

# 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	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	50	21	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	45	19	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	27	15	9
(20.4,23]	Aquitanian	Lower Miocene	21.73500	2	1	1

## [1] 0

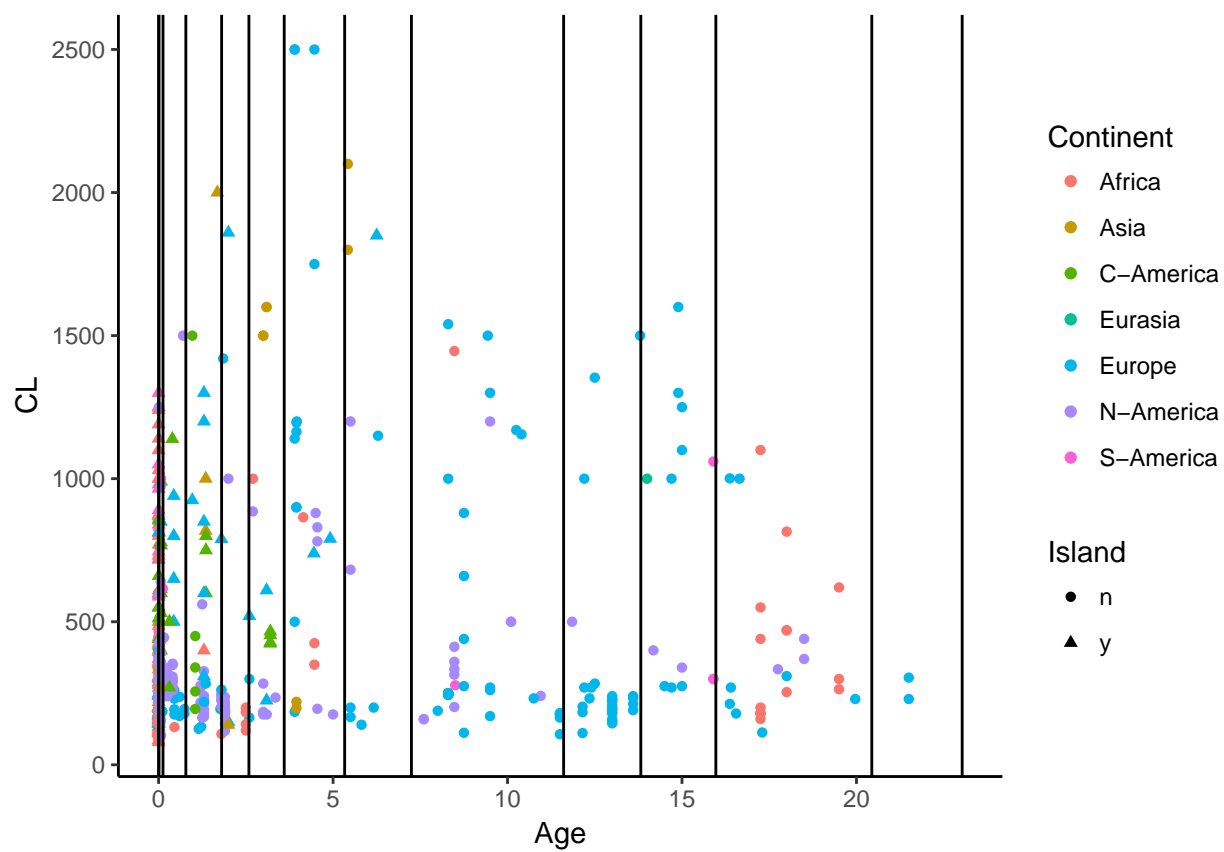


Figure 1: Scatterplot of CL over time, indicating insular (triangle) and continental (circles) and colour indicating continents. Lines indicate bins, dashed line = new bins.

## Maps

### fossil occurrences of testudinidae

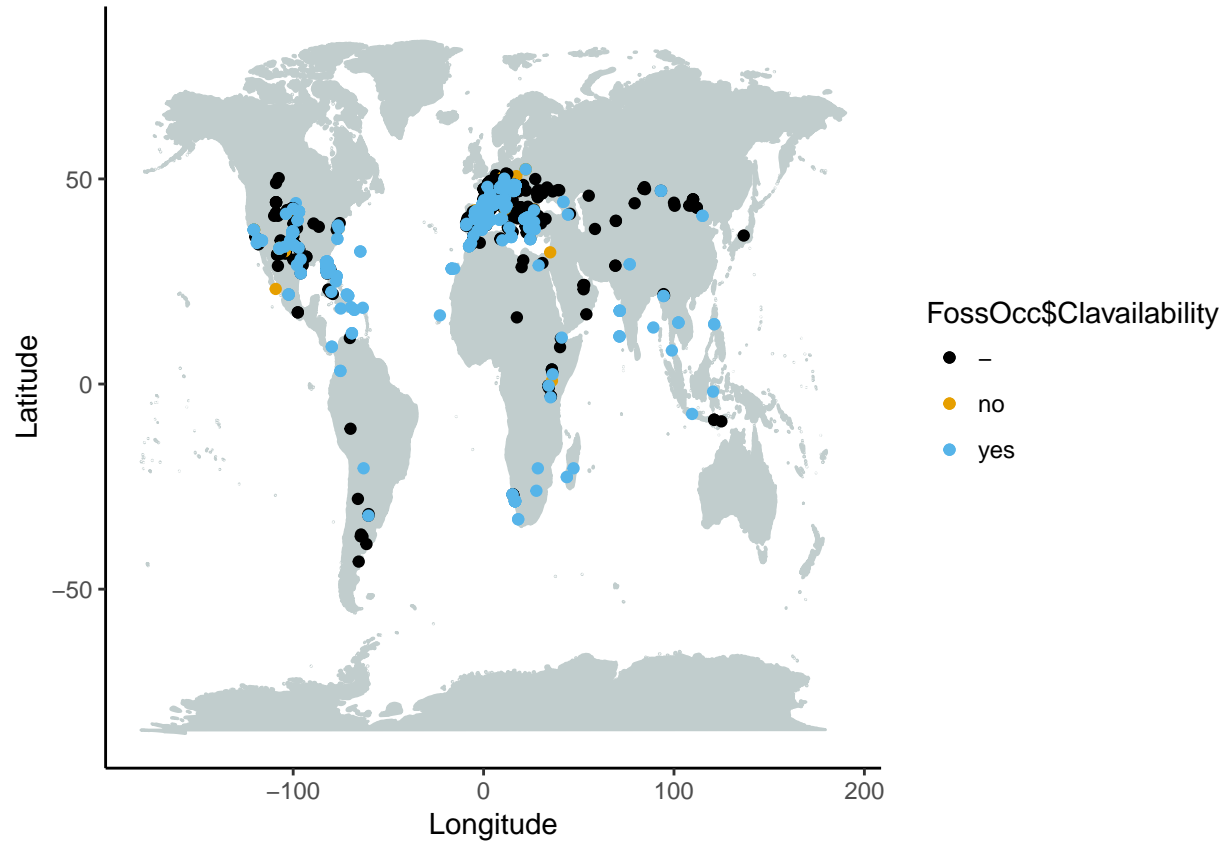


Figure 2: Map displaying all fossil occurrences of testudinids, with color indicating whether relevant literature was available (black if not) and if it was, whether body size data was available or not (yes and no, respectively).

## body size of testudinidae

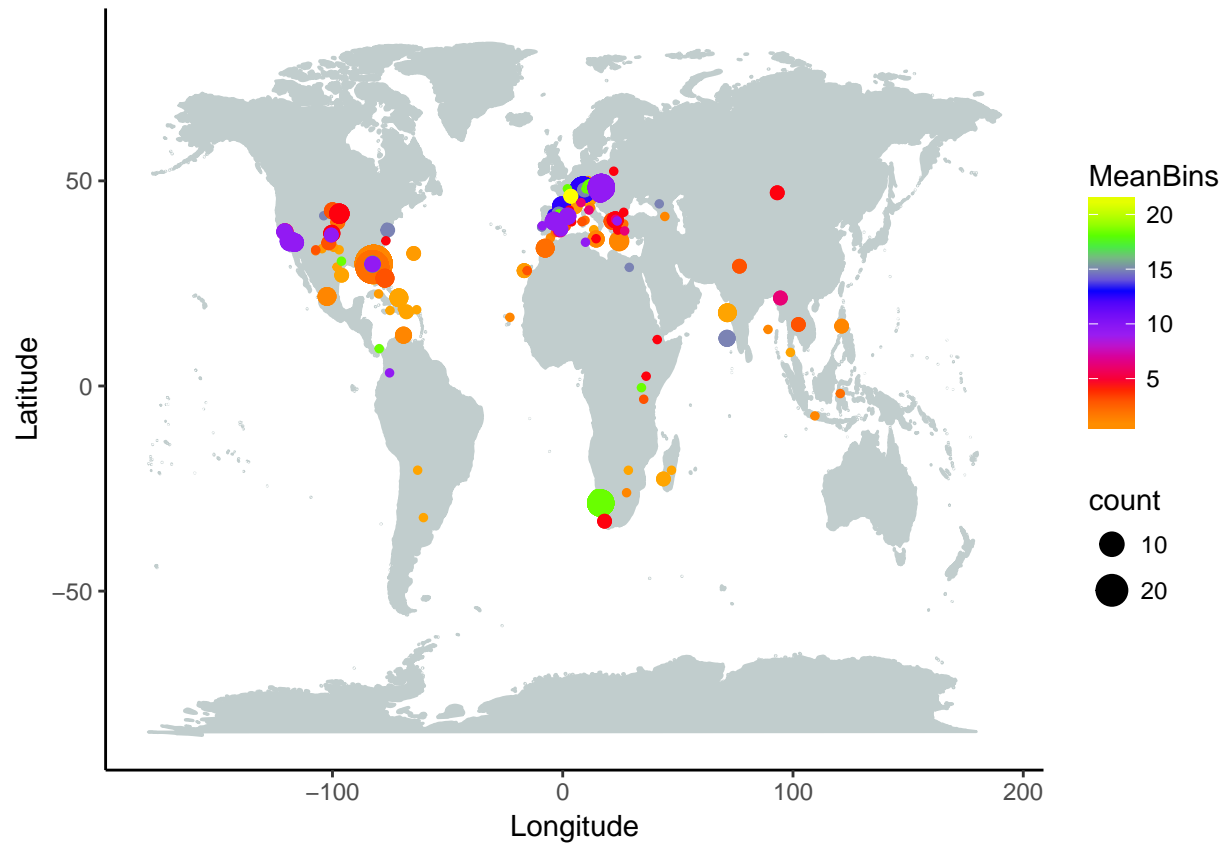
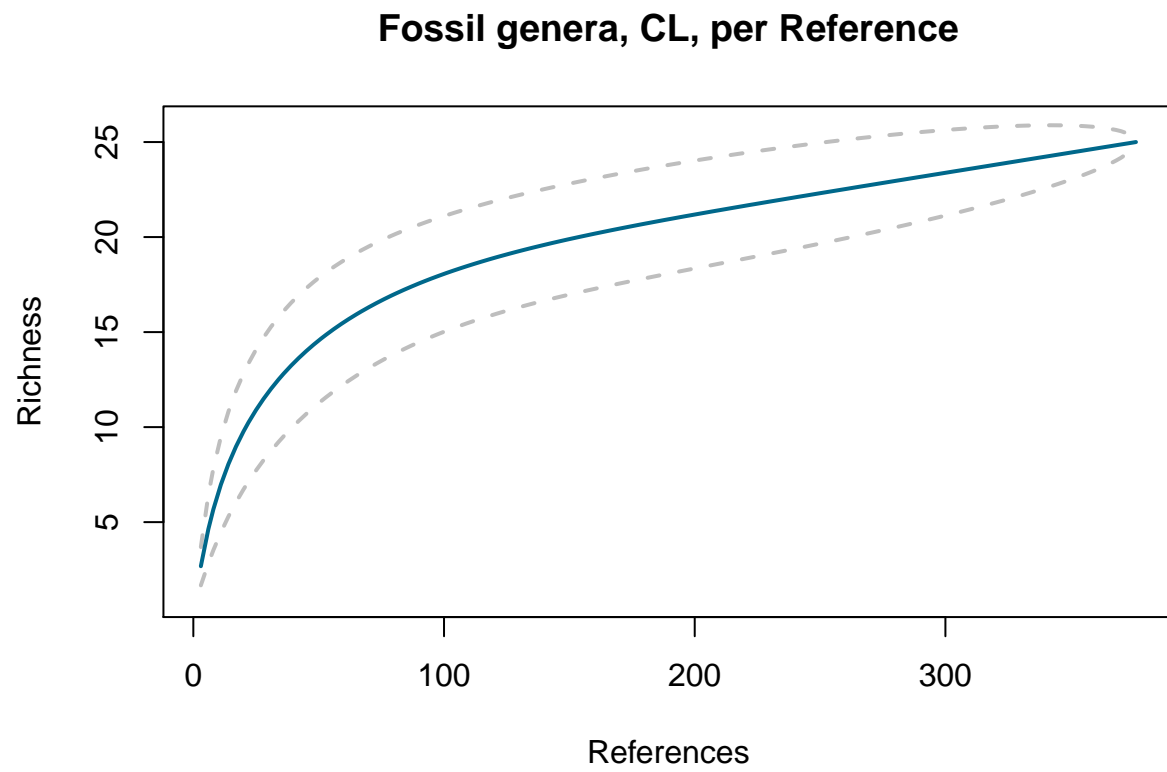


Figure 3: Map displaying all localities for which body size data for testudinids was available in the literature. Size of points denotes sample size, color denotes approximate age.

## Sampling Accumulation Curve



Eurasia

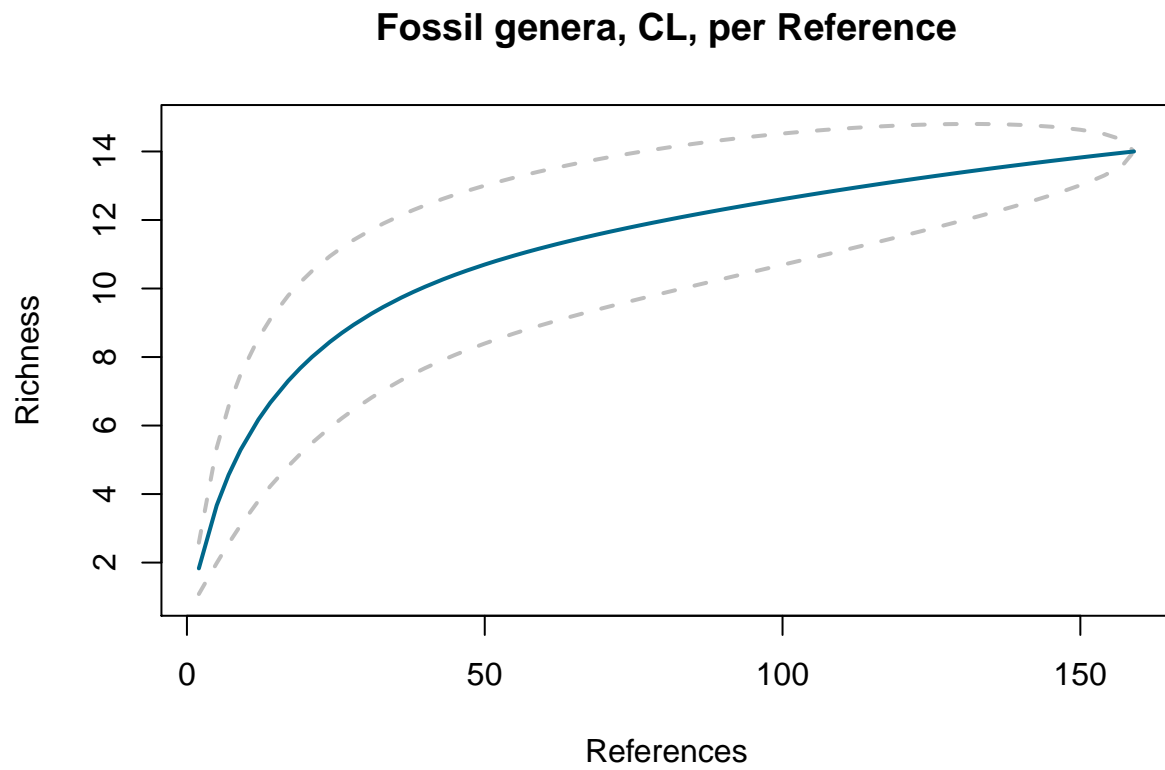


Figure 4: Sampling Accumulation Curve of fossil genera per reference, Eurasia

# Histograms

all

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

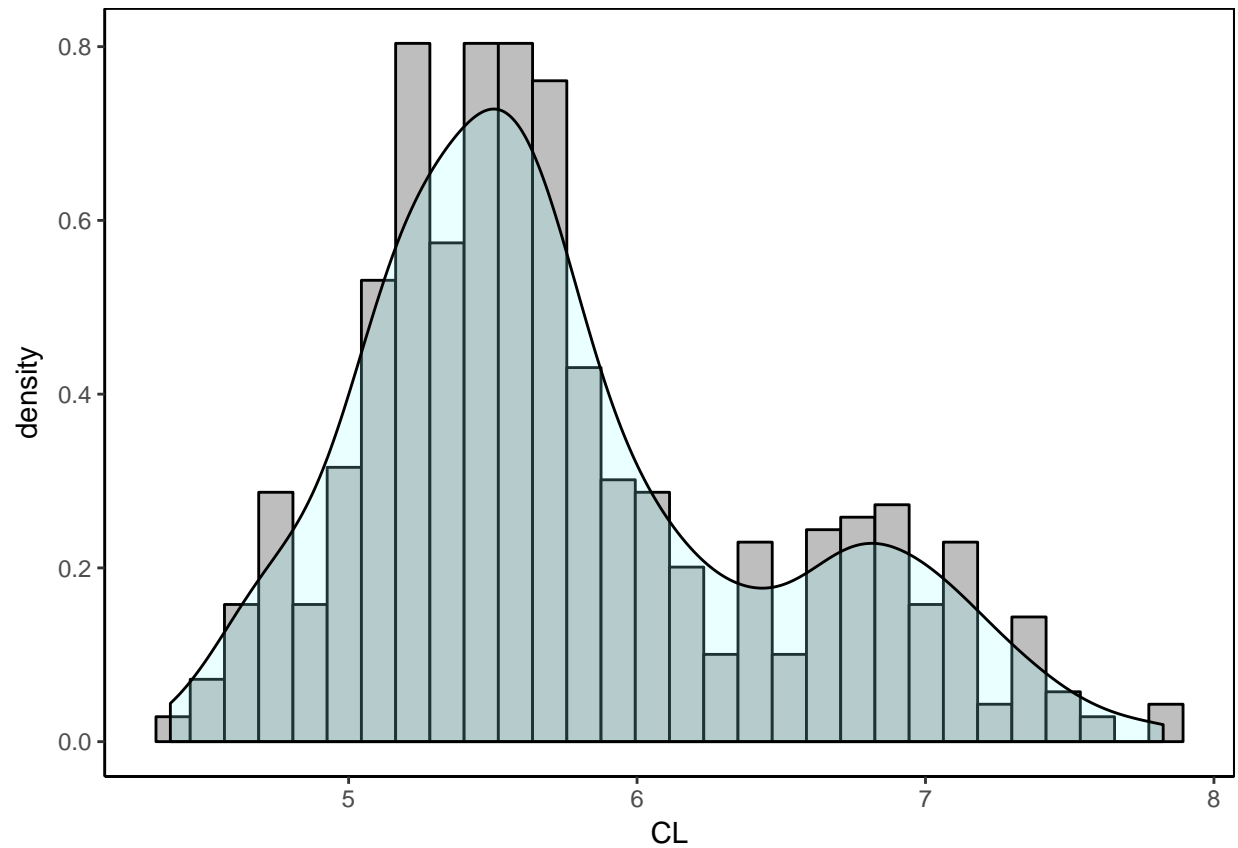
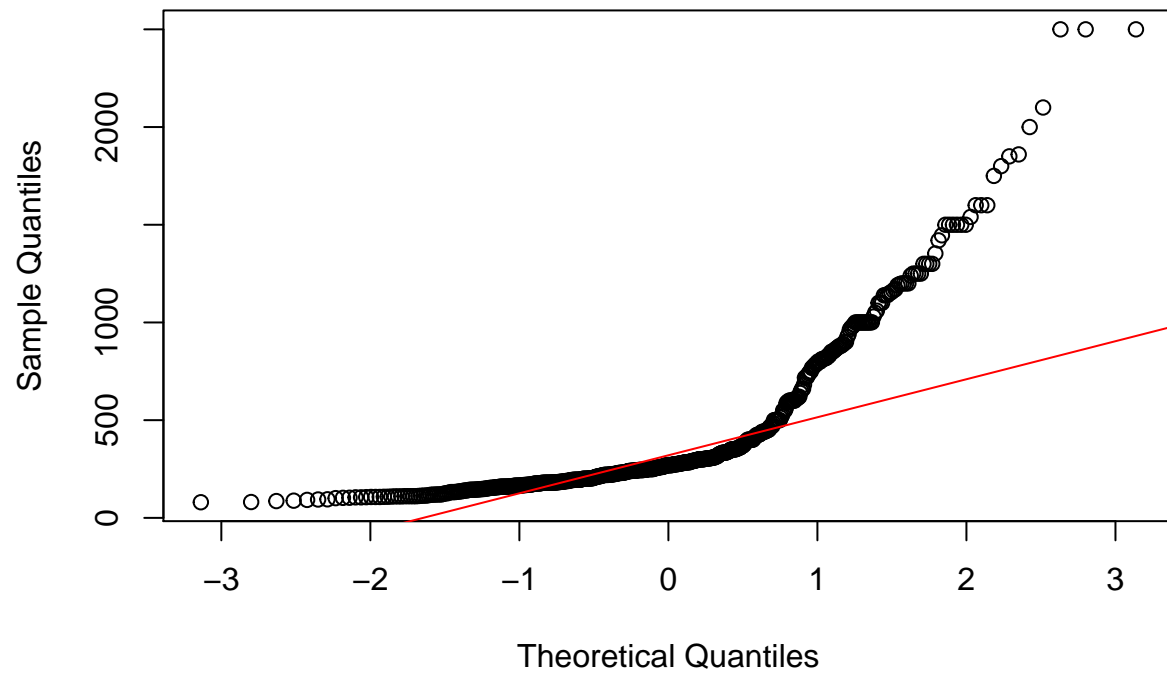


Figure 5: Distribution of body size data, logtransformed, all data.

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

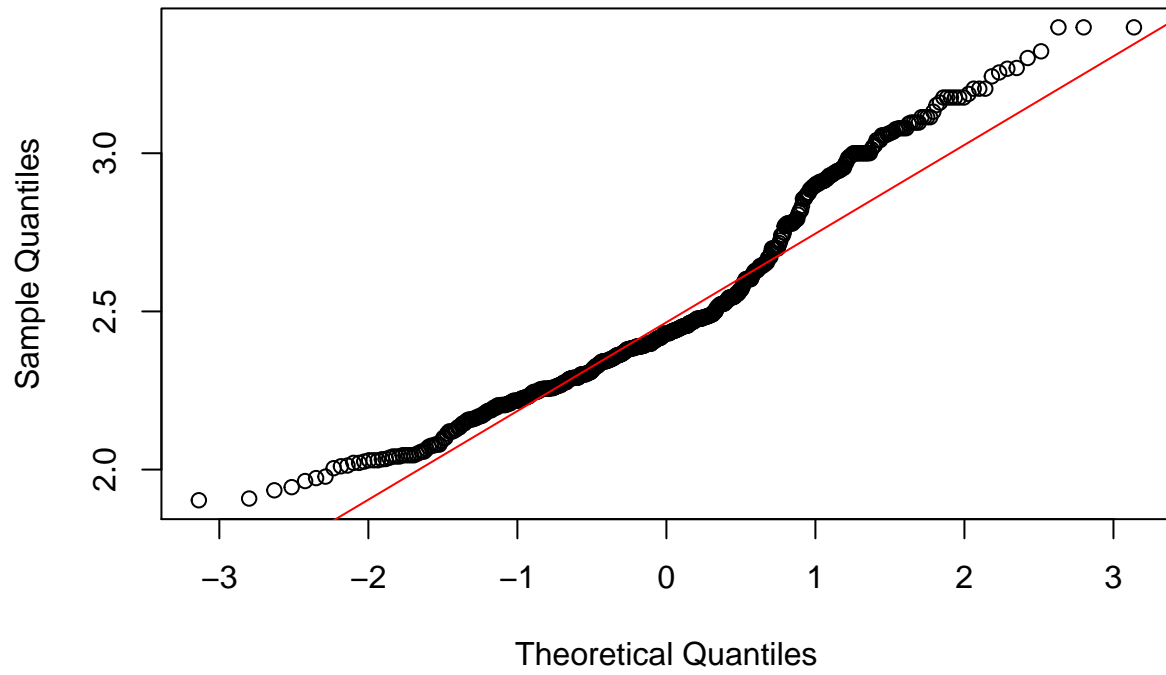


## Normal Q-Q Plot



```
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`.
```

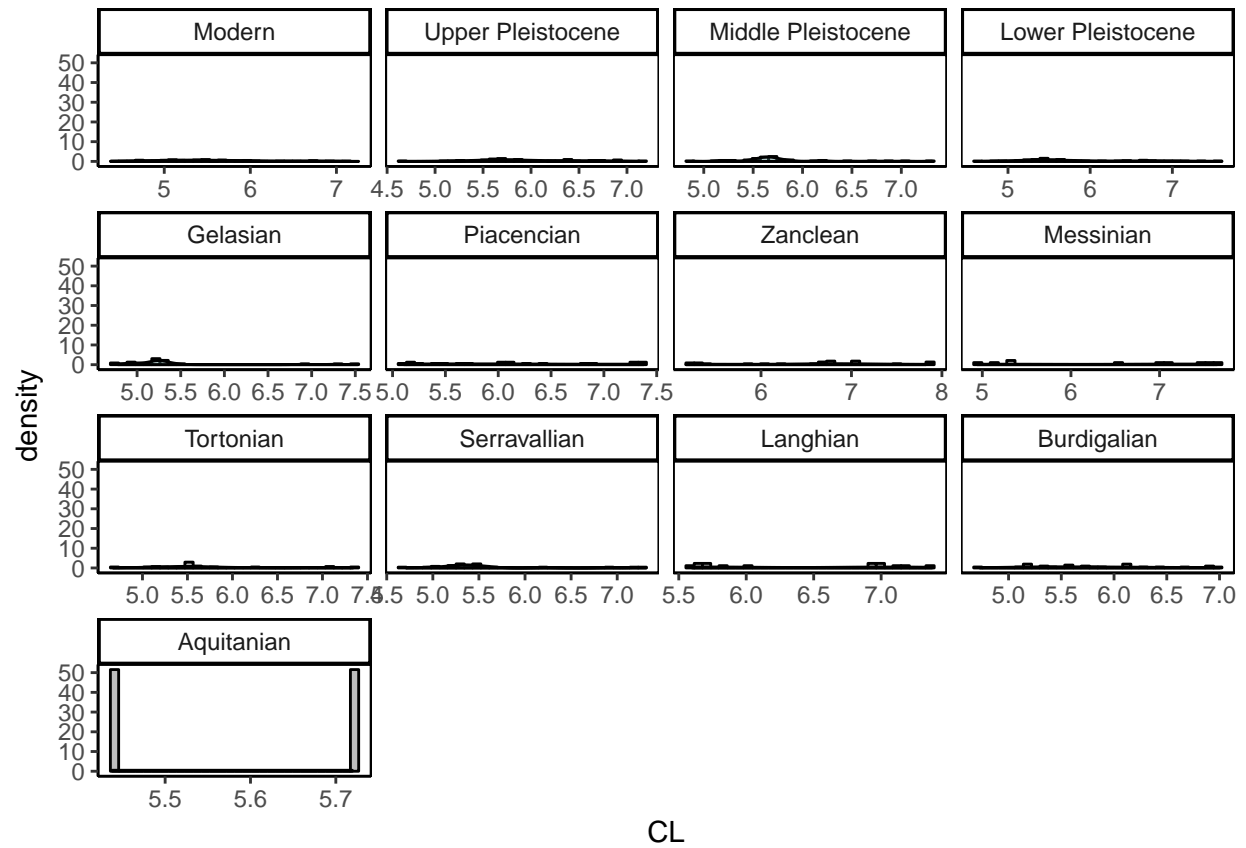


Figure 6: Distribution of body size data per time bin, logtransformed.

## modern vs. fossil

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

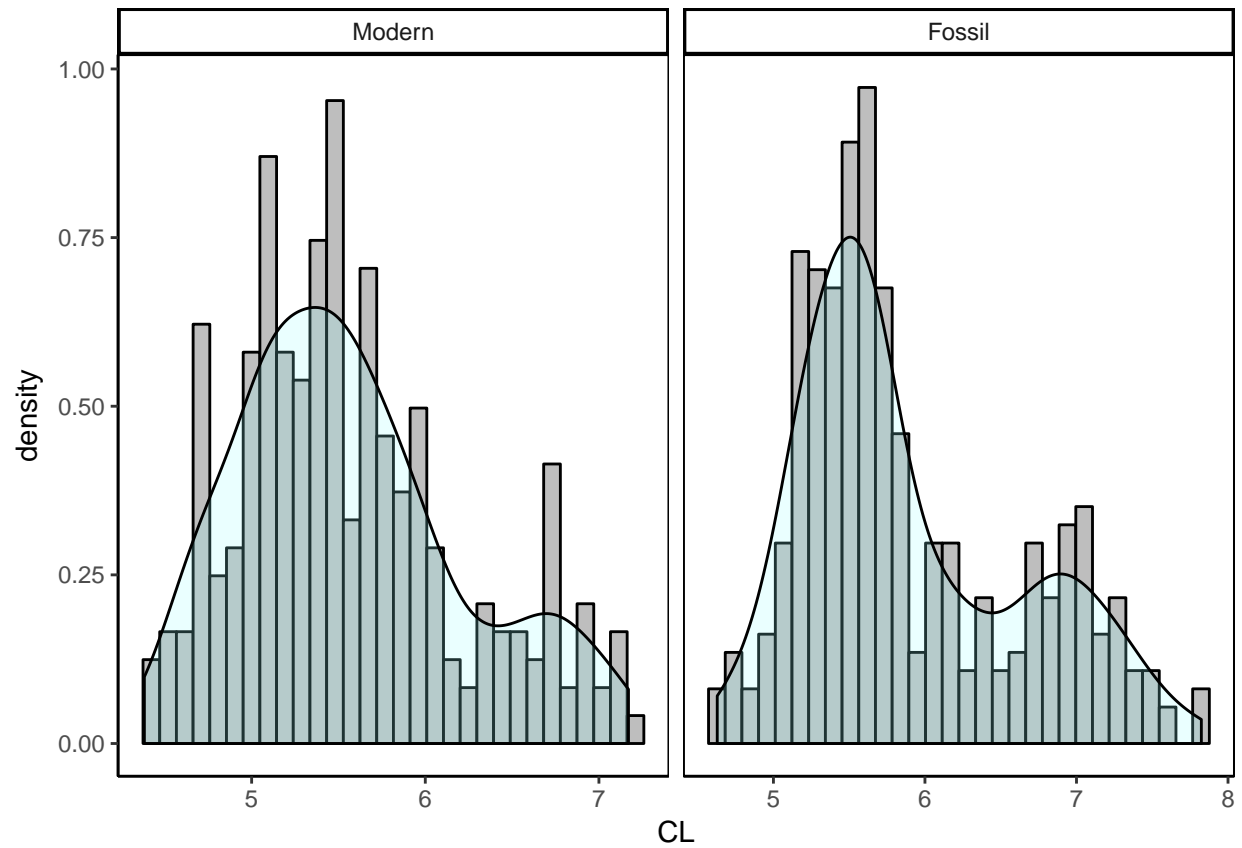


Figure 7: Distribution of body size data modern vs. fossil, logtransformed.

## modern vs. fossil, continental vs. insular

## `stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.

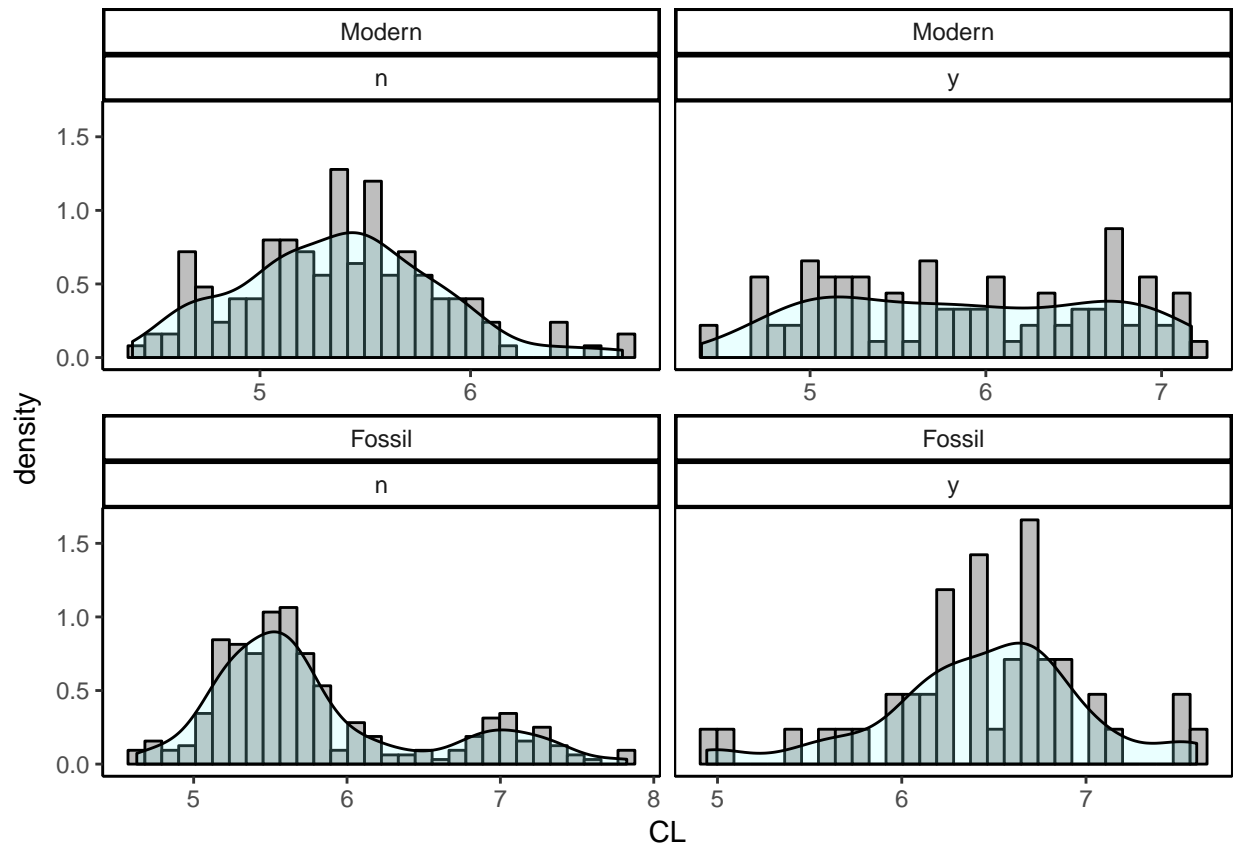


Figure 8: Distribution of body size data modern vs. fossil, continental vs. insular logtransformed.

## continental vs. insular

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

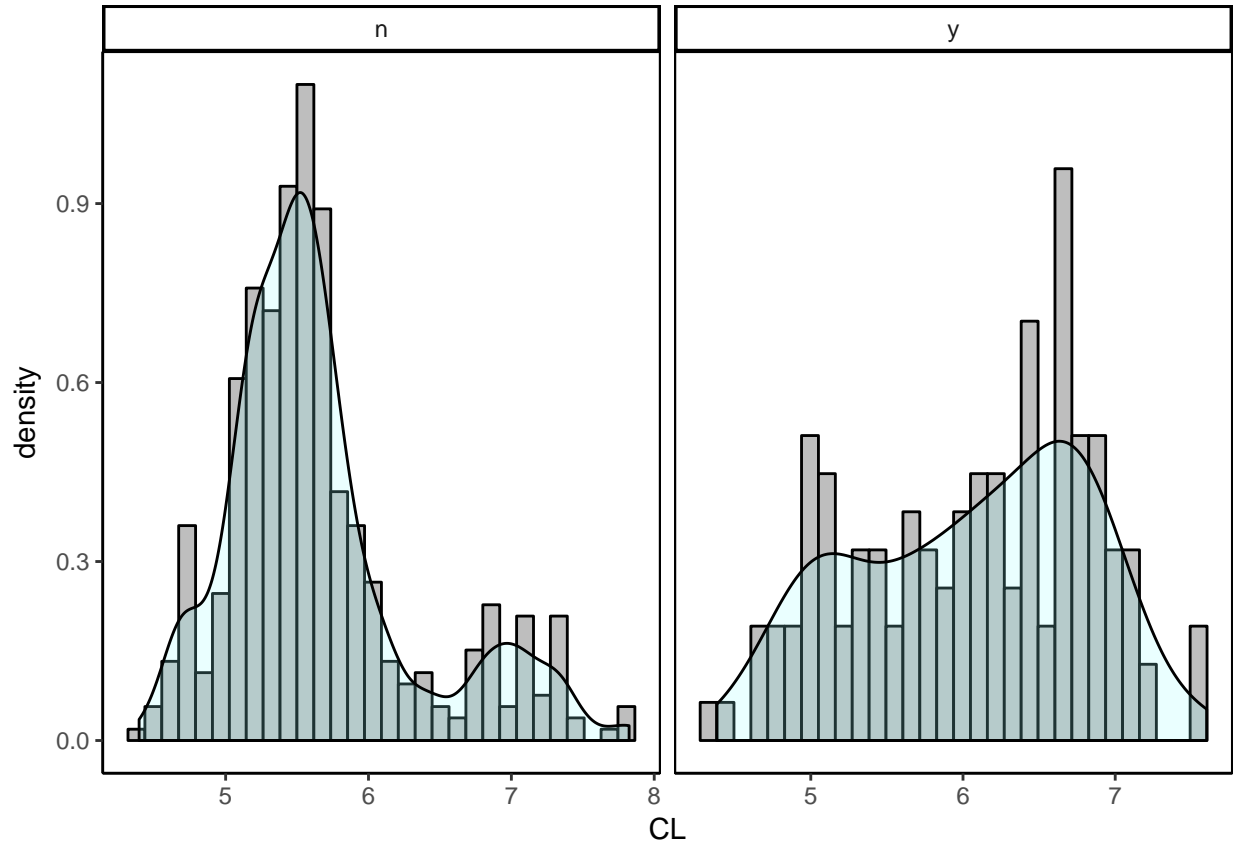


Figure 9: Distribution of body site data of continental (n) and insular(y) species, logtransformed.

## continents

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

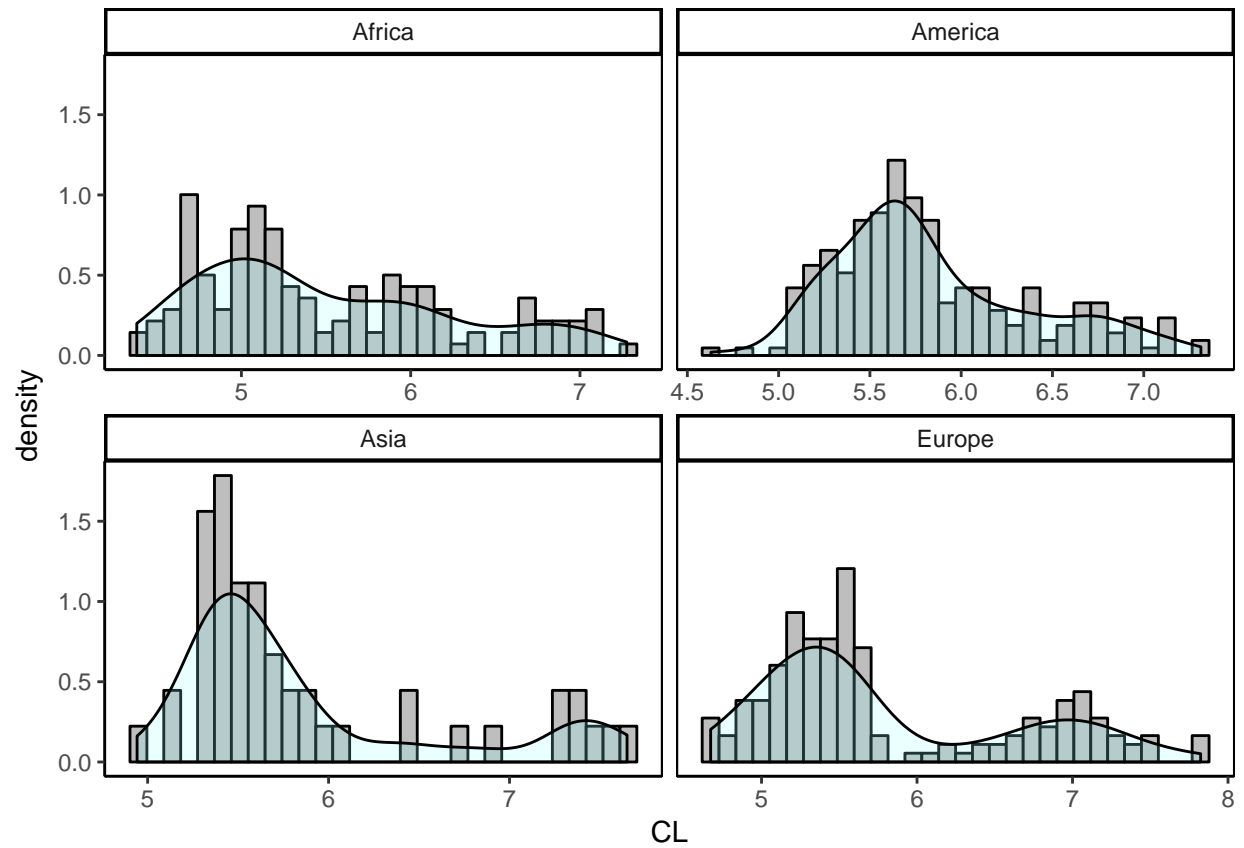


Figure 10: Distribution of body site data per continent, logtransformed.

## 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
587	80.00	2500.0	151134.500	421.5	2.5	270.0	2.4	2.25	0.72	8.80	2.84	all
251	80.00	1300.0	67716.645	328.9	2.4	242.0	2.4	1.85	0.60	5.91	2.73	Modern
47	102.44	1250.0	68679.401	441.9	2.6	334.7	2.5	1.26	0.24	3.85	2.66	Upper Pleistocene
48	132.00	1500.0	63574.869	360.3	2.5	288.8	2.5	2.95	1.50	11.95	5.69	Middle Pleistocene
50	107.80	2000.0	158500.376	446.2	2.5	261.2	2.4	1.99	0.81	6.84	2.69	Lower Pleistocene
24	118.90	1860.0	195107.416	333.4	2.4	186.2	2.3	2.60	2.07	8.39	5.95	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
24	176.00	2500.0	516172.479	953.5	2.8	847.5	2.9	1.08	-0.31	3.32	2.13	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
44	107.00	1540.0	178032.415	468.4	2.5	250.0	2.4	1.46	0.78	3.63	2.48	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
26	113.00	1100.0	79314.551	409.4	2.5	305.0	2.5	1.27	0.40	3.50	2.25	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
251	80.00	1300.0	67716.645	328.9	2.4	242.0	2.4	1.85	0.60	5.91	2.73	Modern
336	102.44	2500.0	202615.683	490.6	2.6	283.9	2.5	1.97	0.76	6.89	2.58	Fossil
446	81.00	2500.0	144598.709	379.1	2.5	250.0	2.4	2.79	1.11	11.62	3.96	continental
141	80.00	2000.0	149135.581	555.6	2.6	486.0	2.7	1.09	-0.25	4.39	2.03	insular
156	81.00	830.0	16385.916	241.9	2.3	220.5	2.3	1.97	0.29	8.59	3.02	modern-con
95	80.00	1300.0	119898.261	471.7	2.6	351.0	2.5	0.82	0.02	2.44	1.75	modern-ins
290	102.44	2500.0	198243.246	452.9	2.5	270.0	2.4	2.20	1.04	7.87	3.14	fossil-con
46	140.00	2000.0	167981.360	728.9	2.8	632.0	2.8	1.41	-0.45	5.23	3.61	fossil-ins
140	80.00	1446.0	92601.871	337.4	2.4	193.5	2.3	1.69	0.64	5.04	2.35	Africa
231	102.44	1500.0	72942.550	403.8	2.5	300.0	2.5	1.83	0.75	6.06	2.94	America
48	140.00	2100.0	290958.216	510.7	2.6	272.5	2.4	1.84	1.25	4.90	3.21	Asia



nCL	min	max	var	mean	logm	med	logmed	skew	logsk	kurt	logku	Variable
168	107.00	2500.0	257472.103	490.4	2.5	245.0	2.4	1.87	0.82	6.32	2.37	Europe

## Boxplots

genera per time bins

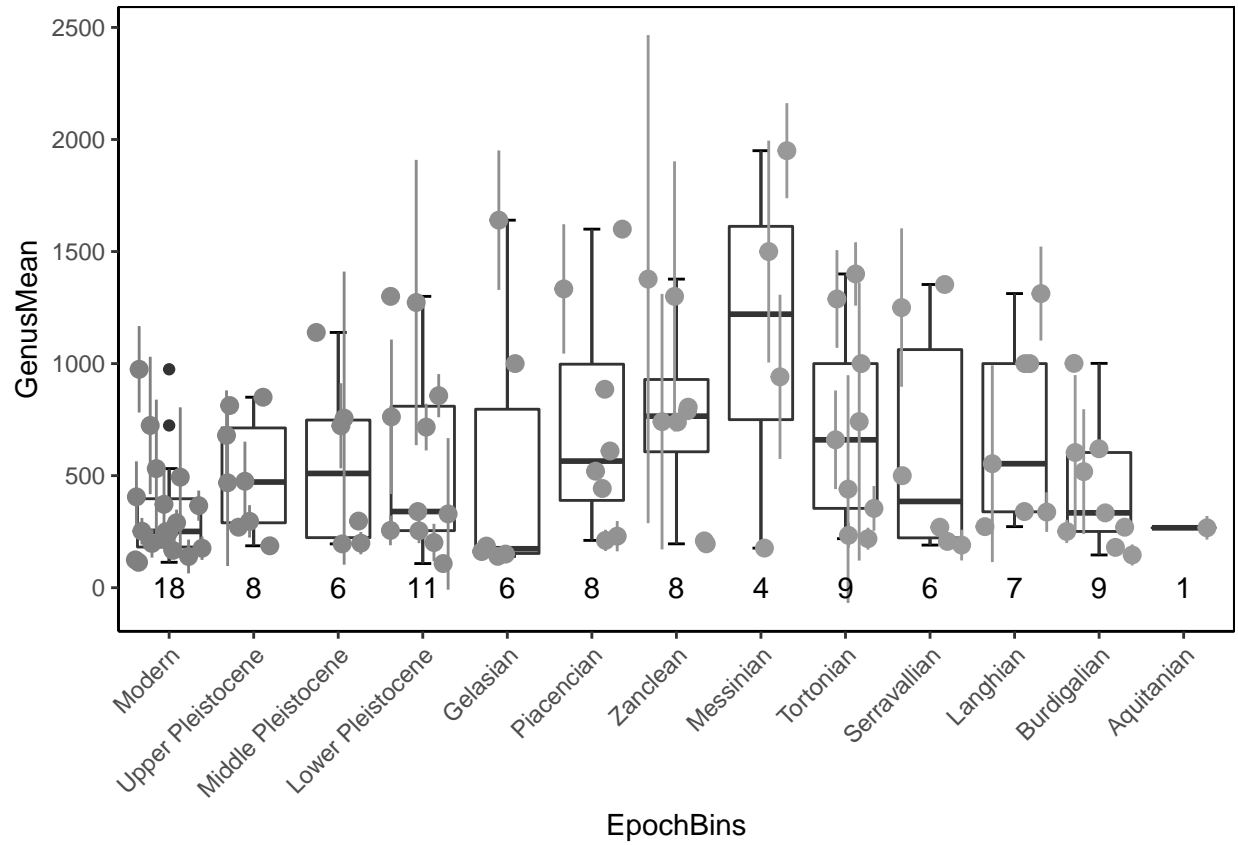


Figure 11: Boxplots of mean CL per time bin, including mean and sd CL for each genus (as pointrange).

continental vs. insular per time bin

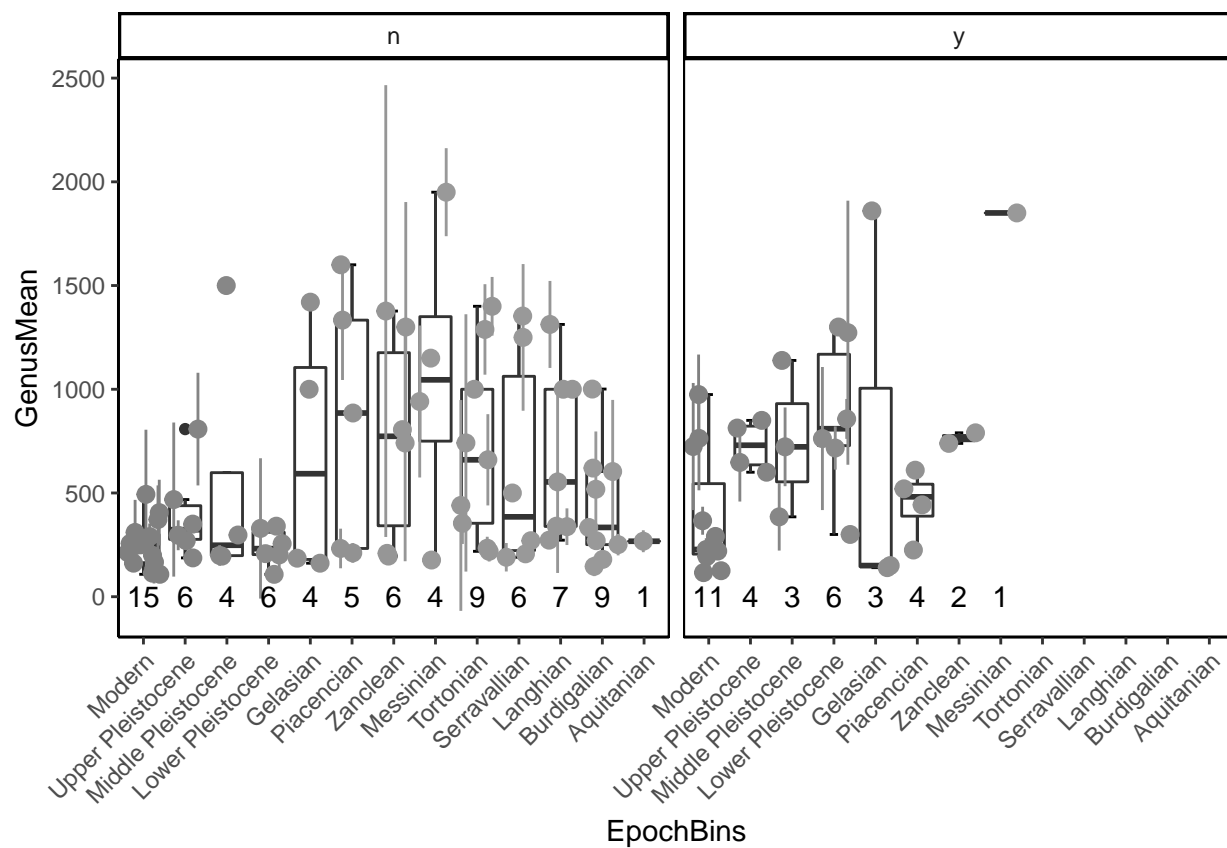


Figure 12: Boxplots of each genus per time bin, continental vs. insular species.

fossil vs. modern

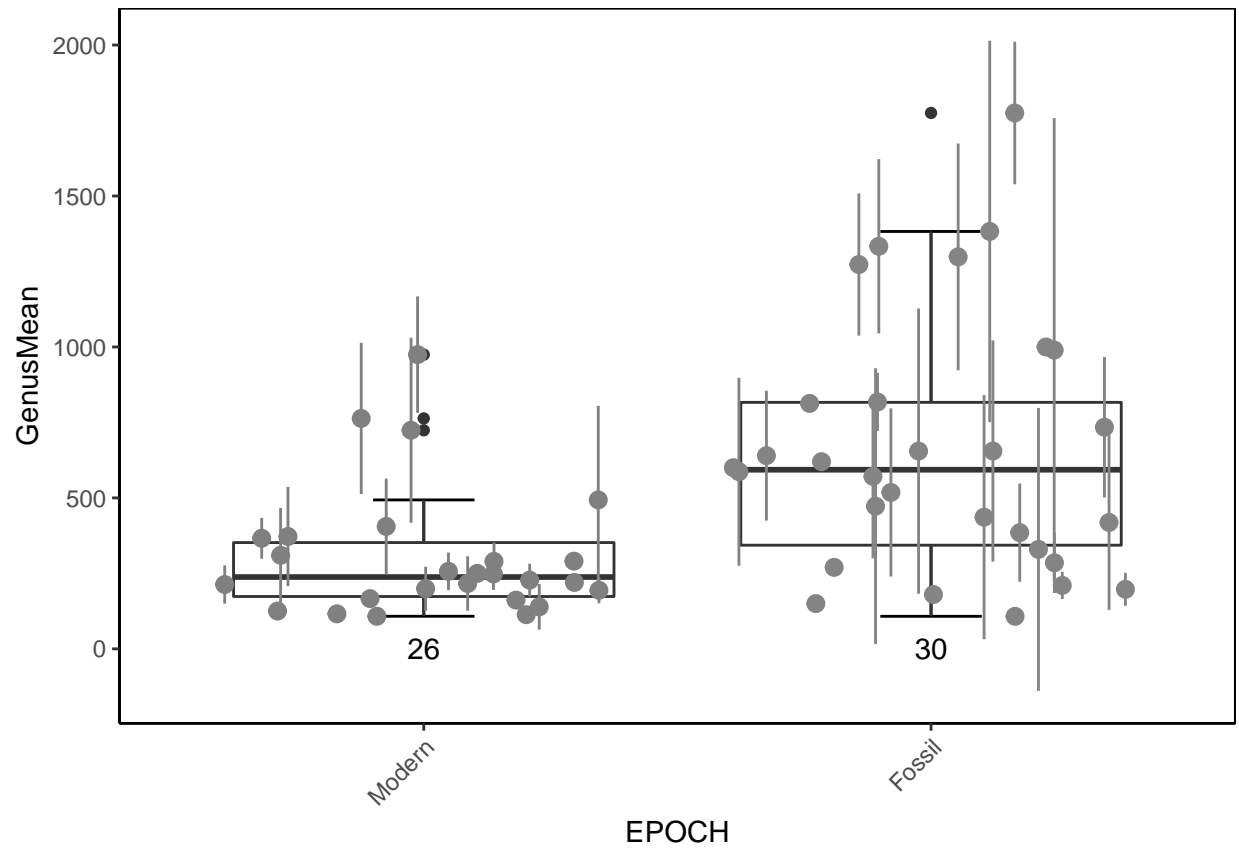
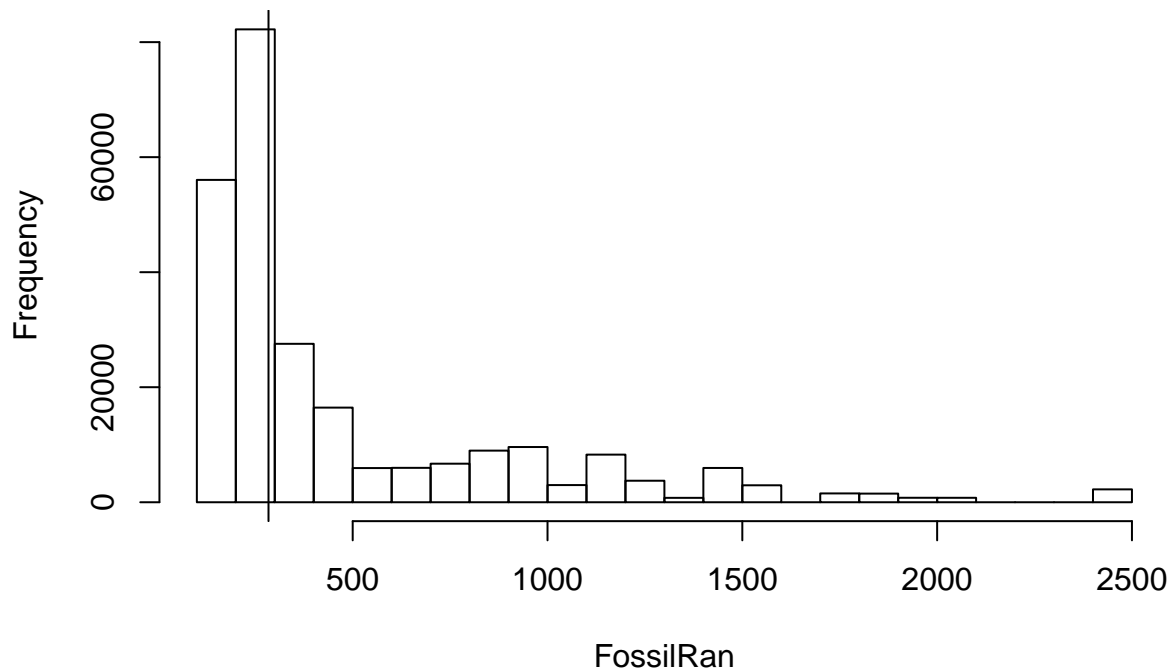


Figure 13: Boxplots fossil vs. modern.

## Histogram of FossilRan



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

```
## [1] 496.5105
```

```
##
```

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

```
##
```

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

```
## W = 23558, p-value = 5.119e-07
```

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

Wilcoxon Rank Sum Test (unpaired data):

modern < fossil ( $P = 5.1187799 \times 10^{-7}$ )

fossil vs. modern, continental vs. insular

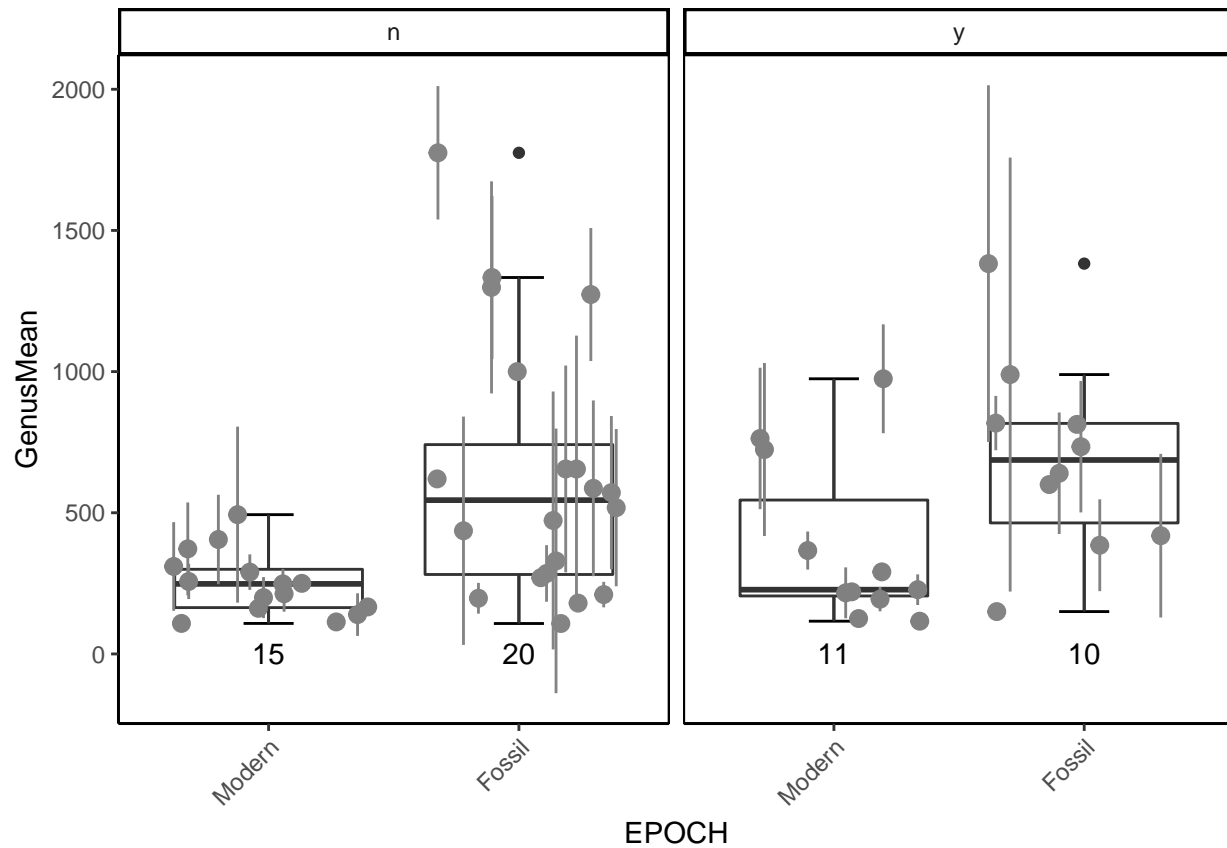


Figure 14: Boxplots fossil vs. modern, continental vs. insular species.

```
## [1] 46
## [1] 46
## [1] 728.8696
## [1] 445.0174
##
## Wilcoxon rank sum test with continuity correction
##
## data: ModernIsland and FossilIsland
## W = 591.5, p-value = 0.0001366
## alternative hypothesis: true location shift is less than 0
## [1] 156
```

```
## [1] 156

## [1] 241.8893

## [1] 443.6324

##
## Wilcoxon rank sum test with continuity correction
##
## data: ModernCon and FossilCon
## W = 8205.5, p-value = 3.296e-07
## alternative hypothesis: true location shift is less than 0
```

Wilcoxon Rank Sum Test (unpaired data):

modern continental < fossil continental ( $P = 3.2960424 \times 10^{-7}$ )

modern insular < fossil insular ( $P = 1.3658794 \times 10^{-4}$ )

## continental vs. insular

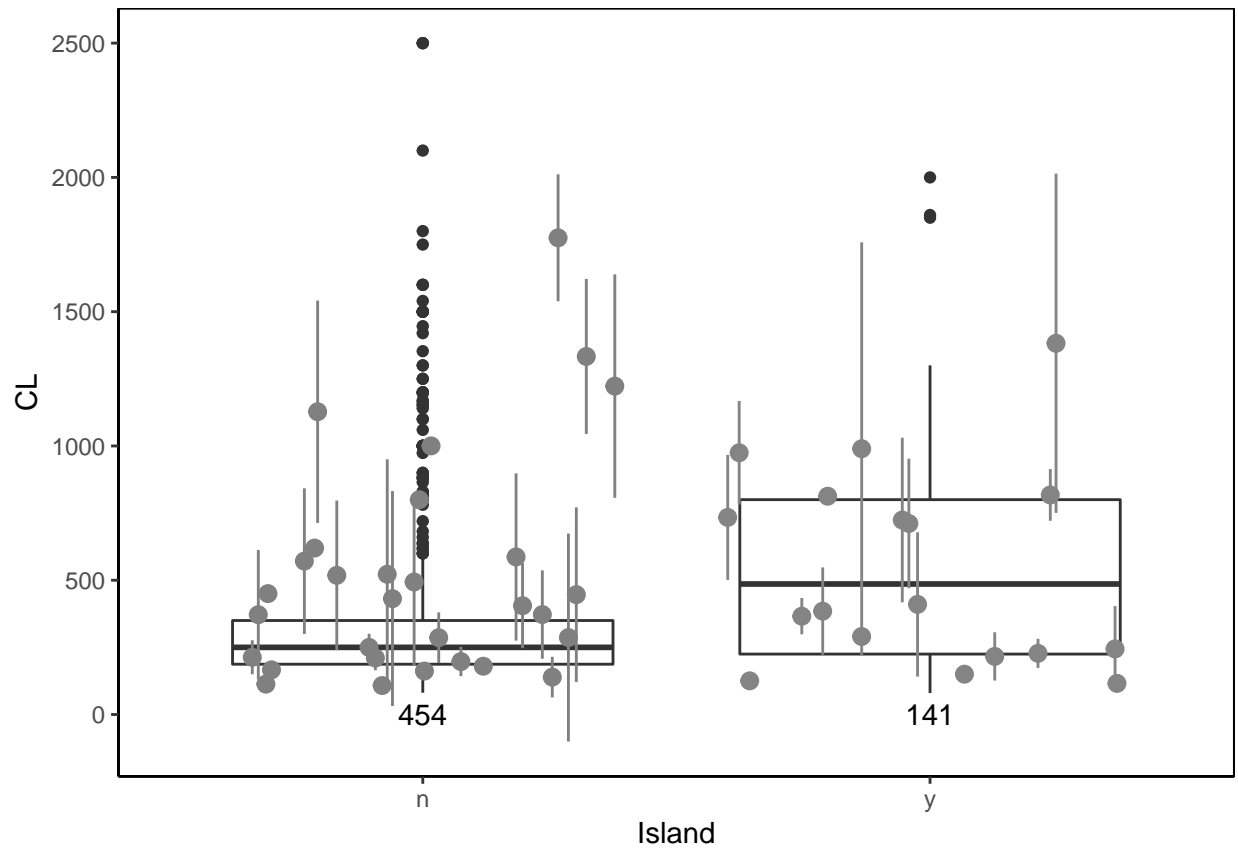


Figure 15: Boxplot continental vs. insular, genera summarised

```
## [1] 141
## [1] 141
## [1] 555.6149
## [1] 326.7837
##
## Wilcoxon rank sum test with continuity correction
##
## data: Insular and Continental
## W = 13799, p-value = 8.781e-09
## alternative hypothesis: true location shift is greater than 0
```

Wilcoxon Rank Sum Test (unpaired data):



continental < insular ( $P = 8.7805326 \times 10^{-9}$ )

# continental vs. insular per time bin

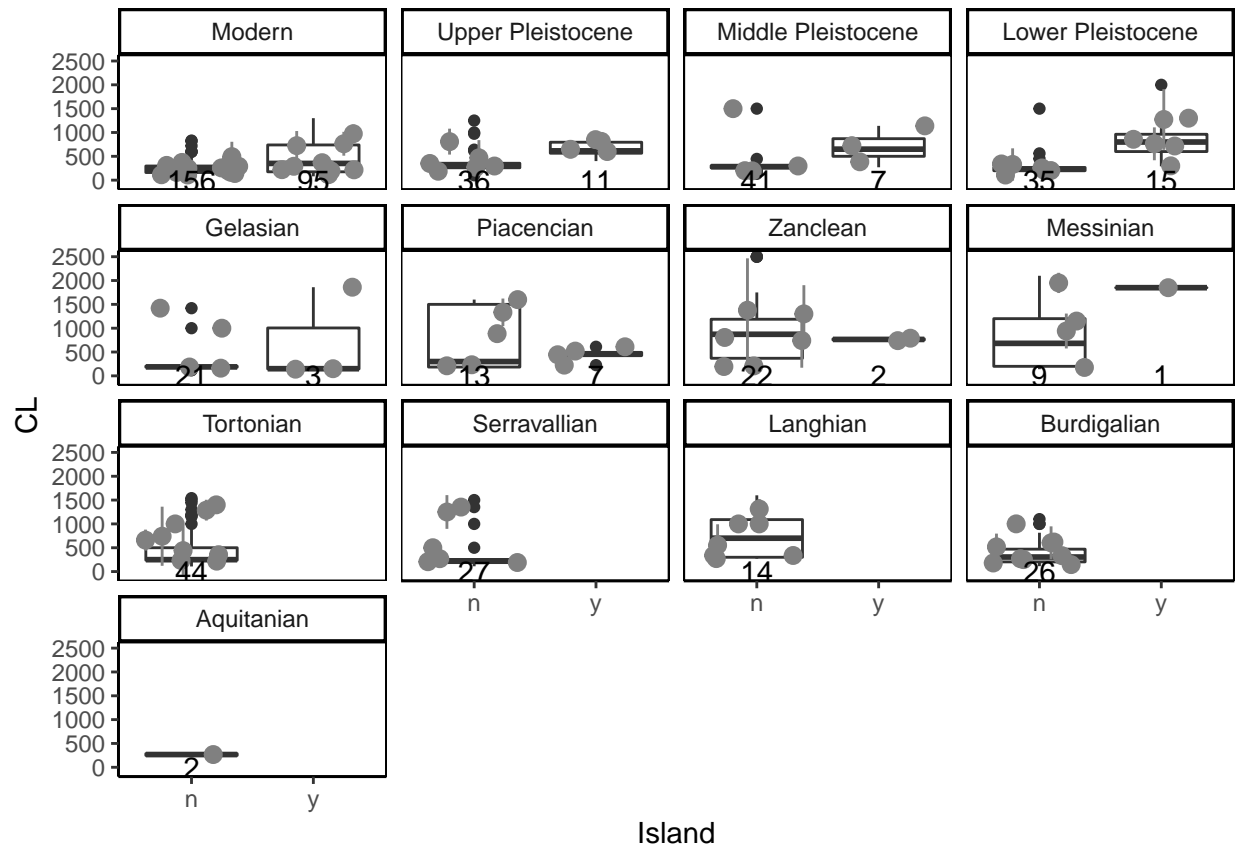


Figure 16: Boxplot continental vs. insular, genera summarised

continents

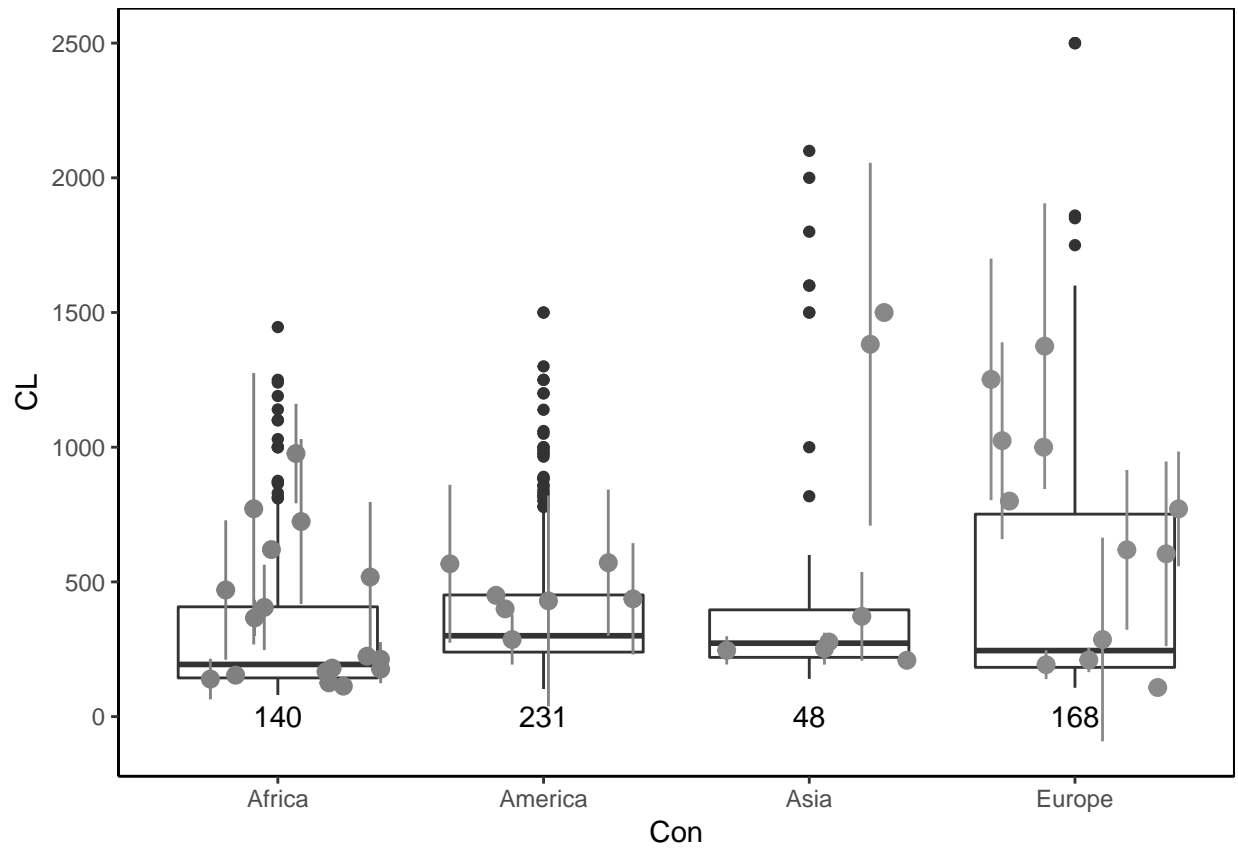


Figure 17: Boxplot: body size on different continents, genera summarised

```
## [1] 140
## [1] 337.37
## [1] 140
## [1] 420.2343
## [1] 140
## [1] 456.4843
##
## Kruskal-Wallis rank sum test
##
## data: list(Africa, America, Eurasia)
## Kruskal-Wallis chi-squared = 27.016, df = 2, p-value = 1.36e-06
```

Wilcoxon Rank Sum Test (unpaired data):

Continent means differ ( $P = 1.3602422 \times 10^{-6}$ ) (still have to look into the details...)

continents, continental vs. insular

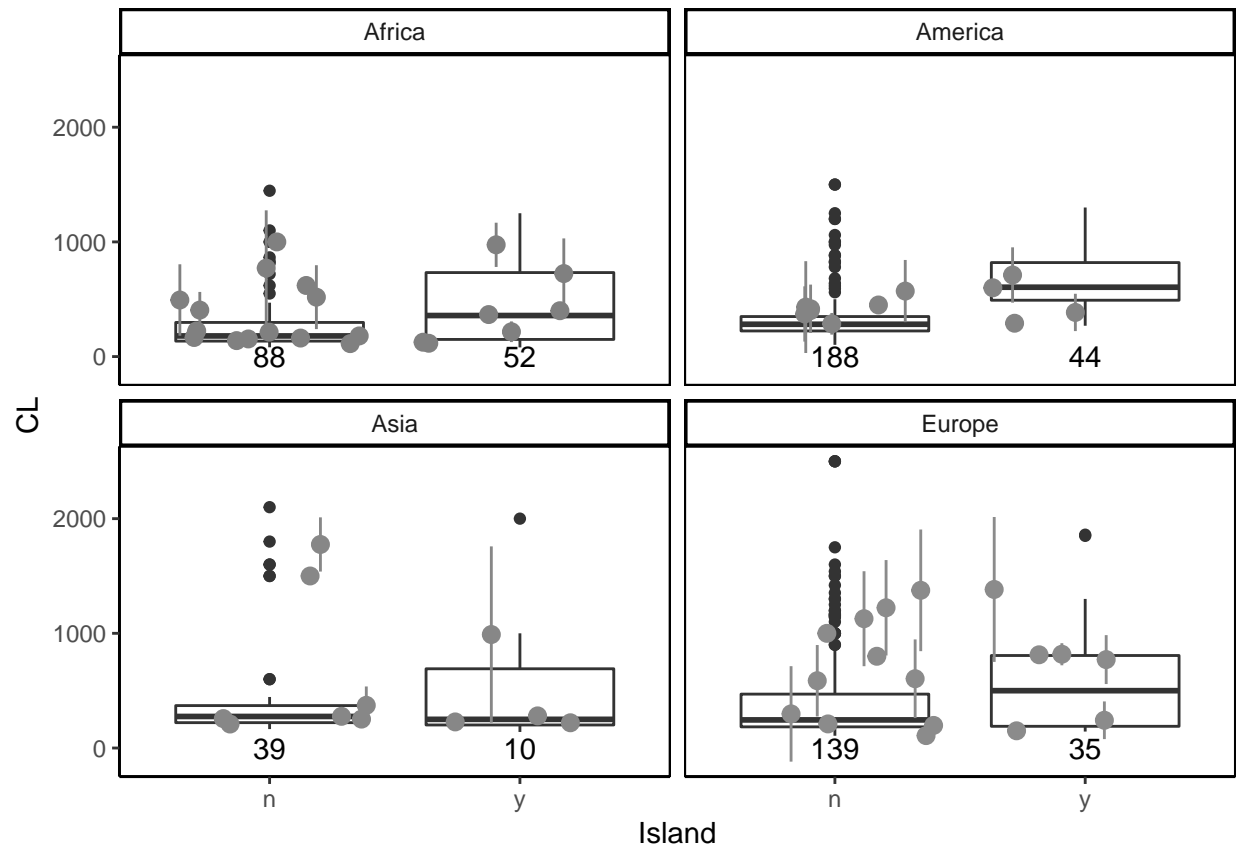


Figure 18: Boxplot: body size on different continents, genera summarised

## paleoTS analysis

all (continental and insular)

genera (all)

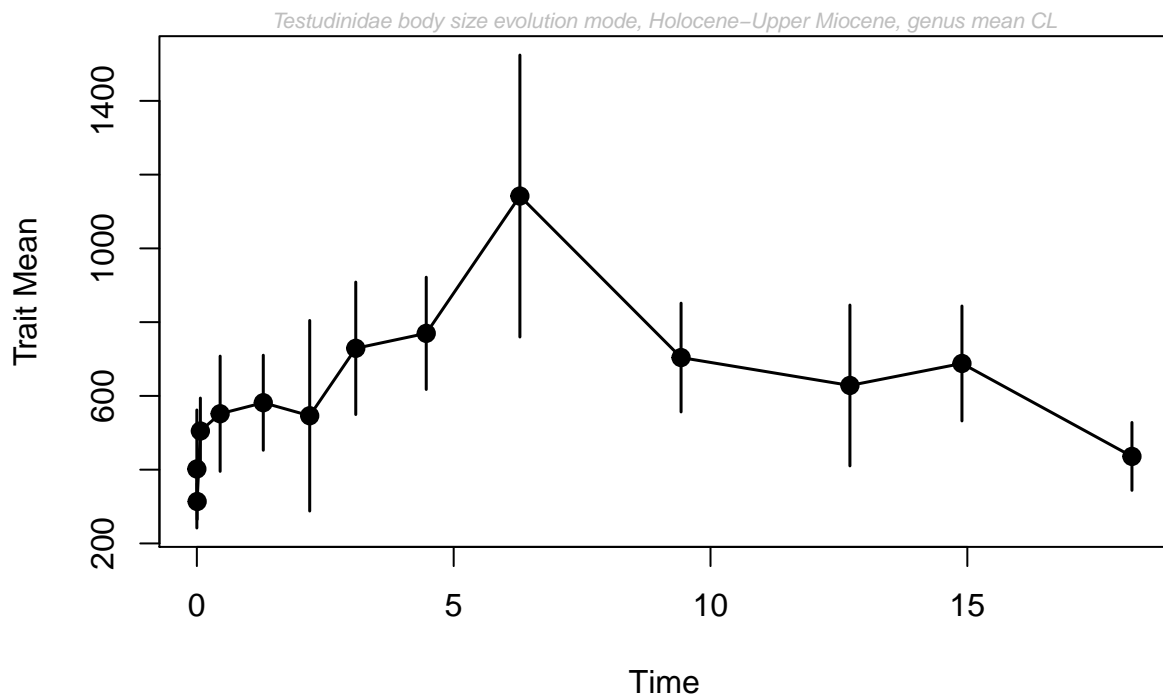


Figure 19: paleoTS plot with genus mean, including island species

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

	logL	K	AICc	Akaike.wt
GRW	-80.19819	2	165.7297	0.172
URW	-80.70616	1	163.8123	0.449
Stasis	-79.40796	2	164.1493	0.379

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

	logL	K	AICc	Akaike.wt
GRW	-80.19819	2	165.7297	0.169
URW	-80.70616	1	163.8123	0.440
Stasis	-79.40796	2	164.1493	0.372
StrictStasis	-83.85393	1	170.1079	0.019

continental (excluding insular species)

genera (continental)

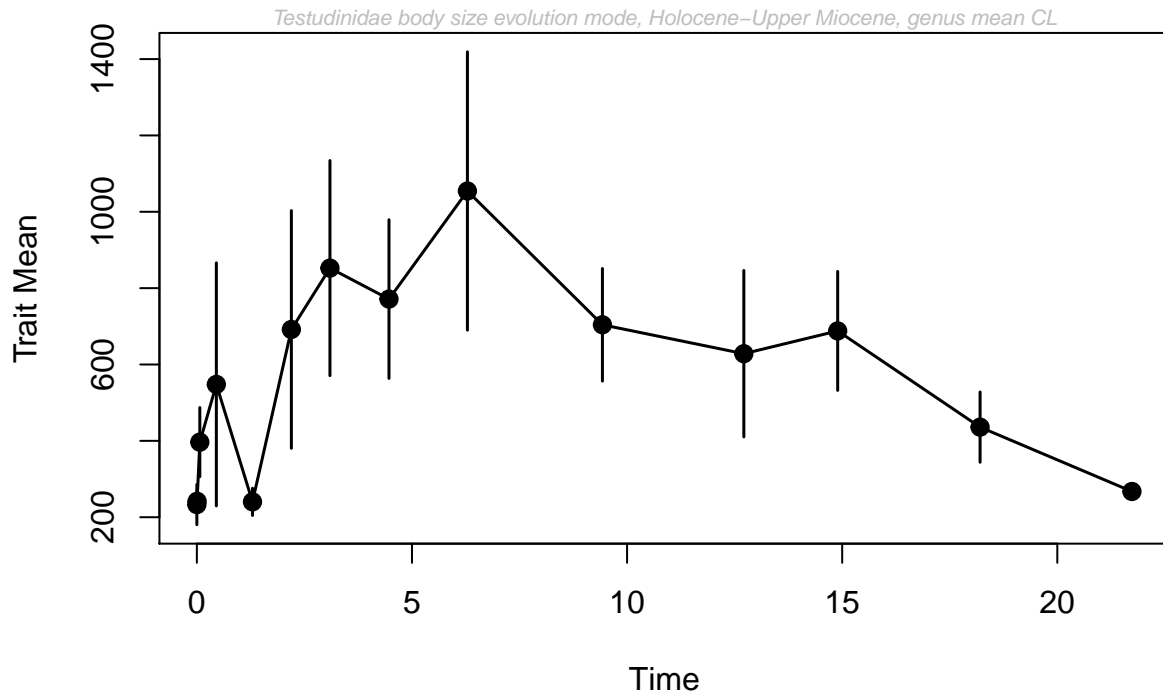


Figure 20: paleoTS plot with genus mean, excluding island species

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

	logL	K	AICc	Akaike.wt
GRW	-86.83104	2	178.8621	0.675
URW	-89.09081	1	180.5452	0.291
Stasis	-89.81705	2	184.8341	0.034



insular (excluding continental)

genera (insular)

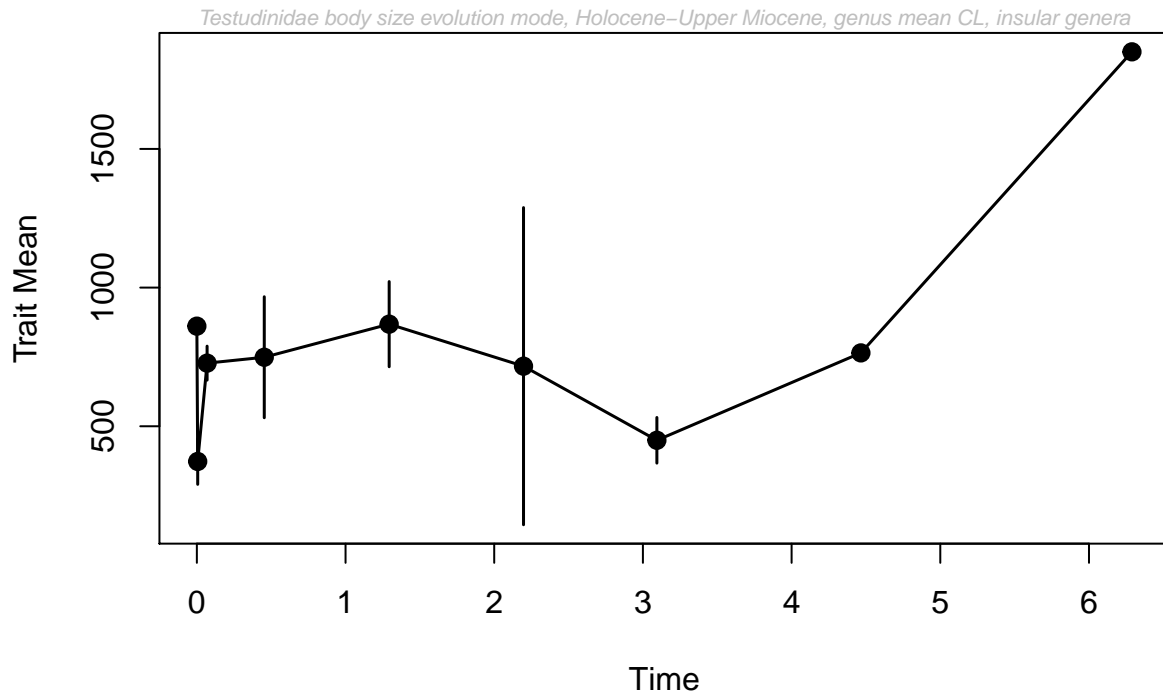


Figure 21: paleoTS plot with genus mean, only insular species

Table 6: 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

per continent

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

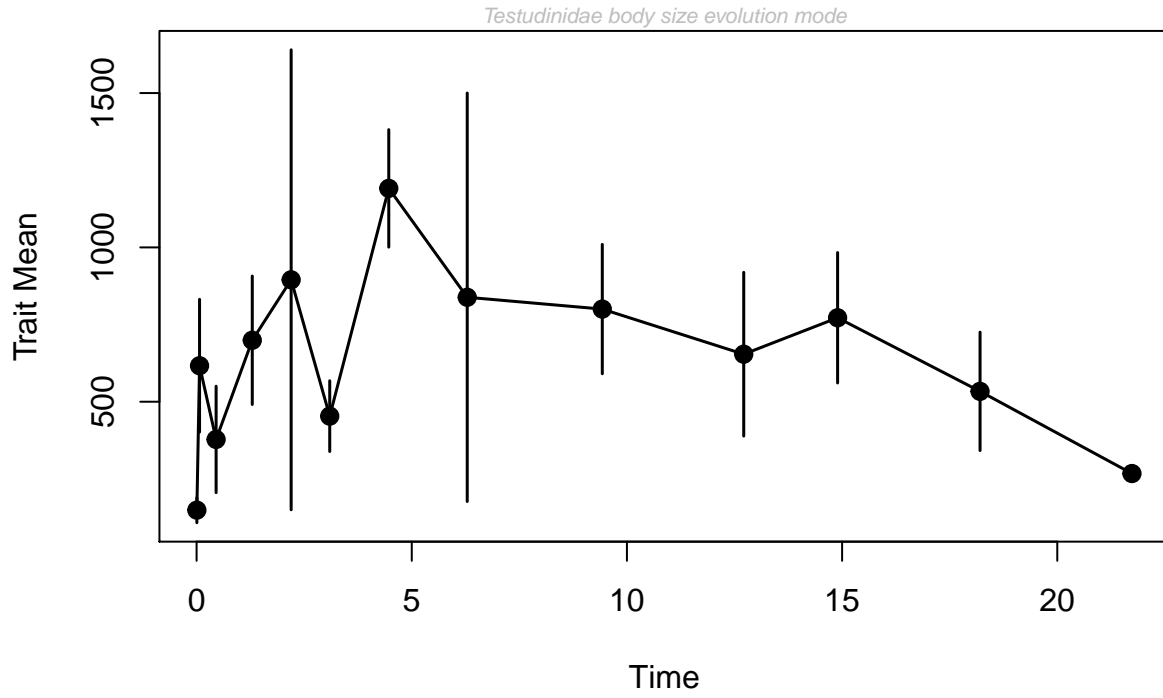


Figure 22: Smaller original bins, genera, Europe

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

	logL	K	AICc	Akaike.wt
GRW	-92.45812	2	190.2496	0.016
URW	-92.63487	1	187.6697	0.059
Stasis	-88.41042	2	182.1542	0.925

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

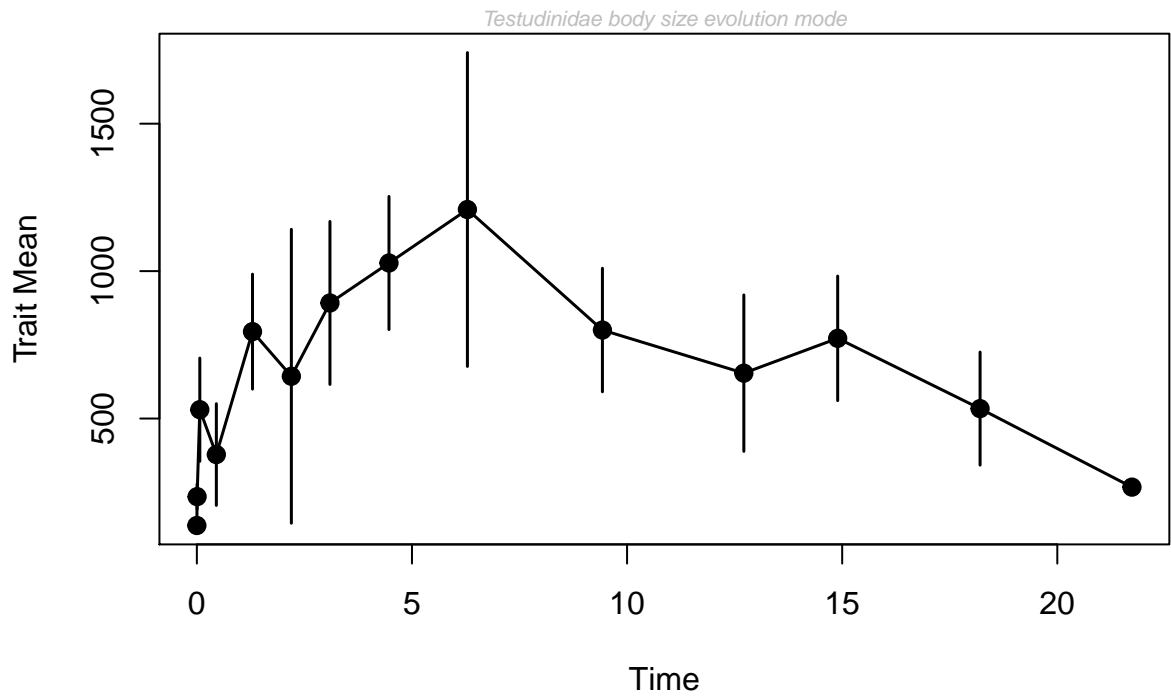


Figure 23: Smaller original bins, genera, Eurasia

Table 8: Model-fitting results for testudinidae, no bins, genera

	logL	K	AICc	Akaike.wt
GRW	-92.32504	2	189.8501	0.251
URW	-93.14200	1	188.6476	0.457
Stasis	-92.17373	2	189.5475	0.292