Following Alligatoridae Family Species Diversity Through Time

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Figure 1: Alligator mississippiensis

Abstract

Since life's beginning on Earth, there has been the rise of many species; most of the once living species are no longer around anymore and there are few species which exibit great longevity. The *Alligatoridae* family of Crocodilians is one such family to whom long living species belong. Alligator mississippiensis is a species belonging to the *Alligatoridae* family and fossils representing this species have dated back greater than 60 million years ago; to the time of the Late Cretacious! While this famliy has one long living species, through the exploration of its fossil occurence data, it can be seen just how much species diversity *Alligatoridae* has had through its existence. Posing larger questions of why is their one long living species, as well as what drives the longevity of these species.

Introduction

The *Alligatoridae* family is made up of species classified as alligators and caimans. *Alligatoridae* belongs to the order Crocodilia which is a sister taxa to birds(aves) and turtles(Testudines) sharing the common feature of an amniotic sac (Dodd 2016) (Figures 2 and 3). All members of the Alligatoridae are carnivorous. Today the *Alligatoridae* family is distributed in Central and South America as well as the Southeastern United States (*The natural history collections* n.d.). Their distinguishing features such as massive skull and short, broad snout have not change significantly since the late Triassic. Members of *Alligatoridea* do not tolerate salt water, therefore their main way of dispersal was via land bridges (Benton 2015). This has proved to be a factor limiting their dispersal abilities, perhaps influencing the ability of these species to be long-living. Although restricted in disperal due to salt water, the genus Alligator within the *Alligatoridae* family relatively more tolerant of cooler conditions and can survive farther from the equator than other members of the Crocodilia order possilby contributing to why fossils belonging to this family have been found as far north as Canada (Benton 2015). Moreover, there is evidence that within *Alligatoridea* the caiman genus evolved from the alligator subclass after its dispersal southward from North America and into South America. The appearance of the *Alligatoridae* family began and has continued to persist since the Late Cretaceous, continuing to survive through the death of the dinosaurs and Earth's glacial periods. In this study, the presence of species within the *Alligatoridae* famliy will be observed through time as well as viewing how rates of speciation and extinction have affected this family.

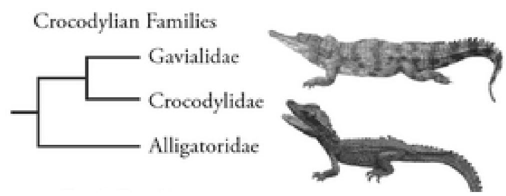


Figure 2: Phylogeny of Alligatoridae sister taxa

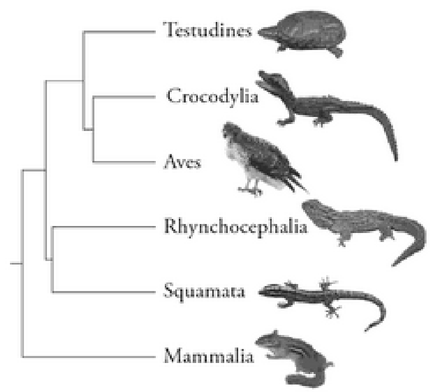


Figure 3: Phylogeny of Crocodilia sister taxa

Figure 4: Fossil belonging to Alligatoridae family

Methods

In order to obtain data to analyze, I used the Paleobio Database that was shown in class. From here I searched for occurence data for the *Alligatoridae* family and found that my original data file from the pbdb website contained 444 specimens using the following shell command:

```
tail -n +19 alligatoridae_pbdb_data.csv | cut -d "," -f7 | sort | wc -l
```

Specimens were identified to the family, genus or species rank within my dataset. Therefore, before I began to analyze the data, I sorted through each occurence and selected only data which was identified to the species rank. This allowed the creatation of a species ranges dictionary using the following python code. Something that was important to include in the function was an if statement that served to only collect data which was identified to the species rank.

```
species_ranges=defaultdict(list)
for line in alligator:
    items = line.split('","')
    min_ma = round(float(items[15]),3)
    max_ma = round(float(items[14]),3)
    species_name = items[9]
    if re.search(r"species", line):
        species_ranges[species_name].append(str(min_ma))
        species_ranges[species_name].append(str(max_ma))
```

From this dictionary, I wrote a .csv file that contained only the genus, species, min_ma and max_ma for specimens identified to the species rank.

```
output=open("alligatoridae_ranges.csv", "w") #i am making the output file
for key, values in species_ranges.items():
    values.sort()
    #the largest value appears last in list and smallest appears first in list
    max_age = values[-1]
    min_age = values[0]
    genus=key.split(" ")[0]
    outline= "{},{},{},{}\n".format(genus, key, min_age, max_age)
    print(outline)
    output.write(outline)
```

The "alligatoridae_ranges.csv" file was read into in Rstudio to first label the data with the appropriate labels then to create an occurrence through time plot using ggplot and forcats:

```
library(ggplot2)
alligatoridae <- read.csv("/home/eeb177-student/Desktop/eeb177-final-project/alligatoridae_ranges.csv",
names(alligatoridae) <- c("genus", "species", "minage", "maxage")

library(forcats)
alligatoridae_occ <- ggplot(alligatoridae, aes(x = fct_reorder(species, minage, .desc = T), maxage, colo
alligatoridae_occ + geom_linerange(aes(ymin = minage, ymax = maxage)) + coord_flip() + theme(axis.text.y
```

Furthermore, using Pyrate a series of plots was constructed showing speciation, extinction rates for the extant species belonging to *Alligatoridae*. First the *Alligatoridae data was processed in R so that pyrate could be run. A total of 1,000,000 simulations were run to create the plots.

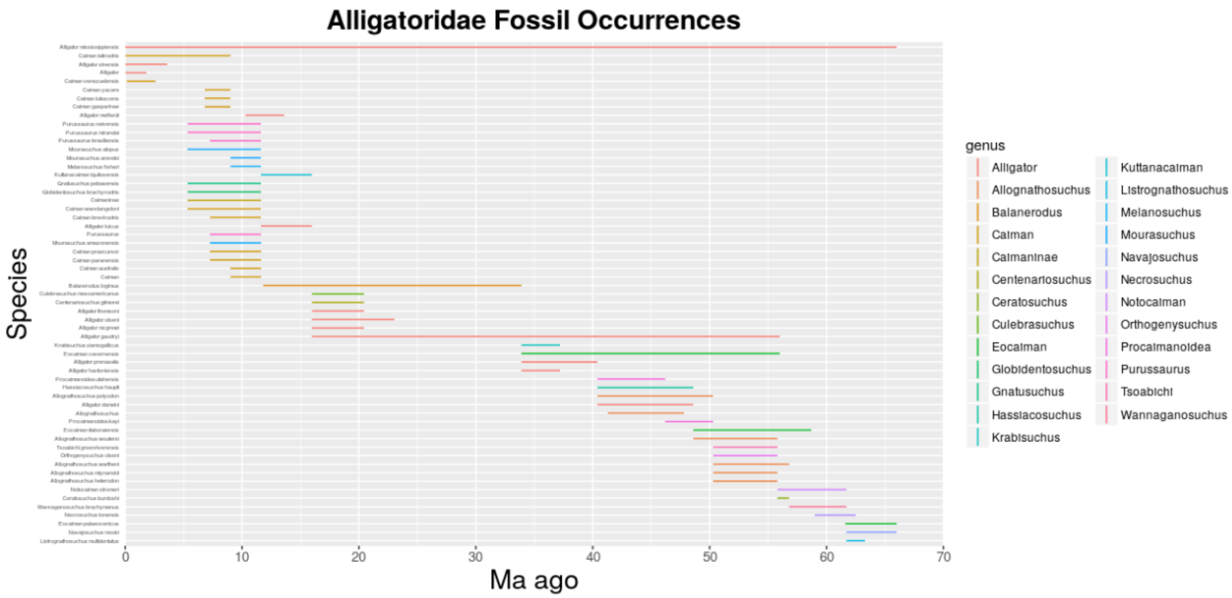
```
source("~/PyRate/pyrate_utilities.r")
extant_alligatoridae = c("Alligator mississippiensis", "Alligator sinensis", "Caiman latirostris", "Cai
extract.ages.pbdb(file = "alligatoridae_occ.csv", extant_species = extant_alligatoridae)
```

```
Orthogenysuchus,Orthogenysuchus olseni,50.3,55.8
Caiman,Caiman australis,11.62,9.0
Alligator,Alligator mcgrewi,15.97,20.43
Caiman,Caiman wannlangstoni,11.608,5.333
Alligator,Alligator hantoniensis,33.9,37.2
Tsoabichi,Tsoabichi greenriverensis,50.3,55.8
Caiman,Caiman gasparinae,6.8,9.0
Caiman,Caiman venezuelensis,0.126,2.588
Notocaiman,Notocaiman stromeri,55.8,61.7
Allognathosuchus,Allognathosuchus woutersi,48.6,55.8
Caiman,Caiman praecursor,11.62,7.246
Alligator,Alligator thomsoni,15.97,20.43
Wannaganosuchus,Wannaganosuchus brachymanus,56.8,61.7
Listrognathosuchus,Listrognathosuchus multidentatus,61.7,63.3
Melanosuchus,Melanosuchus fisheri,11.608,9.0
Allognathosuchus,Allognathosuchus wartheni,50.3,56.8
Alligator,Alligator mississippiensis,0.0,66.0
Procaimanoidea,Procaimanoidea kayi,46.2,50.3
Allognathosuchus,Allognathosuchus mlynarskii,50.3,55.8
Allognathosuchus,Allognathosuchus heterodon,50.3,55.8
Alligator,Alligator sinensis,0.012,3.6
Eocaiman,Eocaiman itaboraiensis,48.6,58.7
Mourasuchus,Mourasuchus amazonensis,11.62,7.246
Purussaurus,Purussaurus mirandai,11.608,5.333
Hassiacosuchus,Hassiacosuchus haupti,40.4,48.6
Ceratosuchus,Ceratosuchus burdoshi,55.8,56.8
Alligator,Alligator,0.012,1.8
Caiman,Caiman,11.62,9.0
Allognathosuchus,Allognathosuchus polyodon,40.4,50.3
Purussaurus,Purussaurus neivensis,11.608,5.333
Caiman,Caiman paranensis,11.62,7.246
Caiman,Caiman latirostris,0.012,9.0
```

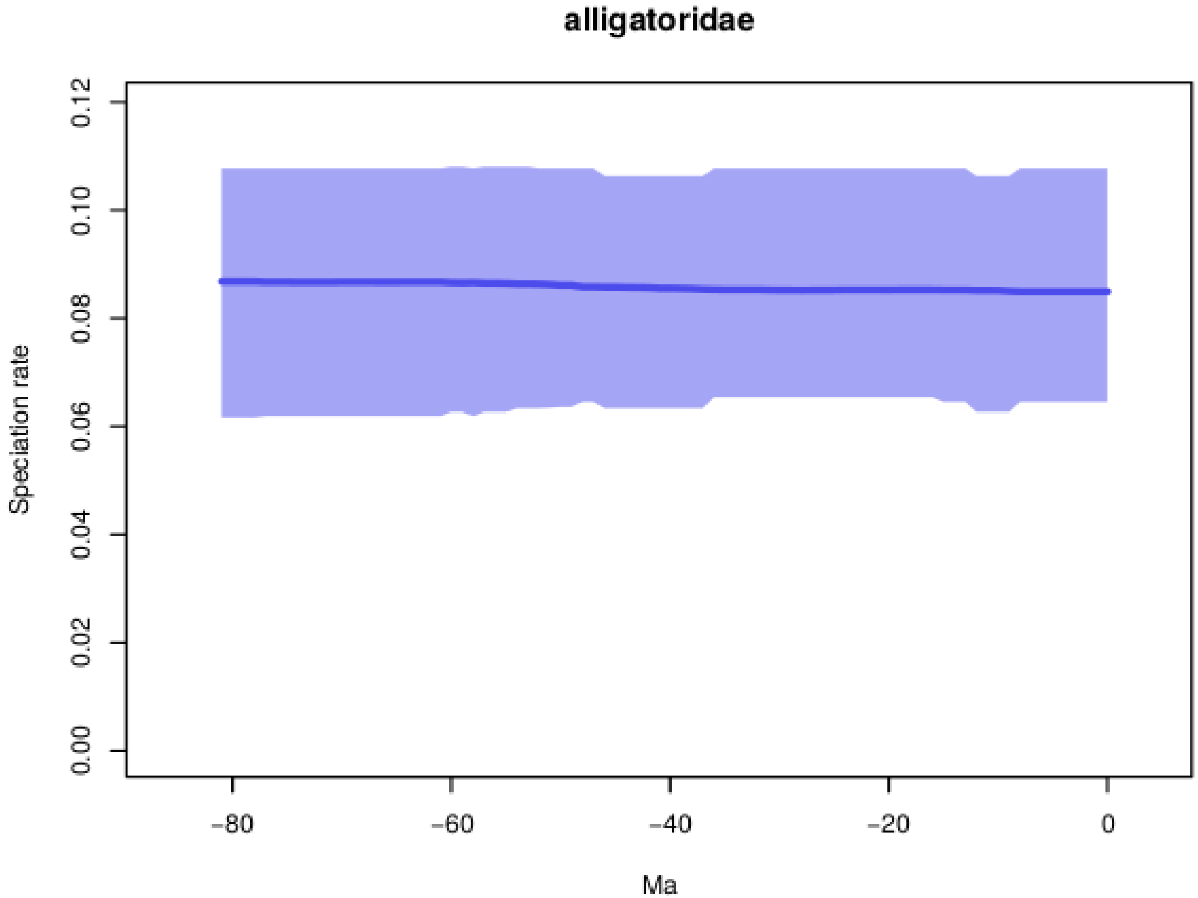
Figure 5: Alligatoridae Ranges file

Results

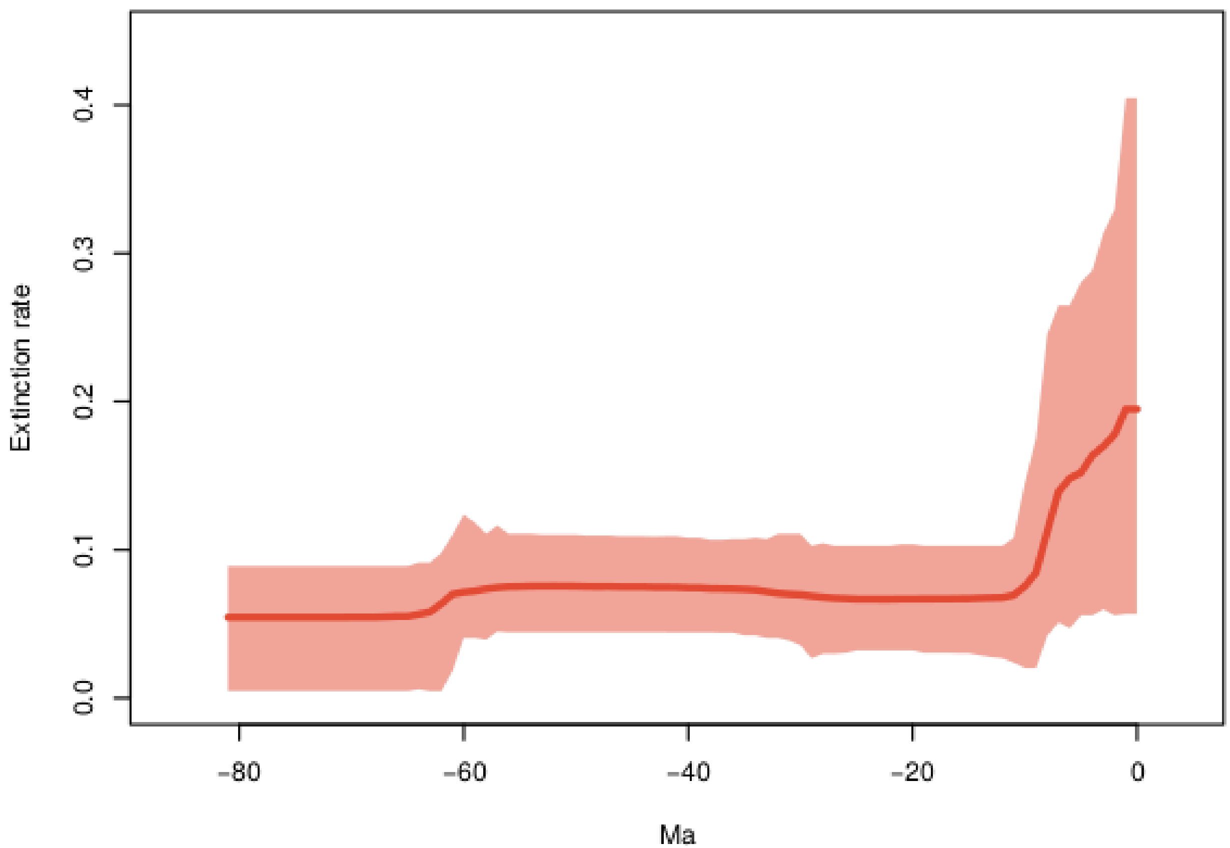
The Alligatoridae Fossil Occurence plot shows that we have fossil evidence showing that the *Alligatoridae* family has species that date almost to 70 million years into the past around the time of the Late Cretacious. Many of the species belonging to family *Alligatoridae* have since gone extinct except for the following species: Alligator mississippiensis, Alligator sinensis, Caiman latirostris, and Caiman venezuelensis. Of these, Alligator mississippiensis has been the longest surviving species as, according to this data, it has been in the fossil record since the oldest known *Alligatoridae* fossils nearly 70 million years old.



The plots from running PyRate for 1,000,000 simulations show the speciation, extinction, net-diversification and longevity of the *Alligatoridae* species. The first plot shown is the Speciation rate through time for the *Alligatoridae* family. Even with 1 million simulations run, it appears that the speciation rate was most likely to be about 0.085 and constant over the last 80 million years.



The next plot done using PyRate is an Extinction curve for the *Alligatoridae* family. There is a visible trend for increasing extinction rate occuring through time. This could be a result of more species being around in general. Although we do see that at present, only 4 extant species are represented in the fossil occurence data.



The net diverisifcation through time plot shows that the peak diverisfication for *Alligatoridae* occurred early in its evolutionary history from about 80-65 million years ago. This is perhaps representative of shifting land masses and then the ice age?

The final plot created using PyRate was the Longevity curve through time. This curve however does not completely agree with the *Alligatoridae* Fossil Occurences plot as it shows that the more ancient a species, the greater its longevity and this is not fully supported when viewing the occurence through time plot made using ggplot. The longevity curve shows that the more younger species had shorter longevity, this is expected as they have not been around long enough to rank high in longevity.

Discussion

The results of this project have raised some interesting questions about the occurence and distribution of members of the *Alligatoridae* family since the Late Cretacious. It would be very interesting if the pbdb website provided data on the exact locations that each specimen was found in order to recreate species occurences map. When on the pbdb website however, I found a map which showed locations of the occurences already (it is linked below). We can see that some *Alligatoridae* specimens occurred in regions as far north as Canada. Clearly it is much to cold today in Canada at those high latitudes, therefore finding remains of members of this family either suggests that Canada once had a much warmer climate. This could be evidence supporting that tectonic plates and thus continents have shifted throughout earths history.

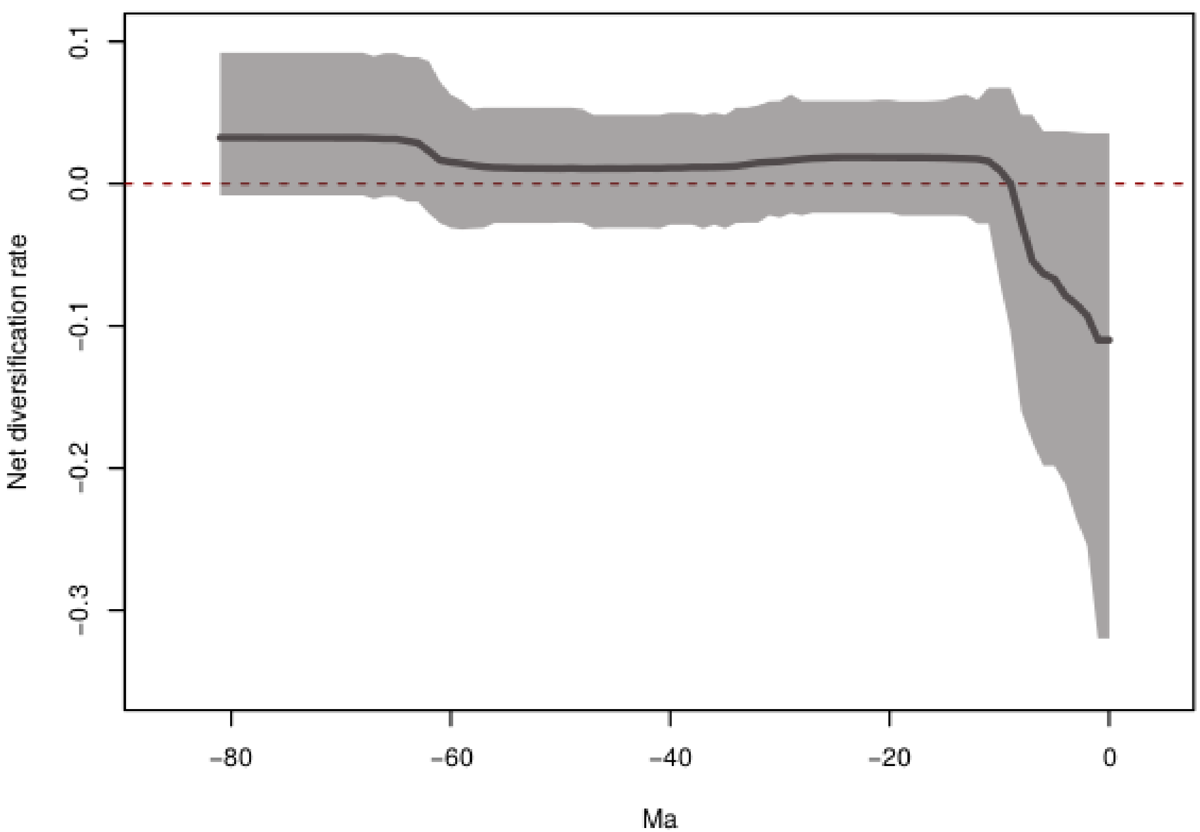


Figure 6: Diversification

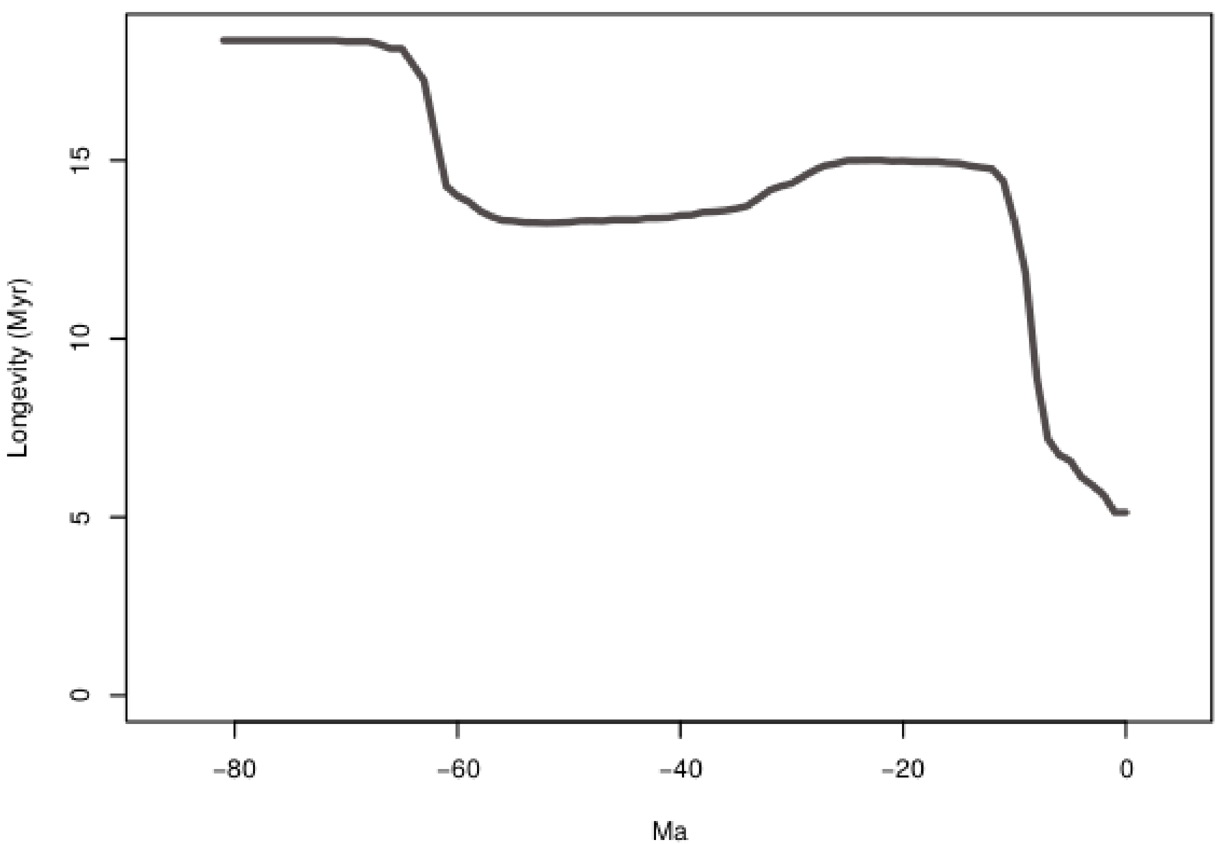
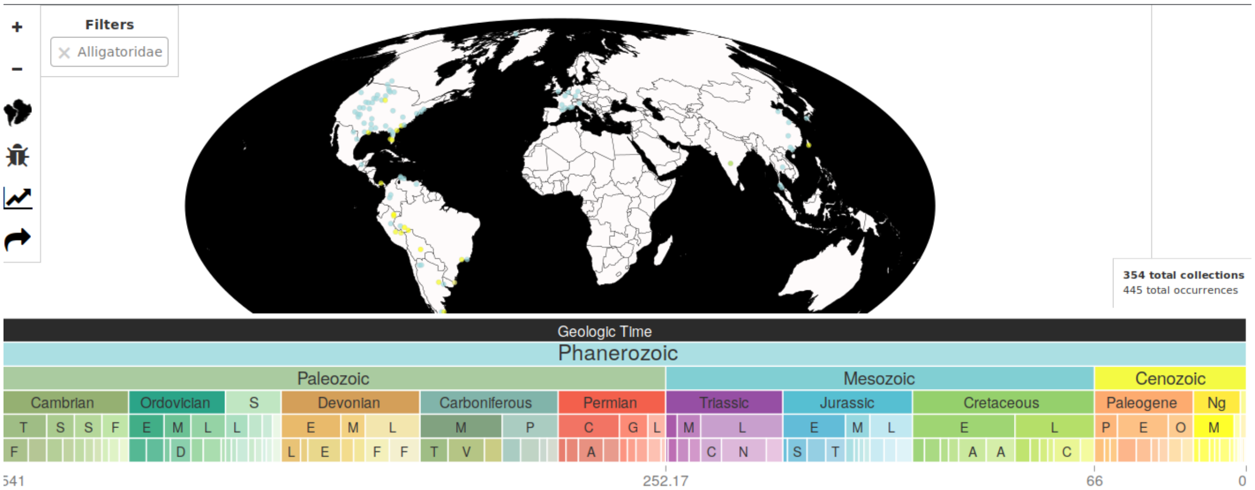
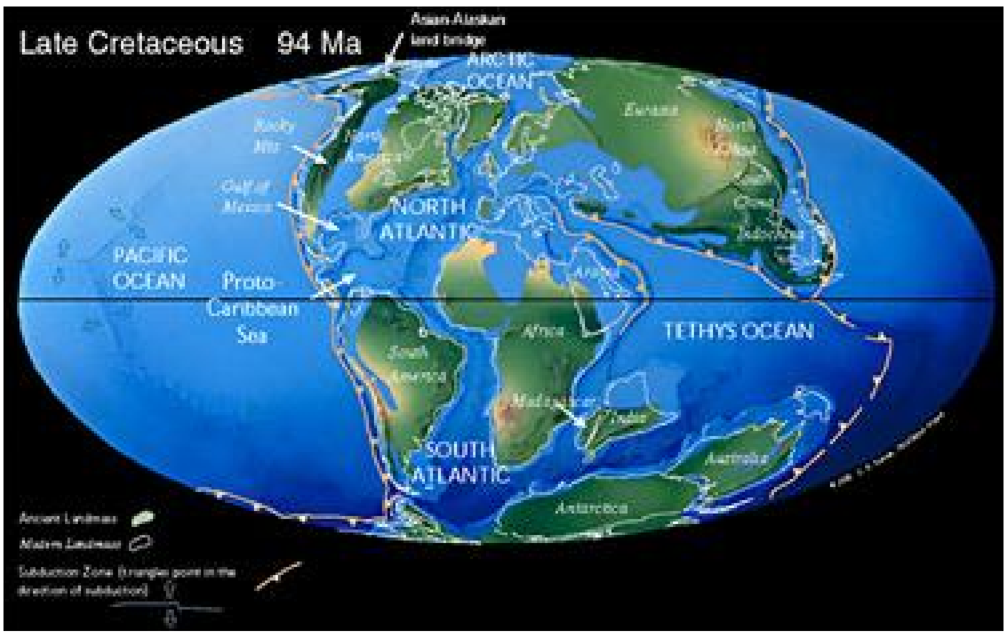


Figure 7: Longevity





Github link

link

References

1.Benton, E., Terry Jr. (2015). *The white river badlands: Geology and paleontology.* Indiana University Press.

2.Dodd, K. (2016). *Reptile ecology and conservation: A handbook of techniques.* Oxford University Press.

3.*The natural history collections: Family alligatoridae.* (n.d.). University of Edinburgh.