HUMBOLDT-UNIVERSITÄT ZU BERLIN

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INSTITUT FÜR BIOLOGIE

MASTERARBEIT

ZUM ERWERB DES AKADEMISCHEN GRADES

MASTER OF SCIENCE

"Körpergrößentrends in fossilen Landschildkröten aus dem Neogen"

"Body size trends in Neogene testudinid tortoises"

vorgelegt von

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Contents

List of Figures

List of Tables

1 Introduction

- Body size as a trait (read Smith, Smith & Lyons) and over time why is it interesting? is there an optimal body size for every organism? how can it be determined? (–> stasis??)

- evolutionary models (read Gene Hunt's paper and Posada, 2003) –> make sense of evolutionary modes: * stasis * unbiased random walk * generalized random wallk

- body size in tortoises (why not use biomass?) - distribution of tortoises (?) - giant tortoises well suited for drifting on ocean currents (Meylan, 2000)

OR -megafauna –> giant tortoises

- human and climatic influence

- purpose of this work: determine body size trends in tortoises and identify evolutionary mode (if possible). what lead to extinction?

2 Material & Methods

2.1 Data collection

I collected data on body size of fossil testudinids from the Miocene until recent times. The body size data set includes 30 genera, comprising over 100 fossil species. The majority of the data was obtained from the primary literature (Table **??**). To find relevant publications, I relied mostly on the references listed in FosFarBase (CITE), PDBD (cite), and "Fossil Turtle Checklist (CITE). Furthermore, the FosFarBase provided fossil occurences of testudinids all over the world, including their exact localities and age (Table **??**), which were used to get an overview over the availability of body size data. For extant taxa, I measured dry material (n = 67) from the collection of the Museum für Naturkunde zu Berlin (MFN). In addition, body size data from the literature was included (Table **??**).

2.2 Body size estimation

Body size is reported as straight carapace length (SCL). Where SCL was not available from the primary literature, it was estimated either from plastron length (PL) or appendicular elements (Table **??**). For carapace length estimations based on plastron length, the measurements from the MFN collection material was used to calculate the ratio between SCL and PL. Since the SC/PL ratio was similar for all species and genera, a single general ratio was calculated for all testudinids and hence used for the SCL estimations unless stated otherwise (Table **??**). For estimations based on femora and humeri, the ratio provided by Hutterer et al. (1998) and Franz et al. (2001), respectively, were used. A number of publications did not state measurements but instead provided scaled figures of the fossil remains, from which SCL, PL or humeri and femur lengths could be measured.

2.3 Analyses

All subsequent analyses were performed with R (version 3.4.1), including the packages dplyr (cite) to prepare the data for the analysis (???) and ggplot2 (cite) to create figures. Sampling Accumulation Curves were created with the R package vegan (Cite) to see if sample size sufficed. This was repeated on genus level, since genera of fossil testudinids are relatively well resolved by now whereas determination on the species level is still somewhat obscure in many cases, as some species were based on scarce material. Since the data set relies on literature, occurrences increase with each added reference and reach a maximum, when no new species/genera are added.

2.3.1 Distribution and statistics

Histograms and boxplots of the entire data set and several subgroups (fossil vs. modern, insular vs. continental...) were created to explore the distribution of body size. The Wilcoxon Rank Sum Test (unpaired data) was used to test for differences between two subgroups. To be able to compare different subgroups, a subsample (1000 repeats) of the respective larger subgroup was taken to compare equal sample sizes.

2.3.2 Body size trends over time

To investigate trends in body size over time, the R package paleoTS (cite) was used. Data were split into time bins according to the stratigraphic timescale/stages (Table 1, Fig. 1). Data older than 23 mya was excluded from the final analysis. To decrease influenec of sampling bias and because Sampling Accumulation Curves showed that the genus level was well sampled in contrast to species level, the mean SCL per genus was calculated before the timescale analysis. The paleoTS plots were created, wich display the mean trait over time and can be fitted to different evolutionary models: stasis, which ...., generalized random walk (GRW), which .... or unbiased random walk (URW), which..... . The Akaike Weight Criterion (AICc) indicates which model is best supported –> see Catalina's Paper and Hunt's papers

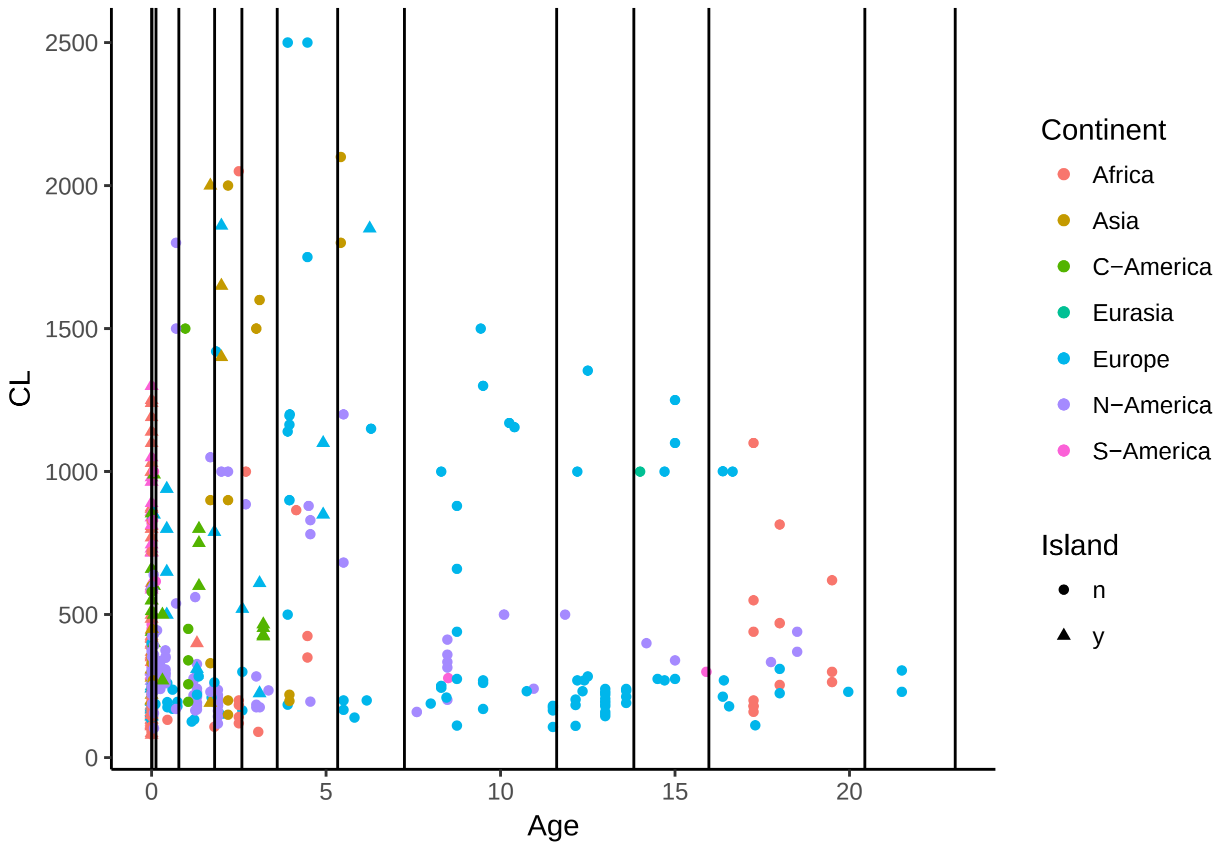

Figure 1: Scatterplot of carapace length over time, indicating insular (triangle) and continental (circles) and colour indicating continents. Lines indicate time bins which correspons to stratigraphic stages.

3 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	17
(0.0117,0.126]	Upper Pleistocene	Upper Pleistocene	0.06885	42	16	7
(0.126,0.781]	Middle Pleistocene	Middle Pleistocene	0.45350	50	11	6
(0.781,1.81]	Lower Pleistocene	Lower Pleistocene	1.29350	49	23	11
(1.81,2.59]	Gelasian	Lower Pleistocene	2.19700	33	15	9
(2.59,3.6]	Piacencian	Upper Pliocene	3.09400	24	15	10
(3.6,5.33]	Zanclean	Lower Pliocene	4.46600	28	16	7
(5.33,7.25]	Messinian	Upper Miocene	6.28900	12	9	6
(7.25,11.6]	Tortonian	Upper Miocene	9.42700	43	19	9
(11.6,13.8]	Serravallian	Middle Miocene	12.71400	26	8	6
(13.8,16]	Langhian	Middle Miocene	14.89500	12	10	8
(16,20.4]	Burdigalian	Lower Miocene	18.20500	28	15	9
(20.4,23]	Aquitanian	Lower Miocene	21.73500	2	1	1