

# MAthesis

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## 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	254	66	18
(0.0117,0.126]	Upper Pleistocene	Upper Pleistocene	0.06885	50	18	8
(0.126,0.781]	Middle Pleistocene	Middle Pleistocene	0.45350	52	12	7
(0.781,1.81]	Lower Pleistocene	Lower Pleistocene	1.29350	53	23	11
(1.81,2.59]	Gelasian	Lower Pleistocene	2.19700	29	11	8
(2.59,3.6]	Piacencian	Upper Pliocene	3.09400	23	14	9
(3.6,5.33]	Zanclean	Lower Pliocene	4.46600	31	17	8
(5.33,7.25]	Messinian	Upper Miocene	6.28900	12	9	6
(7.25,11.6]	Tortonian	Upper Miocene	9.42700	46	20	9
(11.6,13.8]	Serravallian	Middle Miocene	12.71400	27	8	6
(13.8,16]	Langhian	Middle Miocene	14.89500	18	14	9
(16,20.4]	Burdigalian	Lower Miocene	18.20500	29	15	9
(20.4,23]	Aquitanian	Lower Miocene	21.73500	2	1	1

## [1] 0

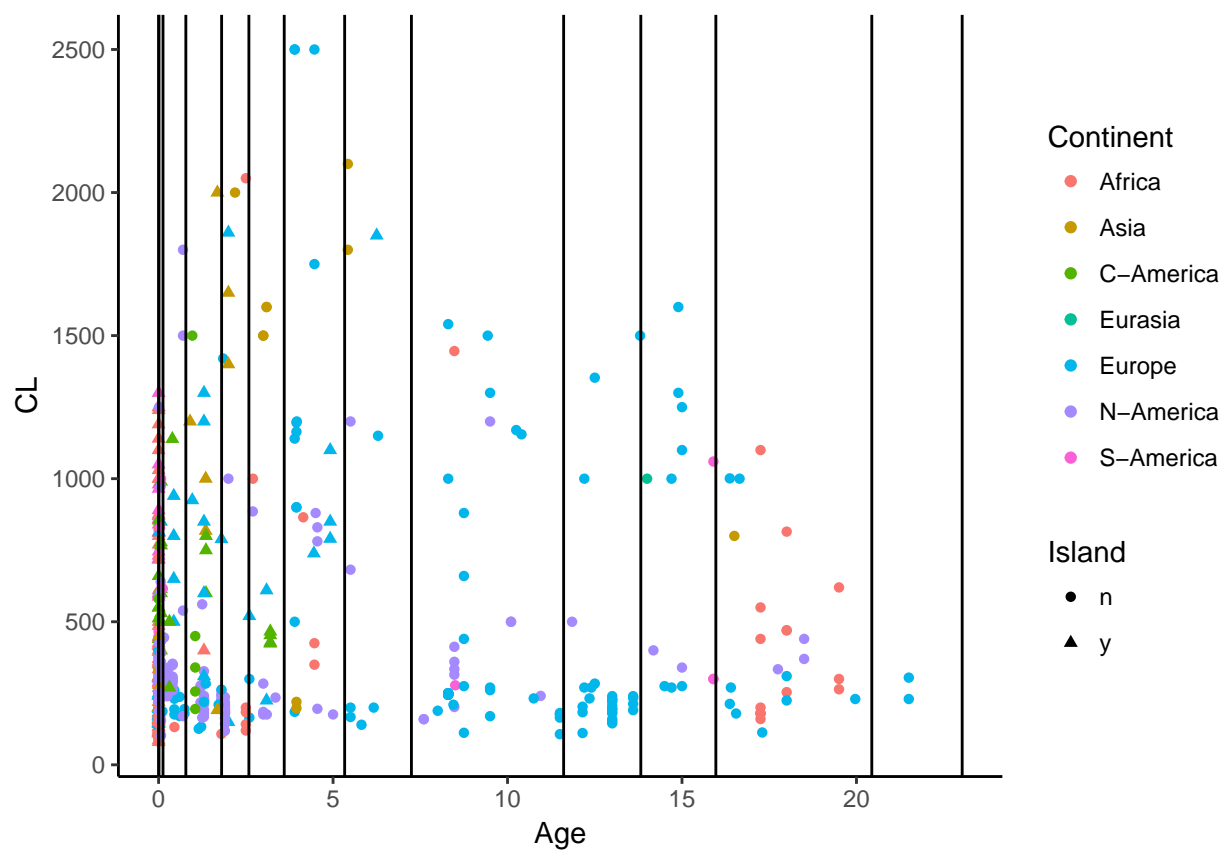


Figure 1: Scatterplot of CL over time, indicating insular (triangle) and continental (circles) and colour indicating continents. Lines indicate bins, dashed line = new bins.

## Maps

### fossil occurrences of testudinidae

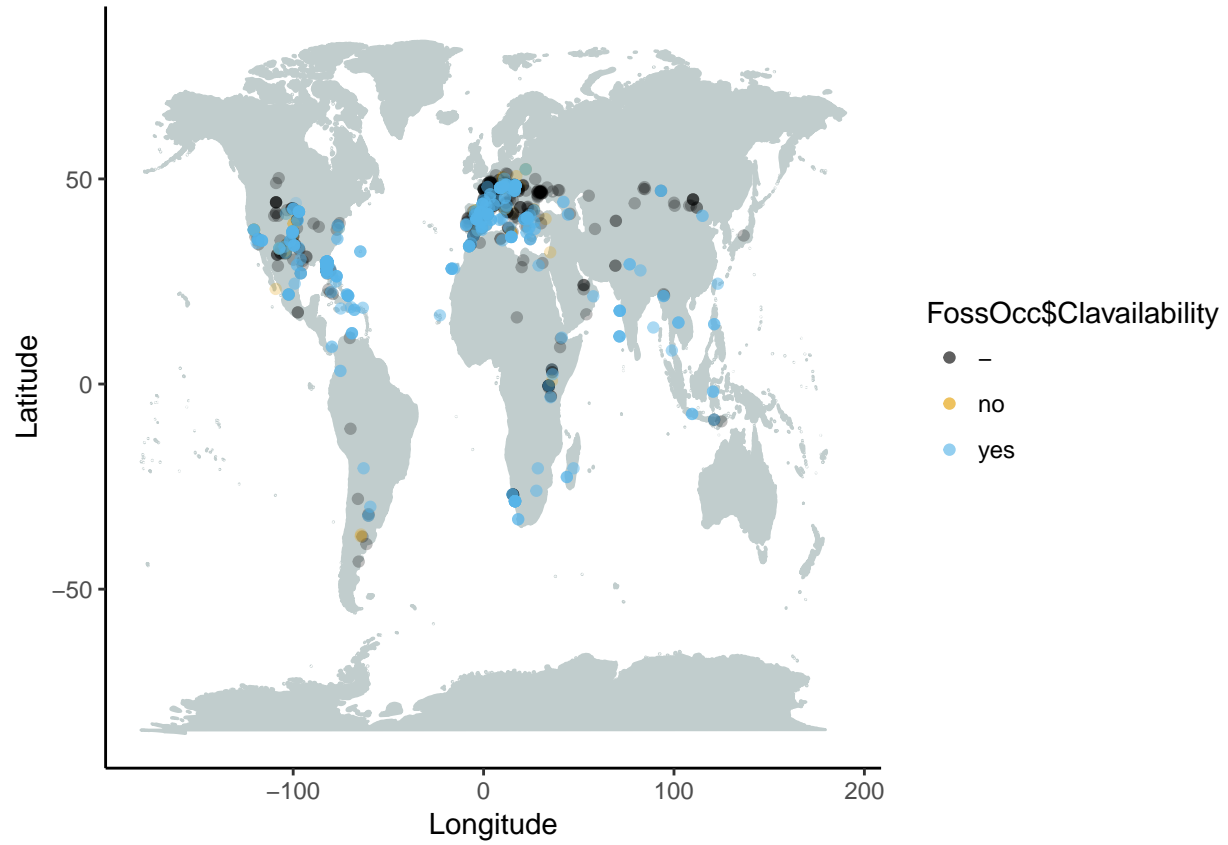


Figure 2: Map displaying all fossil occurrences of testudinids, with color indicating whether relevant literature was available (black if not) and if it was, whether body size data was available or not (yes and no, respectively).

## body size of testudinidae

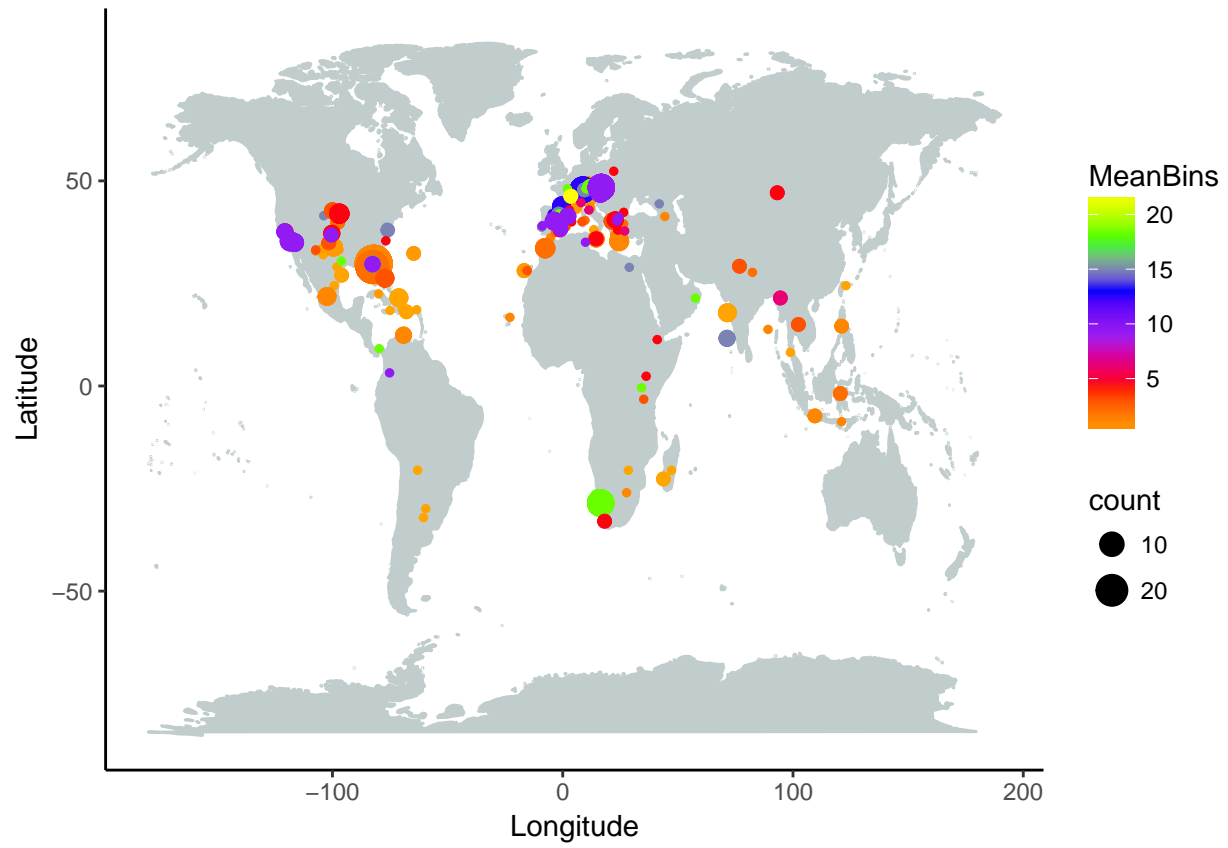
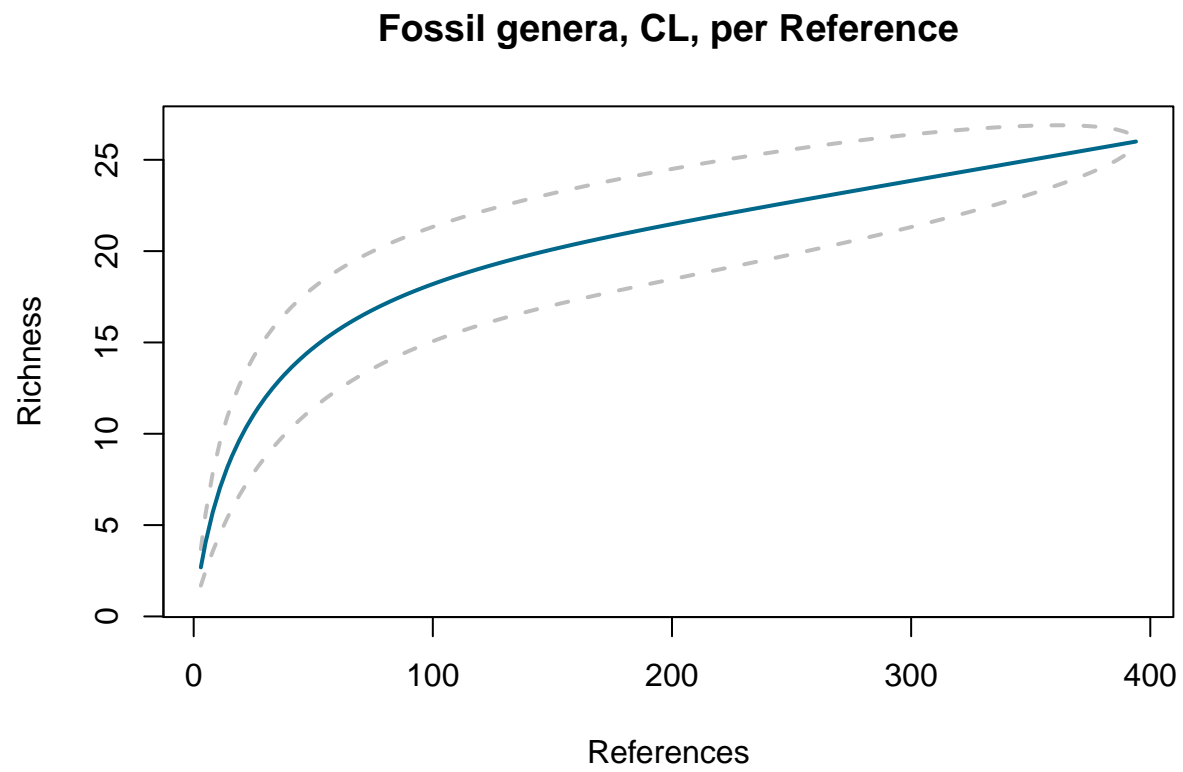


Figure 3: Map displaying all localities for which body size data for testudinids was available in the literature. Size of points denotes sample size, color denotes approximate age.

## Sampling Accumulation Curve



Eurasia

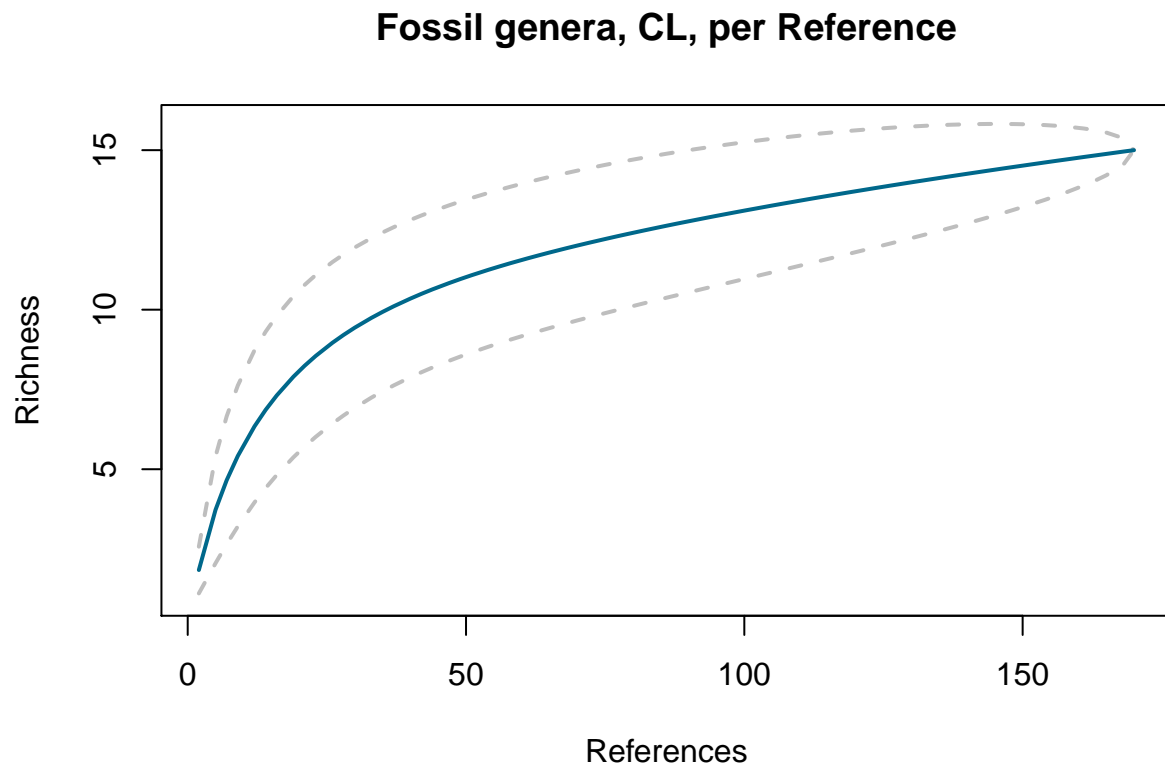


Figure 4: Sampling Accumulation Curve of fossil genera per reference, Eurasia

# Histograms

all

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

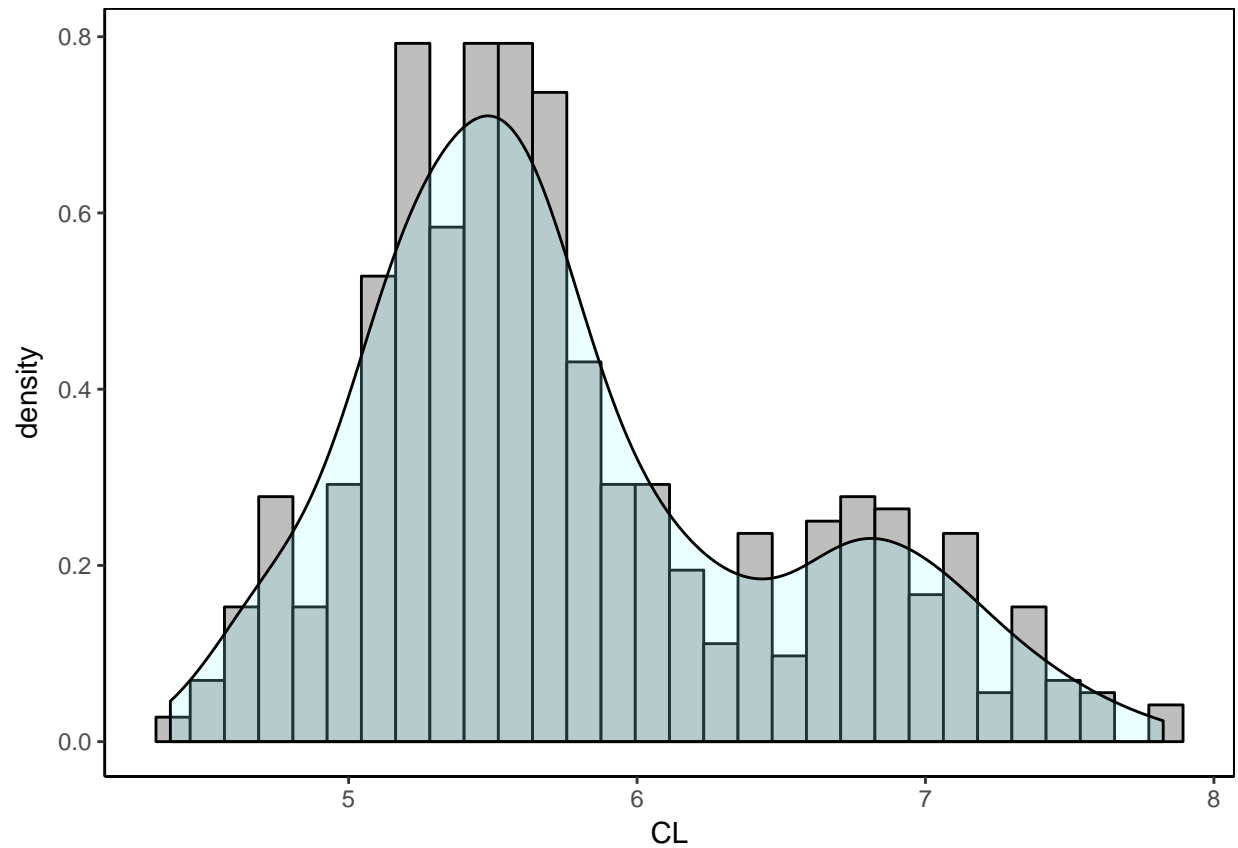
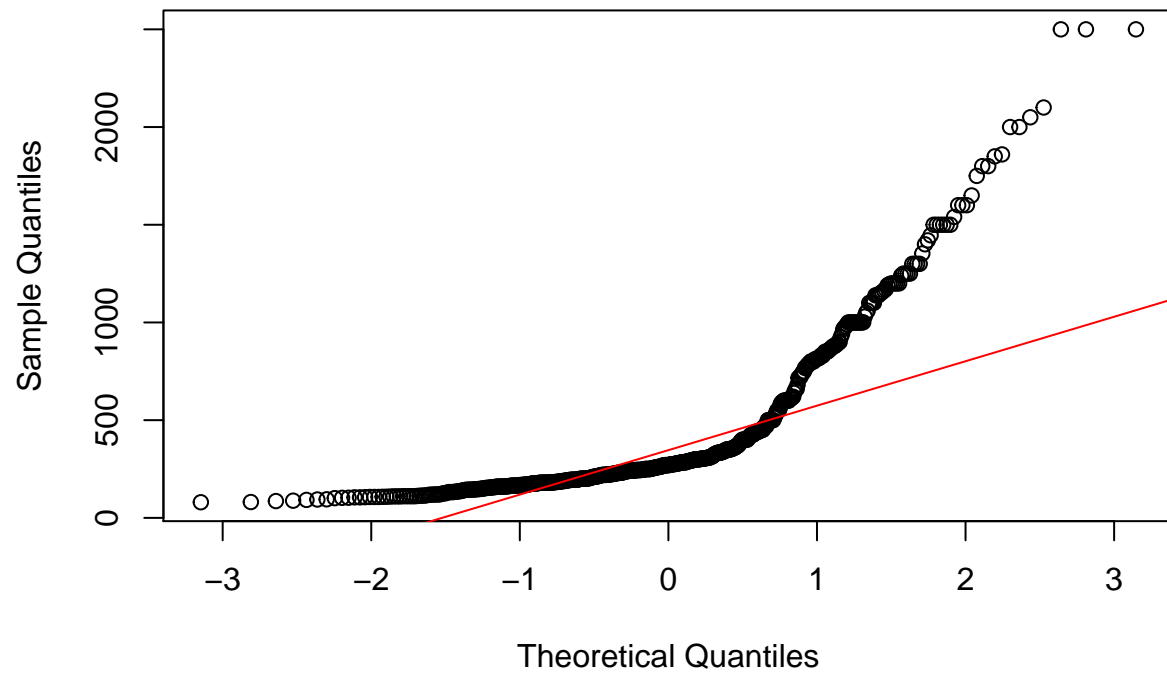


Figure 5: Distribution of body size data, logtransformed, all data.

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

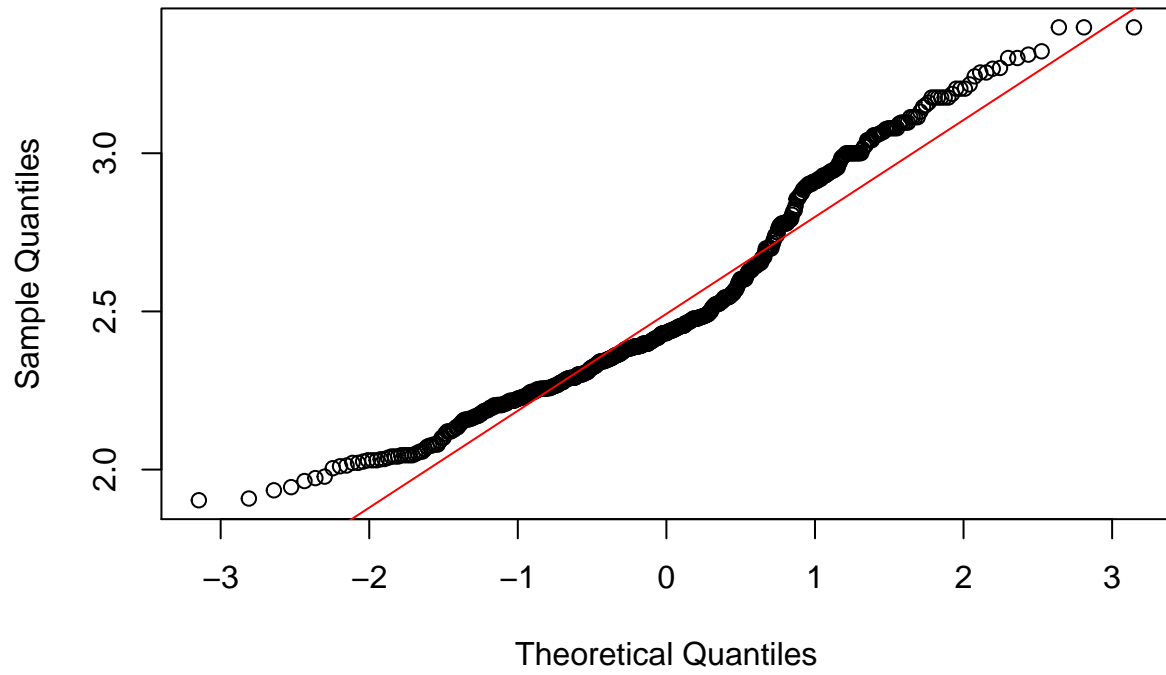


Normal Q-Q Plot



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

Normal Q-Q Plot



per time bin

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

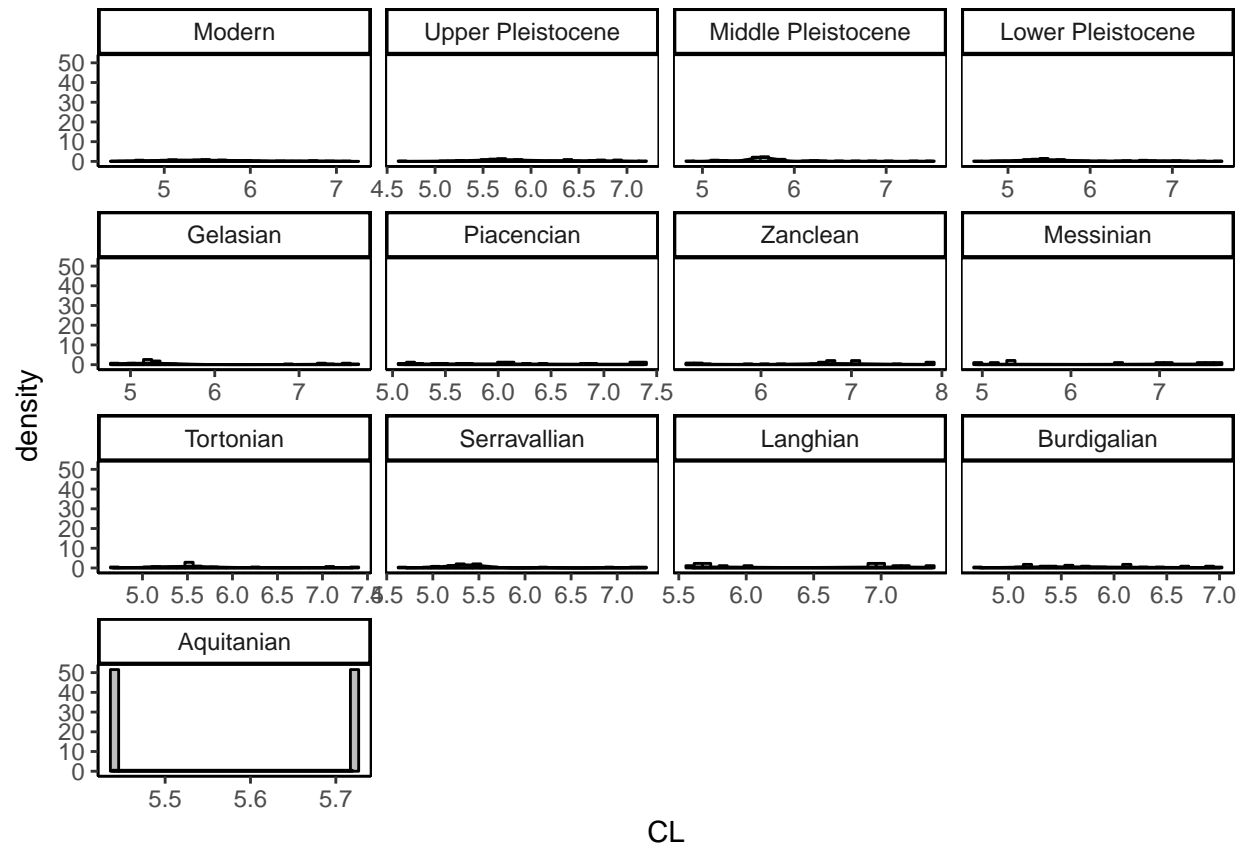


Figure 6: Distribution of body size data per time bin, logtransformed.

## modern vs. fossil

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

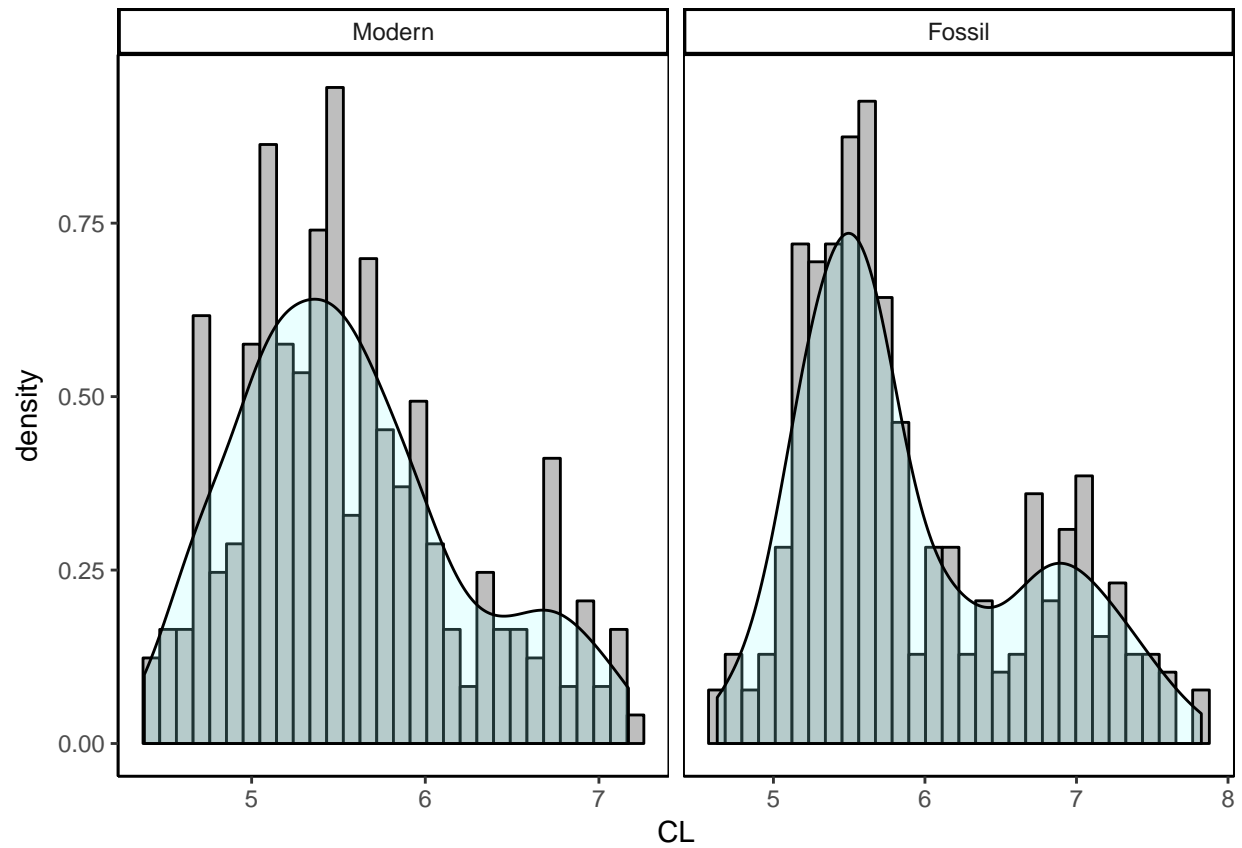


Figure 7: Distribution of body size data modern vs. fossil, logtransformed.

modern vs. fossil, continental vs. insular

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

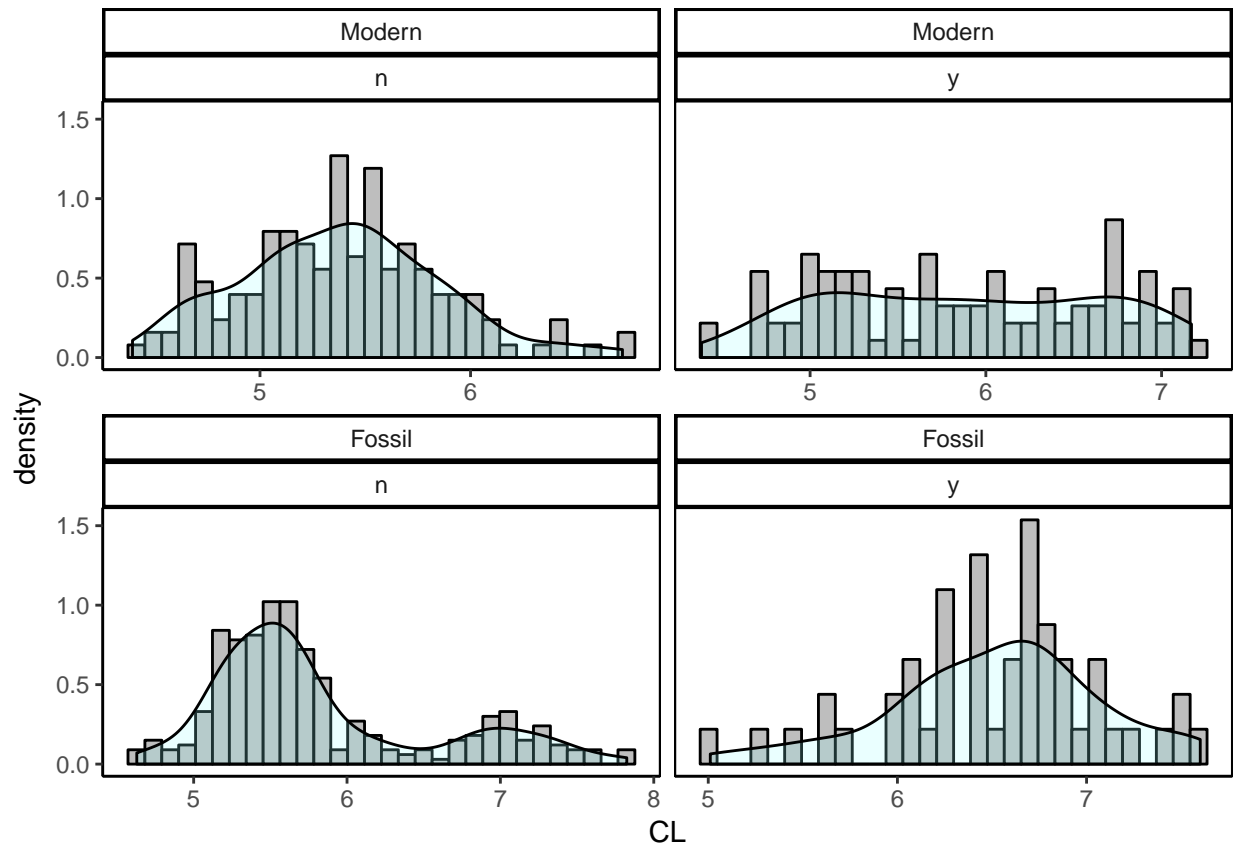


Figure 8: Distribution of body size data modern vs. fossil, continental vs. insular logtransformed.

## continental vs. insular

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

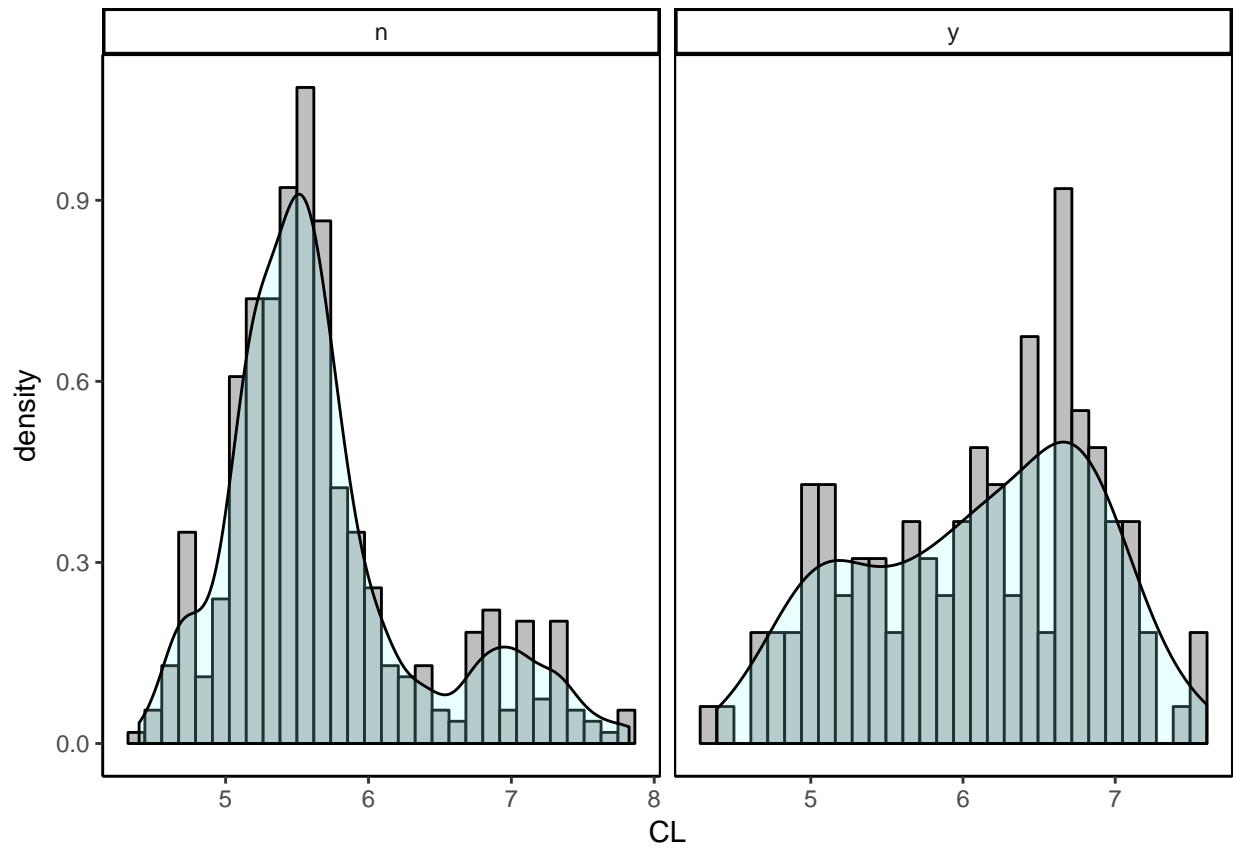


Figure 9: Distribution of body site data of continental (n) and insular(y) species, logtransformed.

## continents

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

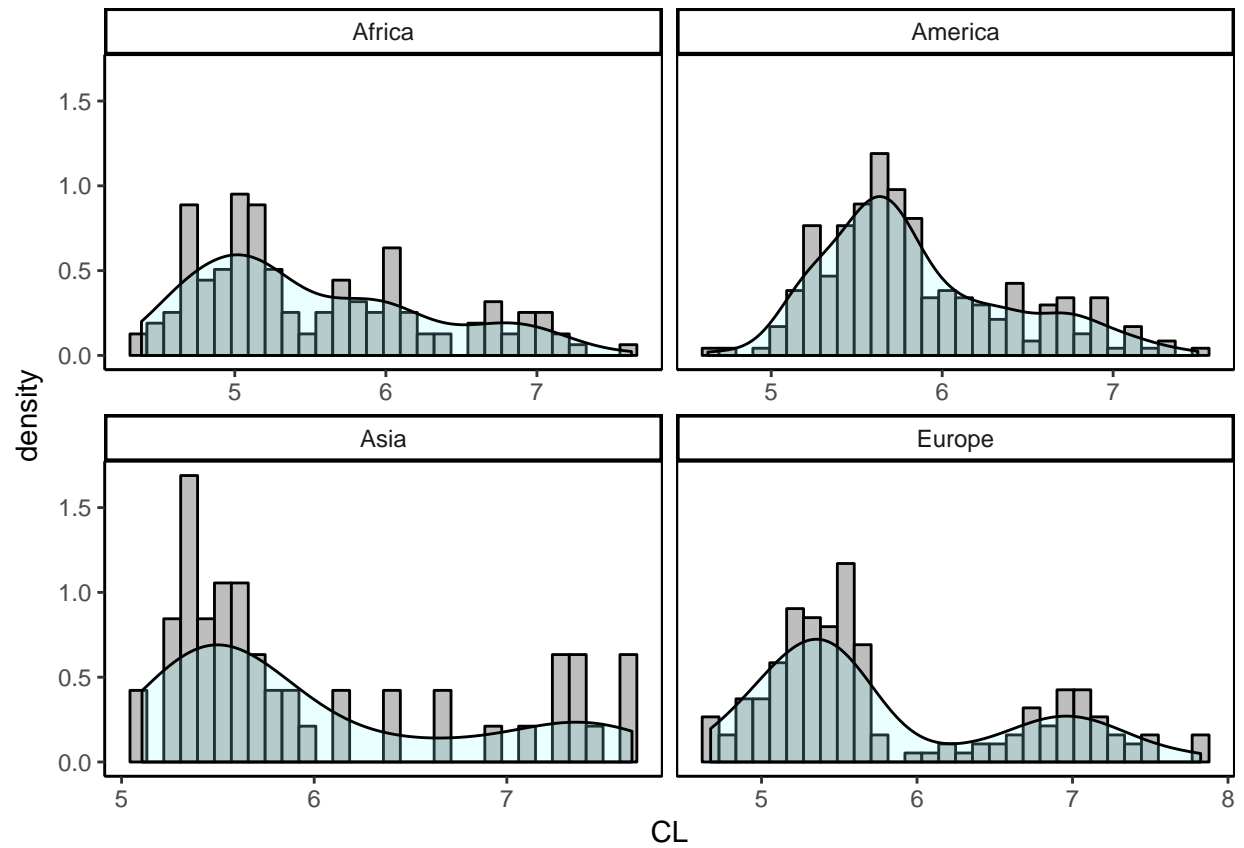


Figure 10: Distribution of body site data per continent, logtransformed.

## 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
606	80.00	2500.0	164878.313	435.8	2.5	270.0	2.4	2.17	0.71	8.11	2.77	all
253	80.00	1300.0	67485.500	330.3	2.4	242.0	2.4	1.83	0.58	5.87	2.69	Modern
49	102.44	1250.0	69690.660	445.9	2.6	334.7	2.5	1.20	0.24	3.61	2.56	Upper Pleistocene
52	132.00	1800.0	99827.711	387.4	2.5	292.5	2.5	3.00	1.52	12.00	5.49	Middle Pleistocene
53	107.80	2000.0	162580.002	451.1	2.5	259.5	2.4	1.88	0.81	6.27	2.59	Lower Pleistocene
27	118.90	2050.0	451139.148	554.2	2.5	193.3	2.3	1.32	1.06	2.99	2.33	Gelasian
20	165.00	1600.0	269797.712	636.6	2.7	440.5	2.6	0.96	0.29	2.38	1.78	Piacencian
26	176.00	2500.0	476162.710	955.2	2.9	857.5	2.9	1.11	-0.40	3.56	2.30	Zanclean
10	140.00	2100.0	602611.211	948.9	2.8	916.0	2.9	0.26	-0.22	1.49	1.29	Messinian
45	107.00	1540.0	175470.119	462.7	2.5	250.0	2.4	1.49	0.81	3.74	2.54	Tortonian
27	111.00	1500.0	126060.404	337.7	2.4	220.0	2.3	2.49	1.77	7.77	5.30	Serravallian
14	270.00	1600.0	230451.330	747.9	2.8	700.0	2.8	0.30	0.03	1.55	1.18	Langhian
28	113.00	1100.0	80293.821	416.7	2.5	305.0	2.5	1.16	0.37	3.18	2.13	Burdigalian
2	230.00	304.7	2790.045	267.4	2.4	267.4	2.4	0.00	0.00	1.00	1.00	Aquitanian
253	80.00	1300.0	67485.500	330.3	2.4	242.0	2.4	1.83	0.58	5.87	2.69	Modern
353	102.44	2500.0	221343.839	511.4	2.6	285.2	2.5	1.84	0.72	6.14	2.45	Fossil
459	81.00	2500.0	157898.595	390.1	2.5	250.0	2.4	2.71	1.11	10.82	3.86	continental
147	80.00	2000.0	160834.346	578.5	2.6	500.0	2.7	1.02	-0.27	3.95	2.05	insular
157	81.00	830.0	17009.024	244.0	2.3	221.0	2.3	1.92	0.29	8.09	2.98	modern-con
96	80.00	1300.0	118641.090	471.5	2.6	353.0	2.5	0.82	0.01	2.47	1.77	modern-ins
302	102.44	2500.0	214525.027	466.1	2.5	270.0	2.4	2.14	1.02	7.33	3.05	fossil-con
51	150.00	2000.0	180825.399	780.0	2.8	750.0	2.9	1.11	-0.40	4.02	3.18	fossil-ins
141	80.00	2050.0	112742.567	349.5	2.4	194.0	2.3	2.09	0.68	7.94	2.47	Africa
238	102.44	1800.0	80283.266	410.8	2.5	301.0	2.5	1.99	0.76	7.18	2.98	America
54	165.00	2100.0	342189.701	593.8	2.6	280.0	2.4	1.40	0.90	3.43	2.27	Asia



nCL	min	max	var	mean	logm	med	logmed	skew	logsk	kurt	logku	Variable
173	107.00	2500.0	254222.839	491.2	2.5	245.0	2.4	1.86	0.81	6.30	2.34	Europe

## Boxplots

genera per time bins

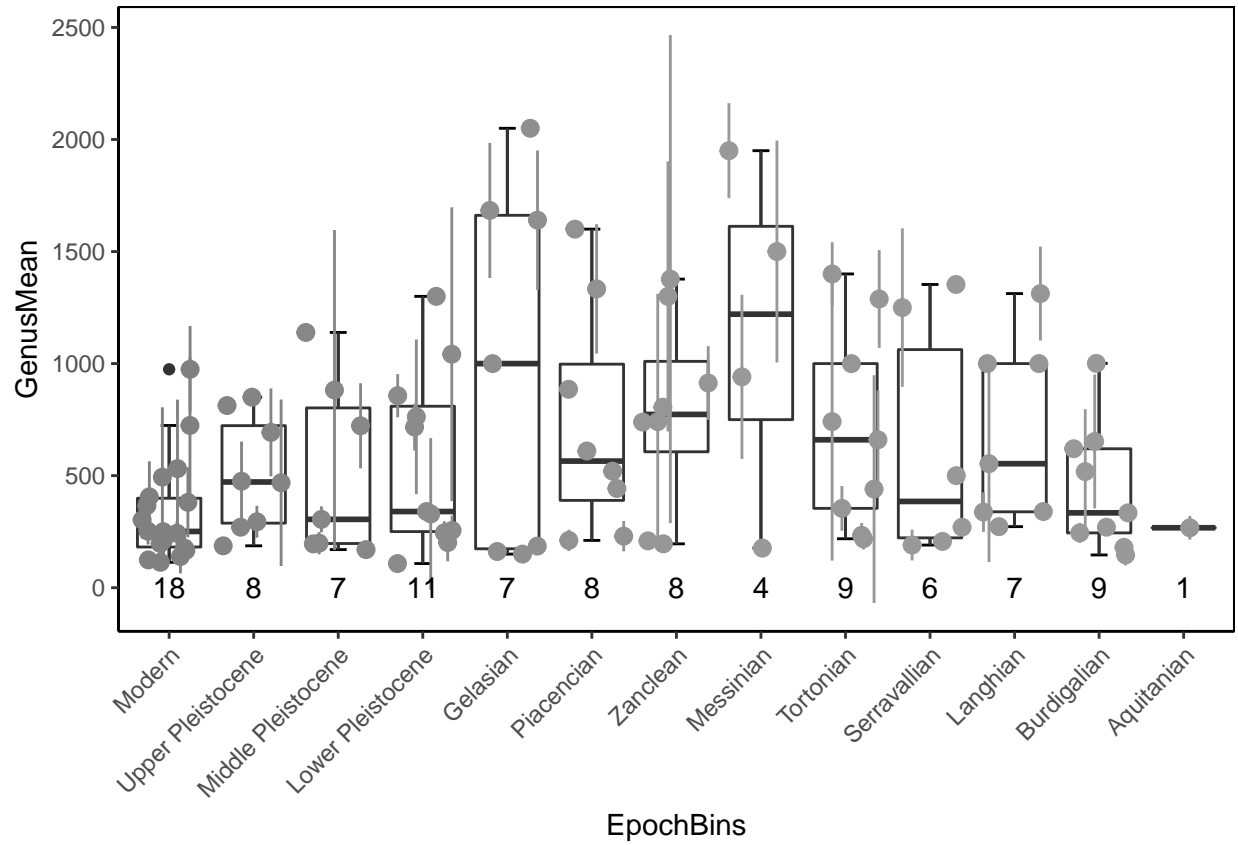


Figure 11: Boxplots of mean CL per time bin, including mean and sd CL for each genus (as pointrange).

continental vs. insular per time bin

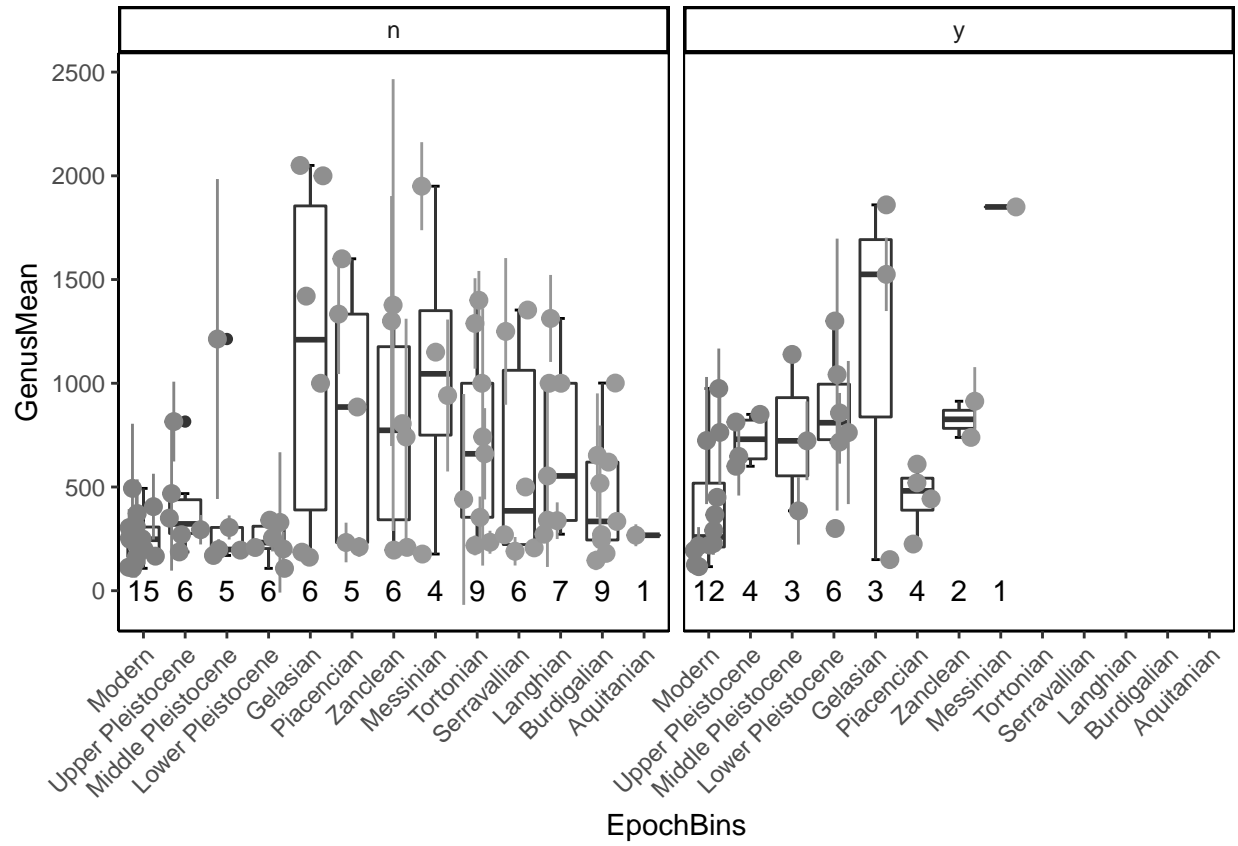


Figure 12: Boxplots of each genus per time bin, continental vs. insular species.

fossil vs. modern

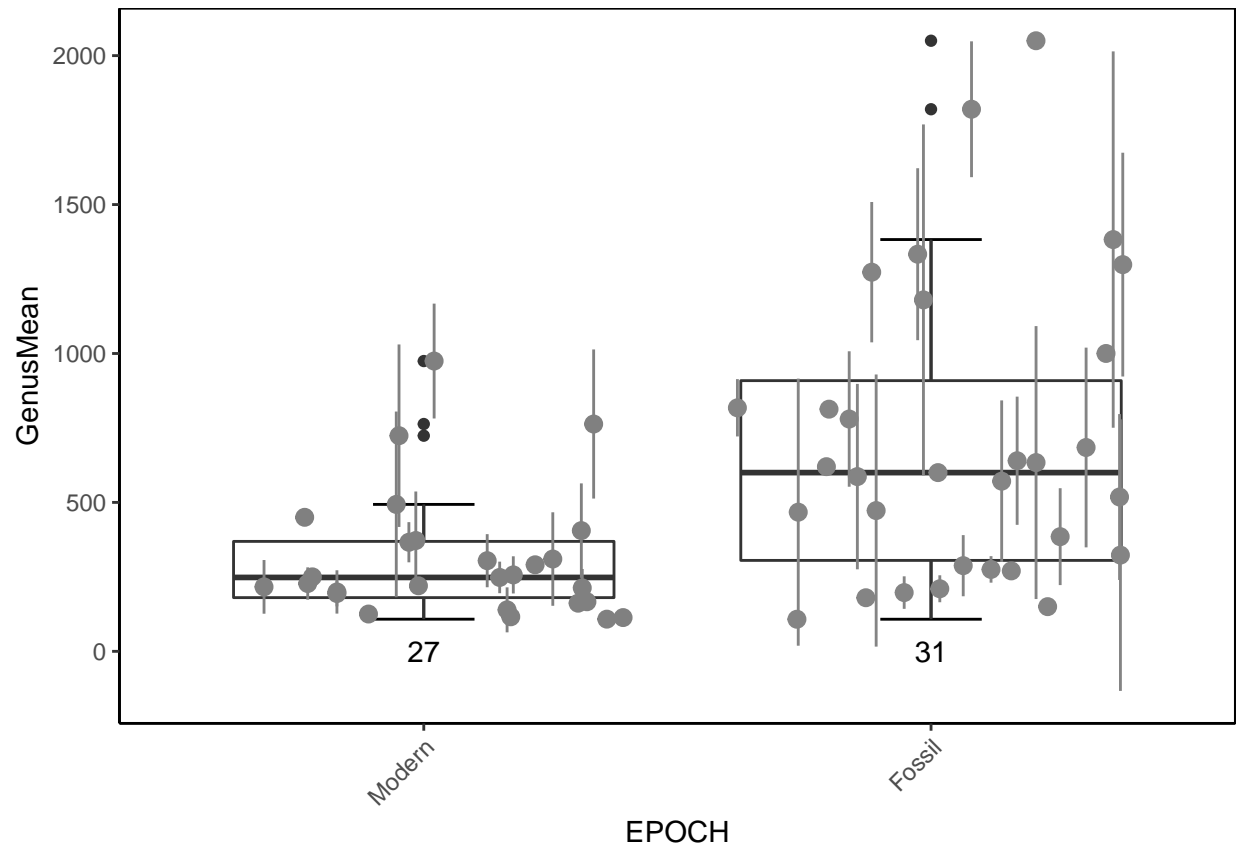
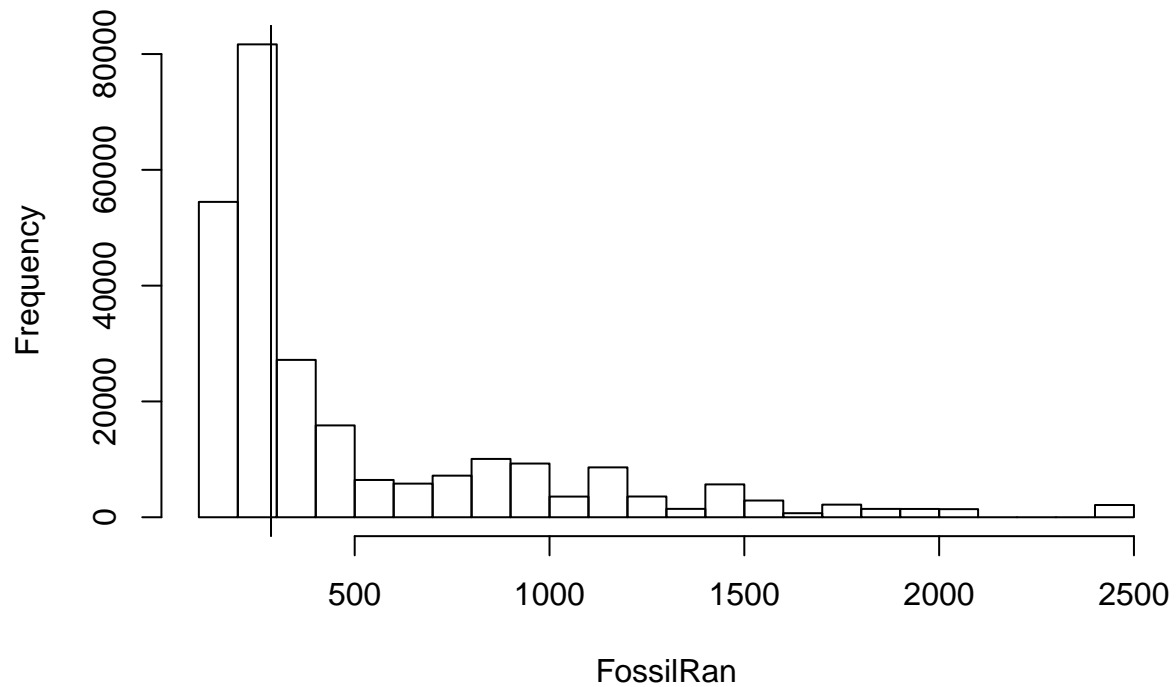


Figure 13: Boxplots fossil vs. modern.

## Histogram of FossilRan



```
## [1] 330.3495
```

```
## [1] 543.8405
```

```
##
```

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

```
##
```

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

```
## W = 22554, p-value = 9.204e-09
```

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

Wilcoxon Rank Sum Test (unpaired data):

modern < fossil ( $P = 9.2038428 \times 10^{-9}$ )

fossil vs. modern, continental vs. insular

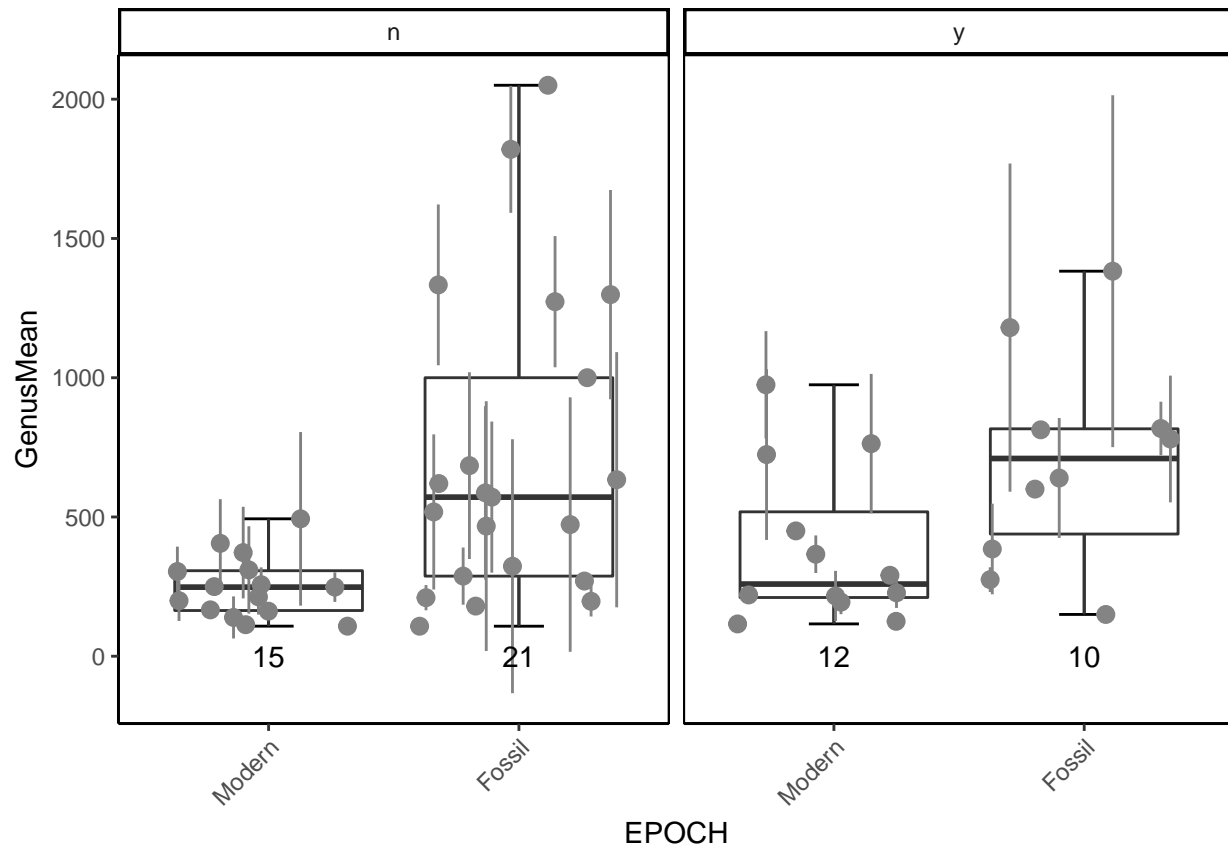


Figure 14: Boxplots fossil vs. modern, continental vs. insular species.

```
## [1] 51
## [1] 51
## [1] 779.9882
## [1] 503.4725
##
## Wilcoxon rank sum test with continuity correction
##
## data: ModernIsland and FossilIsland
## W = 793, p-value = 0.0003449
## alternative hypothesis: true location shift is less than 0
## [1] 157
```

```
## [1] 157

## [1] 244.0429

## [1] 437.3373

##
## Wilcoxon rank sum test with continuity correction
##
## data: ModernCon and FossilCon
## W = 8925, p-value = 1.191e-05
## alternative hypothesis: true location shift is less than 0

Wilcoxon Rank Sum Test (unpaired data):

modern continental < fossil continental ( $P = 1.1909816 \times 10^{-5}$ )

modern insular < fossil insular ( $P = 3.4488268 \times 10^{-4}$ )
```

## continental vs. insular

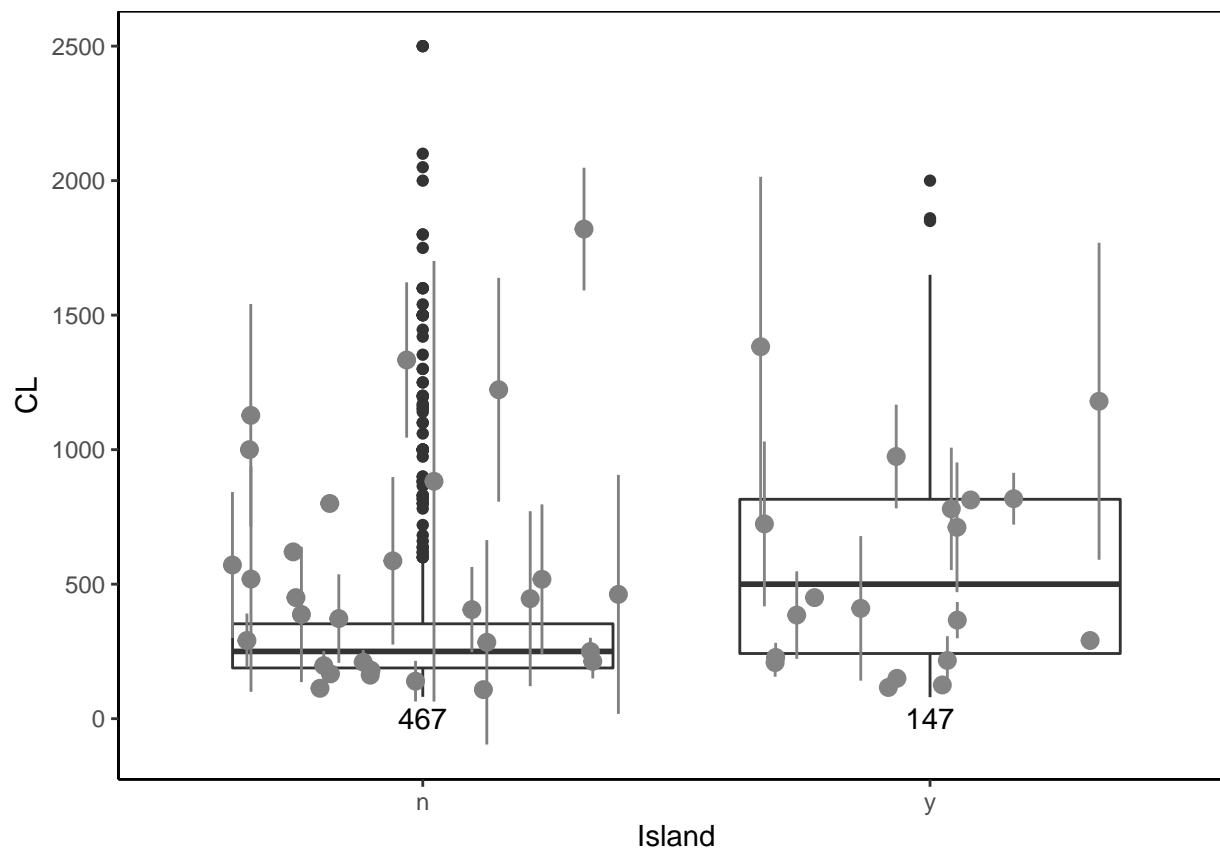


Figure 15: Boxplot continental vs. insular, genera summarised

```
## [1] 147
## [1] 147
## [1] 578.5245
## [1] 358.3856
##
## Wilcoxon rank sum test with continuity correction
##
## data: Insular and Continental
## W = 14740, p-value = 3.363e-08
## alternative hypothesis: true location shift is greater than 0
```

Wilcoxon Rank Sum Test (unpaired data):



continental < insular ( $P = 3.3629549 \times 10^{-8}$ )

# continental vs. insular per time bin

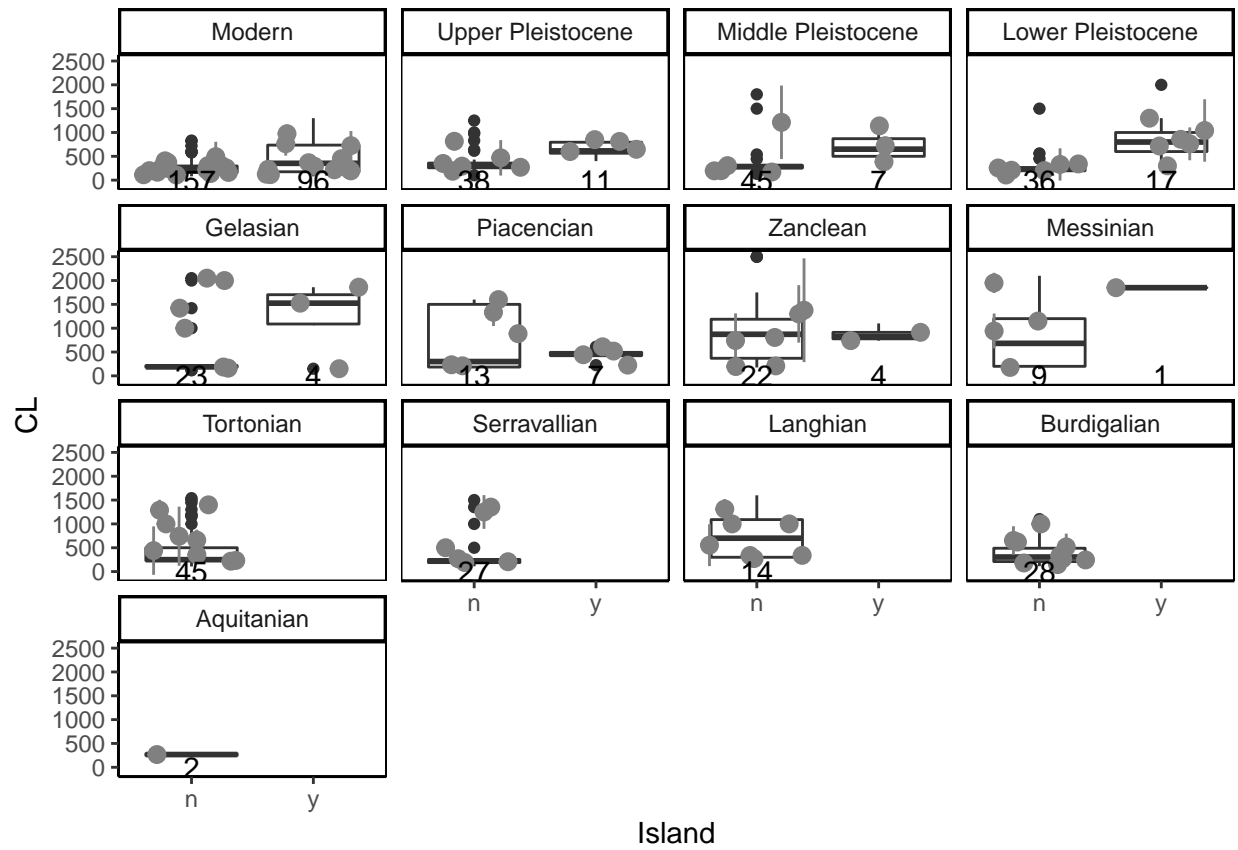


Figure 16: Boxplot continental vs. insular, genera summarised

## continents

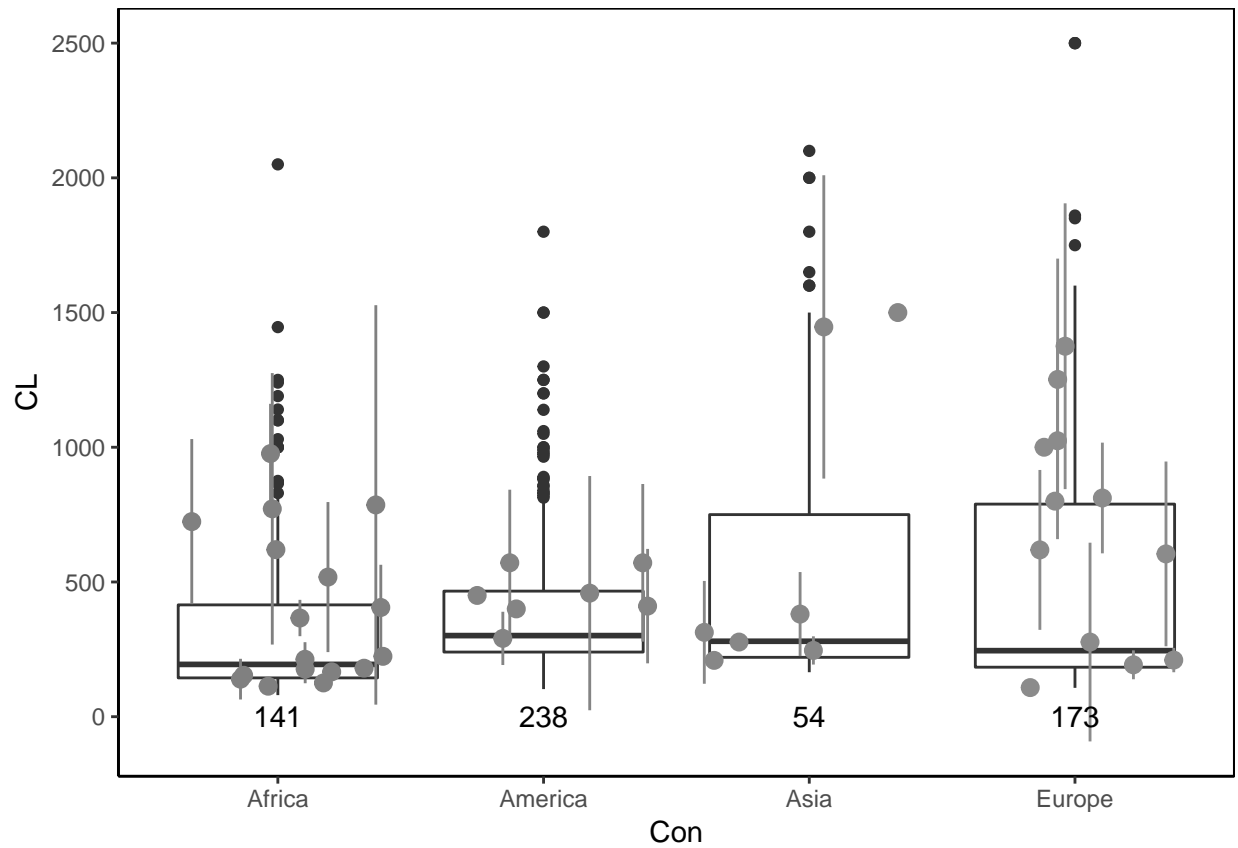


Figure 17: Boxplot: body size on different continents, genera summarised

```
## [1] 141
## [1] 349.5163
## [1] 141
## [1] 408.8097
## [1] 141
## [1] 464.0206
##
## Kruskal-Wallis rank sum test
##
## data: list(Africa, America, Eurasia)
## Kruskal-Wallis chi-squared = 27.794, df = 2, p-value = 9.219e-07
```

Wilcoxon Rank Sum Test (unpaired data):

Continent means differ ( $P = 9.2191886 \times 10^{-7}$ ) (still have to look into the details...)

continents, continental vs. insular

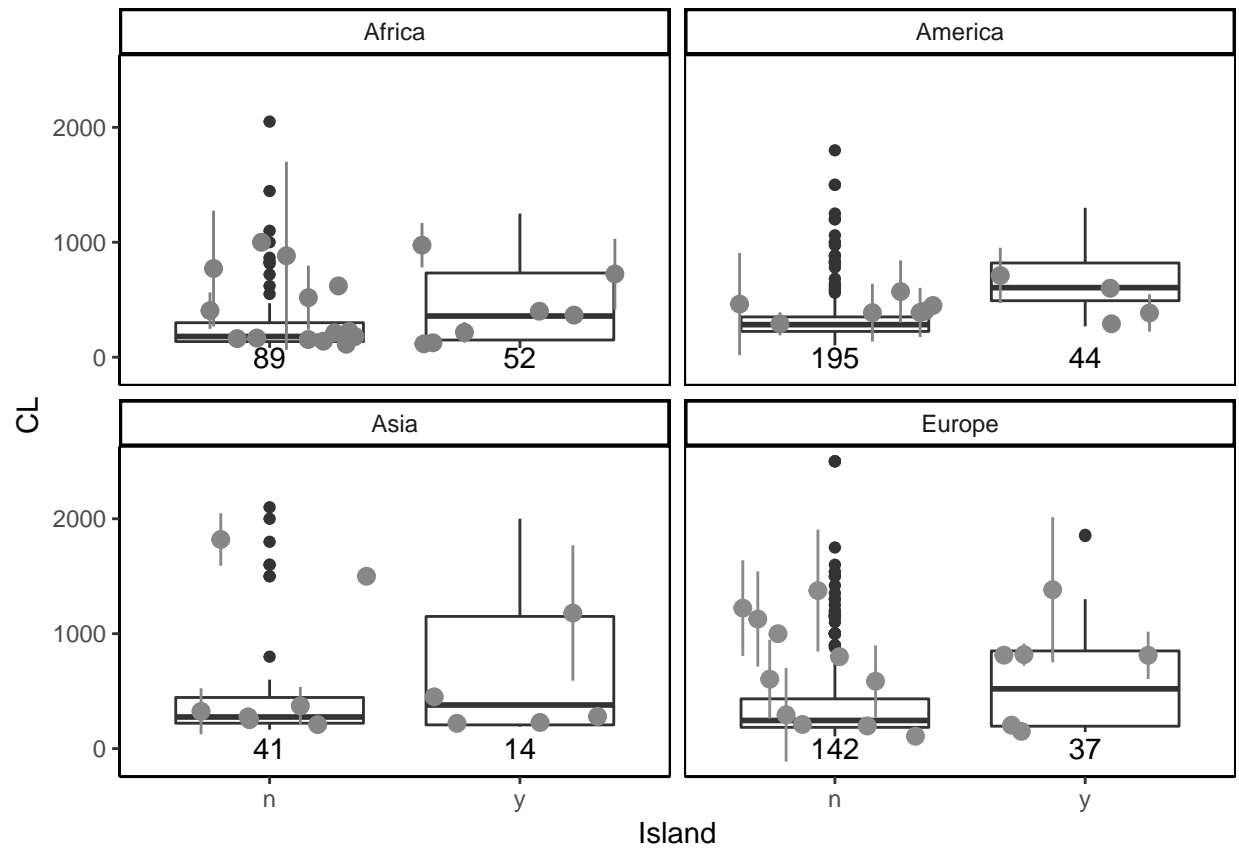


Figure 18: Boxplot: body size on different continents, genera summarised

## paleoTS analysis

all (continental and insular)

genera (all)

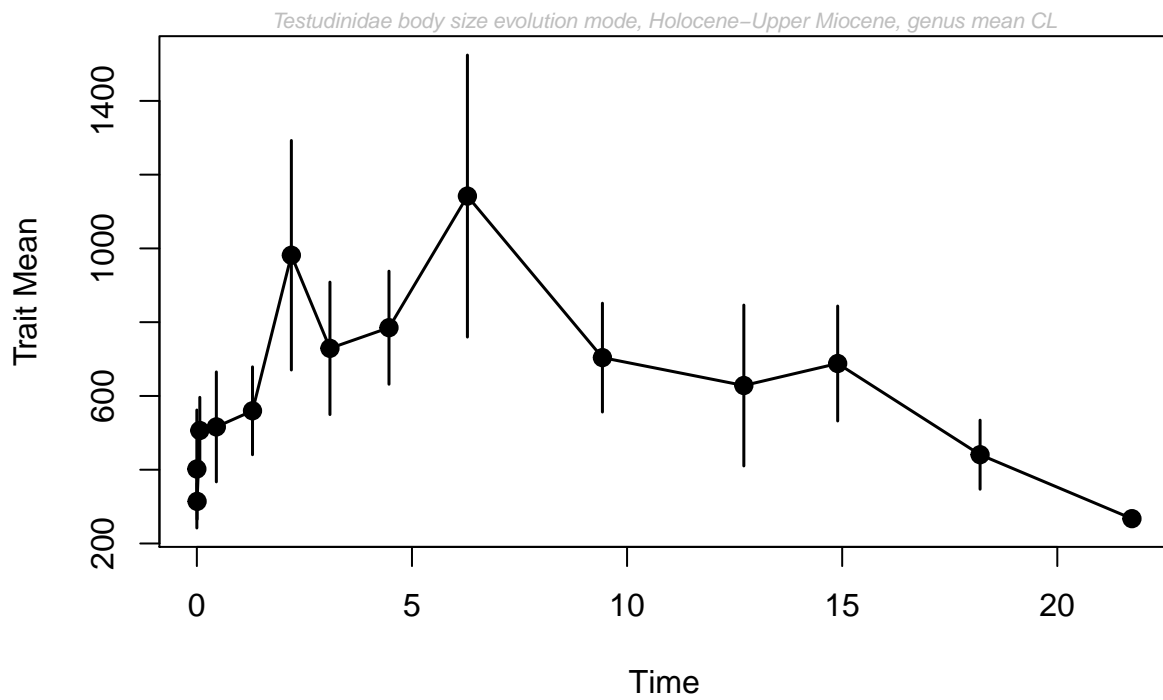


Figure 19: paleoTS plot with genus mean, including island species

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

	logL	K	AICc	Akaike.wt
GRW	-86.72197	2	178.6439	0.507
URW	-88.41476	1	179.1932	0.385
Stasis	-88.27564	2	181.7513	0.107

continental (excluding insular species)

genera (continental)

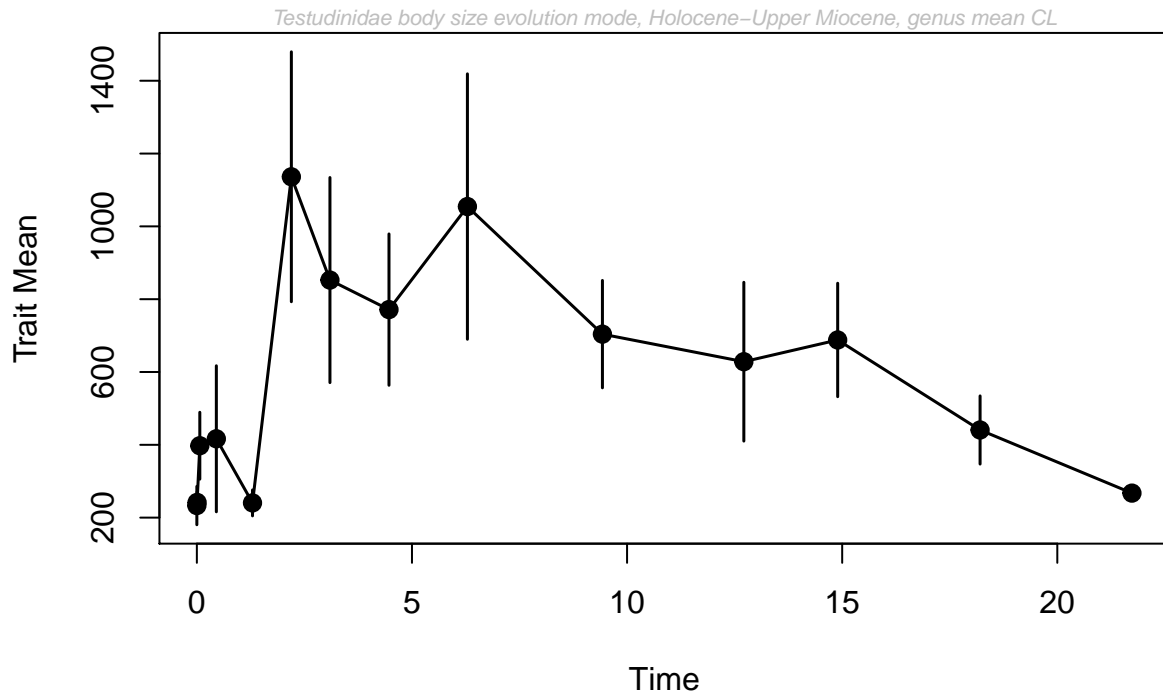


Figure 20: paleoTS plot with genus mean, excluding island species

Table 4: Model-fitting results for testudinidae, genera, excluding insular species

	logL	K	AICc	Akaike.wt
GRW	-88.37116	2	181.9423	0.661
URW	-90.63104	1	183.6257	0.285
Stasis	-90.86596	2	186.9319	0.055

insular (excluding continental)

genera (insular)

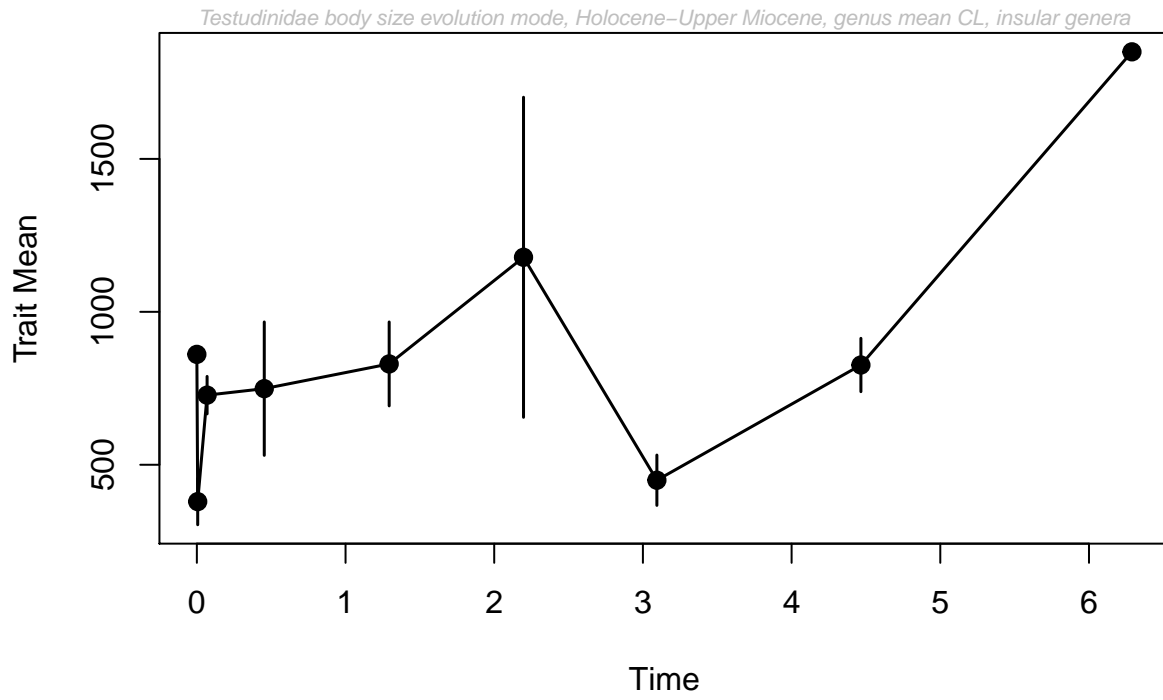


Figure 21: paleoTS plot with genus mean, only insular species

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

	logL	K	AICc	Akaike.wt
GRW	-68.57344	2	143.5469	0
URW	-75.76576	1	154.1982	0
Stasis	-60.41581	2	127.2316	1



per continent

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

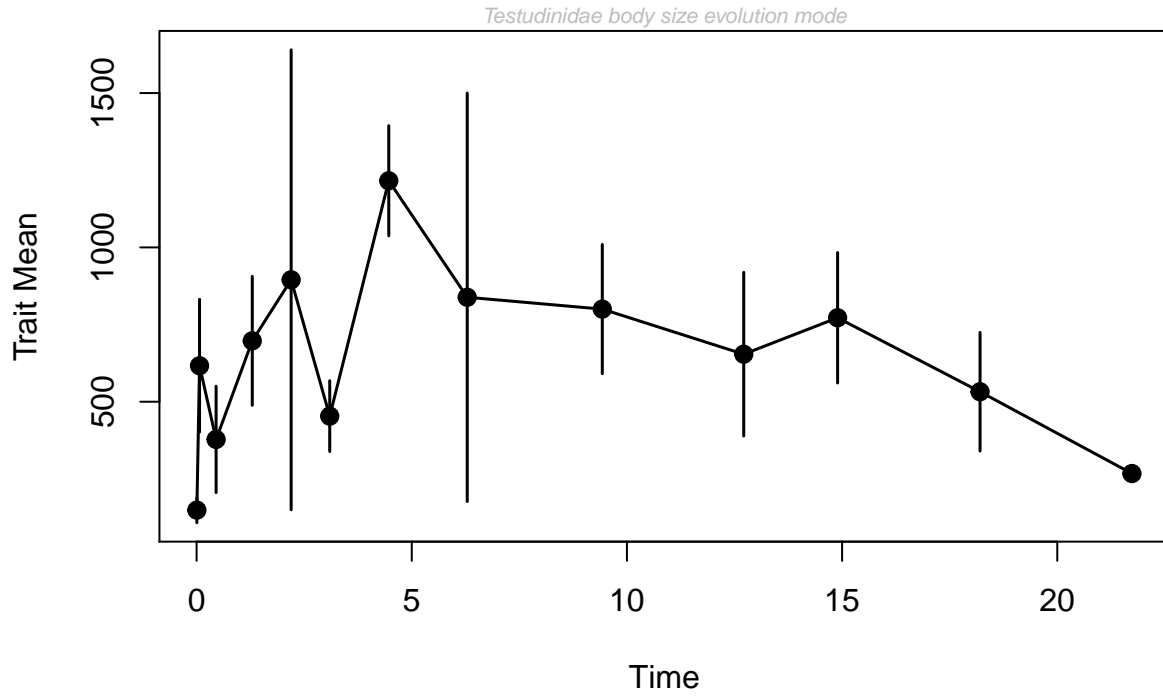


Figure 22: Smaller original bins, genera, Europe

Table 6: Model-fitting results for testudinidae, no bins, genera

	logL	K	AICc	Akaike.wt
GRW	-93.41355	2	192.1604	0.003
URW	-93.53232	1	189.4646	0.012
Stasis	-87.65688	2	180.6471	0.985

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

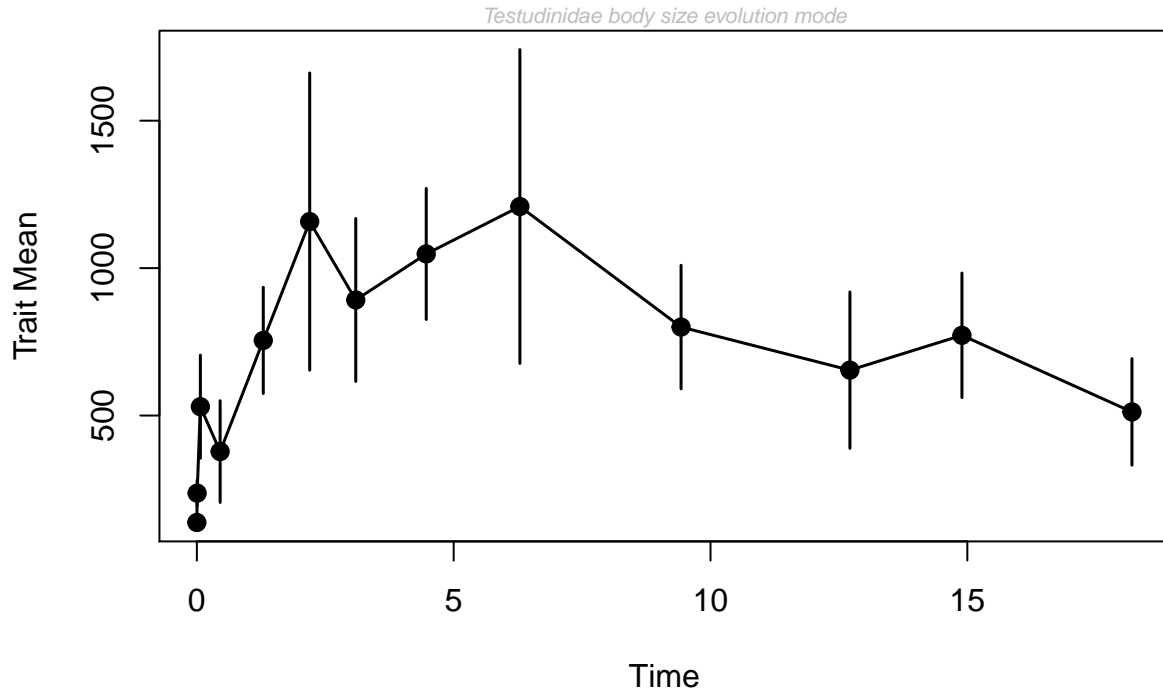


Figure 23: Smaller original bins, genera, Eurasia

Table 7: Model-fitting results for testudinidae, no bins, genera

	logL	K	AICc	Akaike.wt
GRW	-85.97747	2	177.2883	0.139
URW	-86.08949	1	174.5790	0.539
Stasis	-85.14096	2	175.6152	0.321