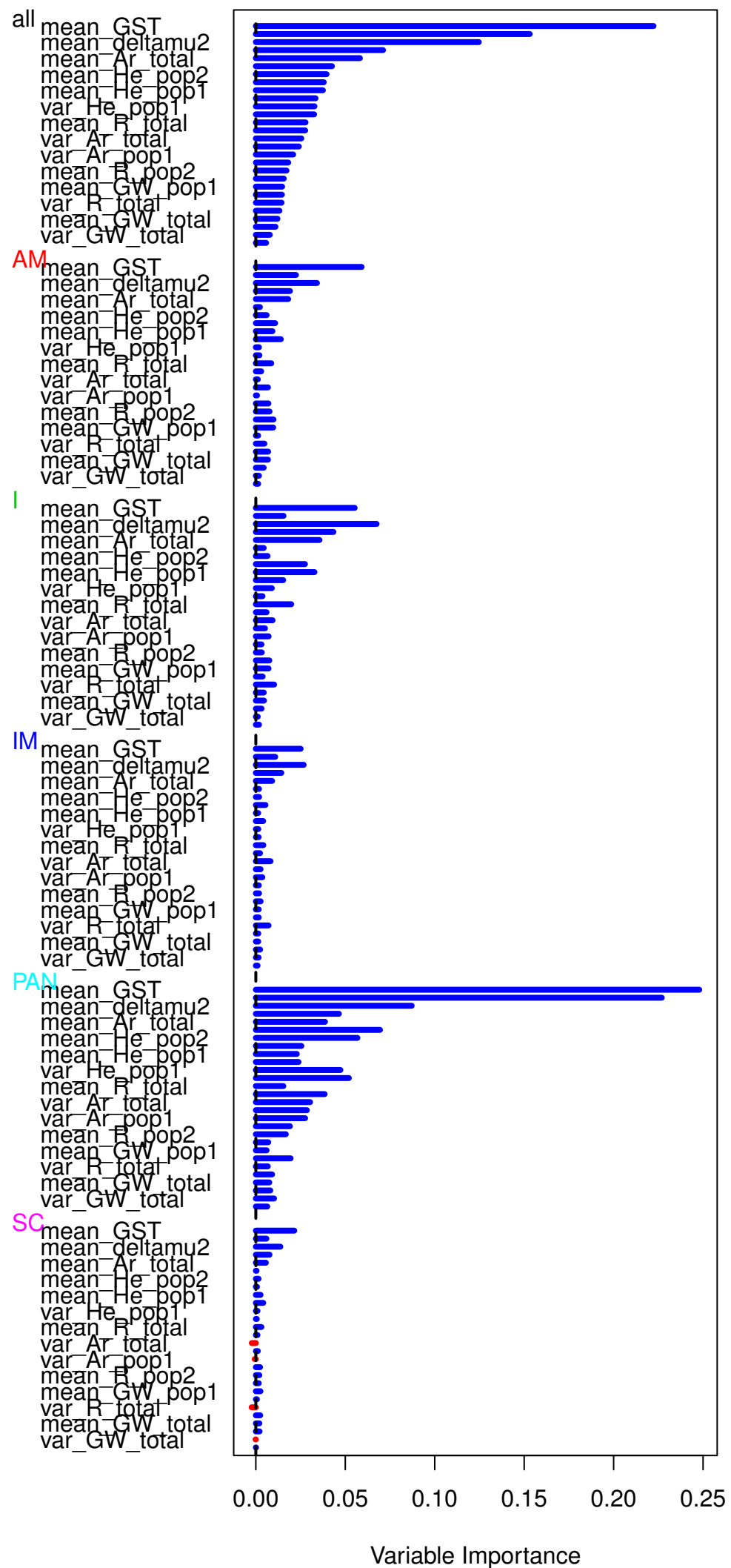
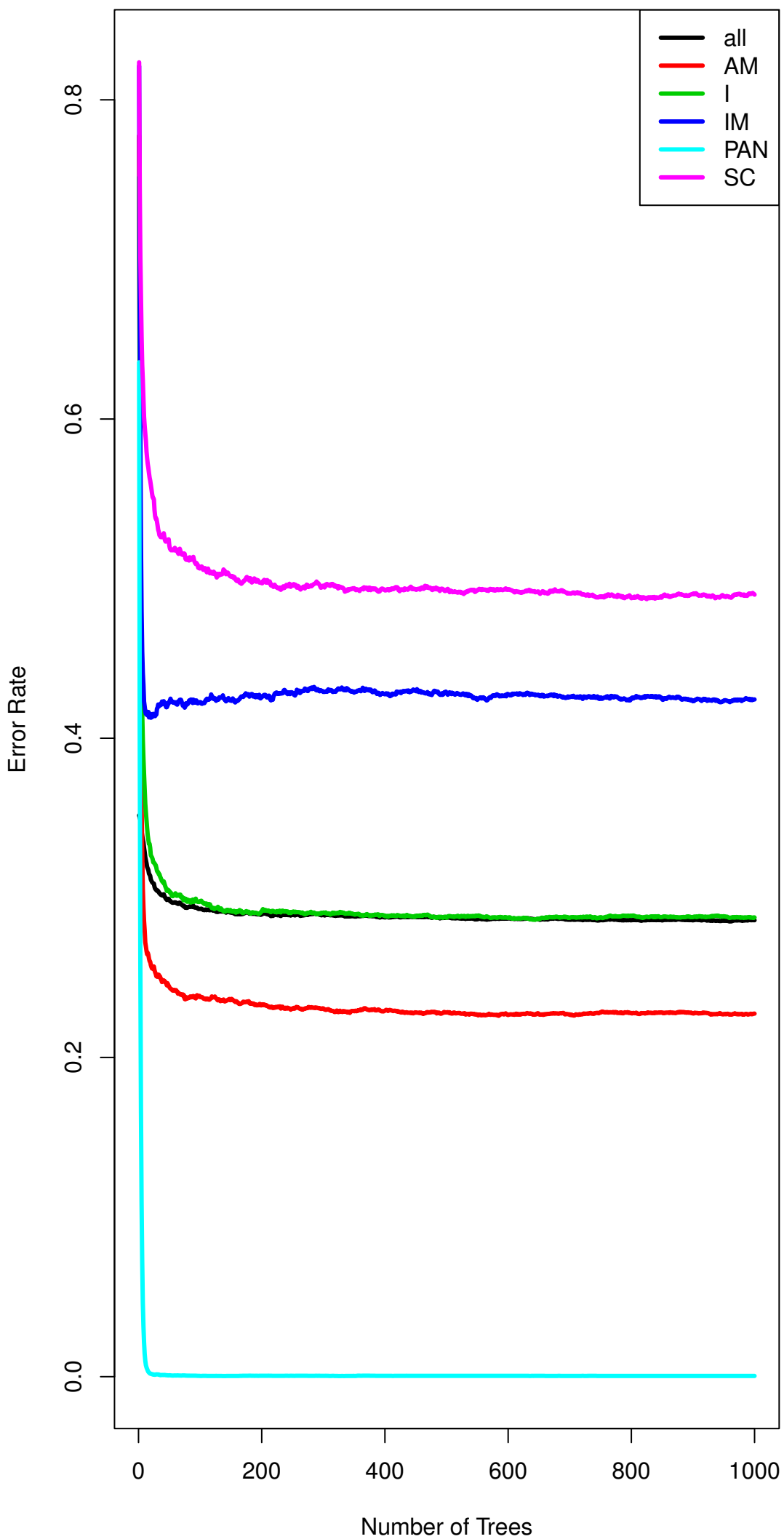
(C) BRE

(D) HEM

(E) OIR

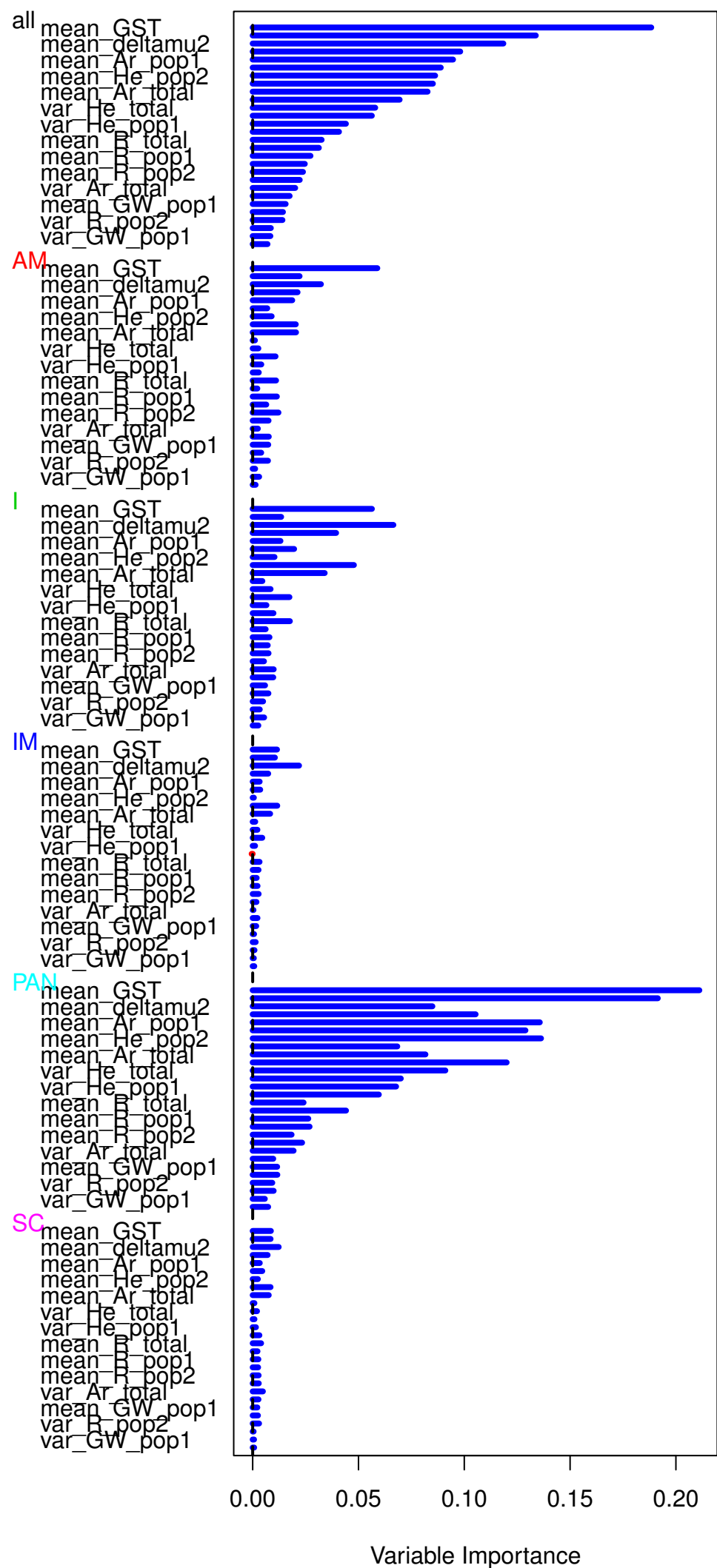
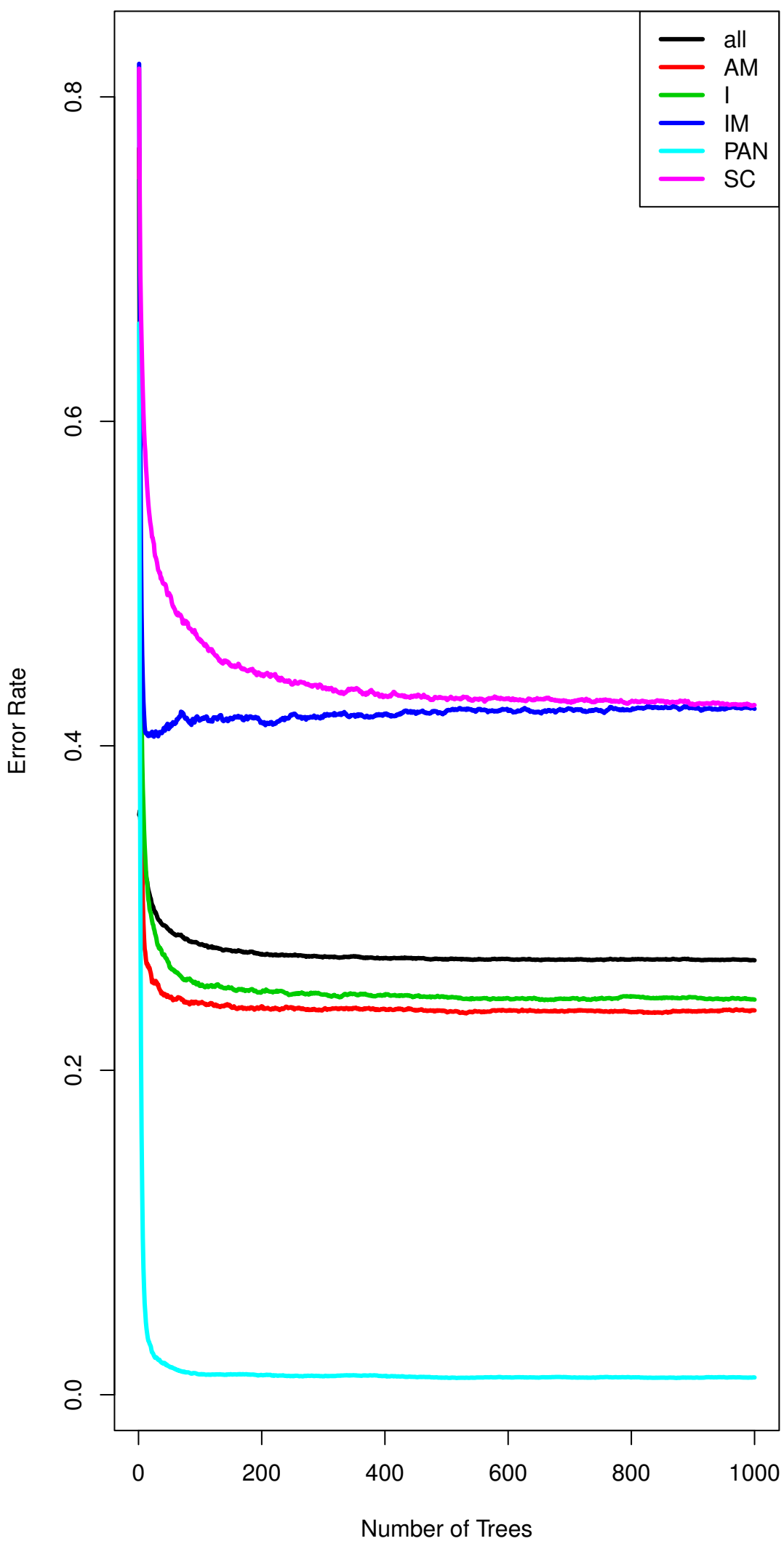
(F) RIS

(A)

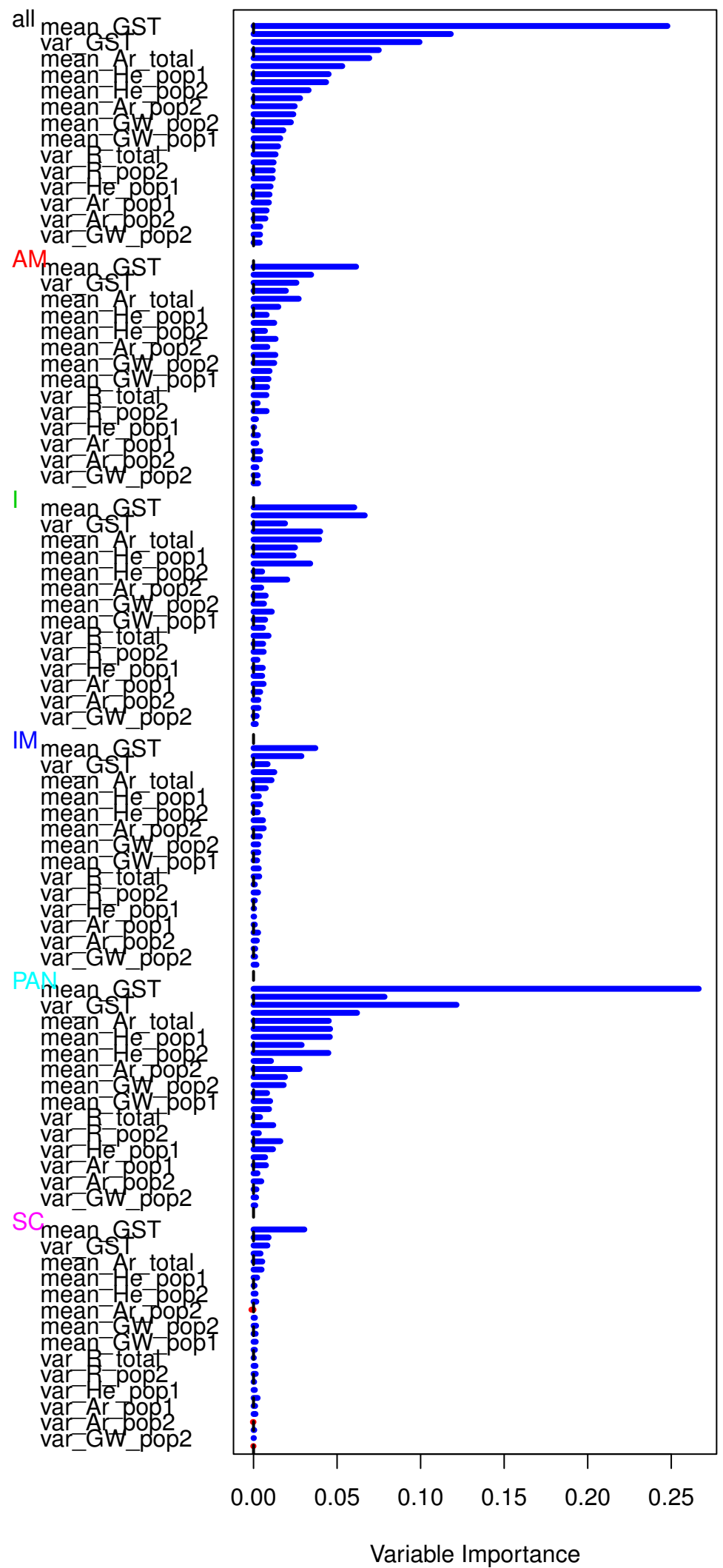
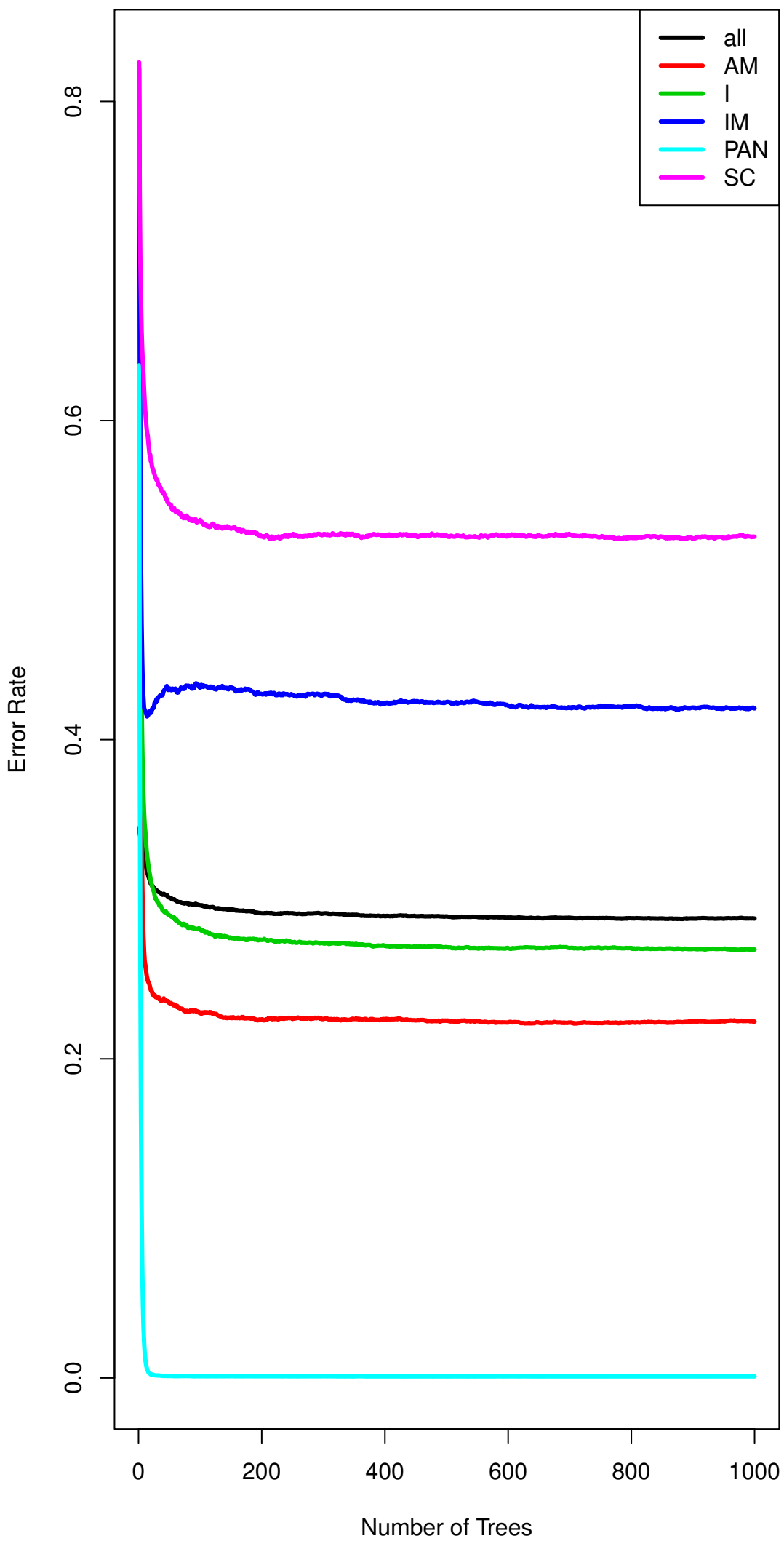




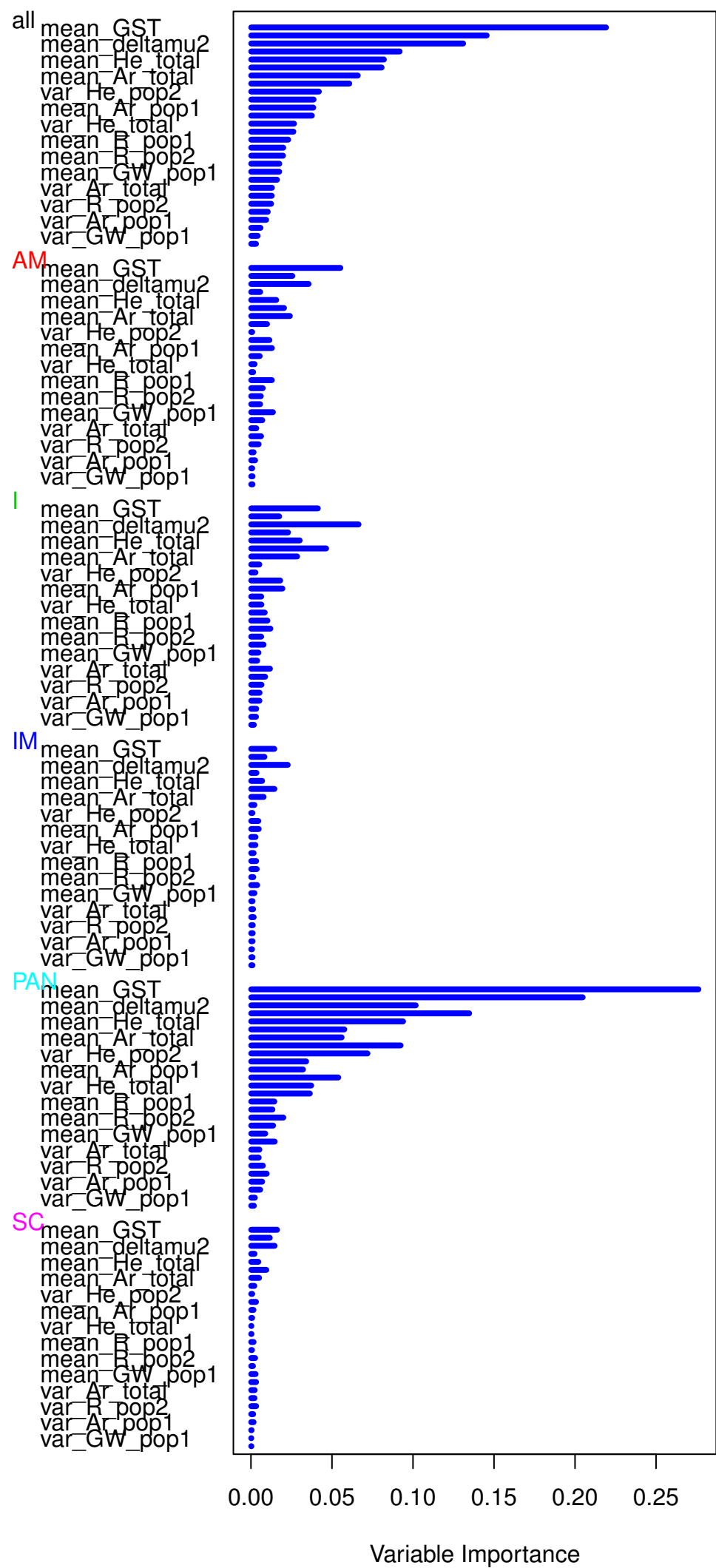
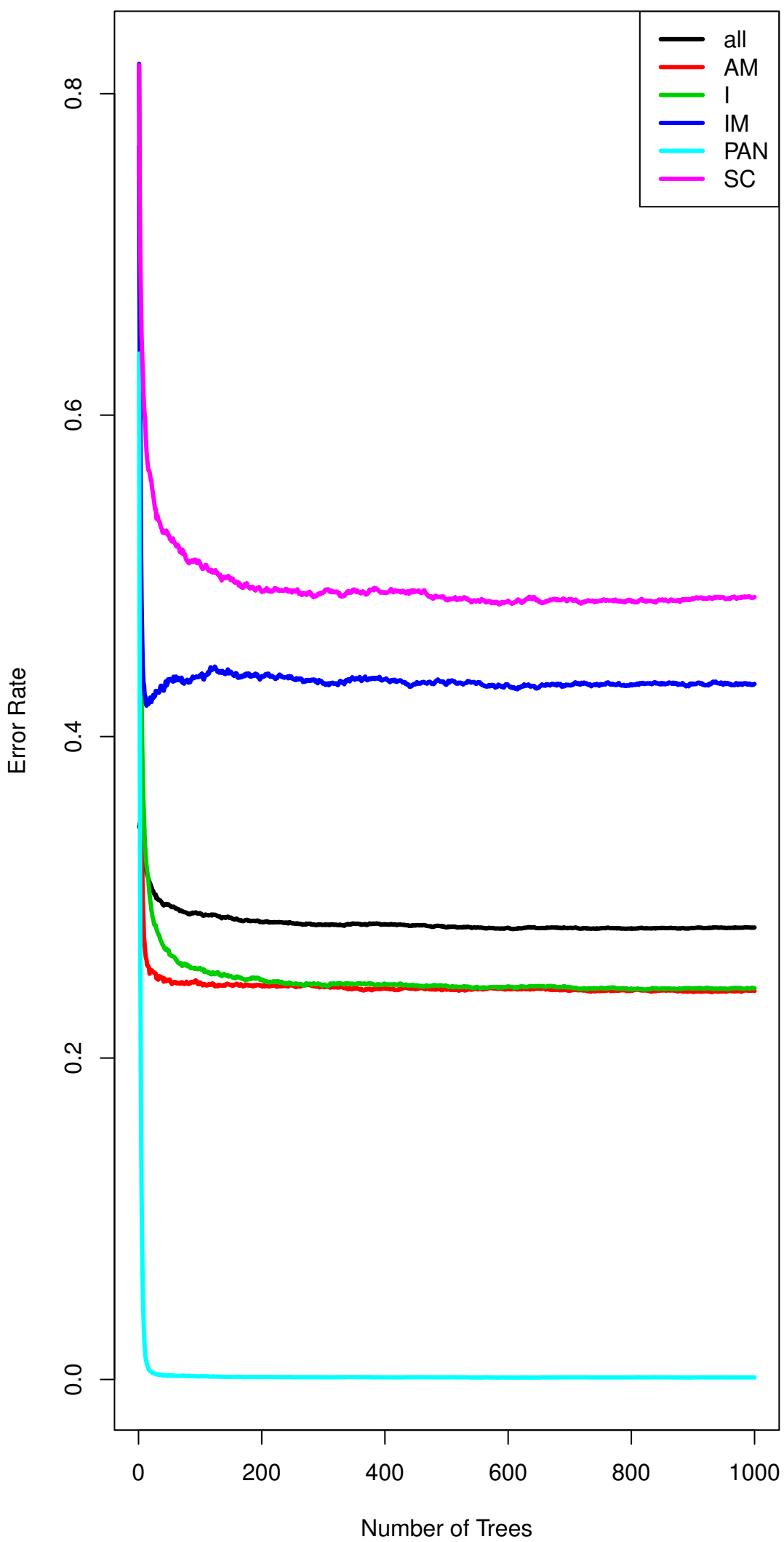
(B)



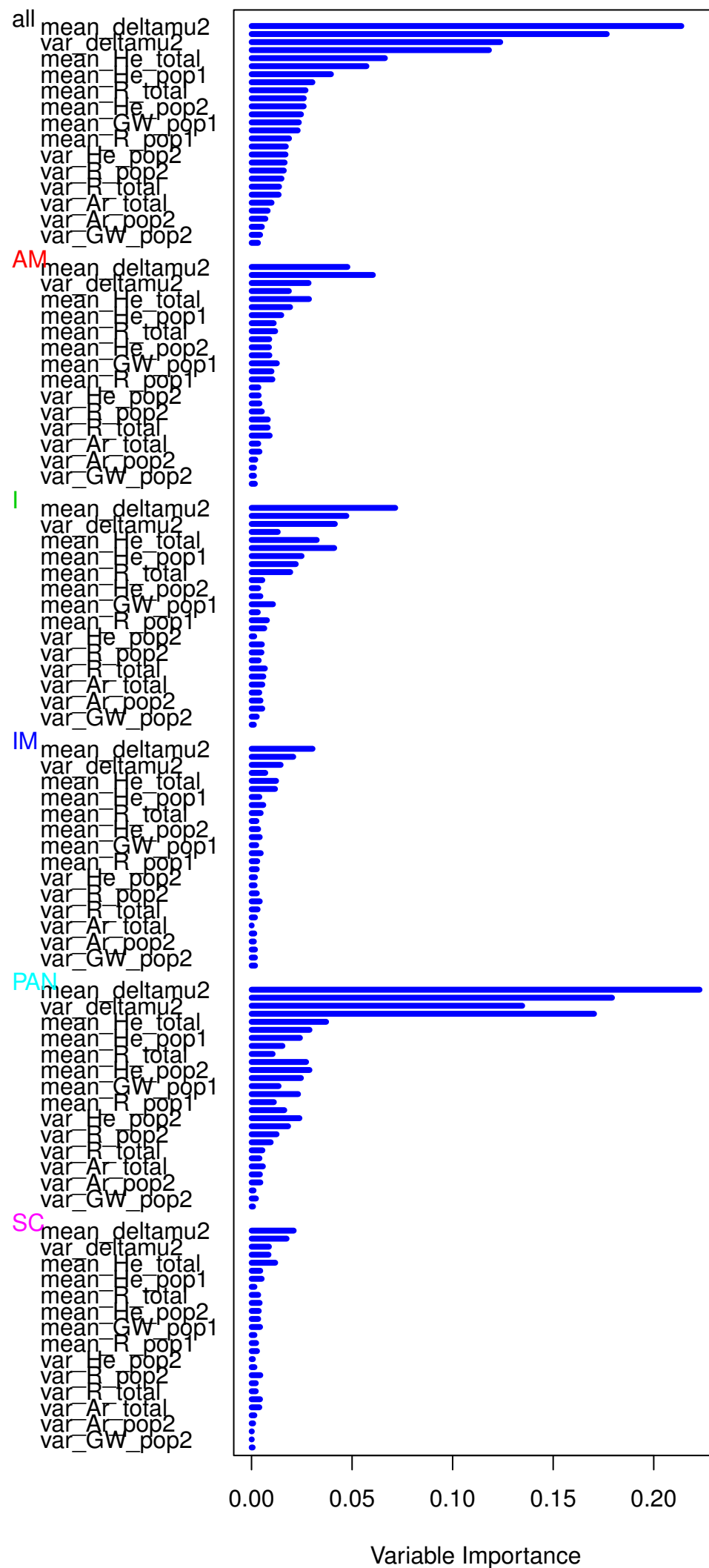
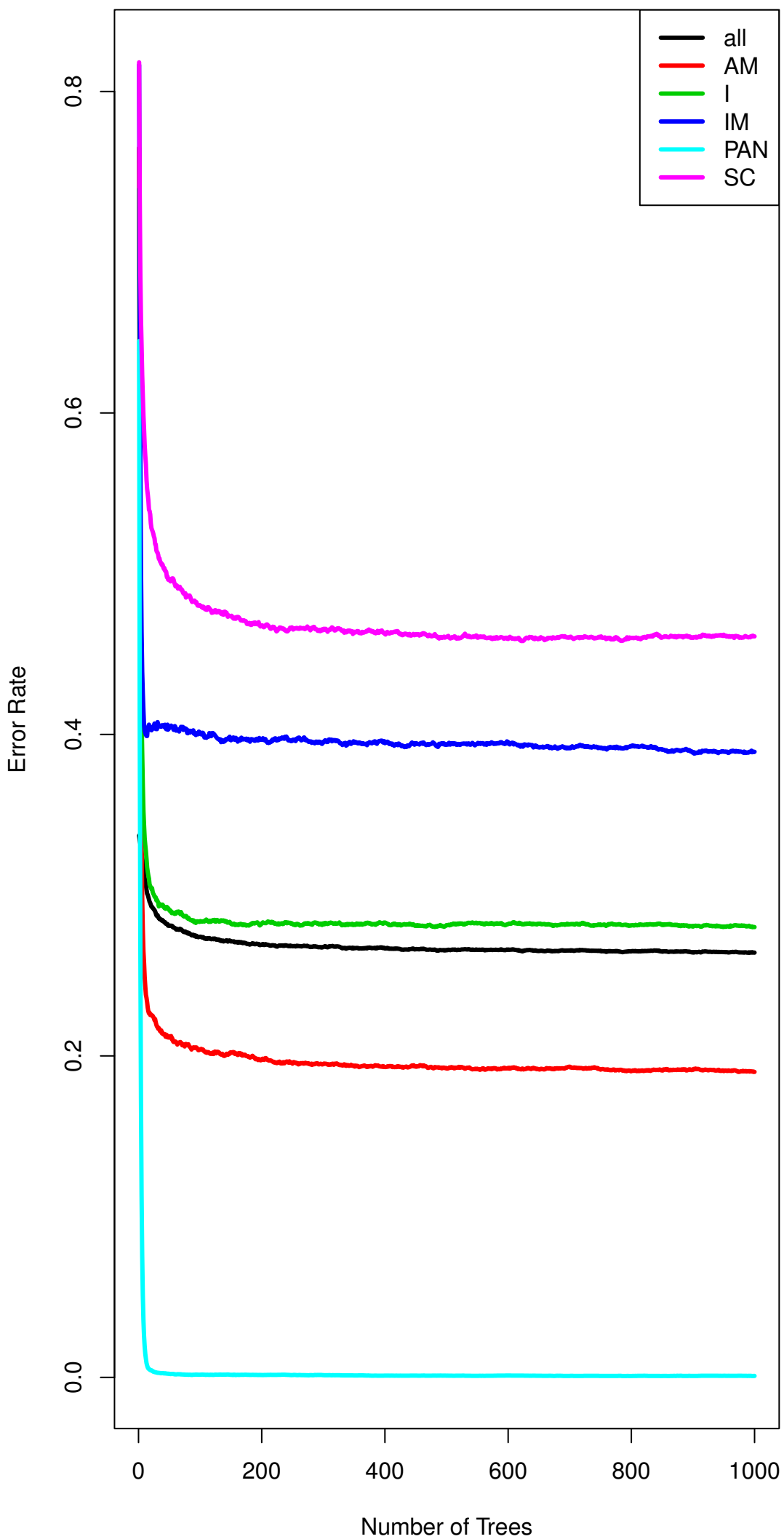
(C)



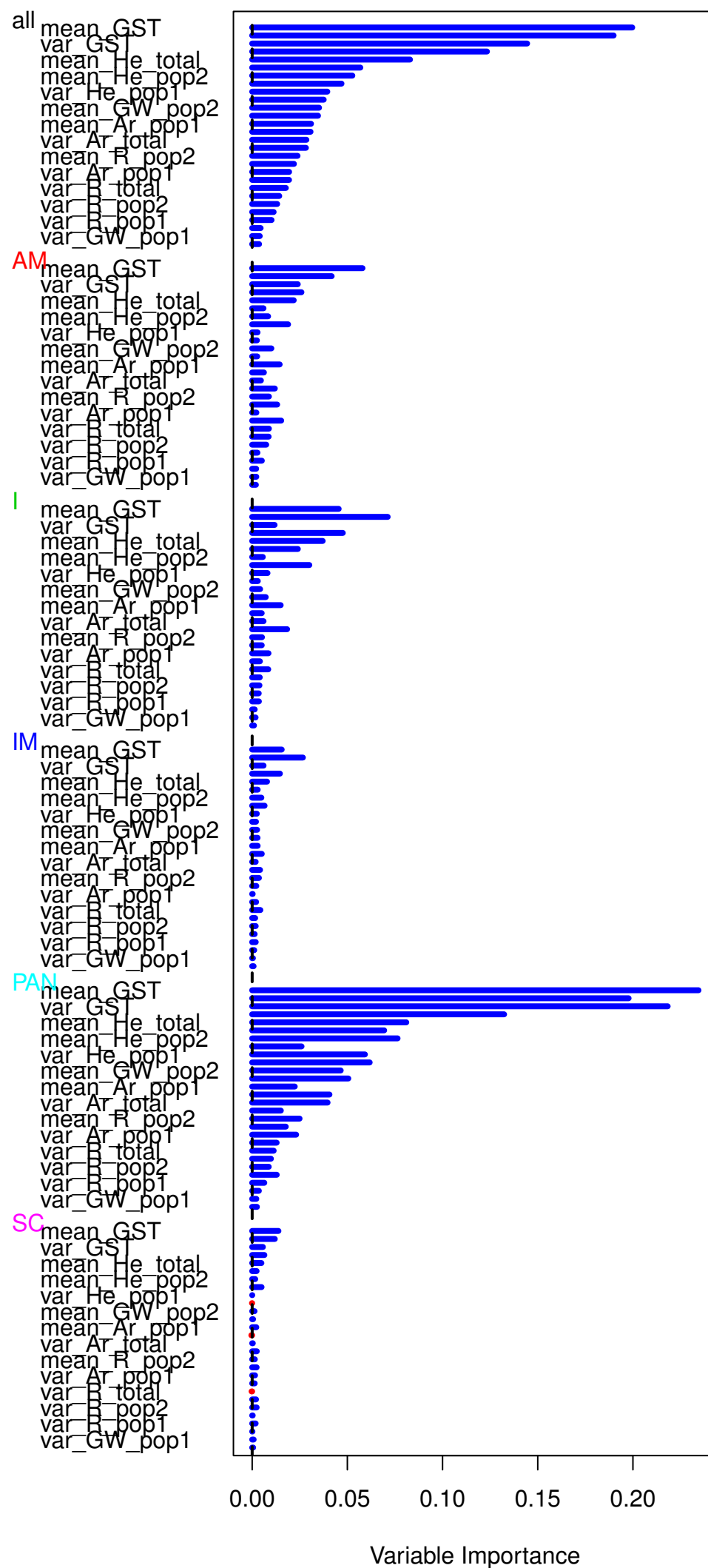
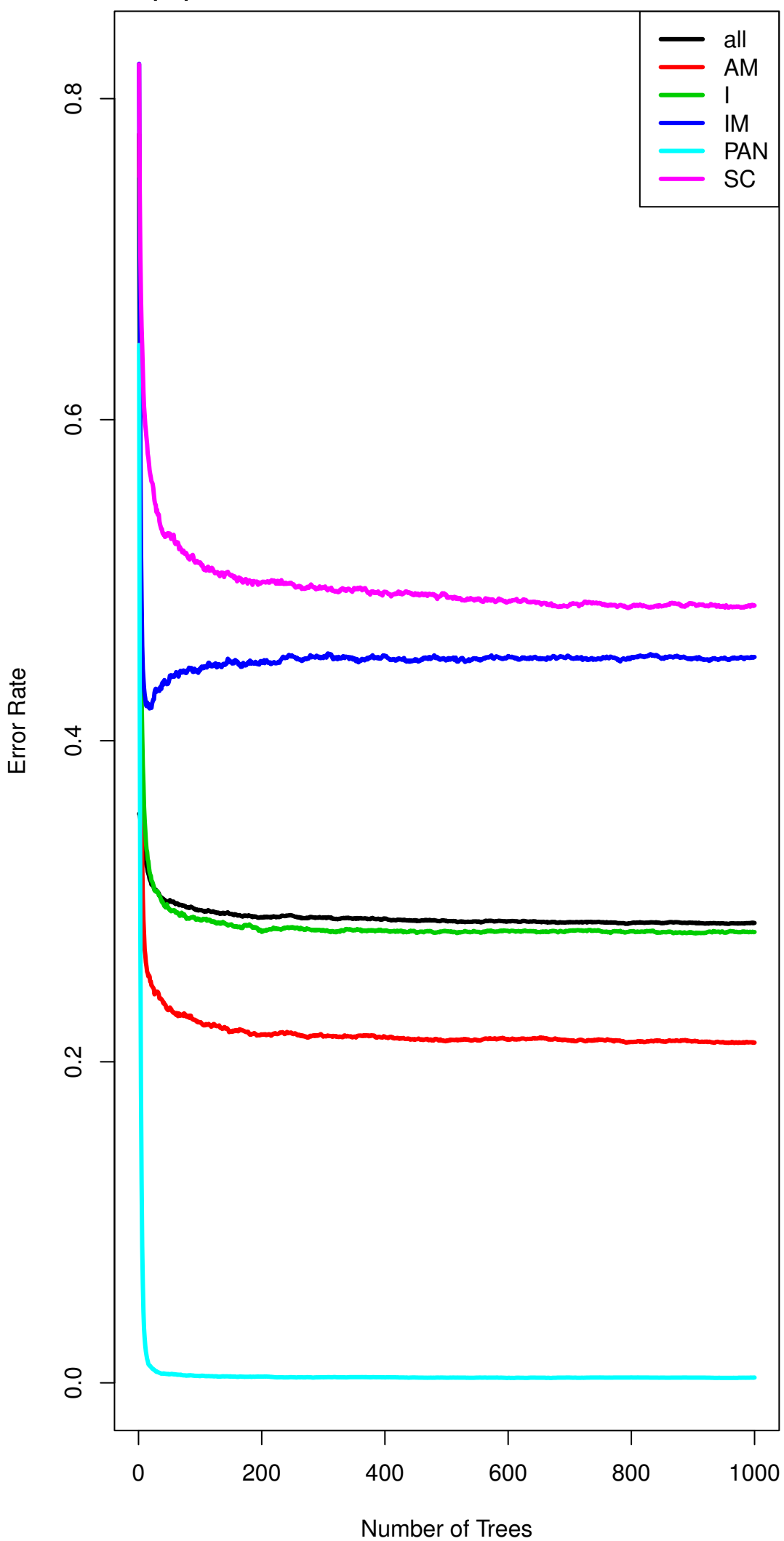
(D)



(E)



(F)



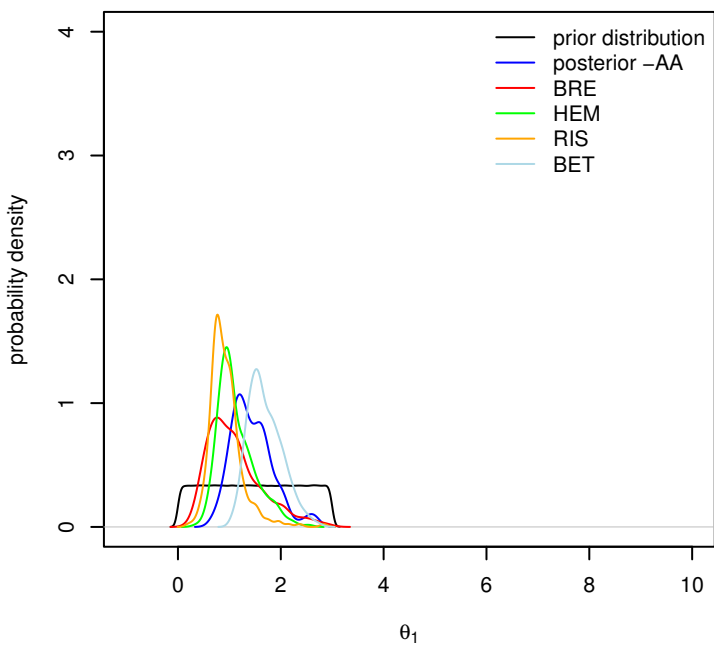
**Figure S2: Prior and Posterior Distribution of parameters estimations in each river under the SC and IM models**

**a) Parameter estimations under scenarios of divergence with gene flow (IM)**

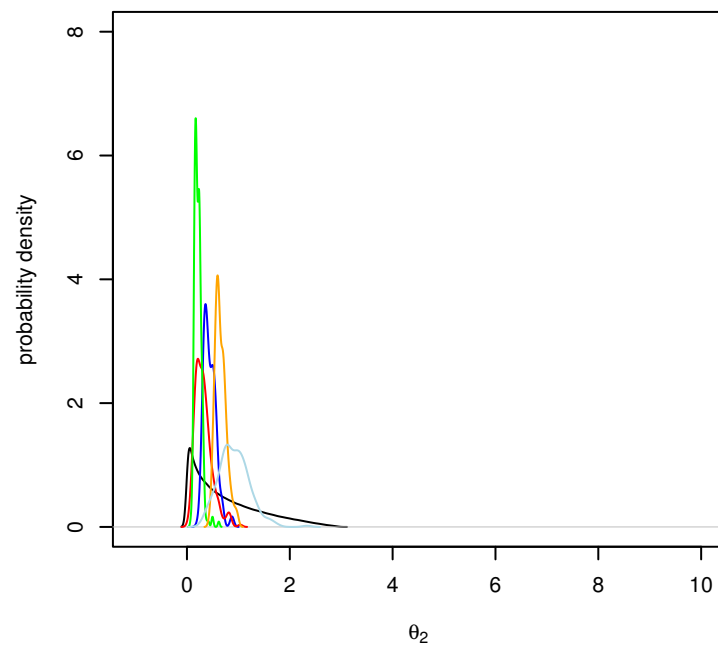
**b) Parameter estimations under scenarios of secondary contact (SC)**

a)

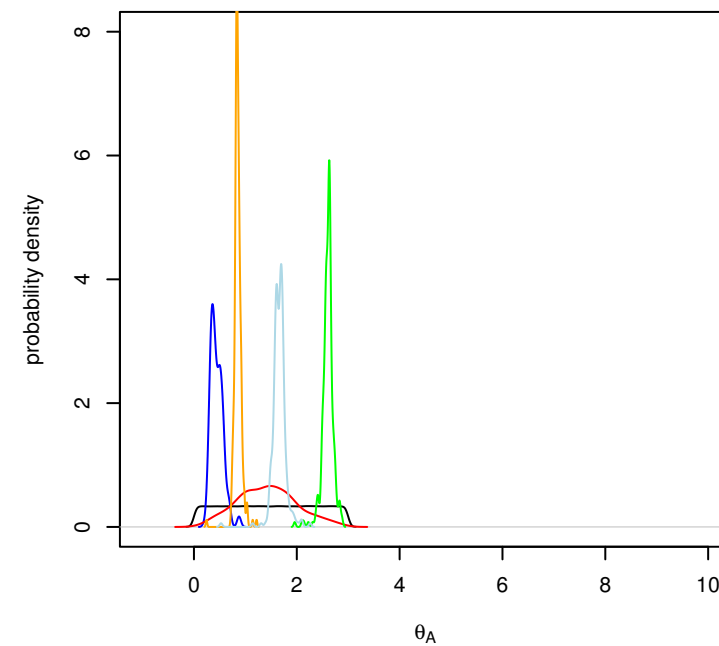
theta1/thetaRef



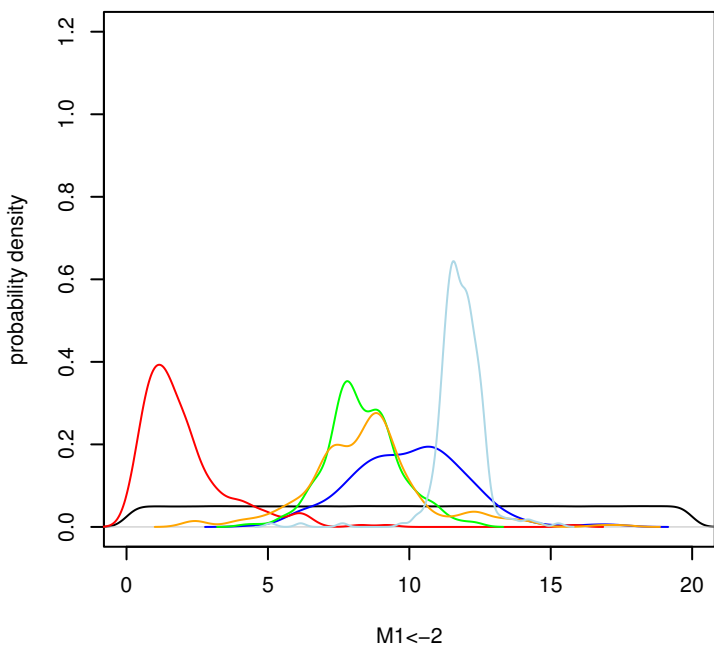
theta2/thetaRef



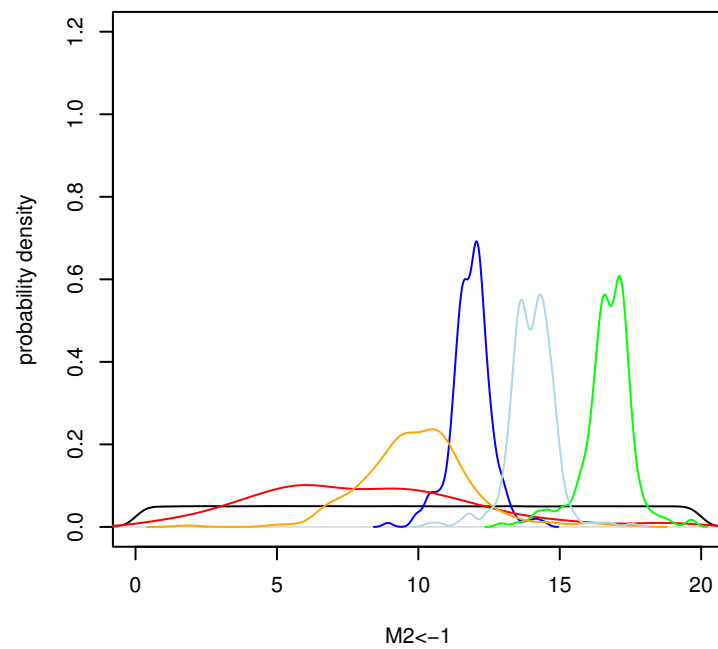
thetaA/thetaRef



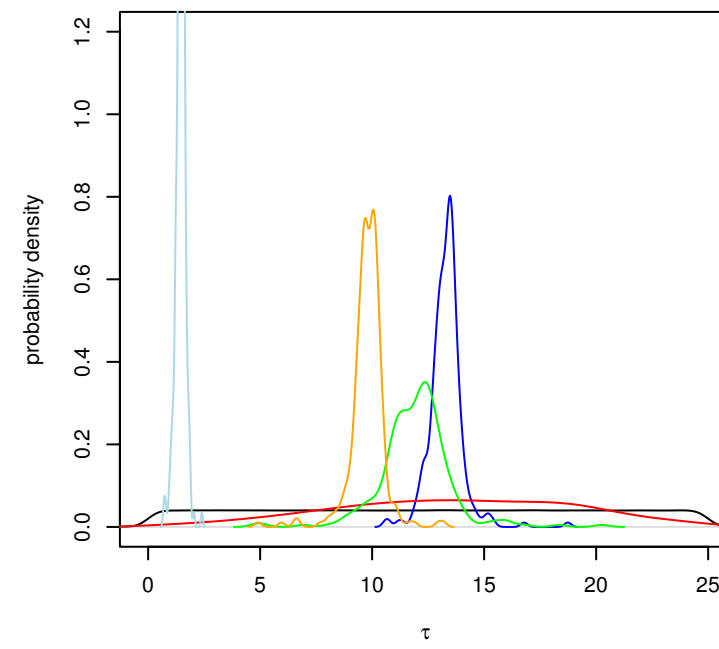
Effective migration rate (from Lp to Lf)



Effective migration rate (from Lf to Lp)

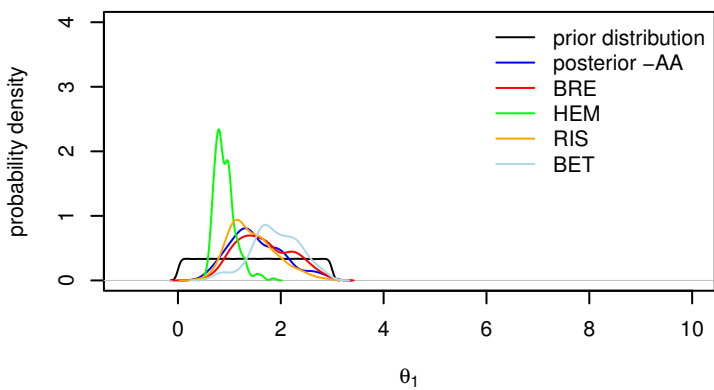


Time Split (4Ngenerations)

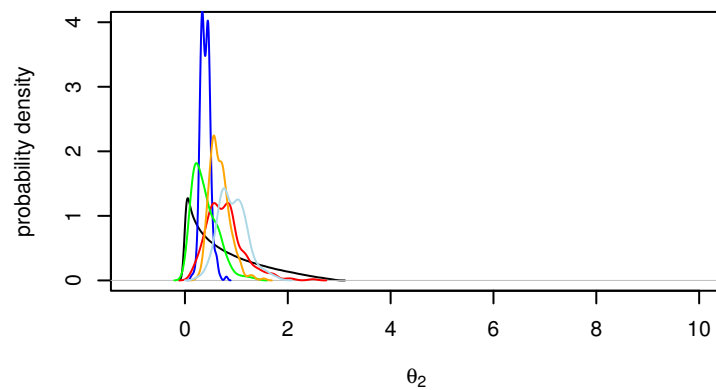


b)

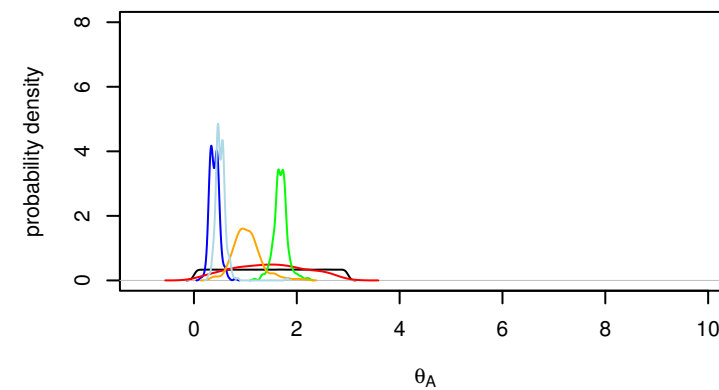
theta1/thetaRef



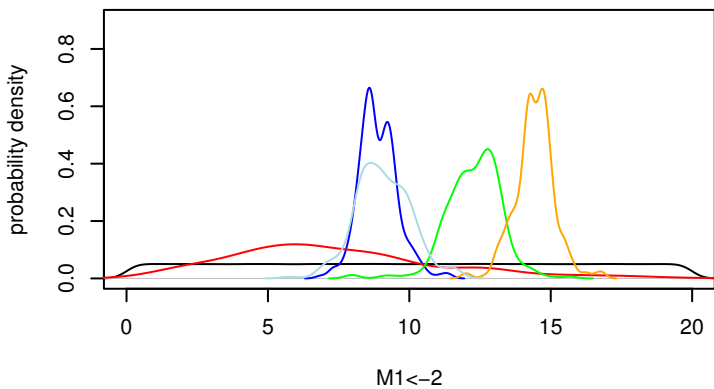
theta2/thetaRef



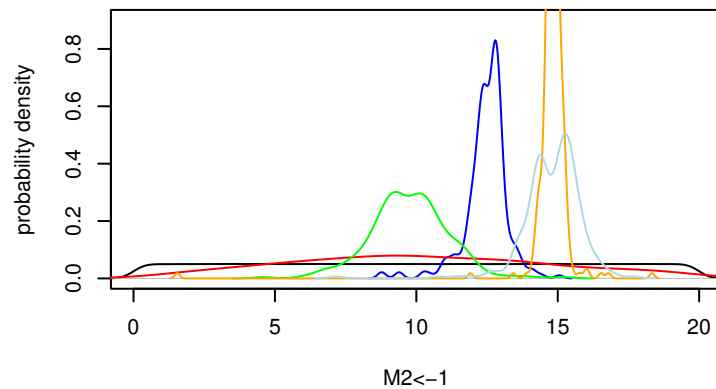
thetaA/thetaRef



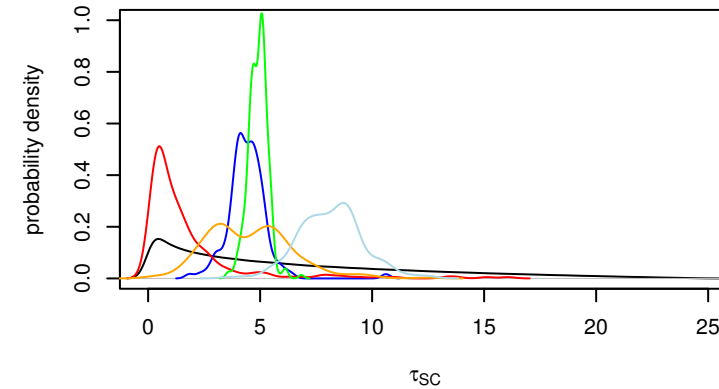
Effective migration rate (from Lp to Lf)



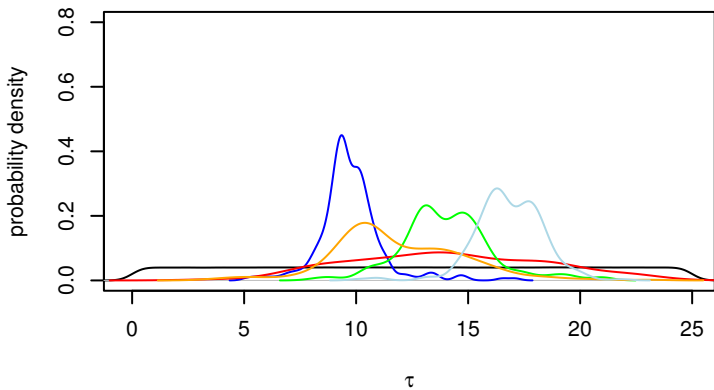
Effective migration rate (from Lf to Lp)



Time Secondary Contact (4Ngenerations)



Divergence time (4Ngenerations)





**Figure S2:** Distribution of summary statistics obtained from the posterior predictive check. Statistics obtained after 10 000 simulations based on posterior distributions. Each page corresponds to a different river and a different model

(A) AA – IM

(B) BET – IM

(C) BRE – IM

(D) HEM – IM

(E) RIS – IM

(F) AA – SC

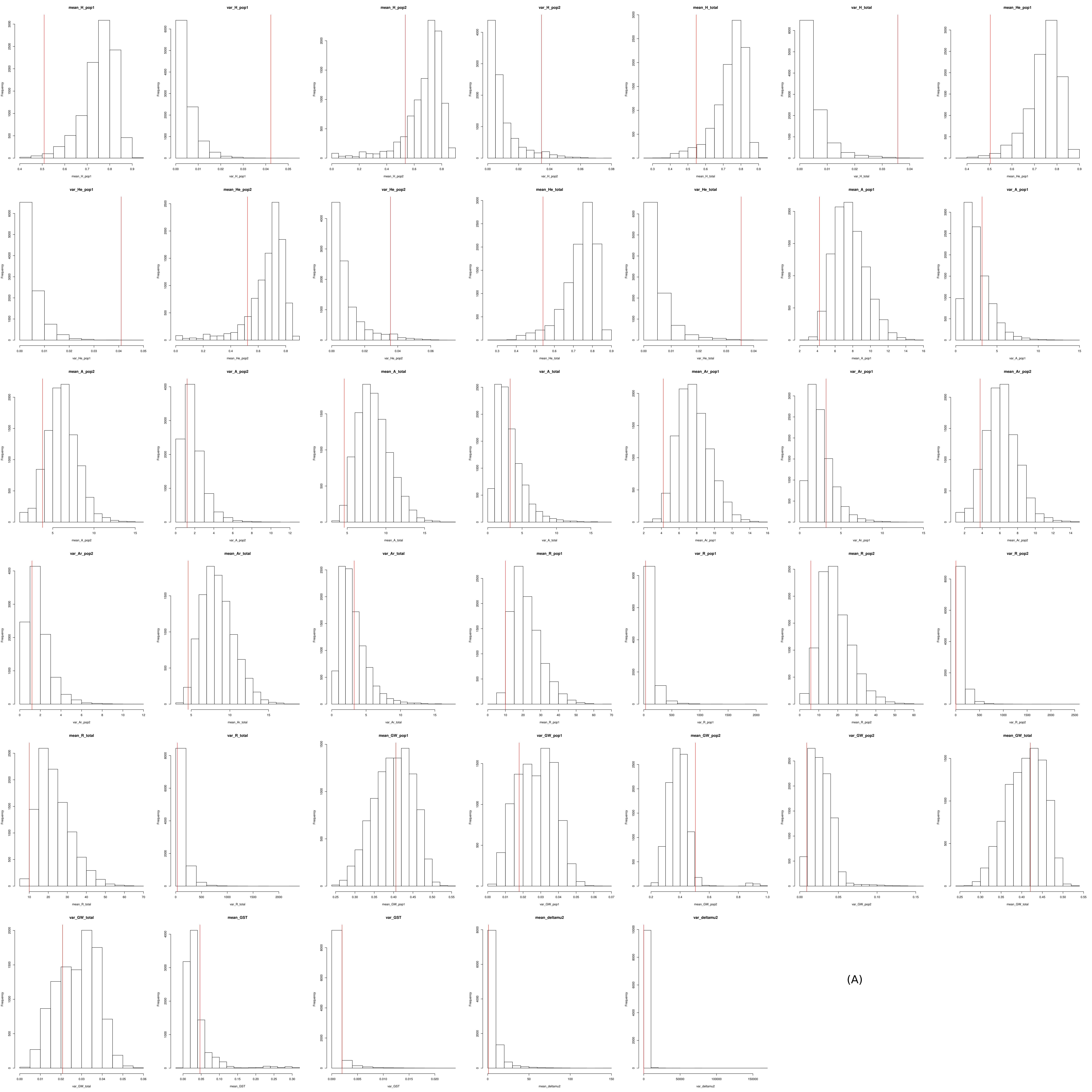
(G) BET – SC

(H) BRE – SC

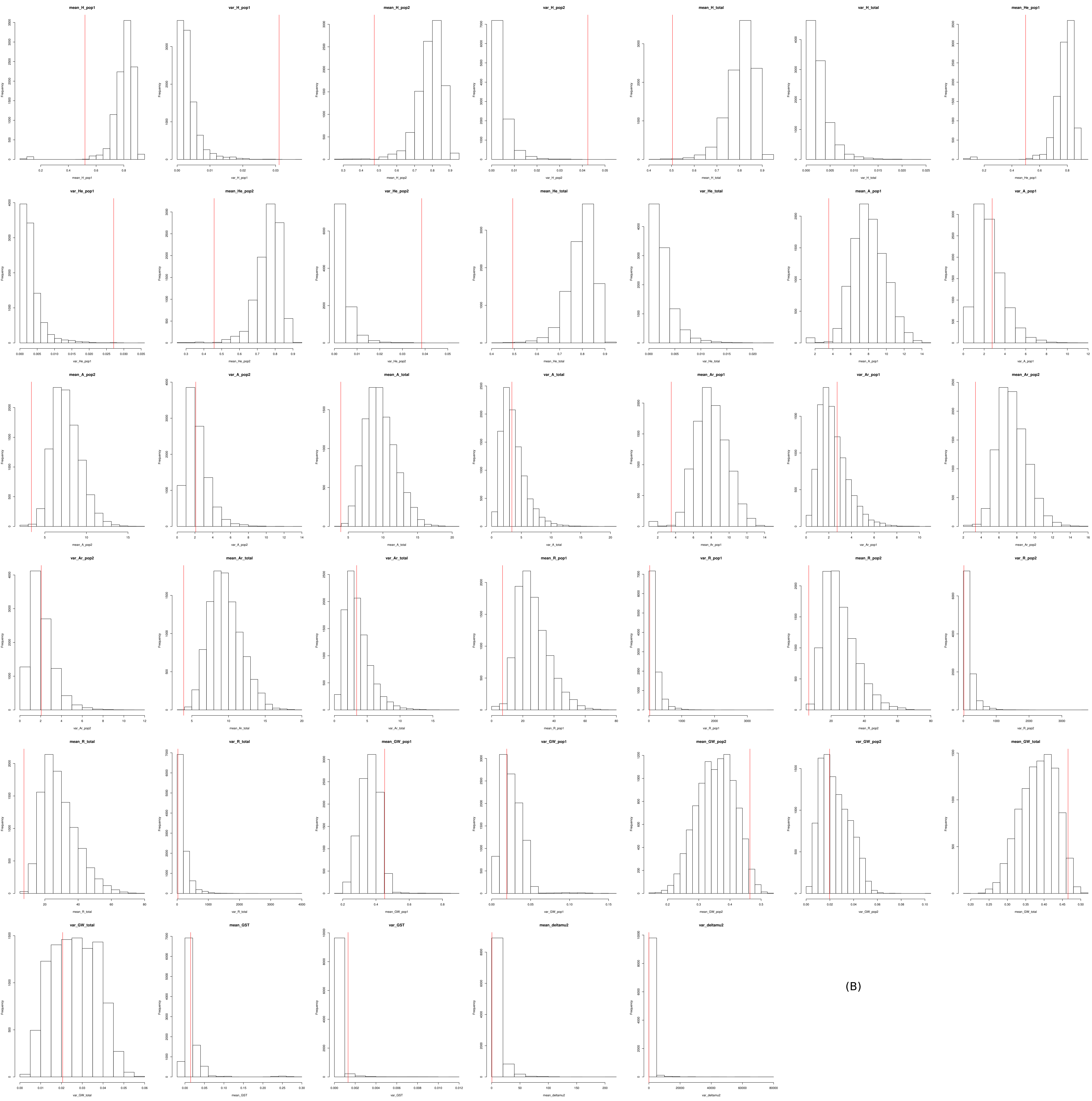
(I) HEM – SC

(J) RIS – SC

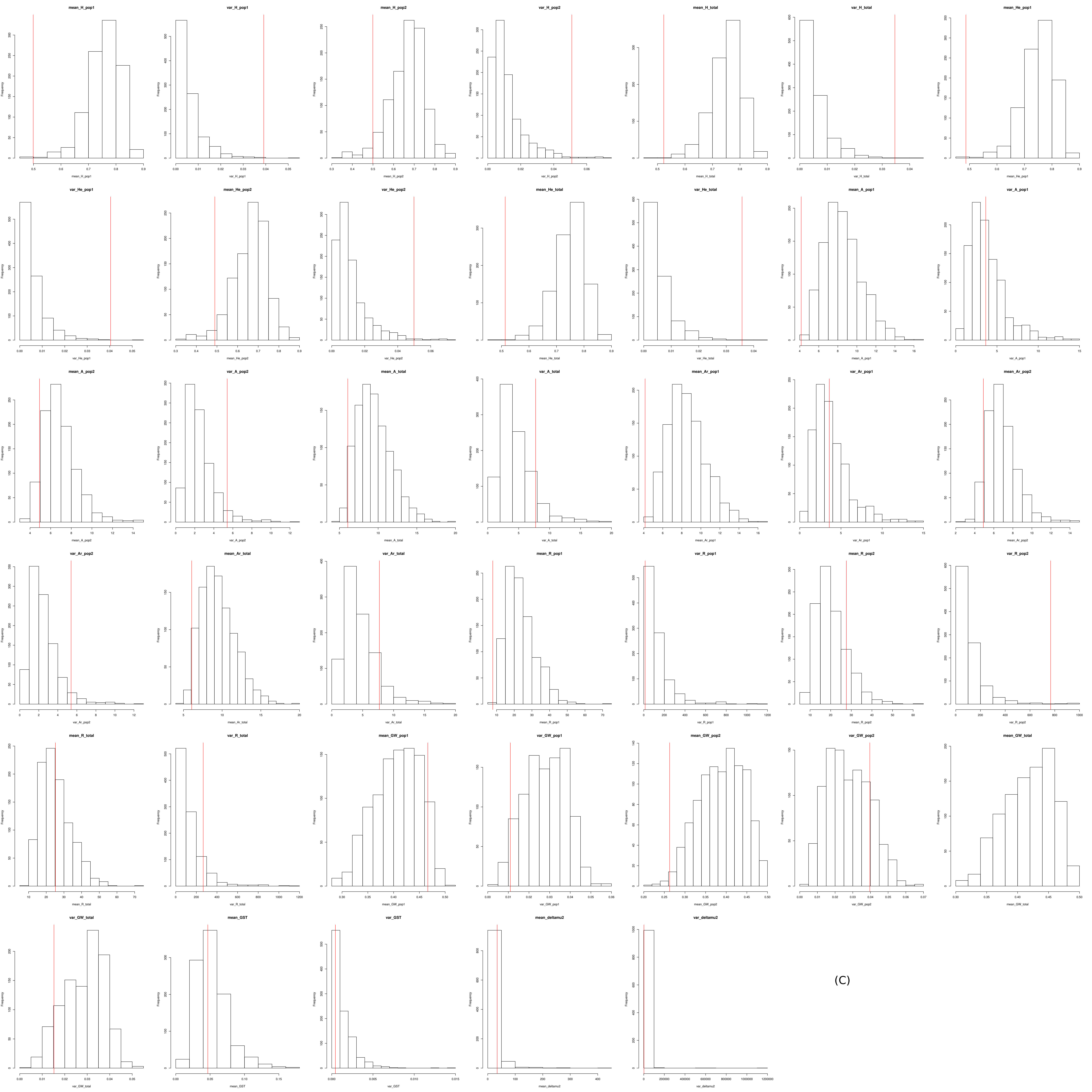
(K) OIR – PAN



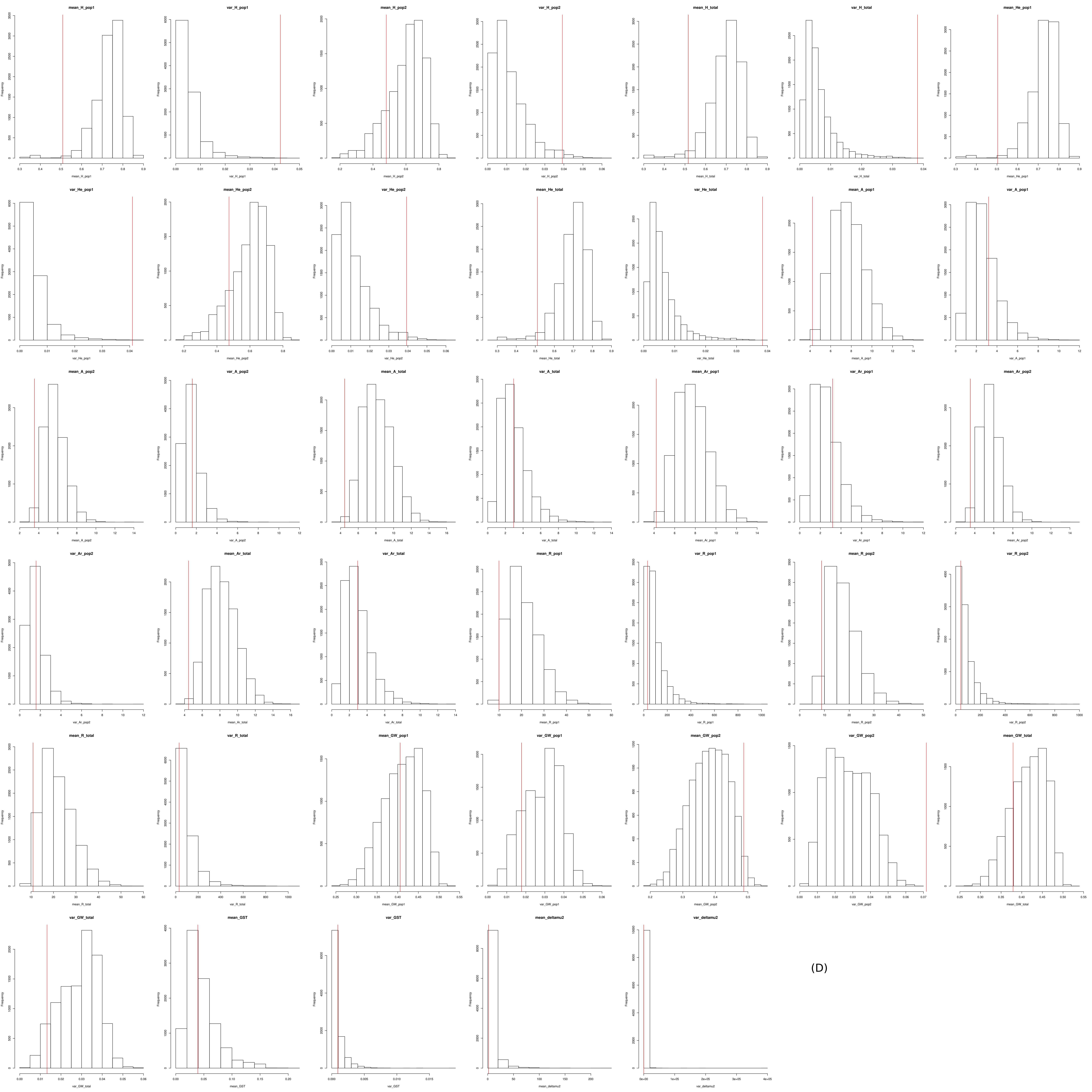
(A)



(B)

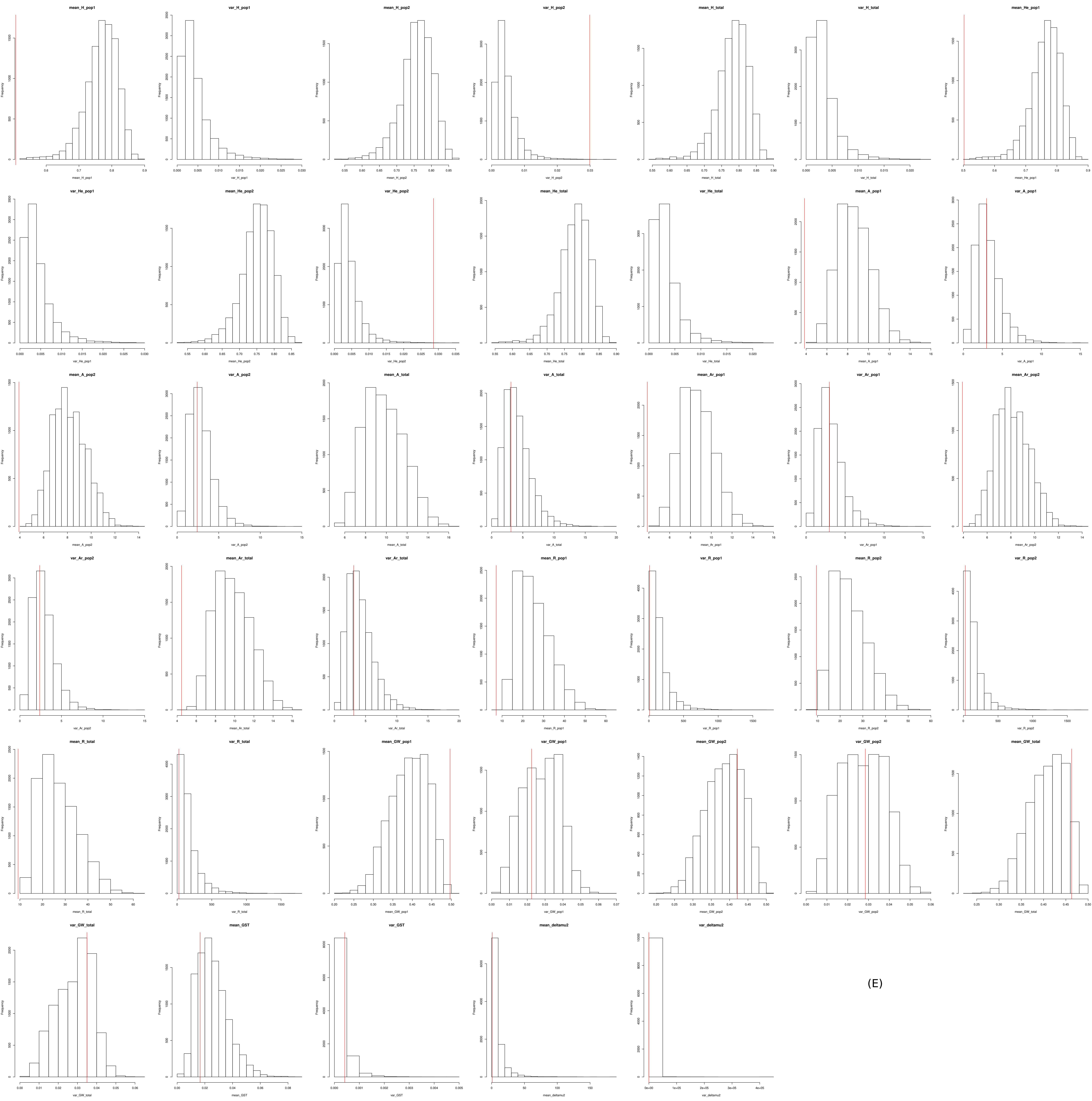


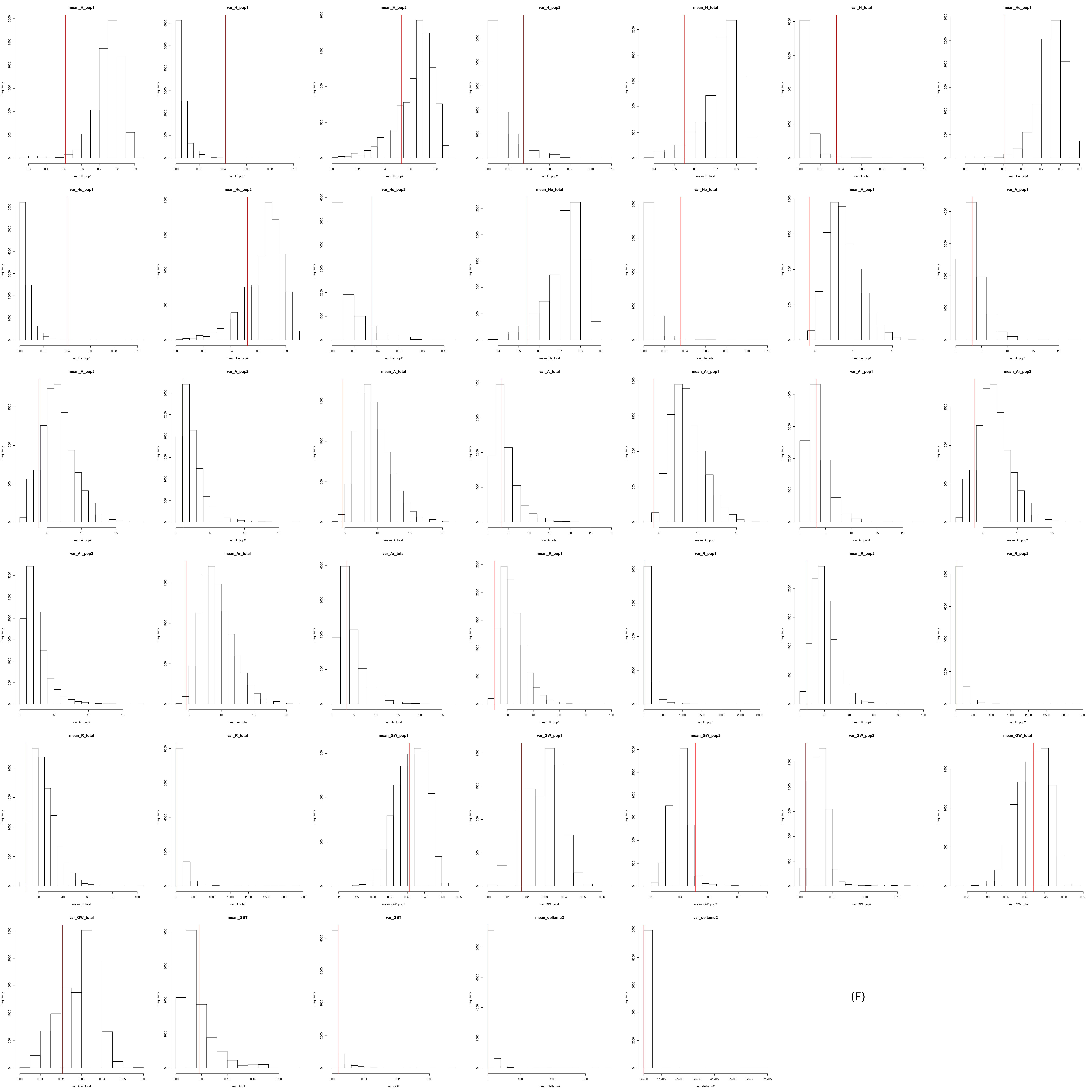
(C)



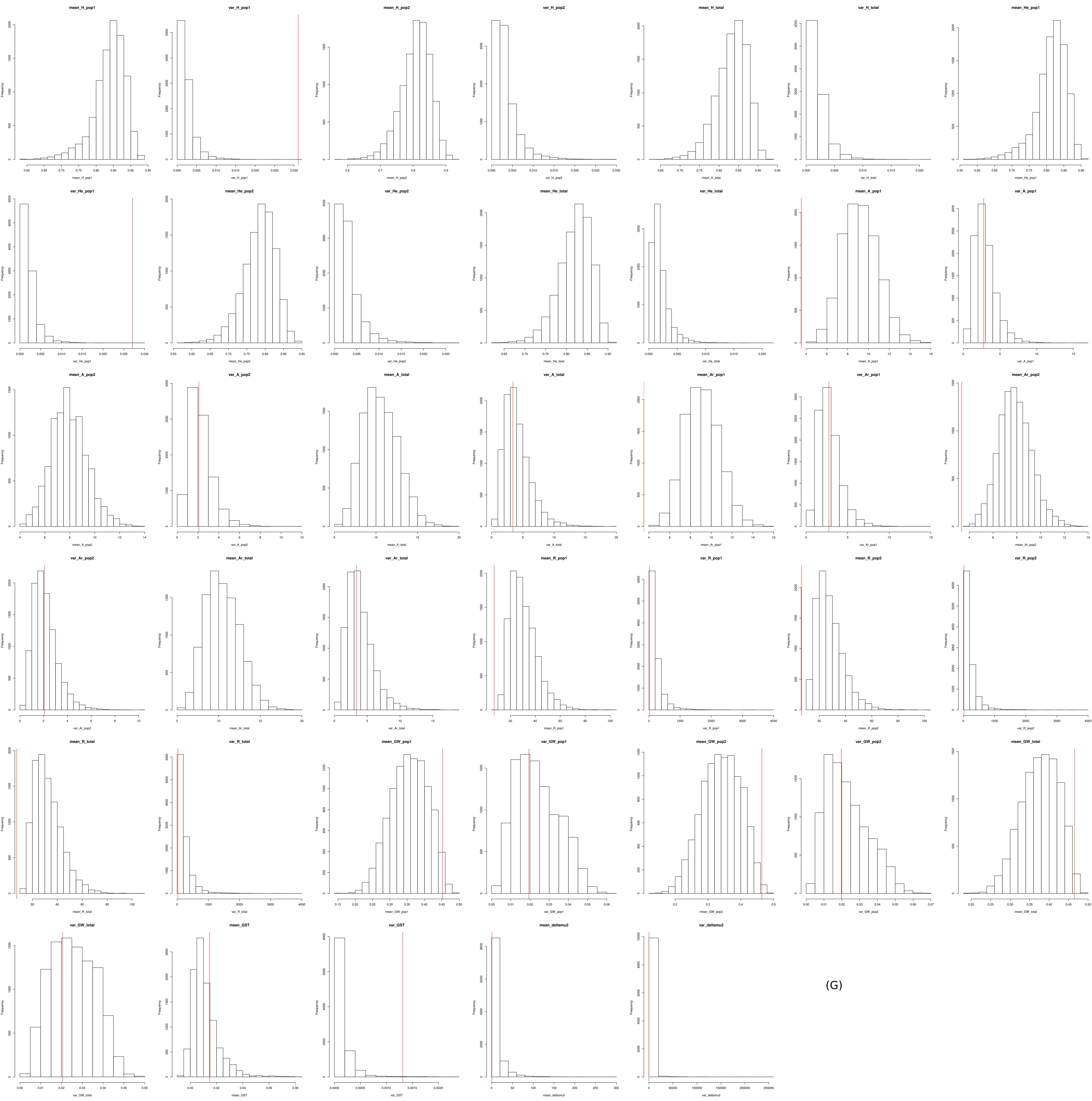
(D)





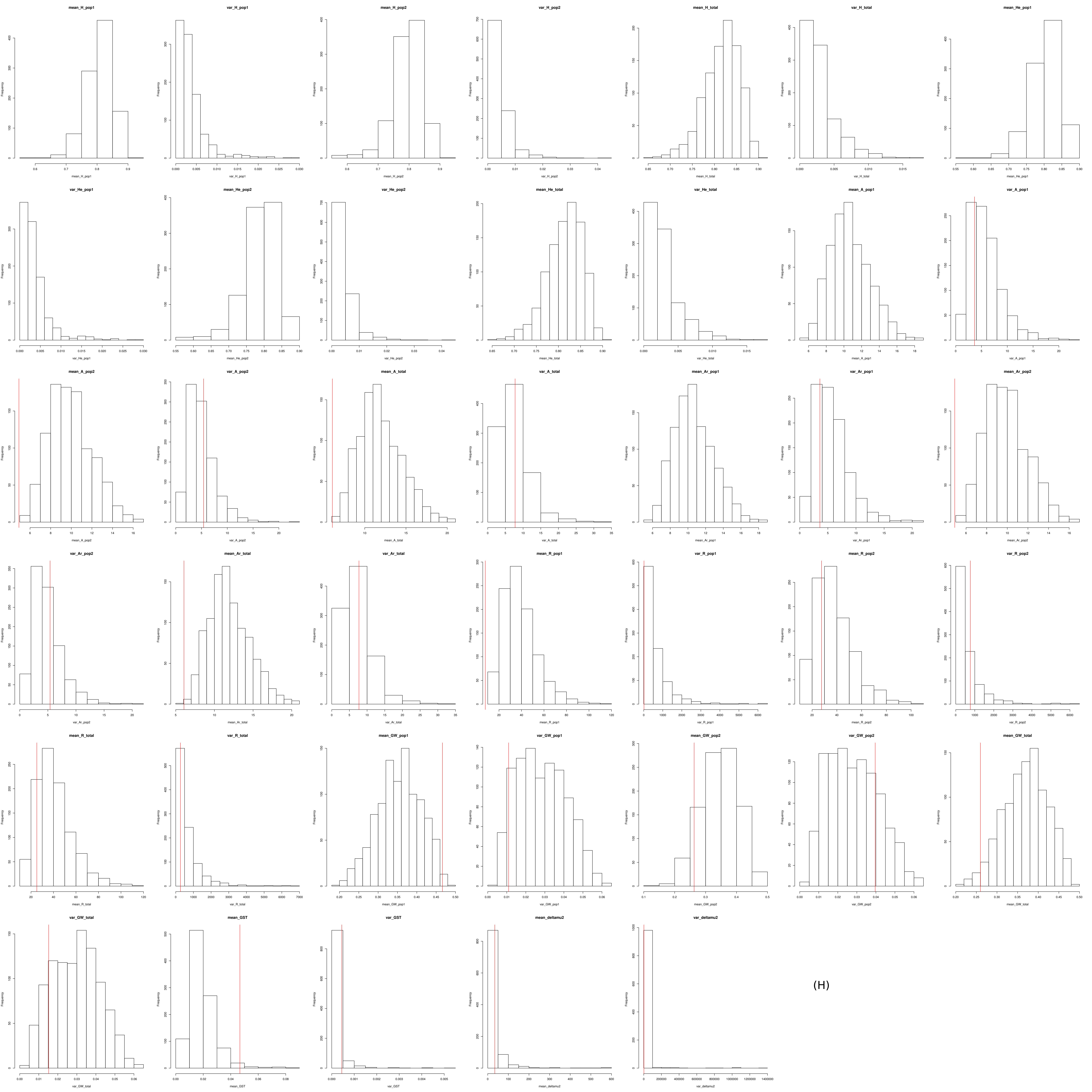


(F)

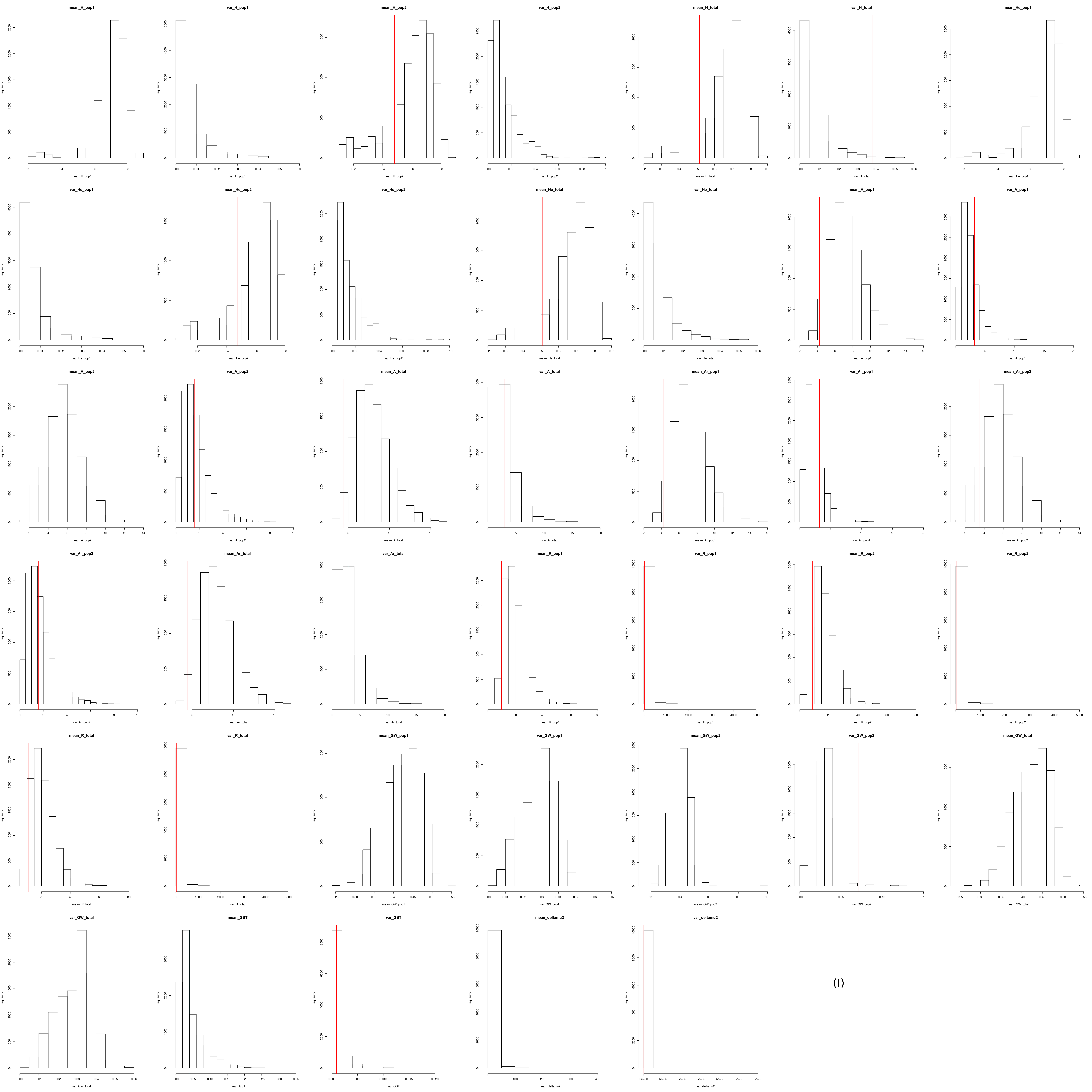


(G)





(H)



(1)

