MAthesis

Contents

Time bins (stratigraphic stages)

Table 1: Smaller time bins with age range, epoch name, mean age and corresponding sample sizes (on individual, species and genus level)

bin	EpochBins	Stages	MeanBins	nIndividuals	nSpecies	nGenera
(0,0.0117]	Modern	Modern	0.00585	252	64	18
(0.0117,0.126]	Upper Pleistocene	Upper Pleistocene	0.06885	48	16	8
(0.126,0.781]	Middle Pleistocene	Middle Pleistocene	0.45350	49	11	6
(0.781,1.81]	Lower Pleistocene	Lower Pleistocene	1.29350	47	19	11
(1.81,2.59]	Gelasian	Lower Pleistocene	2.19700	26	10	7
(2.59,3.6]	Piacencian	Upper Pliocene	3.09400	23	15	9
(3.6,5.33]	Zanclean	Lower Pliocene	4.46600	29	17	8
(5.33,7.25]	Messinian	Upper Miocene	6.28900	12	9	6
(7.25,11.6]	Tortonian	Upper Miocene	9.42700	41	17	8
(11.6,13.8]	Serravallian	Middle Miocene	12.71400	23	8	6
(13.8,16]	Langhian	Middle Miocene	14.89500	17	13	9
(16,20.4]	Burdigalian	Lower Miocene	18.20500	25	13	9

```
## [1] 0
```

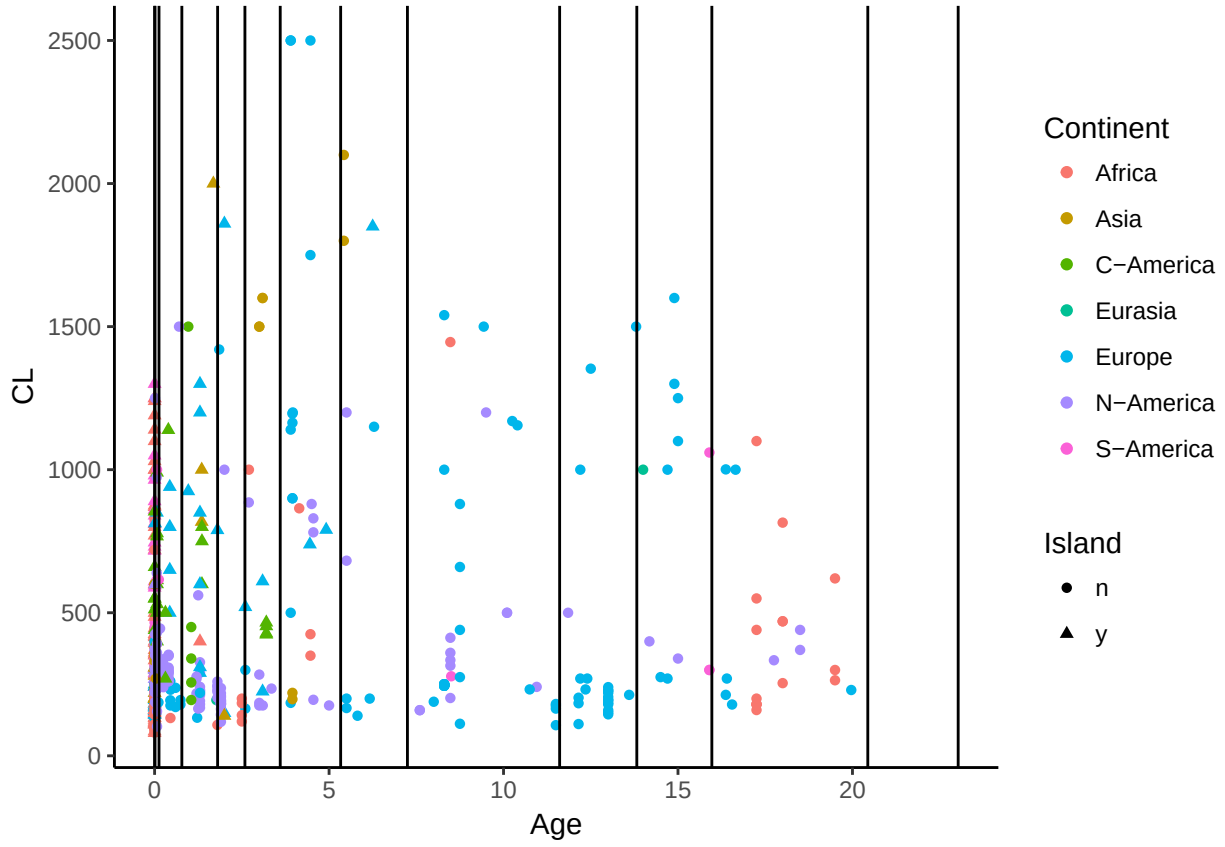


Figure 1: Scatterplot of CL over time, indicating insular (triangle) and continental (circles) and colour indicating continents. Lines indicte bins, dashed line = new bins.

Maps

fossil occurences of testudinidae

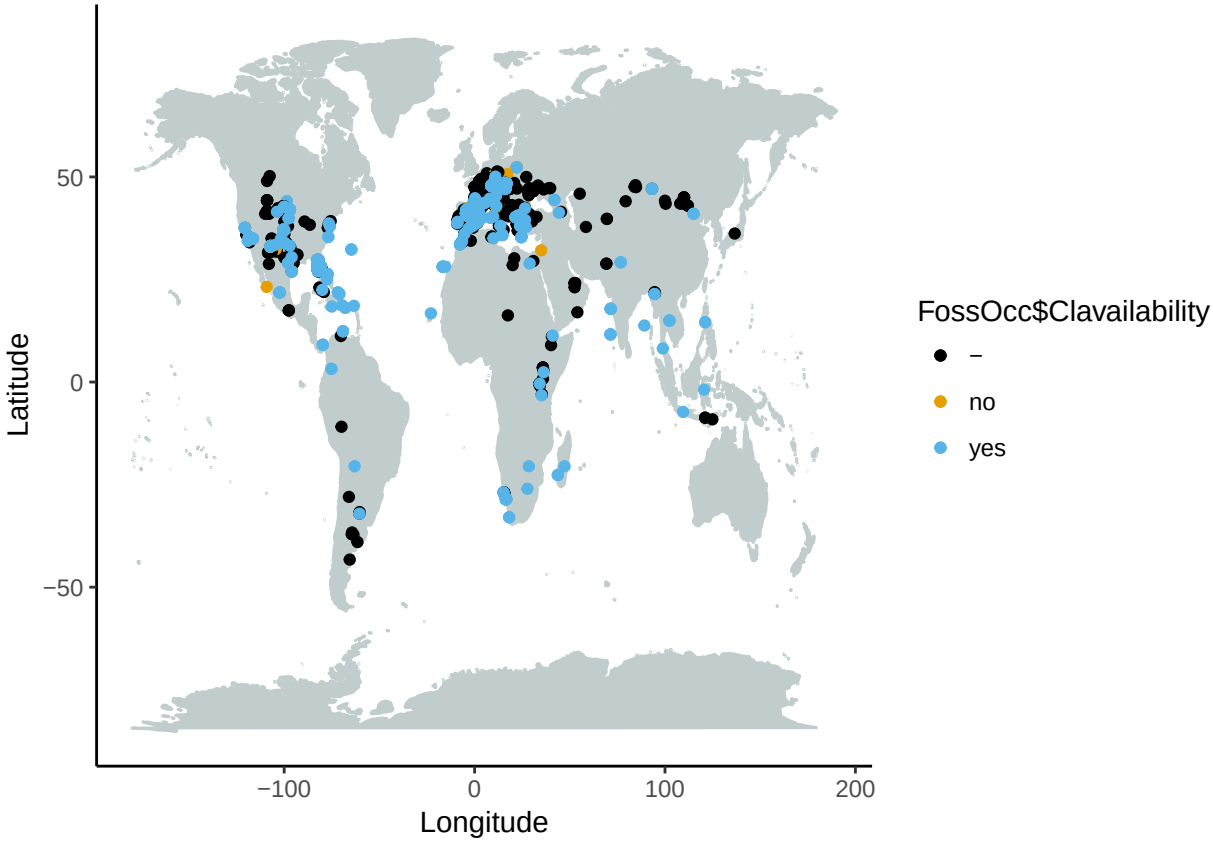


Figure 2: Map displaying all fossil occurrences of testudinids, with color indicating whether relevant literature was available (black if not) and if it was, whether body size data was available or not (yes and no, respectively).

body size of testudinidae

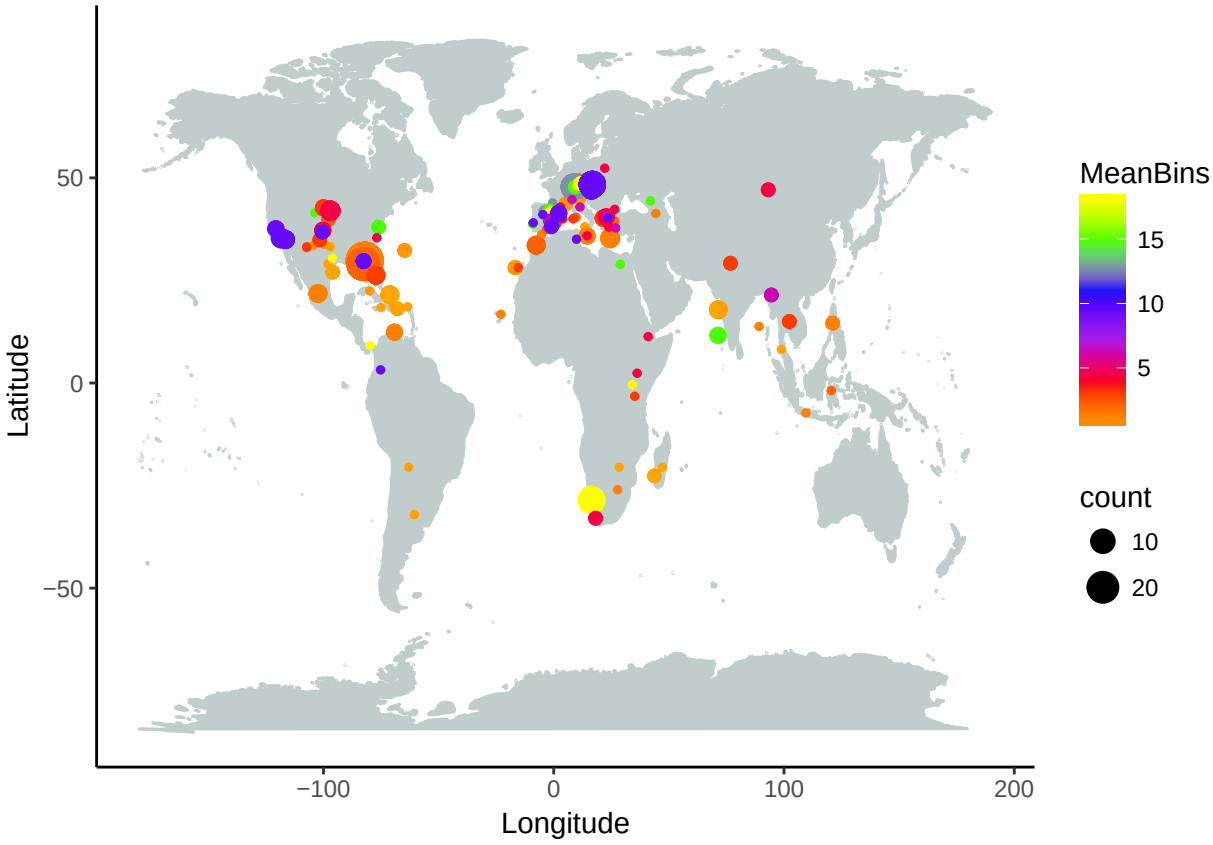
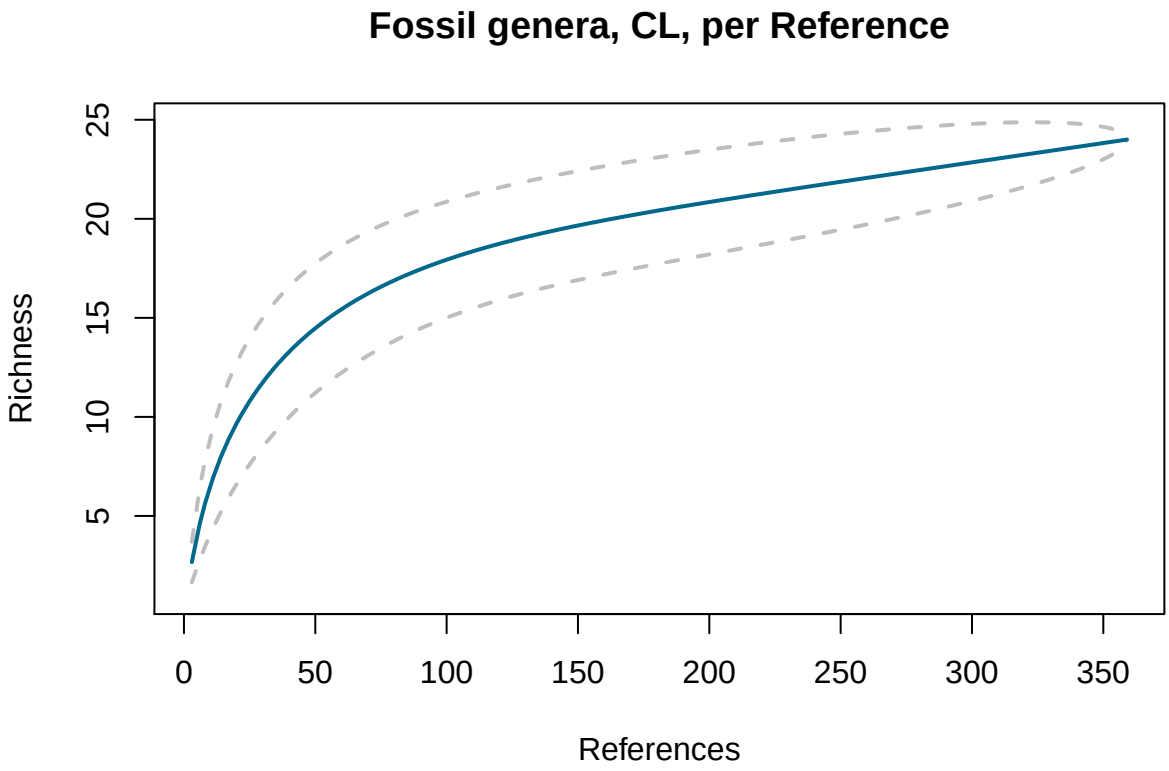


Figure 3: Map displaying all localities for which body size data for testudinids was available in the literature. Size of points denotes sample size, color denotes approximate age.

Sampling Accumulation Curve



Eurasia

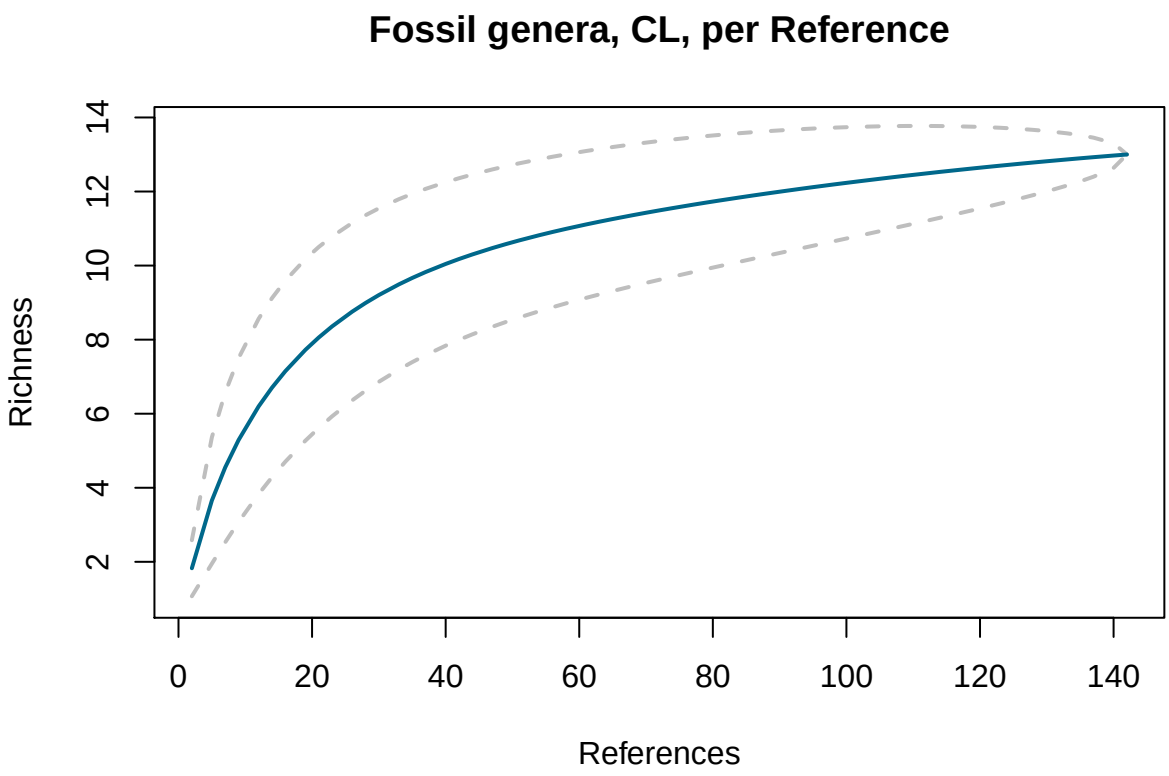


Figure 4: Sampling Accumulation Curve of fossil genera per reference, Eurasia

Histograms

all

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```

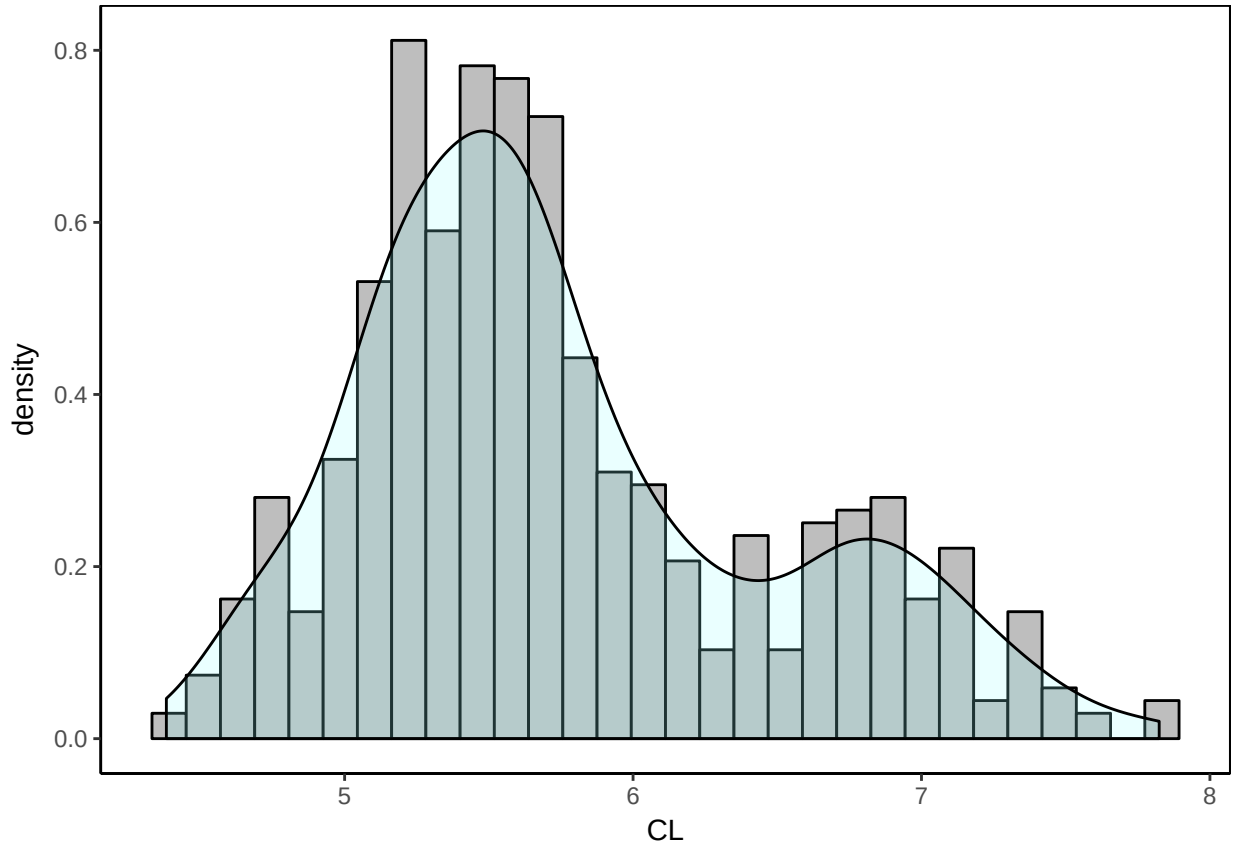
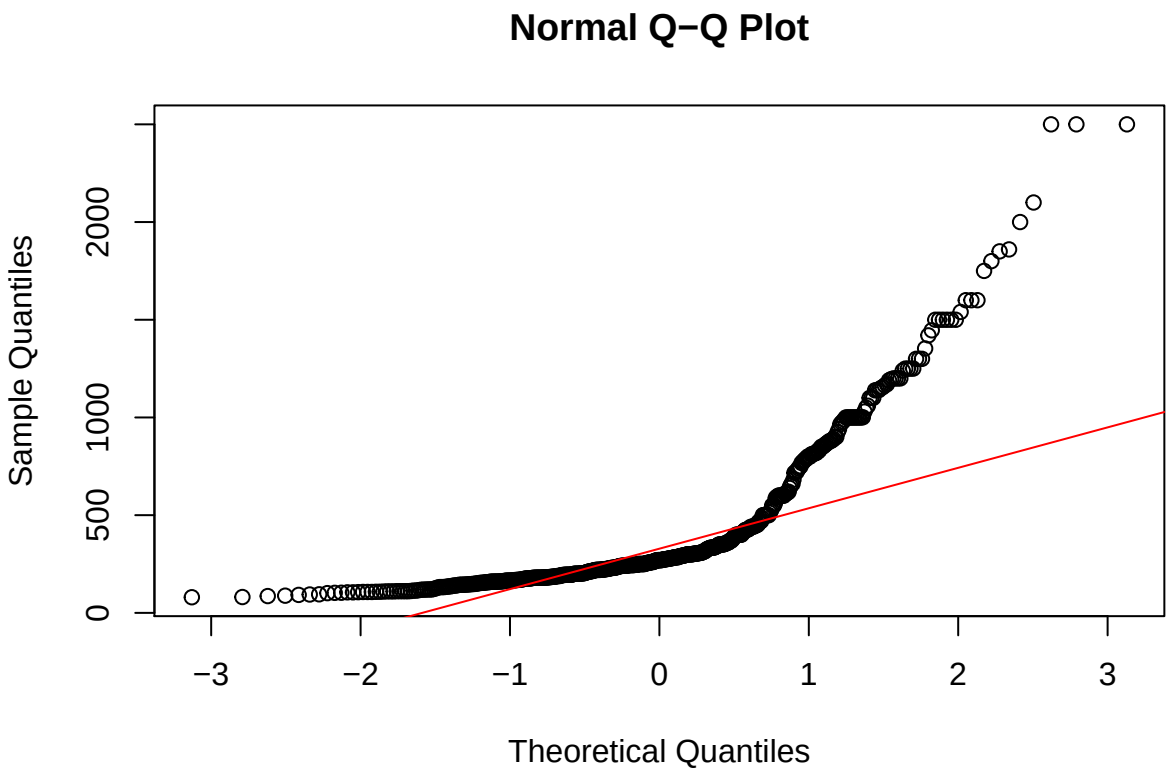
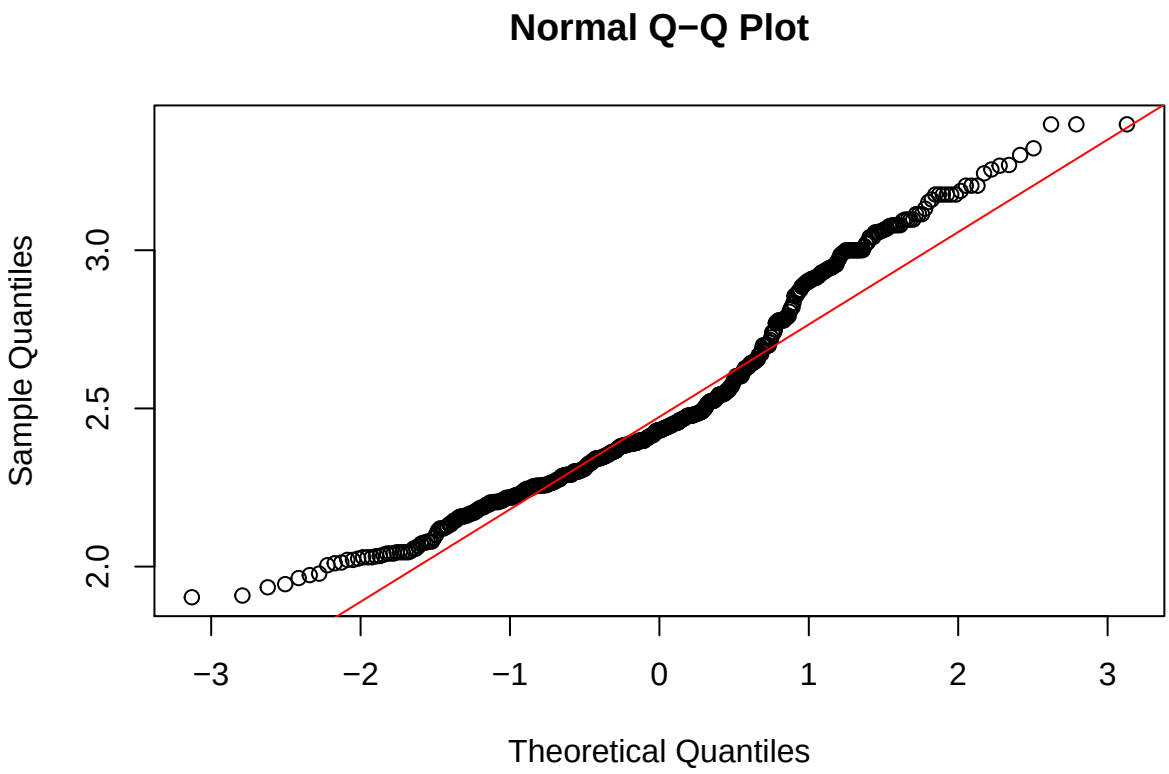


Figure 5: Distribution of body size data, logtransformed, all data.

```
qqnorm(PleiPlioCL$CL); qqline(PleiPlioCL$CL, col=2)
```




```
qqnorm(log10(PleiPlioCL$CL)); qqline(log10(PleiPlioCL$CL), col=2)
```


Normal Q−Q Plot
Sample Quantiles
2.0
2.5
3.0
−3
−2
−1
0
1
2
3
Theoretical Quantiles

per time bin

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```

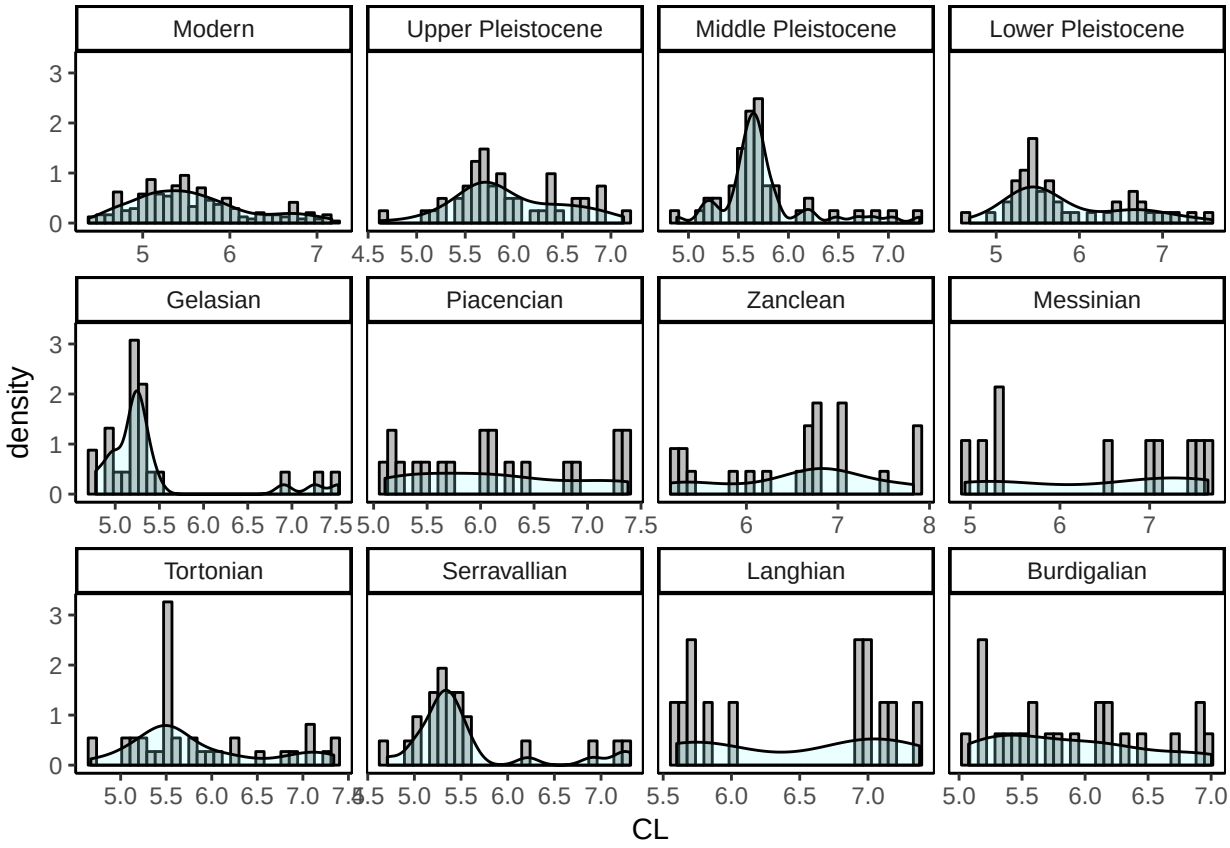


Figure 6: Distribution of body size data per time bin, logtransformed.

modern vs. fossil

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```

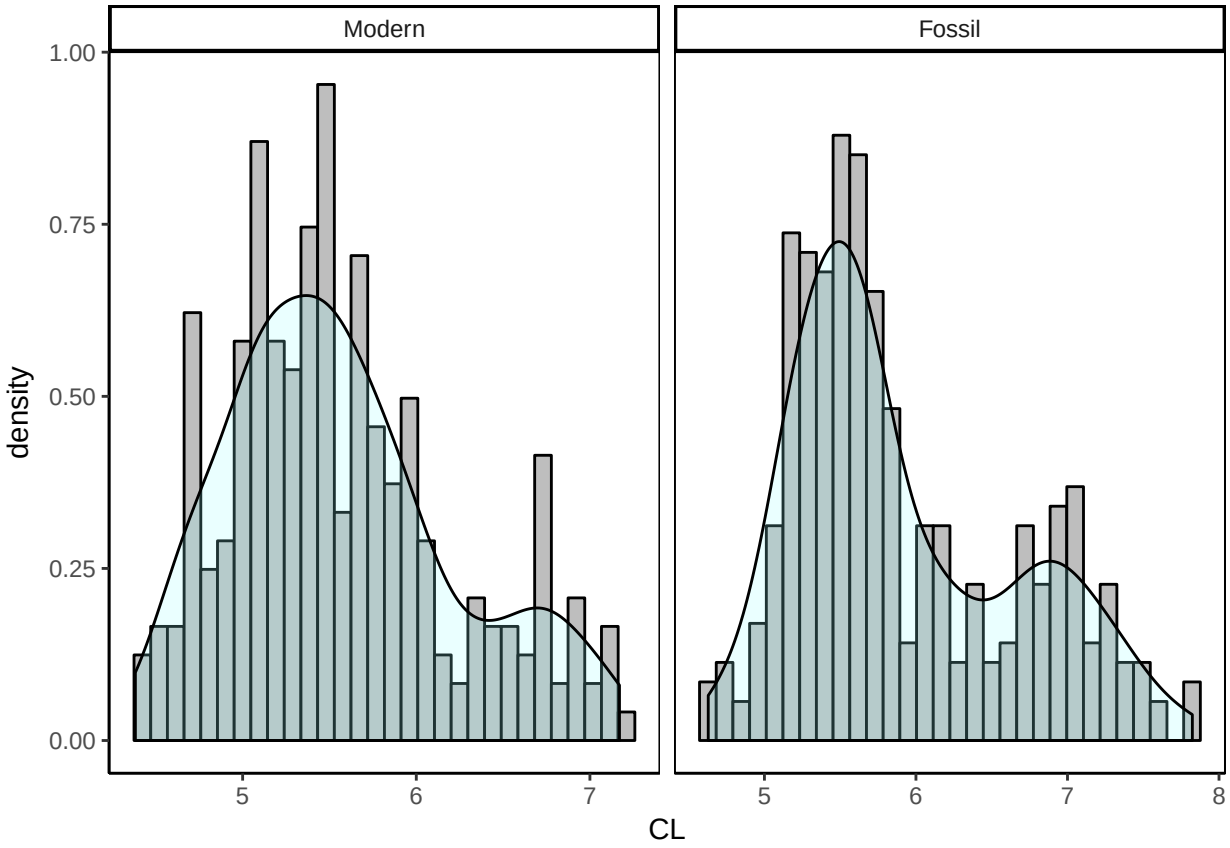


Figure 7: Distribution of body size data modern vs. fossil, logtransformed.

modern vs. fossil, continental vs. insular

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```

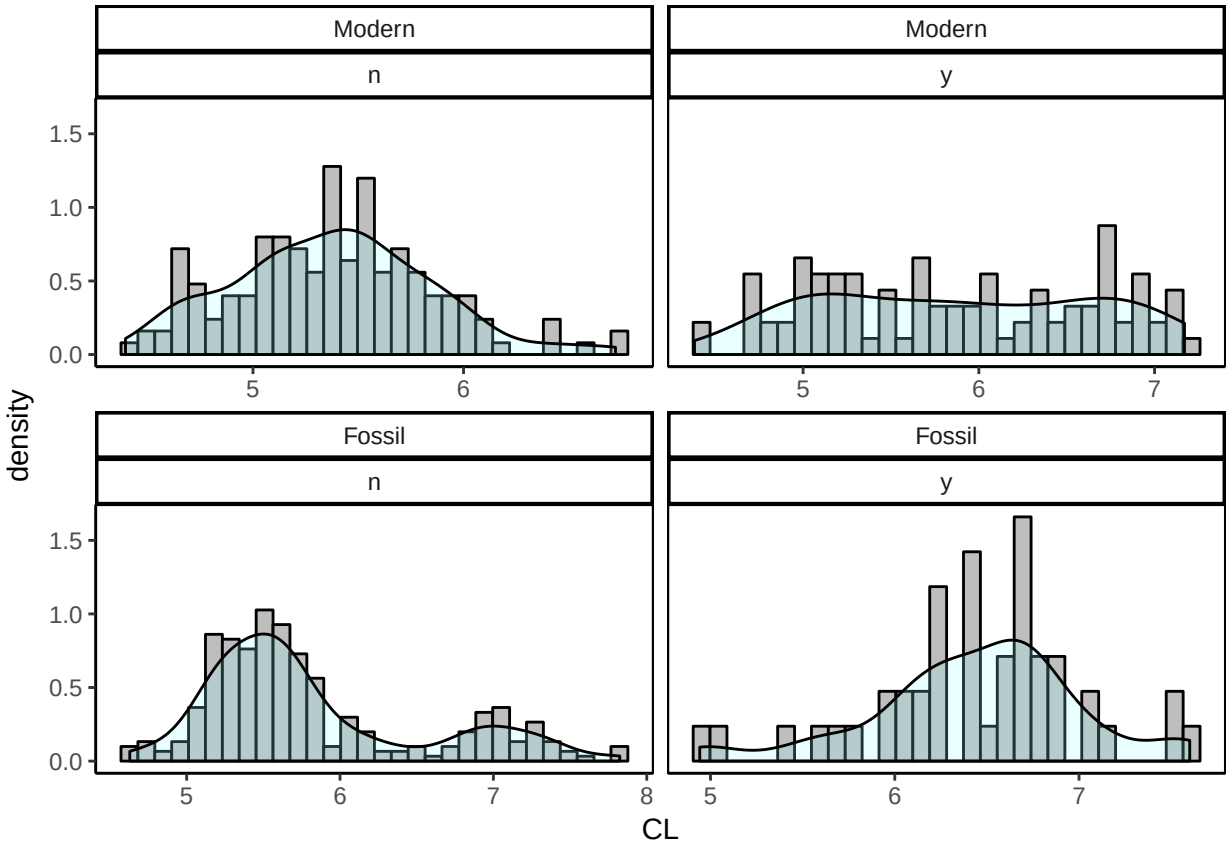


Figure 8: Distribution of body size data modern vs. fossil, continental vs. insular logtransformed.

continental vs. insular

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```

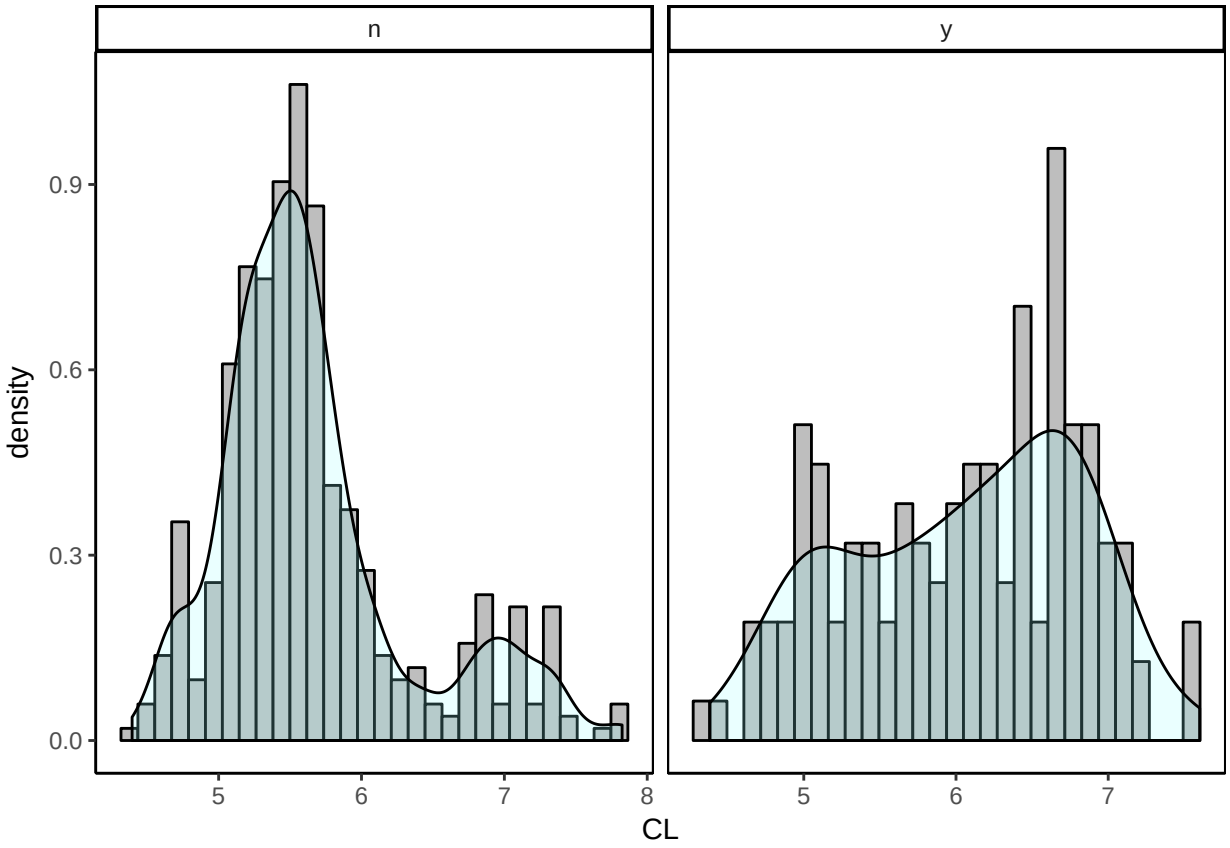


Figure 9: Distribution of body site data of continental (n) and insular(y) species, logtransformed.

continents

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```

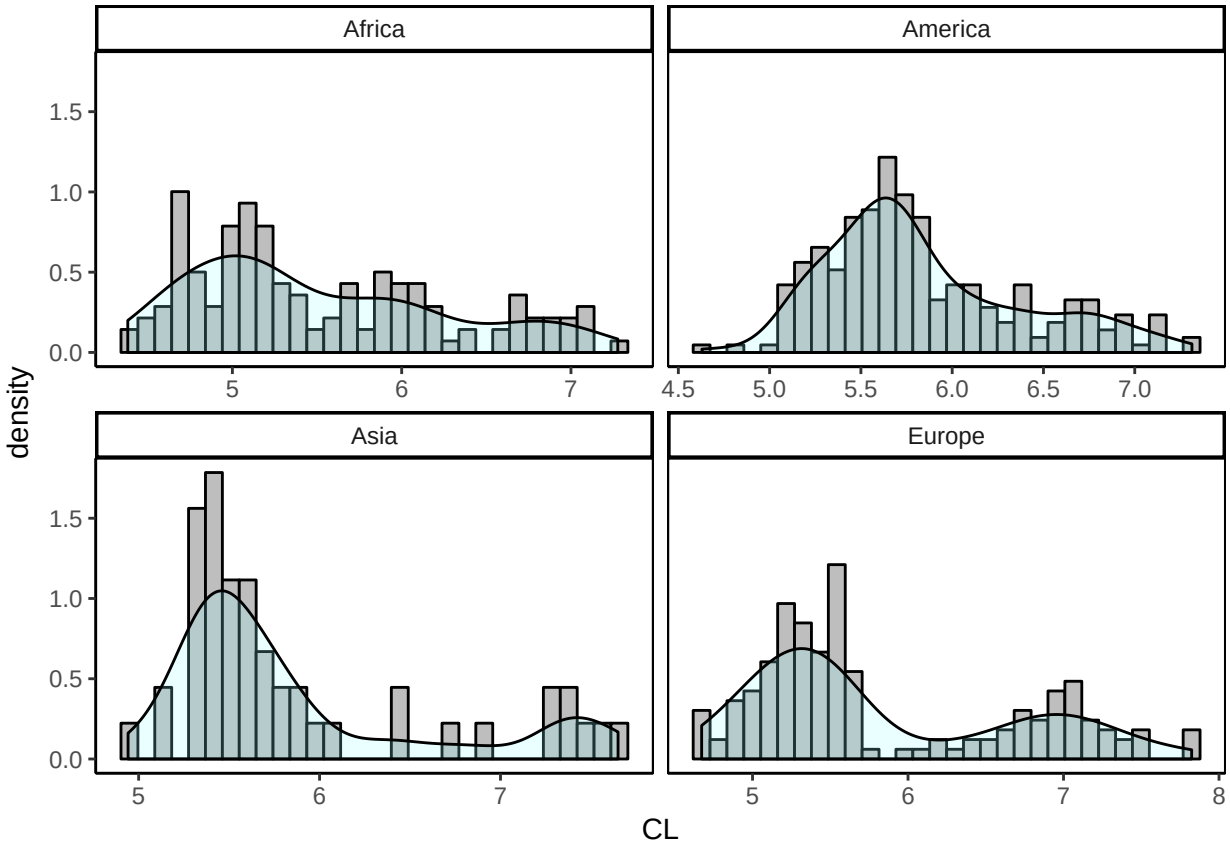


Figure 10: Distribution of body site data per continent, logtransformed.

General statistics

Table 2: General statistics of body size data: all, per time bin, insular and continental, per continent (all referring to CL: min, max, variance, mean, logmean, median, logmedian, skewness, logskewness, kurosis, logkurtosis

nCL	min	max	var	mean	logm	med	logmed	skew	logsk	kurt	logku	Variable
571	80.00	2500	153024.63	424.8	2.5	270.0	2.4	2.23	0.70	8.71	2.79	all
251	80.00	1300	67716.64	328.9	2.4	242.0	2.4	1.85	0.60	5.91	2.73	Modern
47	102.44	1250	68679.40	441.9	2.6	334.7	2.5	1.26	0.24	3.85	2.66	Upper Pleistocene
48	132.00	1500	63574.87	360.3	2.5	288.8	2.5	2.95	1.50	11.95	5.69	Middle Pleistocene
47	107.80	2000	165103.07	460.3	2.5	259.5	2.4	1.90	0.78	6.44	2.55	Lower Pleistocene
24	118.90	1860	195107.42	333.4	2.4	186.2	2.3	2.60	2.07	8.39	5.95	Gelasian
20	165.00	1600	269797.71	636.6	2.7	440.5	2.6	0.96	0.29	2.38	1.78	Piacencian
24	176.00	2500	516172.48	953.5	2.8	847.5	2.9	1.08	-0.31	3.32	2.13	Zanclean
10	140.00	2100	602611.21	948.9	2.8	916.0	2.9	0.26	-0.22	1.49	1.29	Messinian
40	107.00	1540	174154.16	465.2	2.5	250.0	2.4	1.49	0.76	3.81	2.50	Tortonian
23	111.00	1500	146626.87	355.2	2.4	213.0	2.3	2.22	1.60	6.40	4.46	Serravallian
13	270.00	1600	229590.10	784.2	2.8	1000.0	3.0	0.17	-0.11	1.52	1.21	Langhian
24	160.00	1100	81679.97	425.8	2.5	317.0	2.5	1.20	0.48	3.25	2.06	Burdigalian
251	80.00	1300	67716.64	328.9	2.4	242.0	2.4	1.85	0.60	5.91	2.73	Modern
320	102.44	2500	207448.16	500.0	2.6	287.8	2.5	1.92	0.72	6.70	2.50	Fossil
430	81.00	2500	147179.14	381.9	2.5	249.8	2.4	2.76	1.10	11.48	3.89	continental
141	80.00	2000	149135.58	555.6	2.6	486.0	2.7	1.09	-0.25	4.39	2.03	insular
156	81.00	830	16385.92	241.9	2.3	220.5	2.3	1.97	0.29	8.59	3.02	modern-con
95	80.00	1300	119898.26	471.7	2.6	351.0	2.5	0.82	0.02	2.44	1.75	modern-ins
274	102.44	2500	204405.38	461.6	2.5	270.0	2.4	2.15	1.00	7.62	3.02	fossil-con
46	140.00	2000	167981.36	728.9	2.8	632.0	2.8	1.41	-0.45	5.23	3.61	fossil-ins
140	80.00	1446	92601.87	337.4	2.4	193.5	2.3	1.69	0.64	5.04	2.35	Africa
231	102.44	1500	72942.55	403.8	2.5	300.0	2.5	1.83	0.75	6.06	2.94	America
48	140.00	2100	290958.22	510.7	2.6	272.5	2.4	1.84	1.25	4.90	3.21	Asia
152	107.00	2500	273298.31	510.1	2.5	245.0	2.4	1.77	0.74	5.88	2.18	Europe

nCL	min	max	var	mean	logm	med	logmed	skew	logsk	kurt	logku	Variable

Boxplots

genera per time bins

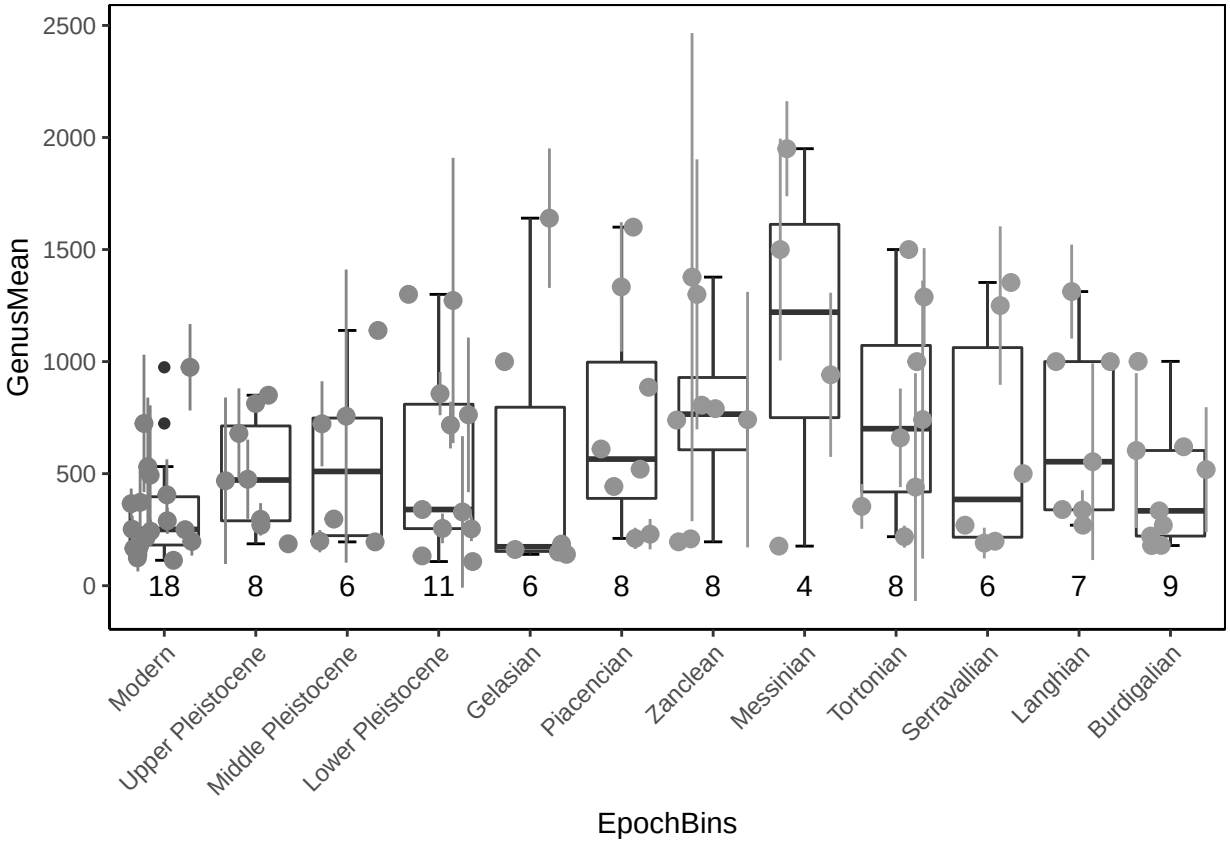


Figure 11: Boxplots of mean CL per time bin, including mean and sd CL for each genus (as pointrange).

continental vs. insular per time bin

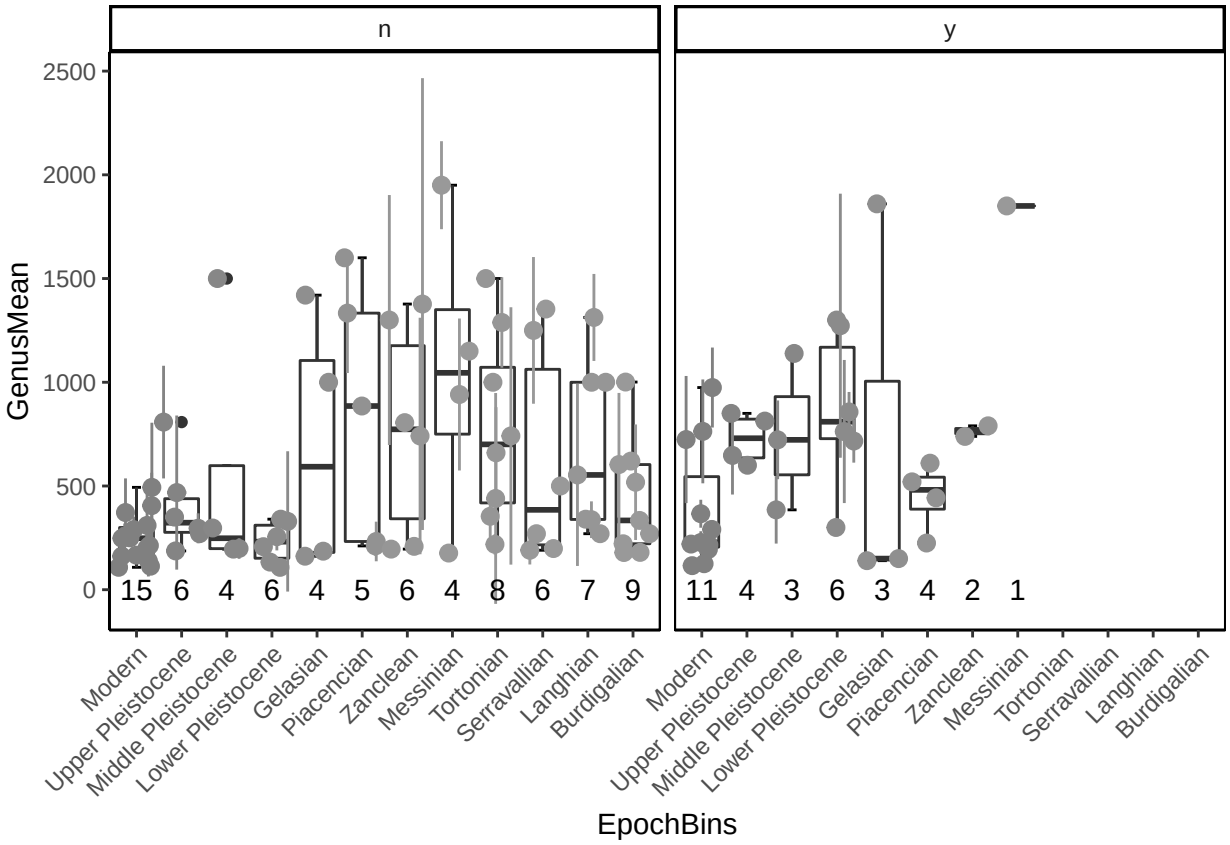


Figure 12: Boxplots of each genus per time bin, continental vs. insular species.

fossil vs. modern

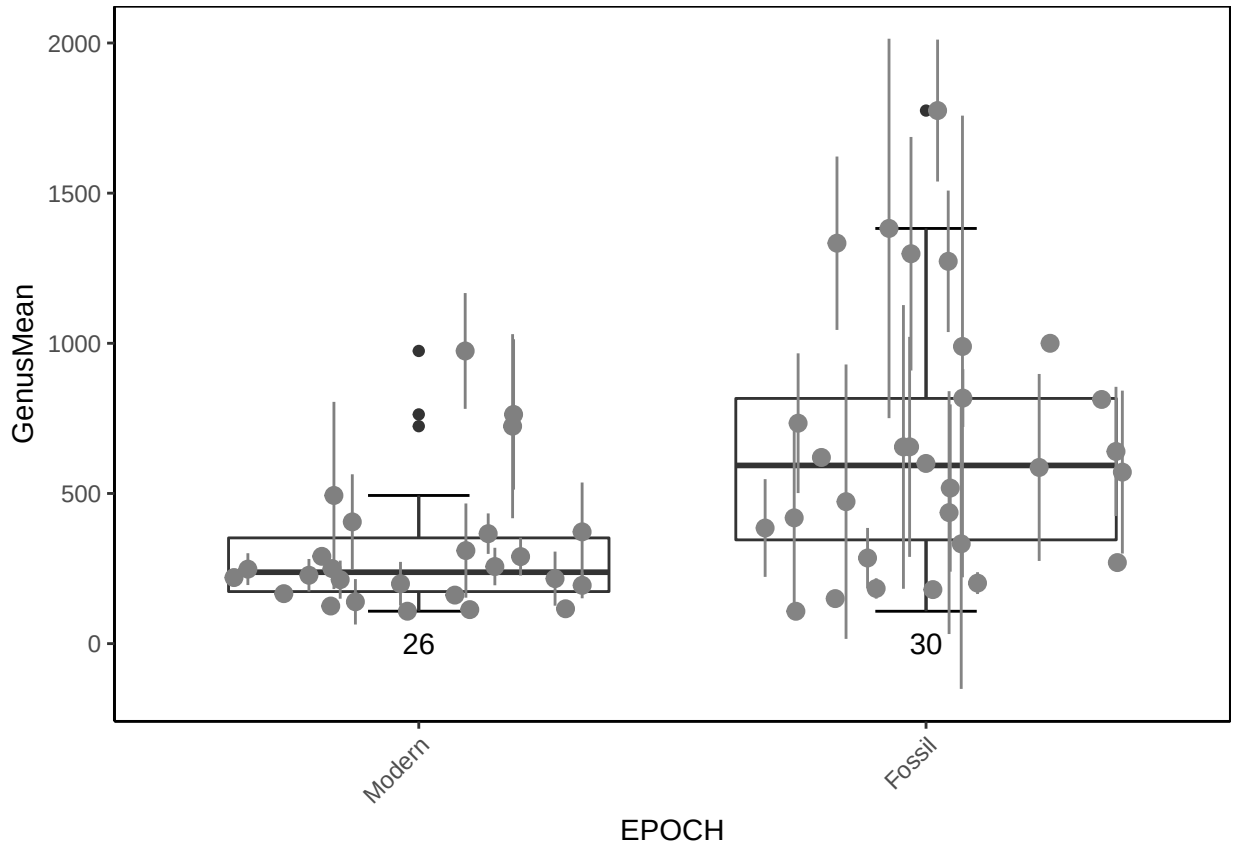


Figure 13: Boxplots fossil vs. modern.

```
## [1] 328.8782
```

```
## [1] 509.0886
```

```
##
```

```
##  Wilcoxon rank sum test with continuity correction
```

```
##
```

```
## data:  Modern and Fossil
```

```
## W = 22778, p-value = 3.996e-08
```

```
## alternative hypothesis: true location shift is less than 0
```

Wilcoxon Rank Sum Test (unpaired data):

modern $<$ fossil ($\mathrm{P} = 3.9958136 \times 10^{-8}$)

fossil vs. modern, continental vs. insular

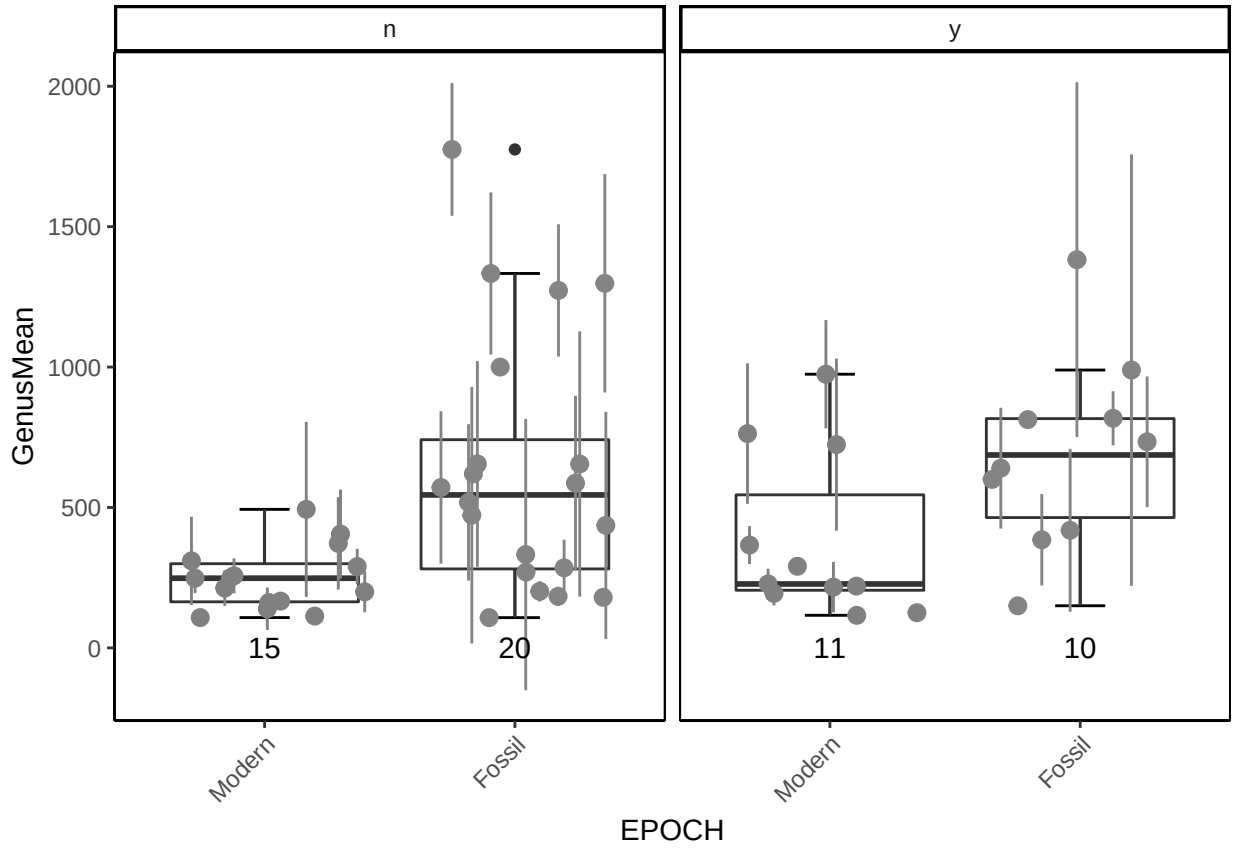


Figure 14: Boxplots fossil vs. modern, continental vs. insular species.

```
## [1] 46

## [1] 46

## [1] 728.8696

## [1] 461.4283

##
##  Wilcoxon rank sum test with continuity correction
##
## data:  ModernIsland and FossilIsland
## W = 632.5, p-value = 0.0004512
## alternative hypothesis: true location shift is less than 0

## [1] 156
```

```
## [1] 156
```

```
## [1] 241.8893
```

```
## [1] 464.5914
```

```
##
```

```
##  Wilcoxon rank sum test with continuity correction
```

```
##
```

```
## data:  ModernCon and FossilCon
```

```
## W = 7939.5, p-value = 5.577e-08
```

```
## alternative hypothesis: true location shift is less than 0
```

Wilcoxon Rank Sum Test (unpaired data):

modern continental $<$ fossil continental ($\mathrm{P} = 5.5765854 \times 10^{-8}$)

modern insular $<$ fossil insular ($\mathrm{P} = 4.5116729 \times 10^{-4}$)

continental vs. insular

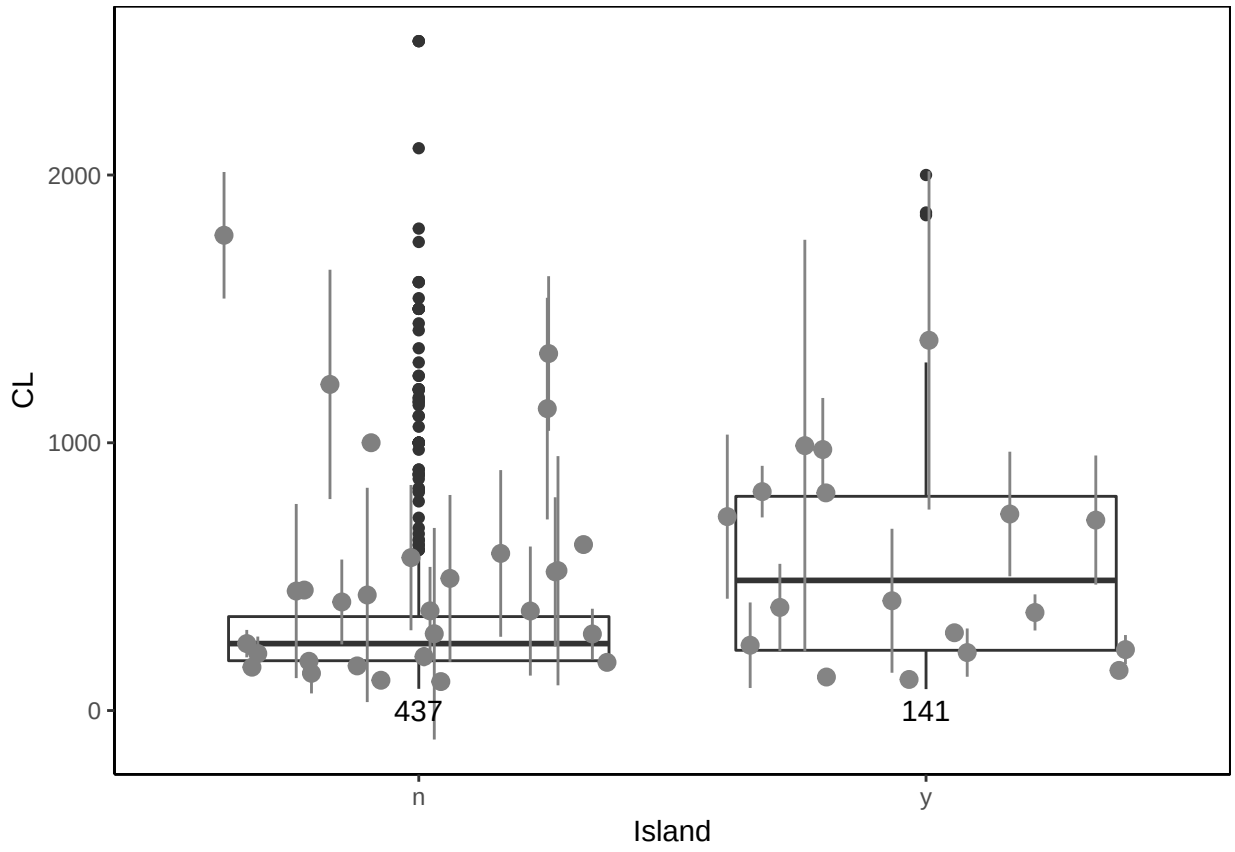


Figure 15: Boxplot continental vs. insular, genera summarised

```
## [1] 141
```

```
## [1] 141
```

```
## [1] 555.6149
```

```
## [1] 351.7519
```

```
##
```

```
##  Wilcoxon rank sum test with continuity correction
```

```
##
```

```
## data:  Insular and Continental
```

```
## W = 13183, p-value = 1.096e-06
```

```
## alternative hypothesis: true location shift is greater than 0
```

Wilcoxon Rank Sum Test (unpaired data):

continental $<$ insular ($P = 1.0964413 \times 10^{-6}$)

continental vs. insular per time bin

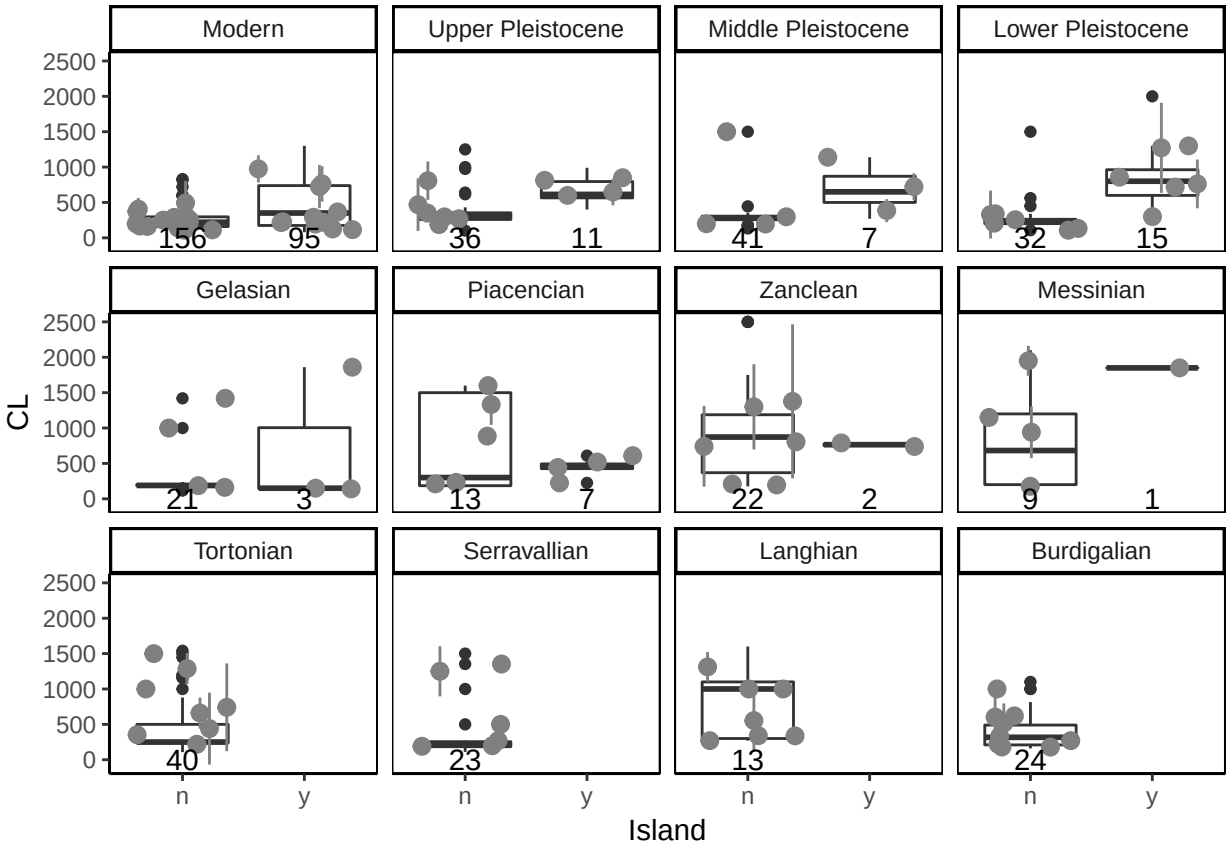


Figure 16: Boxplot continental vs. insular, genera summarised

continents

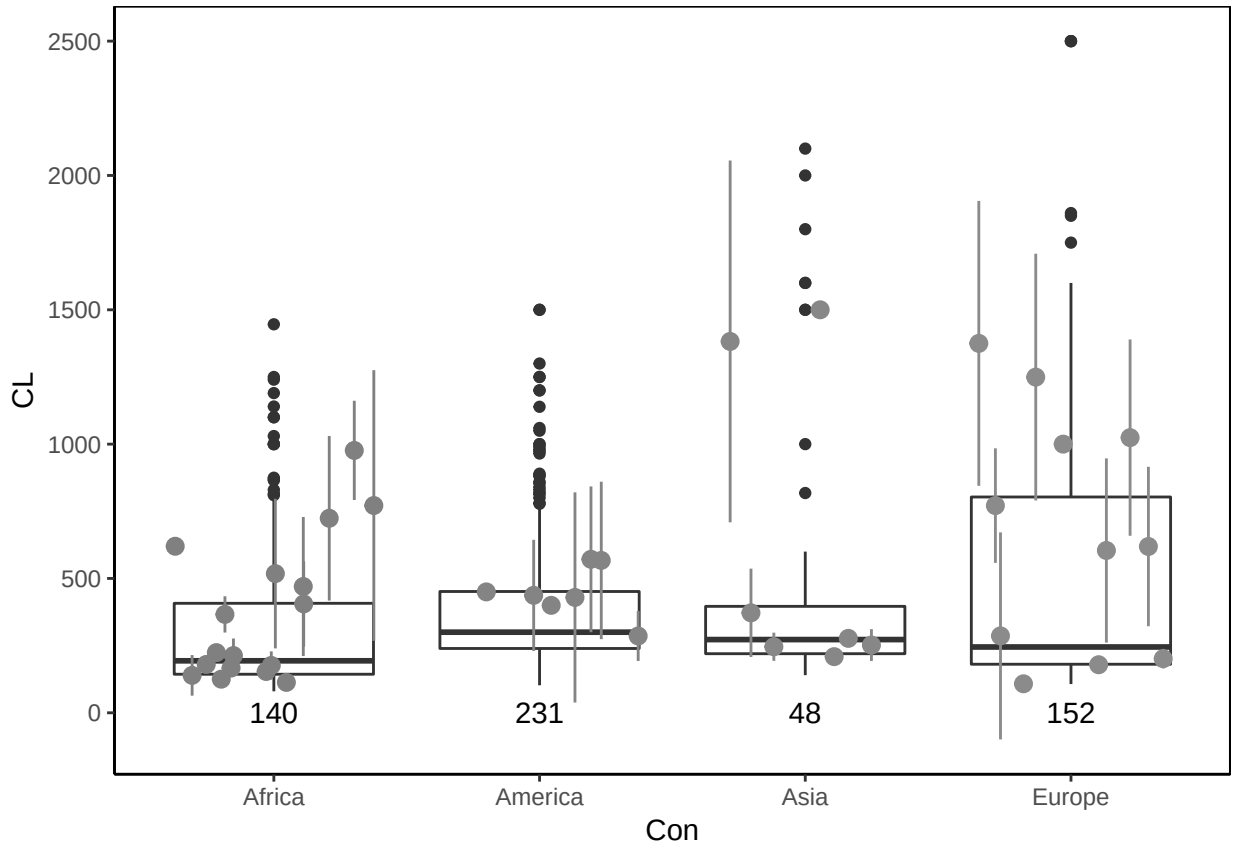


Figure 17: Boxplot: body size on different continents, genera summarised

```
## [1] 140

## [1] 337.37

## [1] 140

## [1] 410.1668

## [1] 140

## [1] 530.1764

##
##  Kruskal-Wallis rank sum test
##
## data:  list(Africa, America, Eurasia)
## Kruskal-Wallis chi-squared = 25.858, df = 2, p-value = 2.426e-06
```

Wilcoxon Rank Sum Test (unpaired data):

Continent means differ ($P = 2.4262449 \times 10^{-6}$) (still have to look into the details...)

continents, continental vs. insular

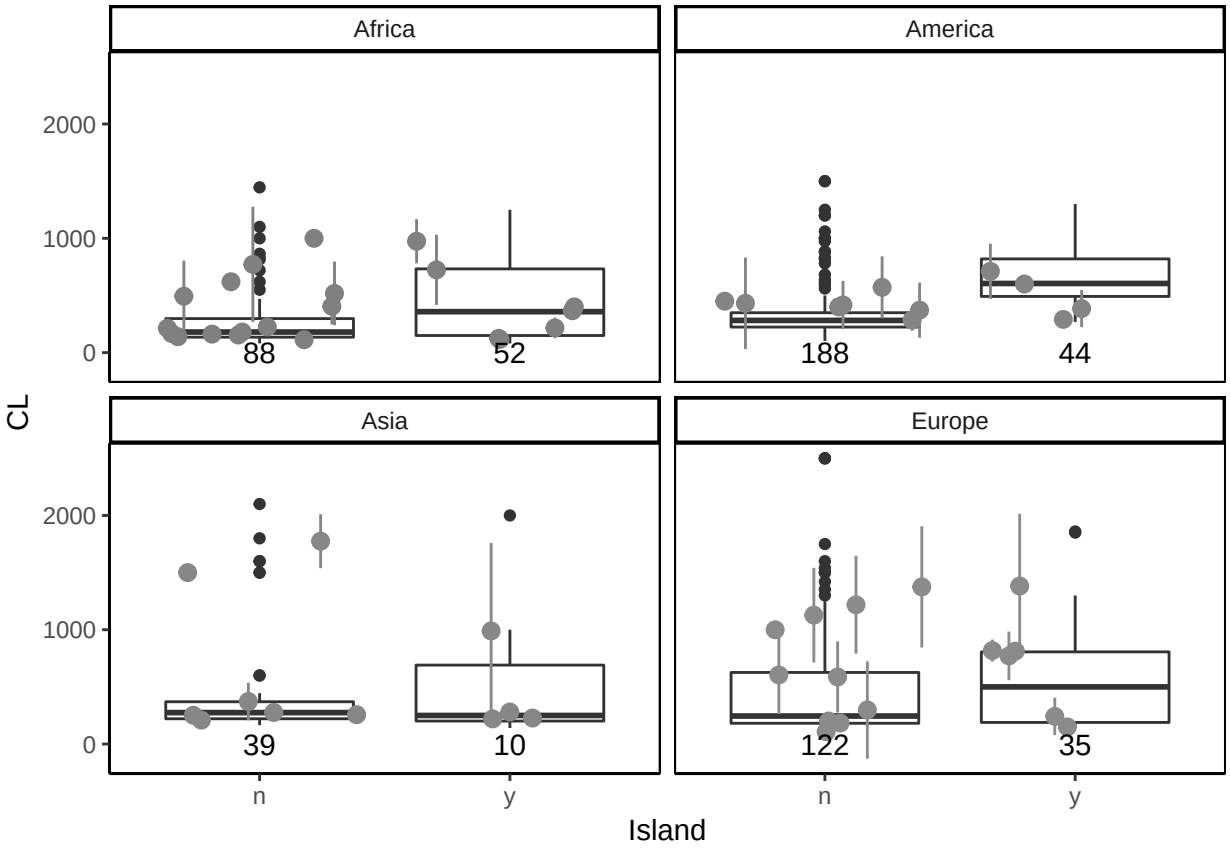


Figure 18: Boxplot: body size on different continents, genera summarised

paleoTS analysis

all (continental and insular)

genera (all)

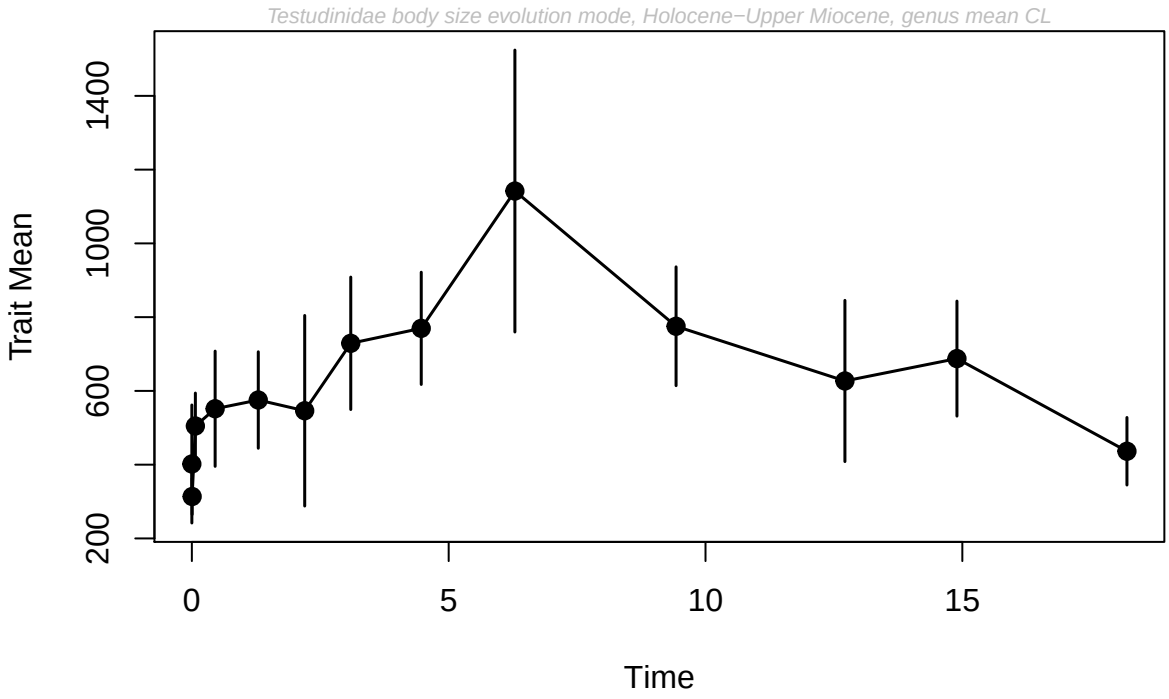


Figure 19: paleoTS plot with genus mean, including island species

Table 3: Model-fitting results for testudinidae, genera, including island species

	logL	K	AICc	Akaike.wt
GRW	-80.10095	2	165.5352	0.206
URW	-80.67684	1	163.7537	0.502
Stasis	-79.75270	2	164.8387	0.292

Table 4: Model-fitting results for testudinidae (4 models), genera, including island species

	logL	K	AICc	Akaike.wt
GRW	-80.10095	2	165.5352	0.204
URW	-80.67684	1	163.7537	0.496
Stasis	-79.75270	2	164.8387	0.288
StrictStasis	-84.43223	1	171.2645	0.012

continental (excluding insular species)

genera (continental)

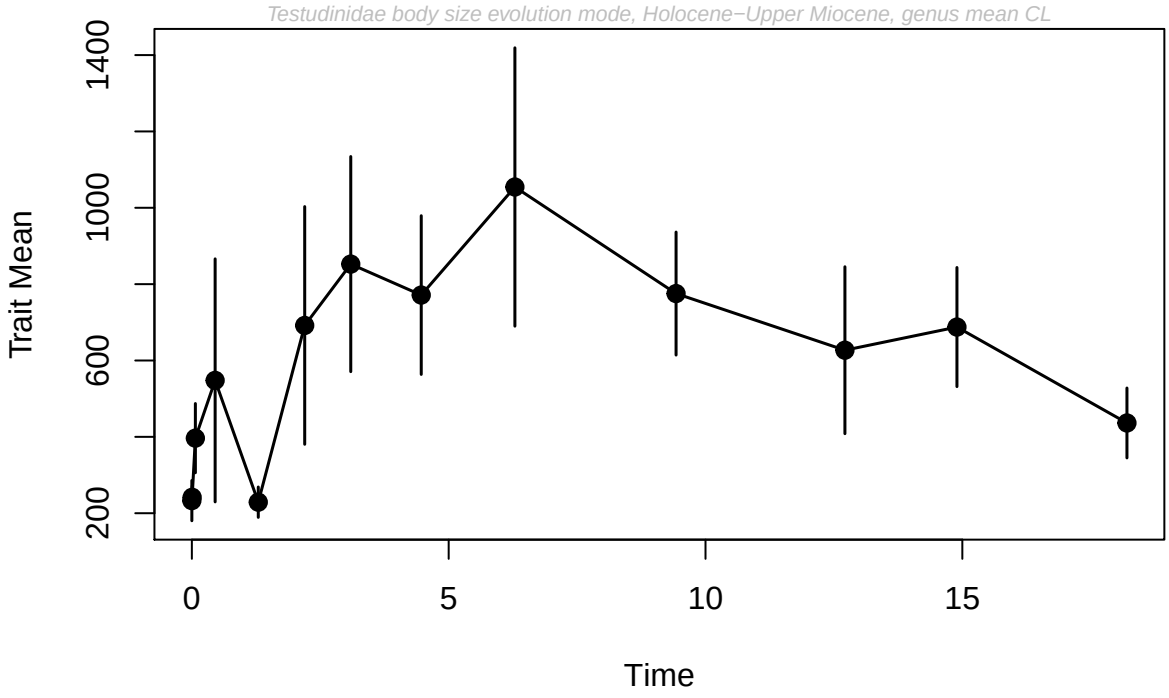


Figure 20: paleoTS plot with genus mean, excluding island species

Table 5: Model-fitting results for testudinidae, genera, excluding insular species

	logL	K	AICc	Akaike.wt
GRW	-81.39555	2	168.1244	0.295
URW	-82.05507	1	166.5101	0.662
Stasis	-83.32821	2	171.9897	0.043

Table 6: Model-fitting results for testudinidae, genera, excluding insular species

	logL	K	AICc	Akaike.wt
GRW	-81.39555	2	168.1244	0.295
URW	-82.05507	1	166.5101	0.662
Stasis	-83.32821	2	171.9897	0.043
StrictStasis	-92.50213	1	187.4043	0.000

insular (excluding continental)

genera (insular)

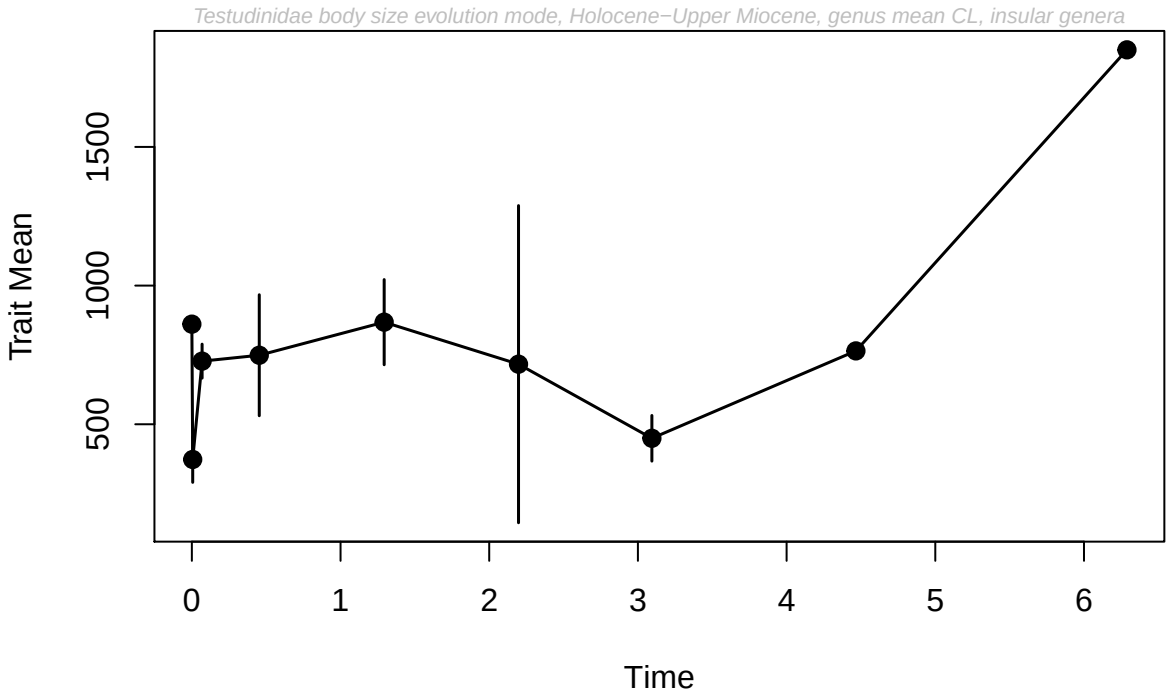


Figure 21: paleoTS plot with genus mean, only insular species

Table 7: Model-fitting results for testudinidae, genera, only insular species

	logL	K	AICc	Akaike.wt
GRW	-68.48011	2	143.3602	0
URW	-75.20567	1	153.0780	0
Stasis	-60.38739	2	127.1748	1

Equal time bins

genera (equal bins)

Table 8: paleoTS object, equal time bins, genera)

tt	mm	vv	nn
0.00025	335.6380	49292.698	17
0.50025	557.6242	95029.158	12
1.50000	558.2001	194613.806	11
2.50000	627.7867	235547.641	5
3.50000	758.8929	285072.539	7
4.50000	961.8833	621030.522	6
5.50000	1020.0000	797671.000	3
6.50000	850.0000	845000.000	2
7.50000	174.2500	435.125	2
8.50000	770.9667	229304.487	6
9.50000	1350.0000	45000.000	2
10.50000	527.1000	143534.355	5
11.50000	328.5000	58824.500	2
12.50000	602.1210	291476.249	5
13.50000	904.3333	420956.333	3
14.50000	651.9800	224901.227	5
15.50000	553.3333	0.000	1
16.50000	532.6600	183446.278	5
17.50000	366.5238	41915.395	3
18.50000	405.0000	0.000	1
19.50000	377.3333	44841.333	3
23.50000	406.2500	0.000	1
25.50000	450.0000	0.000	1
32.50000	275.0000	0.000	1
33.50000	400.0000	0.000	1
49.50000	617.5000	0.000	1

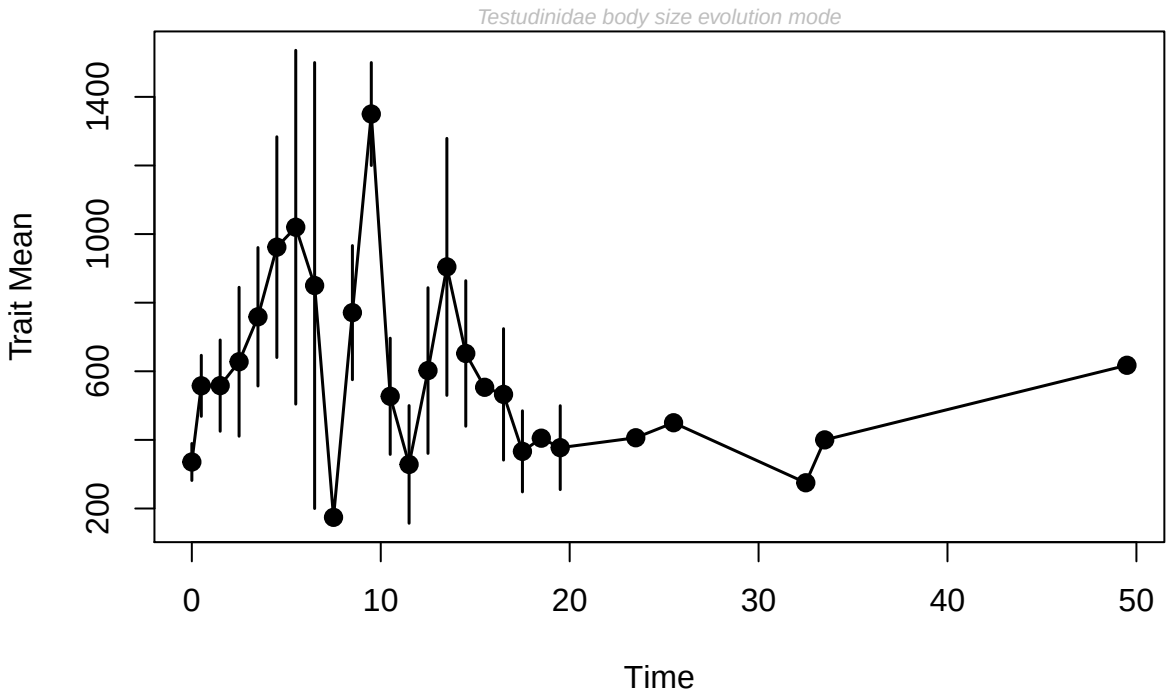


Figure 22: Equal bins, genera

Table 9: Model-fitting results for testudinidae, equal time bins, genera

	logL	K	AICc	Akaike.wt
GRW	-179.4657	2	363.4769	0.006
URW	-180.1926	1	362.5590	0.009
Stasis	-174.3472	2	353.2398	0.985

larger equal bins

genera (larger equal bins)

Table 10: PaleoTS object, larger equal bins, genera

tt	mm	vv	nn
0.5	406.1103	74156.024	21
1.5	558.2001	194613.806	11
2.5	627.7867	235547.641	5
3.5	758.8929	285072.539	7
4.5	961.8833	621030.522	6
5.5	1020.0000	797671.000	3
6.5	850.0000	845000.000	2
7.5	174.2500	435.125	2
8.5	770.9667	229304.487	6
9.5	1350.0000	45000.000	2
10.5	527.1000	143534.355	5
11.5	328.5000	58824.500	2
12.5	602.1210	291476.249	5
13.5	904.3333	420956.333	3
14.5	651.9800	224901.227	5
15.5	553.3333	0.000	1
16.5	532.6600	183446.278	5
17.5	366.5238	41915.395	3
18.5	405.0000	0.000	1
19.5	377.3333	44841.333	3
23.5	406.2500	0.000	1
25.5	450.0000	0.000	1
32.5	275.0000	0.000	1
33.5	400.0000	0.000	1
49.5	617.5000	0.000	1

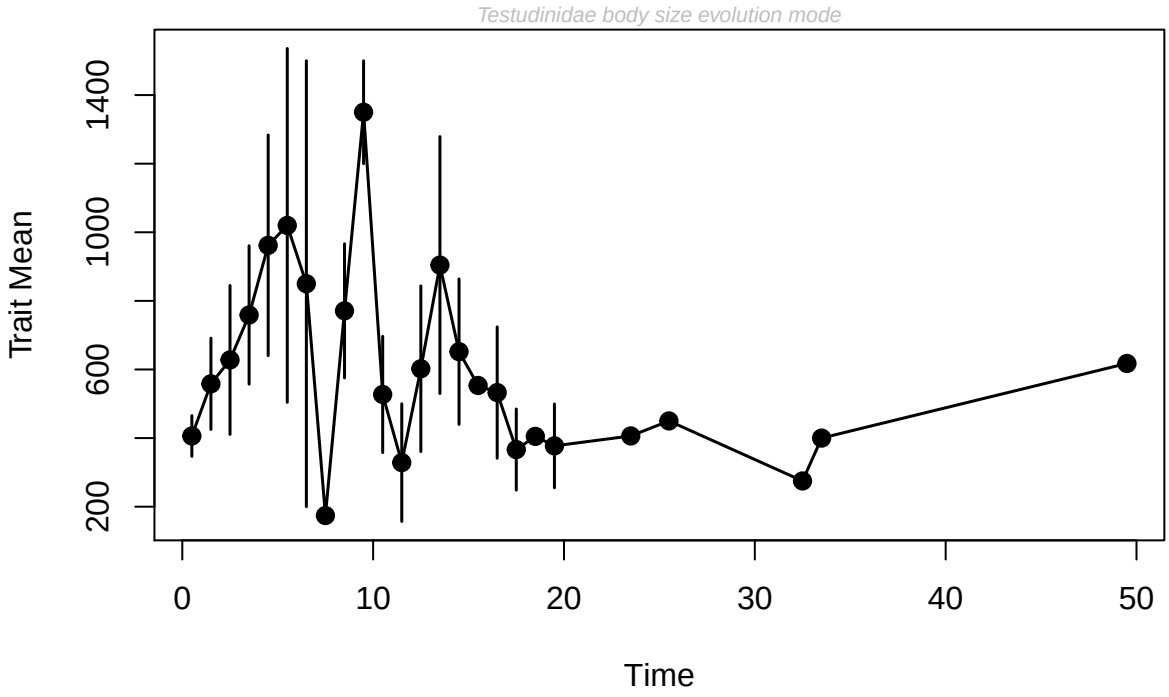


Figure 23: Larger equal bins, genera

Table 11: Model-fitting results for testudinidae, larger equal time bins, genera

	logL	K	AICc	Akaike.wt
GRW	-172.4164	2	349.4042	0.012
URW	-172.9589	1	348.0997	0.023
Stasis	-168.0413	2	340.6540	0.965

per continent

Europe, smaller original bins (see Table 2), genera

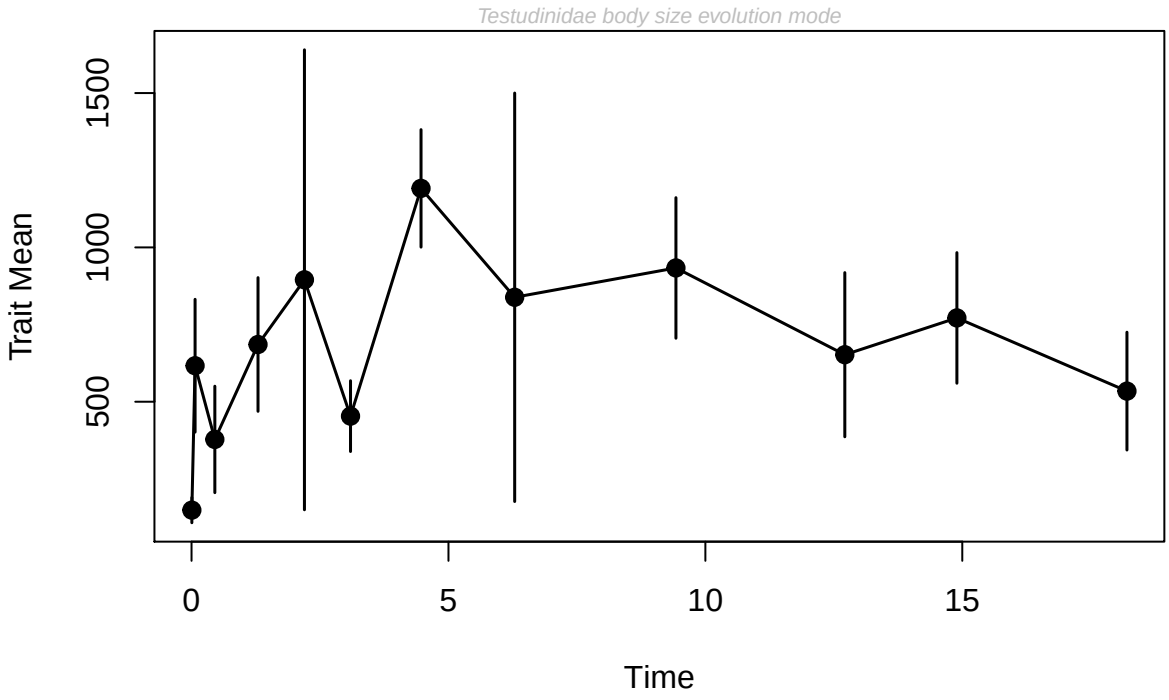


Figure 24: Smaller original bins, genera, Europe

Table 12: Model-fitting results for testudinidae, no bins, genera

	logL	K	AICc	Akaike.wt
GRW	-85.36329	2	176.2266	0.001
URW	-85.37027	1	173.1850	0.006
Stasis	-78.70862	2	162.9172	0.993

Eurasia, smaller original bins (See Table 2), genera

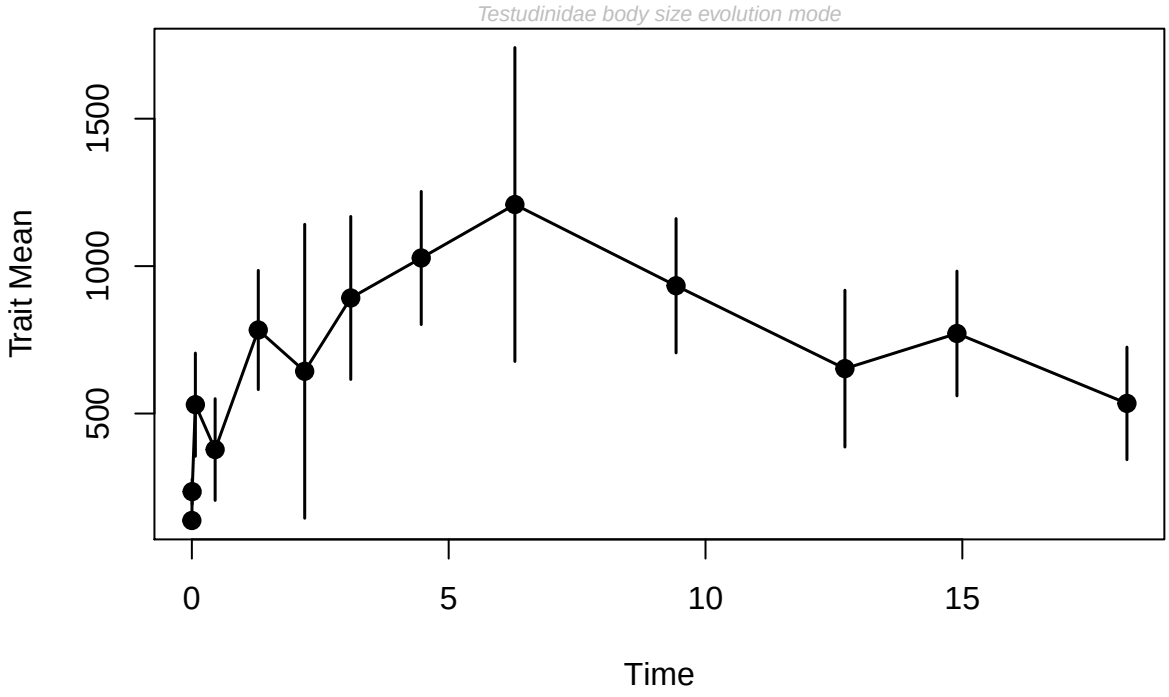


Figure 25: Smaller original bins, genera, Eurasia

Table 13: Model-fitting results for testudinidae, no bins, genera

	logL	K	AICc	Akaike.wt
GRW	-85.88537	2	177.1041	0.141
URW	-86.03691	1	174.4738	0.526
Stasis	-85.02733	2	175.3880	0.333