

Body size trends in Neogene tortoises

Did tortoises evolve towards a smaller body size?

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Introduction
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Material & Methods
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Body size distribution
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Differences
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Body size trends
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Summary
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Body size trends in Neogene tortoises

Terrestrial Tortoises

- 2 clades:

Body size trends in Neogene tortoises

Terrestrial Tortoises



Rhodin et al. (2015)

- 2 clades:
 - \dagger Meiolaniidae
(Australia, S-America)

Body size trends in Neogene tortoises

Terrestrial Tortoises



Rhodin et al. (2015)



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 - Testudinidae (extant terrestrial tortoises)

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→ oldest fossils from N-America + Europe (Eocene)

Terrestrial Tortoises



Rhodin et al. (2015)

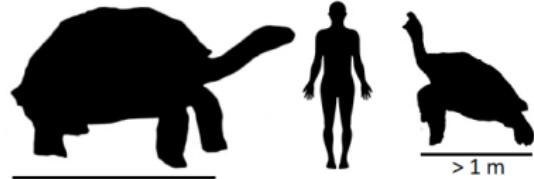


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- 2 clades:
 - † Meiolaniidae (Australia, S-America)
→ Lower Cretaceous – Holocene
 - Testudinidae (extant terrestrial tortoises)
→ oldest fossils from N-America + Europe (Eocene)
- throughout Earth's history: many large forms

Body size trends in Neogene tortoises

Largest tortoises

*Megalochelys atlas**Centrochelys sulcata*

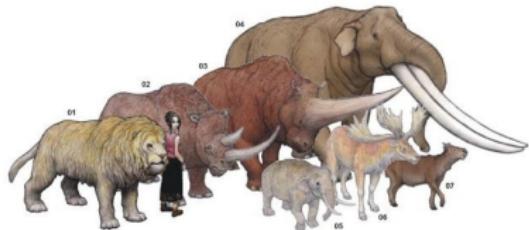
80 cm

*Chelonoidis sp.*

Body size trends in Neogene tortoises

Megafauna

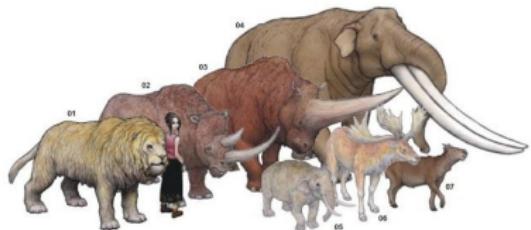
- animals with body mass $> 44 \text{ kg}$ = megafauna



Megafauna da Eurásia: leão das cavernas (01 - *Panthera l. spelaea*), rinocerontes peludos (02 - *Coelodonta* e 03 - *Elasmotherium*), elefantes gigantes (04 - *Stegodon*) e anões (05 - *Elephas falconeri*), cervos gigantes (06 - *Sinomegaceros*) e cabrito (07 - *Myotragus*). Assim como na África, a parte continental foi relativamente pouparada, mas as ilhas (especialmente as mediterrâneas) foram arrasadas.

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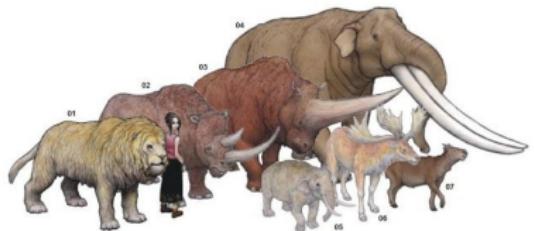
Megaflora



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- mammalian megafauna: probably went extinct due to human influence!

Megaфаuna



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- animals with body mass $> 44 \text{ kg}$ = megaфаuna
- mammalian megaфаuna: probably went extinct due to human influence!
- megaфаuna extinctions → humans or climate change?

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① Body size distribution of Testudinidae?

Body size trends in Neogene tortoises

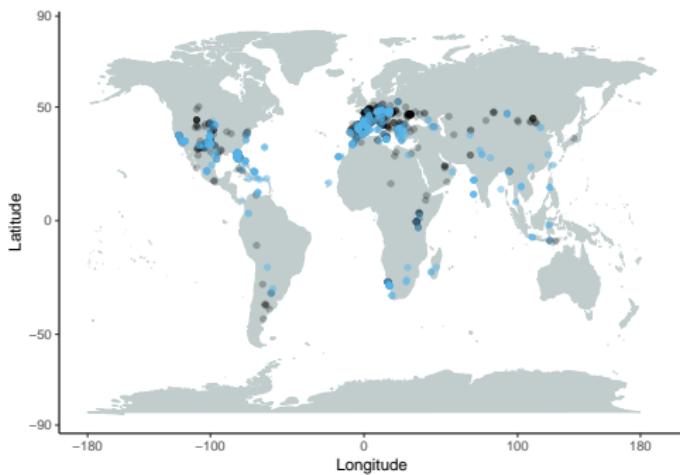
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Body size trends in Neogene tortoises

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Body size trends in Neogene tortoises

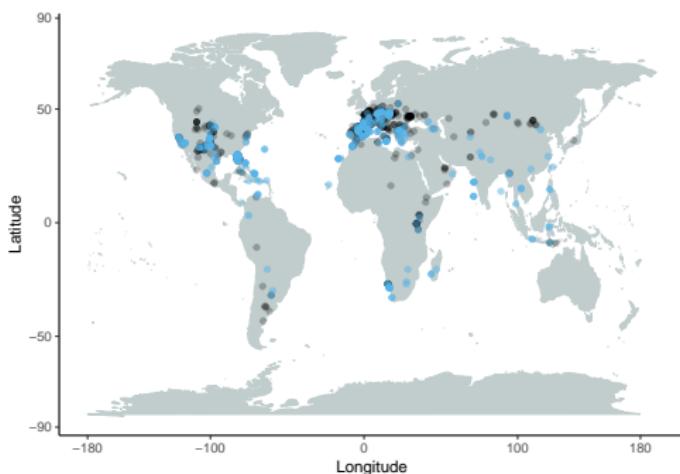
Data set



- occurrences (black): 796 individuals, 647 localities (Eocene – recent)

Body size trends in Neogene tortoises

Data set



- occurrences (black): 796 individuals, 647 localities (Eocene – recent)
- body size data (blue): 376 individuals, 193 localities (Miocene – recent) (106 loc in FFB)

Carapace length measurements/estimations



Straight carapace length [mm]

Body size trends in Neogene tortoises

Carapace length measurements/estimations



exact measurements
(literature)



Straight carapace length [mm]

Carapace length measurements/estimations



exact measurements
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CL estimations
- plastron length
- femora/humeri lengths



Straight carapace length [mm]

Carapace length measurements/estimations



exact measurements
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Straight carapace length [mm]

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- plastron length
- femora/humeri lengths



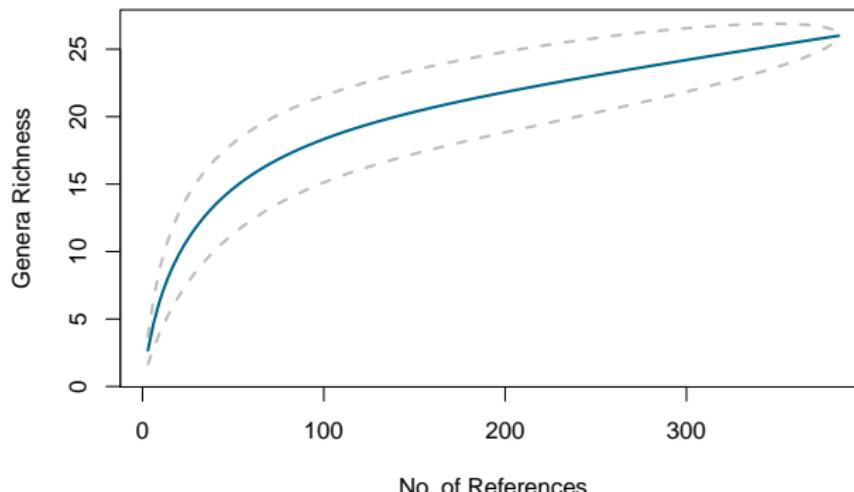
Methods

- sampling accumulation curves to check if sampling was sufficient

Body size trends in Neogene tortoises

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 - use genera
- histograms/density plots and boxplots (plus kruskal-wallis test, wilcoxon rank test)

Methods

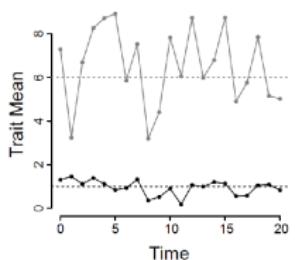
- sampling accumulation curves to check if sampling was sufficient

→ use genera

- histograms/density plots and boxplots (plus kruskal-wallis test, wilcoxon rank test)

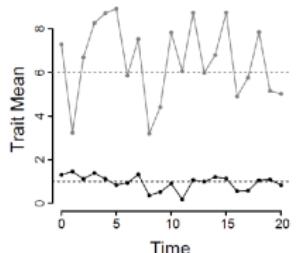
- paleoTS: fit different models to evolutionary trajectory of testudinid body size

Body size trends in Neogene tortoises

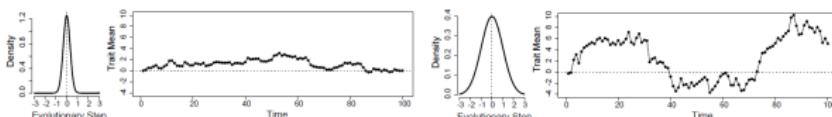


Stasis (change fluctuates around mean)
net change = 0

Body size trends in Neogene tortoises



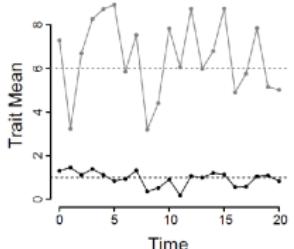
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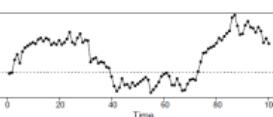
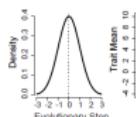
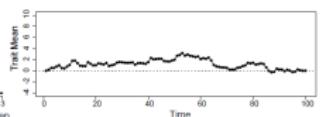
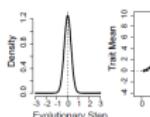
URW (unbiased random walk = non-directional change)

Hunt & Carrano, 2010

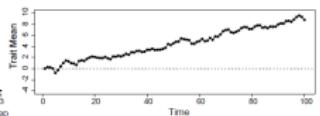
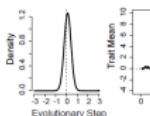
Body size trends in Neogene tortoises



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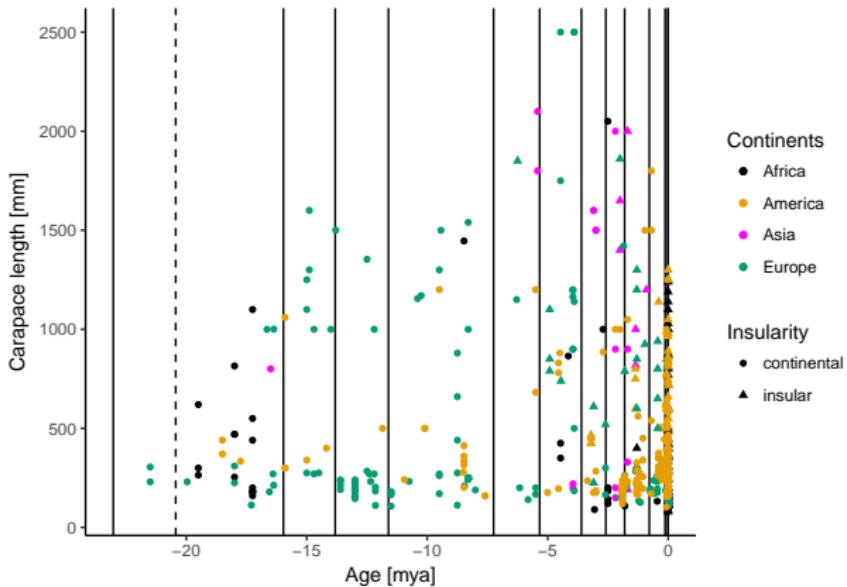
URW (unbiased random walk = non-directional change)



GRW (generalized random walk) =
directional change

Hunt & Carrano, 2010

Body size trends in Neogene tortoises

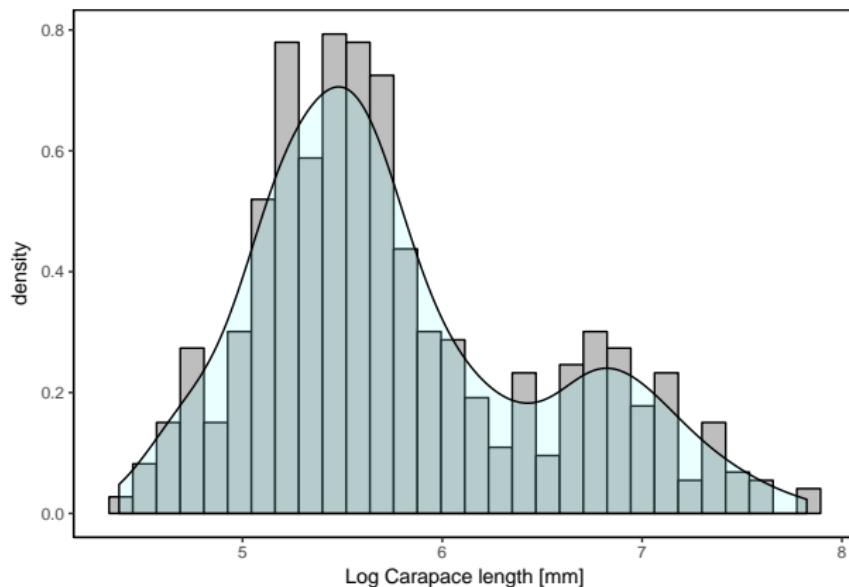


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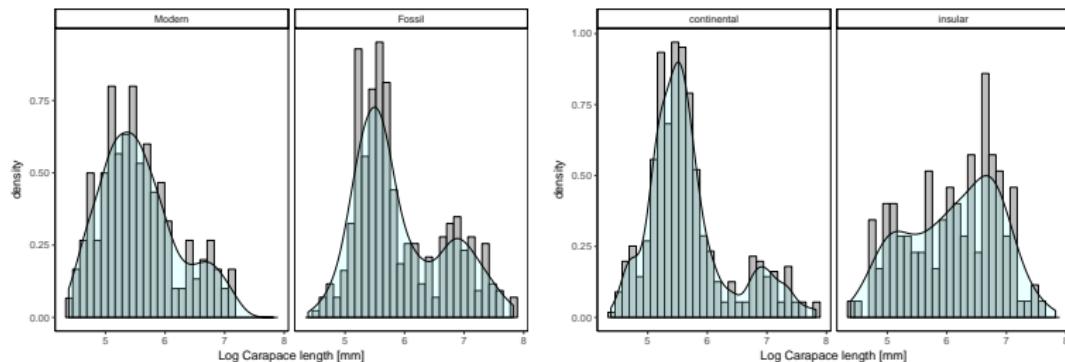
Body size distribution – complete data set



- bimodal distribution – right-skewed: small body sizes are more frequent

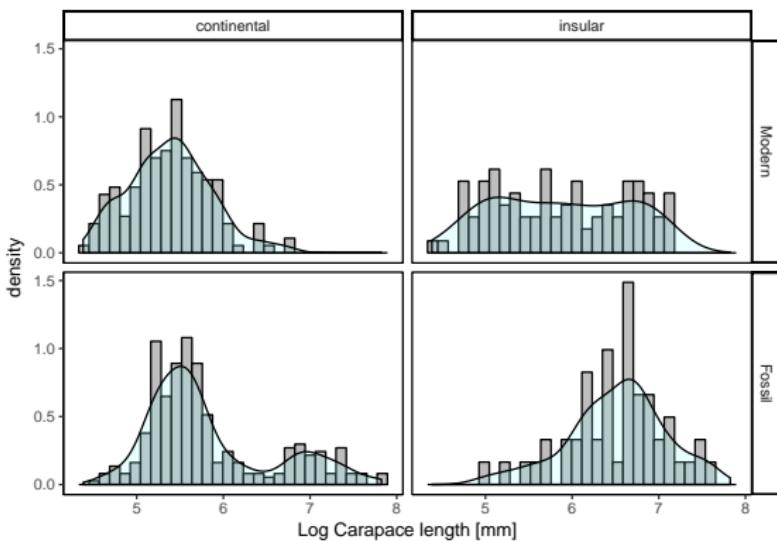
Body size trends in Neogene tortoises

Body size distribution – subsets



- islands: higher abundance of larger-bodied tortoises (left-skewed)

Body size trends in Neogene tortoises



- modern continents: no large taxa!

Body size trends in Neogene tortoises

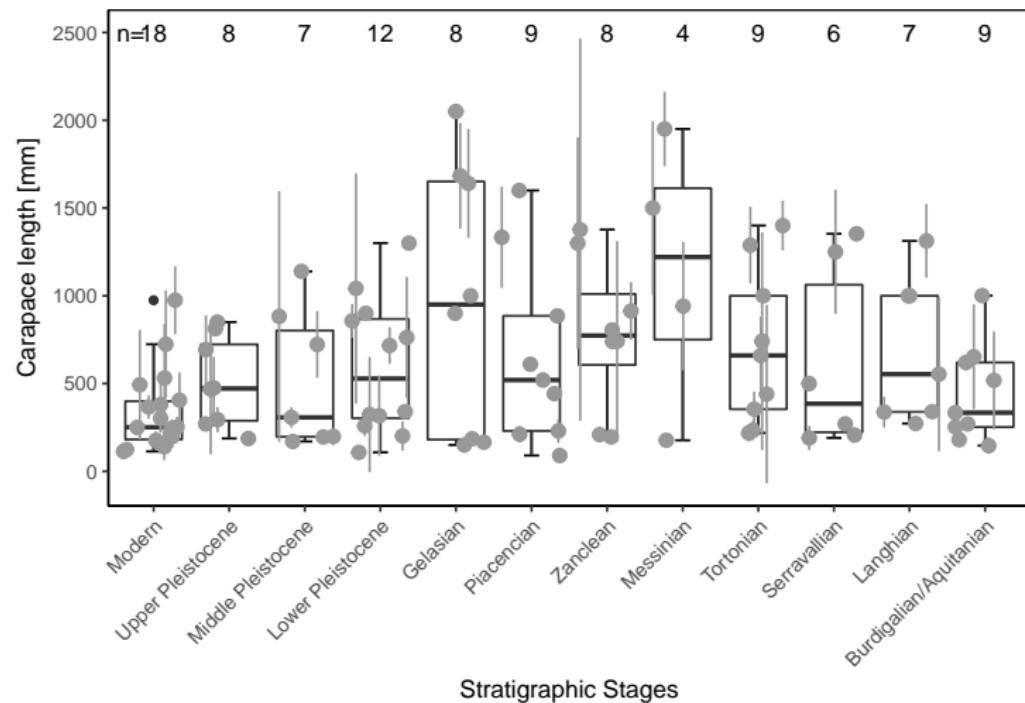
- right-skewed body size distributions frequent in animal record: smaller animals usually more abundant - WHY? (competition, take up less space, need fewer resources, shorter generation times etc.)
- left-skewed on islands: island rule? (has been found for turtles in other studies → Angielzcyk + Jaffe??)
- relatively constant through time

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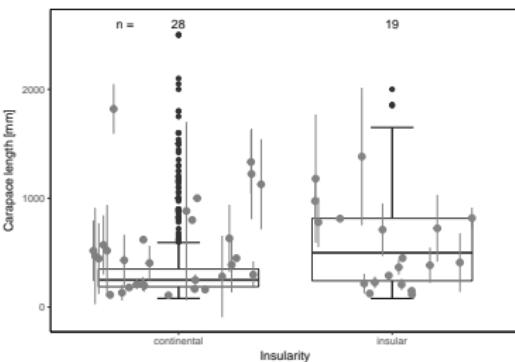
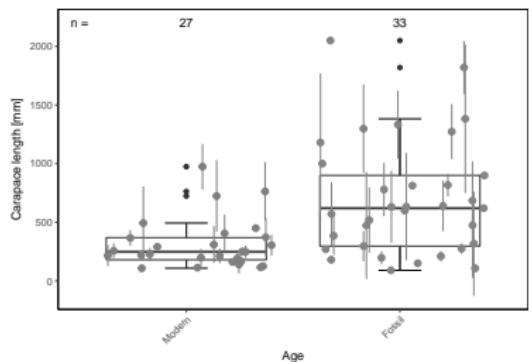
Comparison across time bins



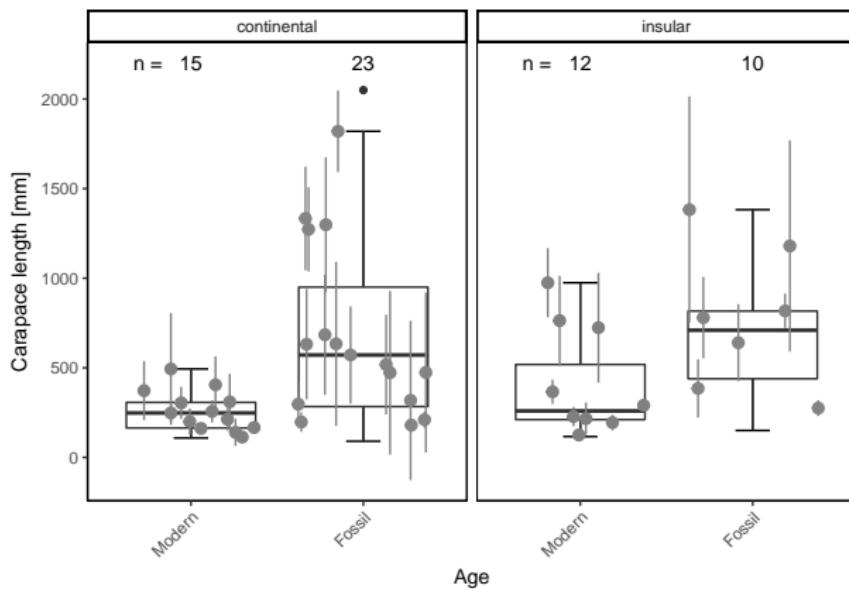
- only significant differences: Modern < Upper Pleistocene,

Body size trends in Neogene tortoises

Modern < fossil, continental < insular



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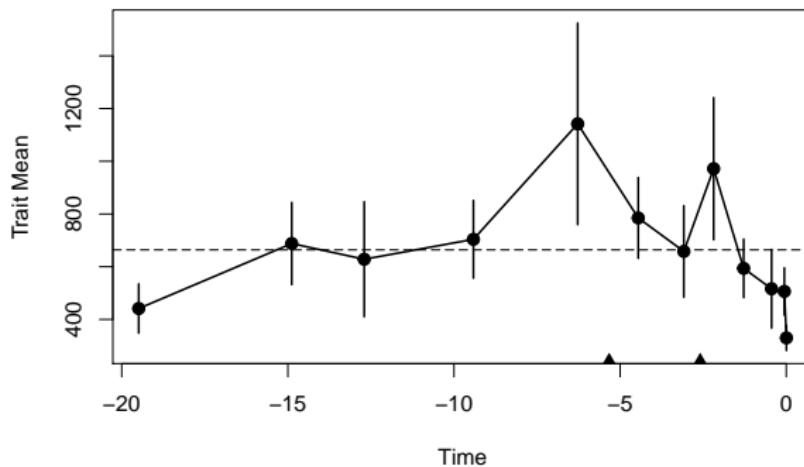


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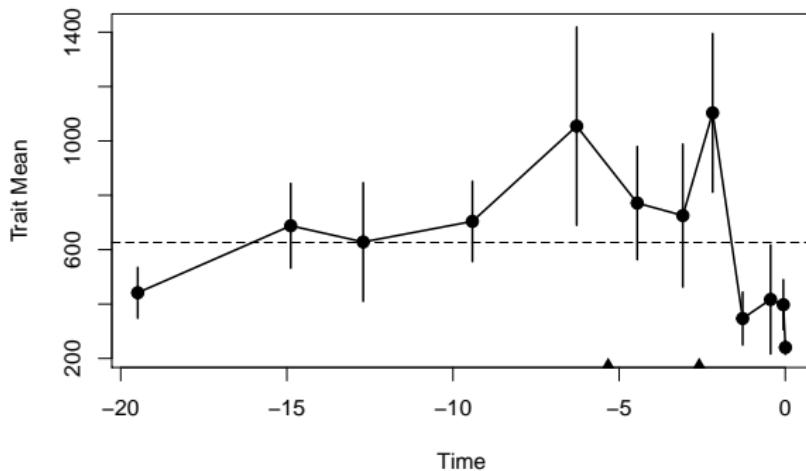
Body size trends in Neogene tortoises

Time-scale analysis



complete dataset → stasis

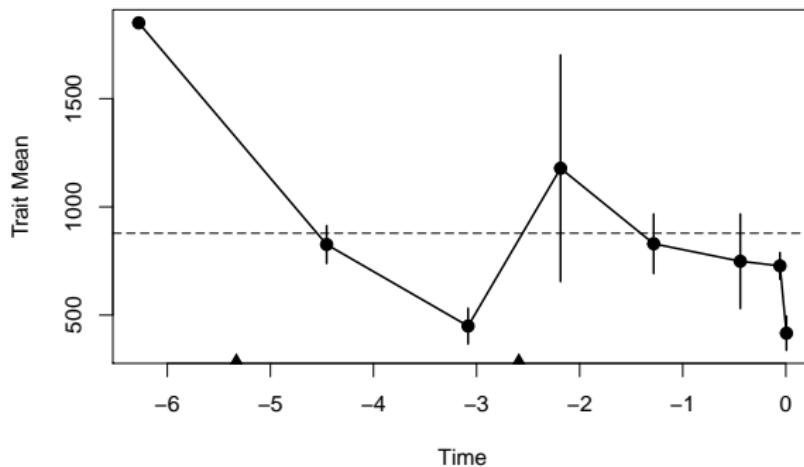
Body size trends in Neogene tortoises



continental dataset →unbiased random walk (URW)

Body size trends in Neogene tortoises

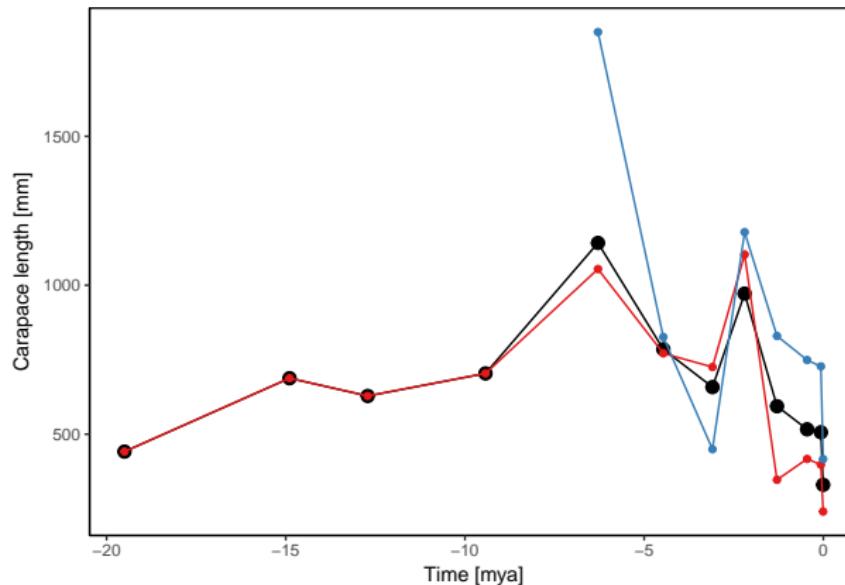
Time-scale analysis



insular dataset → stasis

Body size trends in Neogene tortoises

Time-scale analysis



black: complete dataset (stasis), red: continental (URW), blue: insular (stasis)

Body size trends in Neogene tortoises

- in total no significant change in body size in general and on islands

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- in total no significant change in body size in general and on islands
- non-directional change on continents →size-biased extinction (giant tortoises)

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Pleistocene extinction

- human influence

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 - many records of exploitation of tortoises around the world
 - in some areas tortoise body size as proxy for human population size
- climatic influence
 - giant tortoise cannot cope with cold winters –*i* too large to burrow
 - run risk of overheating (e. g. Aldabra Atoll: overheating main reason for death)

Thank you!