Body size trends in Neogene tortoises

30.05.2017

TO DO:

- figure out if Checklist data is of any use (means? medians? sample size?) or see if authors can provide necessary data
- do paleoTS analyses with FFB data set
- read Hunt papers (see citations in Catalina's paper 2006, 2008, 2008, 2010; also 2015)
- figure out how to implement phylogeny... well, figure out how to do paleoTS analyses with more than one taxon without pooling everything together (as in Test2)

06.06.2017

```
tidyCL<-read.csv("tortoises_tidy.csv", sep=";", header=TRUE)


colnames(tidyCL)[6] <- "MAmin"
colnames(tidyCL)[7] <- "Mamax"
colnames(tidyCL)[17] <- "CL"
colnames(tidyCL)[18] <- "PL"


statsCL <- tidyCL %>%
  dplyr::filter(!is.na(CL)) %>%
  summarise(min = min(CL), max = max(CL), var(CL), mean= mean(CL), median= median(CL))#, skew(CL), kurt



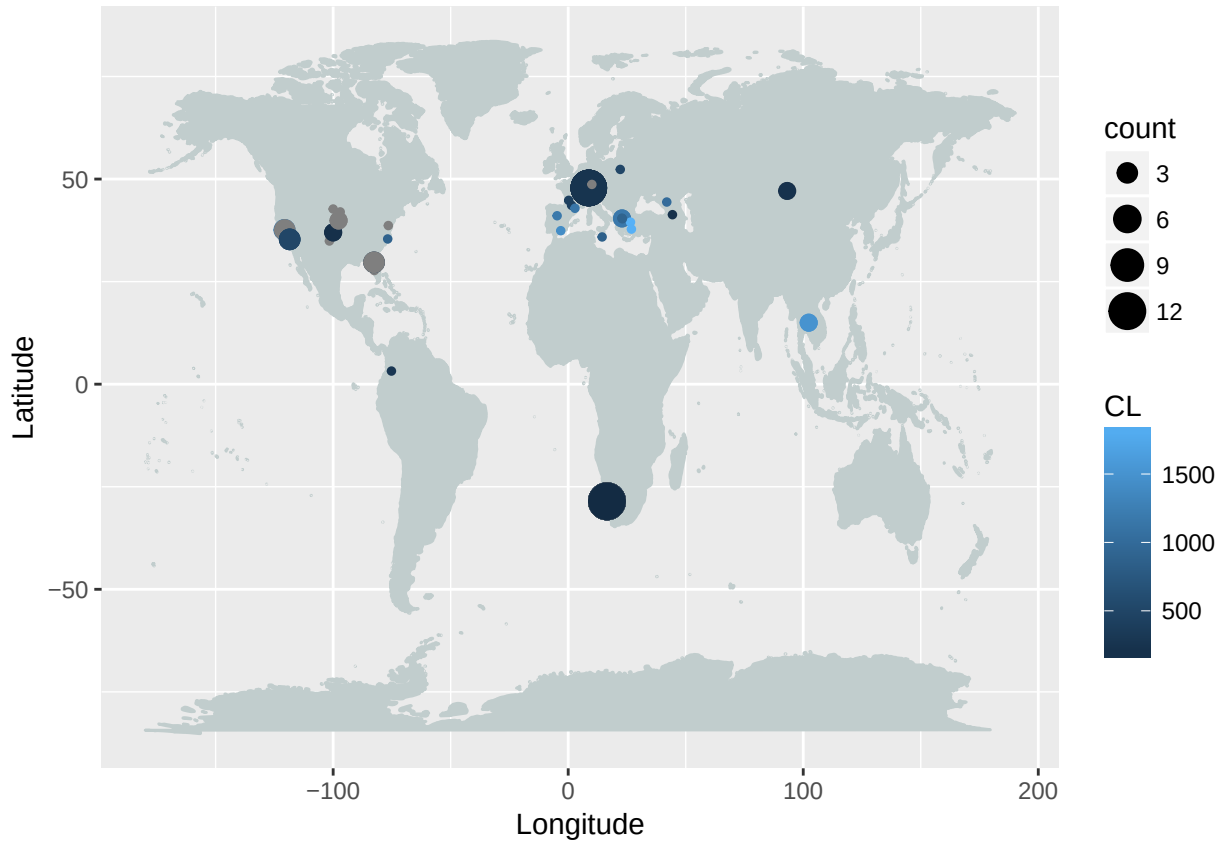
Map <- tidyCL %>%
  dplyr::select(Genus, Taxon, Latitude, Longitude, Country, CL, PL) %>%
  group_by(Latitude) %>%
  mutate(count= n())

mapWorld <- borders("world", colour="azure3", fill="azure3") # create a layer of borders


mp <- Map %>%
  ggplot(aes(Longitude, Latitude)) + mapWorld +
#  geom_point(fill="red", colour="red", size=0.5) +
  geom_point(aes(Longitude, Latitude,colour=CL, size=count))

mp
```

```
## Warning: Removed 1 rows containing missing values (geom_point).
```




```
library(plotly)
```

```
##
## Attaching package: 'plotly'
```

```
## The following object is masked from 'package:ggplot2':
##
##     last_plot
```

```
## The following object is masked from 'package:stats':
##
##     filter
```

```
## The following object is masked from 'package:graphics':
##
##     layout
```

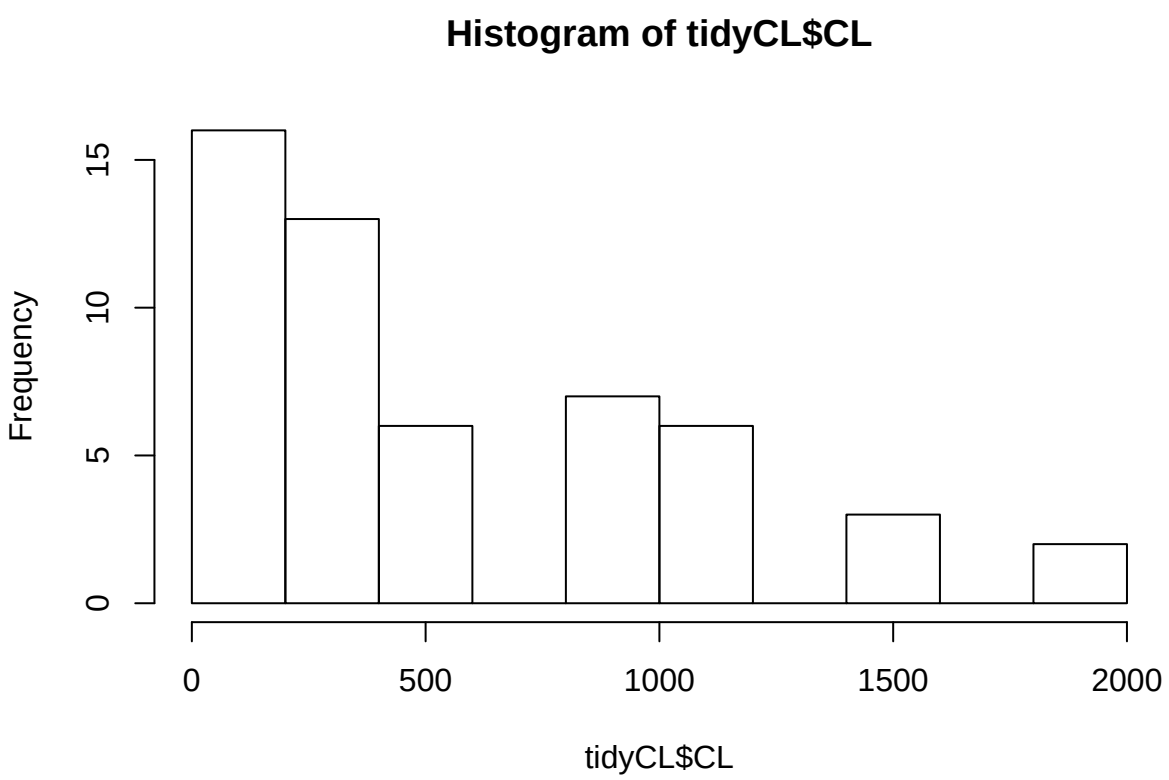
```
ggplotly(mp)
```

```
## We recommend that you use the dev version of ggplot2 with `ggplotly()`
## Install it with: `devtools::install_github('hadley/ggplot2')`
```

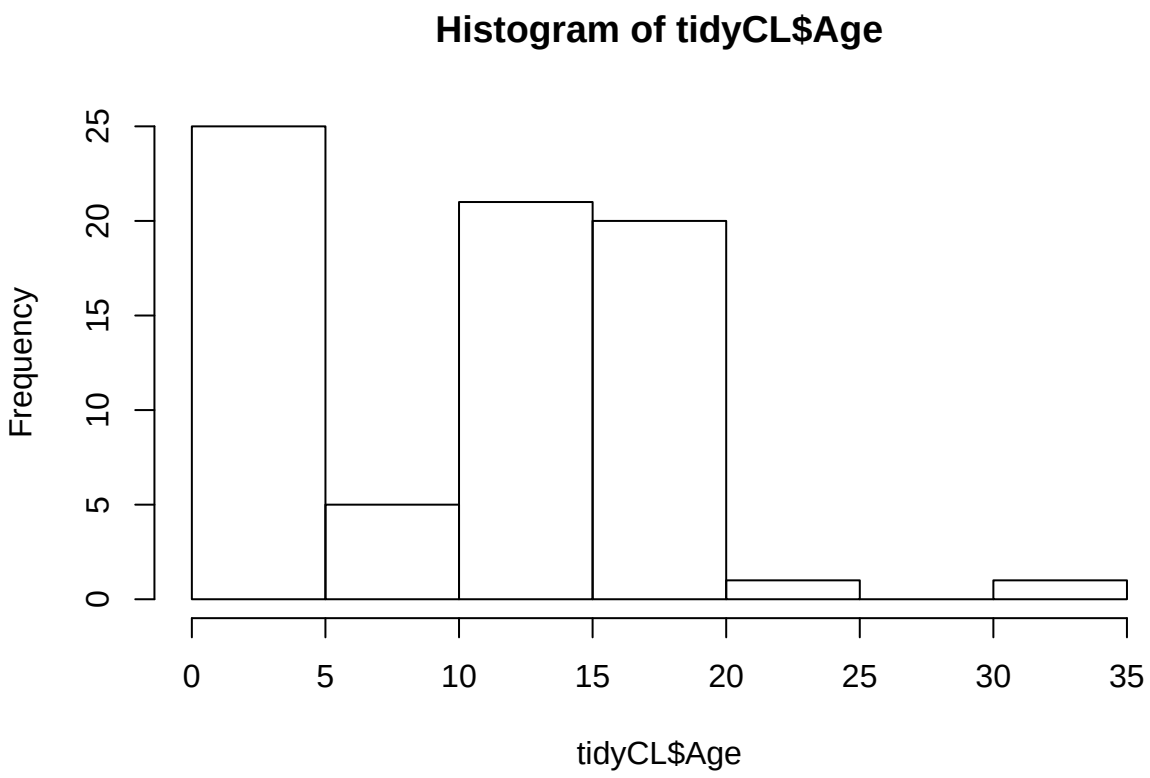
Get an overview over body size data

```
tidyCL <-  tidyCL %>%
  mutate(Age= (MAmin+Mamax)/2)

hist(tidyCL$CL)
```




```
hist(tidyCL$Age)
```



TO DO:

- map localities with differing colors for: CL available, CL extrapolated (from PL or figures), CL missing
- complete data set!
- get missing refences/make list of missing references

08.06.17

Map all localities with sample size and age indicated (regardless of whether CL information is available):

```
test<-read.csv("tortoises13-04.csv", sep=";", header=TRUE)

colnames(test)[6] <- "Mamin"
colnames(test)[7] <- "Mamax"

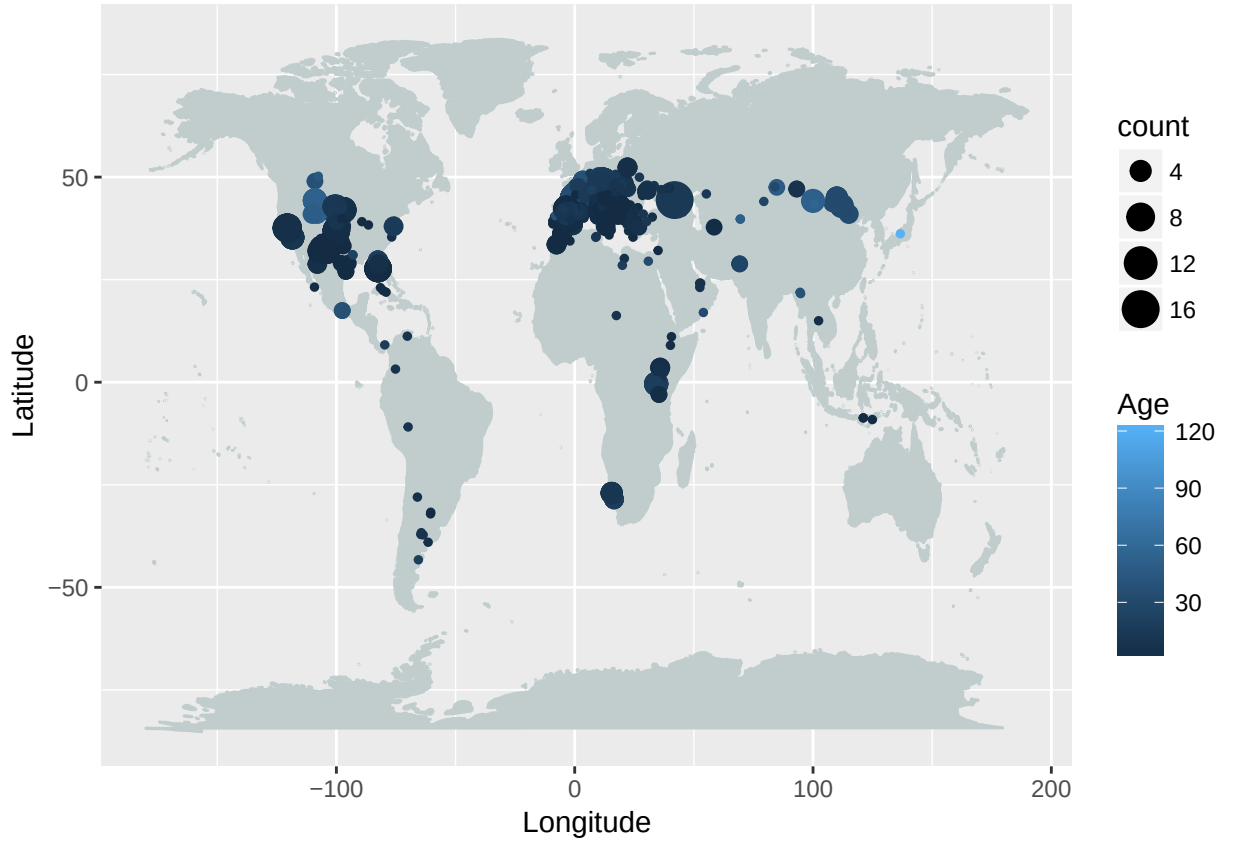
Test <- test %>%
  dplyr::select(Locality, Country, Latitude, Longitude, Mamin, Mamax, Epoch, Genus, Species, Taxon, CL)
  mutate(Age= (Mamin+Mamax)/2) %>%   # create mean age
  group_by(Latitude) %>%
  mutate(count= n())

#mapWorld <- borders("world", colour="azure3", fill="azure3") # create a layer of borders

map <- Test %>%
```

```
  ggplot(aes(Longitude, Latitude)) + mapWorld +
  #geom_point(fill="red", colour="red", size=0.5) +
  geom_point(aes(Longitude, Latitude,colour=Age, size=count))

map
```




```
ggplotly(map)
```

```
## We recommend that you use the dev version of ggplot2 with `ggplotly()`
## Install it with: `devtools::install_github('hadley/ggplot2')`
```

TO DO:

- get general statistical overview over data (stru, normal distribution?, mean/mode/median/min/max, hist plot etc. –> see Catalina's paper)

Try paleoTS with some first real data. Here is the underlying data:

```
tidyCL
```

```
##                                                        Locality
## 1           UCMP V71137, Turlock Lake 10, Stanislaus County, California
## 2       UCMP V-3952, Ingram Creek site 8, Stanislaus County, California
## 3           UCMP V81248, Turlock Lake 11, Stanislaus County, California
## 4                              Randle Cliff, Calvert County, Maryland
## 5                      Cragin Quarry Local Fauna, Meade County, Kansas
## 6                                      Santee, Knox County, Nebraska
```

```
## 7              North Cita Canyon (Middle Stratum), Randall County, Texas
## 8                      Leisey Shell Pit 1A, Hillsborough County, Florida
## 9                          Sand Draw local fauna, Brown County, Nebraska
## 10                  McGehee Farm near Newberry, Alachua County, Florida
## 11                               Arredondo IIA, Alachua County, Florida
## 12     Epanomi (EPN I), western Chalkidiki Peninsula, Thessaloniki area
## 13    Epanomi (EPN II), western Chalkidiki Peninsula, Thessaloniki area
## 14                         Hohenhöwen, Engen, Hegau, southwestern Germany
## 15                         Hohenhöwen, Engen, Hegau, southwestern Germany
## 16                         Hohenhöwen, Engen, Hegau, southwestern Germany
## 17                         Hohenhöwen, Engen, Hegau, southwestern Germany
## 18                         Hohenhöwen, Engen, Hegau, southwestern Germany
## 19                         Hohenhöwen, Engen, Hegau, southwestern Germany
## 20                         Hohenhöwen, Engen, Hegau, southwestern Germany
## 21                         Hohenhöwen, Engen, Hegau, southwestern Germany
## 22                         Hohenhöwen, Engen, Hegau, southwestern Germany
## 23                     Altan-Teli main fossiliferous bed (Dzereg valley)
## 24                     Altan-Teli main fossiliferous bed (Dzereg valley)
## 25                     Sawrock Canyon local fauna, Seward County, Kansas
## 26                     Sawrock Canyon local fauna, Seward County, Kansas
## 27                              Baby 2, Saint-André-et-Appelles, Gironde
## 28            Toulouse Puits Borderouge niveau inférieur, Haute-Garonne
## 29                                                                Dmanisi
## 30     Lee Creek Mine, Yorktown Sample, Beaufort County, North Carolina
## 31            Iron Canyon Fauna, Mojave Desert, Kern County, California
## 32                Ricardo Fauna, Mojave Desert, Kern County, California
## 33                Ricardo Fauna, Mojave Desert, Kern County, California
## 34                   Thomas Farm Local Fauna, Gilchrist County, Florida
## 35                   Thomas Farm Local Fauna, Gilchrist County, Florida
## 36                                    San Nicolas, UCMP locality V4536
## 37                                                Lesbos Island, F-Site
## 38                                               Kirchdorf an der Iller
## 39                                                      Belomechetskaya
## 40           Elisabethfeld (= Elisabeth Bay) area, northern Sperrgebiet
## 41           Elisabethfeld (= Elisabeth Bay) area, northern Sperrgebiet
## 42                                                                Auchas
## 43                                                                Auchas
## 44                                                                Auchas
## 45                                                                Auchas
## 46                                                             Arrisdrift
## 47                                                             Arrisdrift
## 48                                                             Arrisdrift
## 49                                                             Arrisdrift
## 50                                                             Arrisdrift
## 51                                                             Arrisdrift
## 52                                                             Arrisdrift
## 53                                                             Arrisdrift
## 54                                                                Samos 1
## 55              Serrat-d´en-Vacquer near Perpignan, Pyrénées-Orientales
## 56                                Zebbug and Gahr Dalam Cave deposits
## 57                           El Lugarejo (Arévalo), Ávilla, Castilla
## 58                                         Fonelas P-1, Guadix Basin
## 59                       White Rock local fauna, Republic County, Kansas
## 60                       White Rock local fauna, Republic County, Kansas
```

```
## 61 Tha Chang area, Chaloem Pra Kiat district, Nakhon Ratchasima Province
## 62 Tha Chang area, Chaloem Pra Kiat district, Nakhon Ratchasima Province
## 63      Nea Kallikratia, western Chalkidiki Peninsula, Thessaloniki area
## 64       Nea Michaniona, western Chalkidiki Peninsula, Thessaloniki area
## 65                                                          Sandelzhausen
## 66                                Sandelzhausen unterer Geröllmergel (B)
## 67                                                           Gammelsdorf
## 68                                                           Gammelsdorf
## 69                                        Altenstadt, 7 km S Illertissen
## 70                          Hohenhöwen, Engen, Hegau, southwestern Germany
## 71                          Hohenhöwen, Engen, Hegau, southwestern Germany
## 72                                                 Steinheim a. Albuch
## 73                                                              W??e 1
## 74
##     Country Latitude Longitude
## 1       USA  37.6000 -120.6000
## 2       USA  37.6000 -120.8000
## 3       USA  37.6000 -120.6000
## 4       USA  38.6665  -76.5298
## 5       USA  37.2242 -100.4176
## 6       USA  42.0000  -97.0000
## 7       USA  34.9000 -101.6000
## 8       USA  27.7000  -82.5000
## 9       USA  42.7000 -100.0000
## 10      USA  29.7000  -82.6000
## 11      USA  29.6000  -82.4000
## 12   Greece  40.4046   22.8980
## 13   Greece  40.4046   22.8980
## 14  Germany  47.8356    8.7490
## 15  Germany  47.8356    8.7490
## 16  Germany  47.8356    8.7490
## 17  Germany  47.8356    8.7490
## 18  Germany  47.8356    8.7490
## 19  Germany  47.8356    8.7490
## 20  Germany  47.8356    8.7490
## 21  Germany  47.8356    8.7490
## 22  Germany  47.8356    8.7490
## 23 Mongolia  47.1000   93.1667
## 24 Mongolia  47.1000   93.1667
## 25      USA  37.0000 -100.0000
## 26      USA  37.0000 -100.0000
## 27   France  44.8120    0.2133
## 28   France  43.6000    1.4333
## 29  Georgia  41.3200   44.3500
## 30      USA  35.4000  -76.8000
## 31      USA  35.3000 -118.5000
## 32      USA  35.3000 -118.5000
## 33      USA  35.3000 -118.5000
## 34      USA  29.7000  -82.6000
## 35      USA  29.7000  -82.6000
## 36 Colombia   3.2000  -75.2000
## 37   Greece  39.5000   26.5000
## 38  Germany  48.0728   10.1424
## 39   Russia  44.4000   41.9333
```

```
## 40  Namibia -26.9161   15.1838
## 41  Namibia -26.9161   15.1838
## 42  Namibia -28.5500   16.5000
## 43  Namibia -28.5500   16.5000
## 44  Namibia -28.5500   16.5000
## 45  Namibia -28.5500   16.5000
## 46  Namibia -28.5500   16.5000
## 47  Namibia -28.5500   16.5000
## 48  Namibia -28.5500   16.5000
## 49  Namibia -28.5500   16.5000
## 50  Namibia -28.5500   16.5000
## 51  Namibia -28.5500   16.5000
## 52  Namibia -28.5500   16.5000
## 53  Namibia -28.5500   16.5000
## 54   Greece  37.8000   26.9000
## 55   France  42.8800    2.8800
## 56    Malta  35.8897   14.4425
## 57    Spain  41.0560   -4.7169
## 58    Spain  37.4170   -3.1670
## 59      USA  39.9000  -97.7000
## 60      USA  39.9000  -97.7000
## 61 Thailand  14.9874  102.3352
## 62 Thailand  14.9874  102.3352
## 63   Greece  40.3146   23.0462
## 64   Greece  40.4731   22.8385
## 65  Germany  48.6283   11.7960
## 66  Germany  48.6283   11.7960
## 67  Germany  48.5495   11.9382
## 68  Germany  48.5495   11.9382
## 69  Germany  48.1542   10.1178
## 70  Germany  47.8356    8.7490
## 71  Germany  47.8356    8.7490
## 72  Germany  48.6939   10.0678
## 73   Poland  52.3500   22.1500
## 74               NA        NA
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## 35 a sinkhole lake that then collapsed into a larger underground chamber earliest Hemmingfordian Nor
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```
## 73
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##     MAmin  Mamax                Epoch        upper.stage
## 1   5.000  6.000     Pliocene/Miocene           Zanclean
## 2   9.000 10.000              Miocene          Tortonian
## 3   5.000  6.000     Pliocene/Miocene           Zanclean
## 4  15.000 15.800              Miocene           Langhian
## 5   0.300  0.300          Pleistocene Middle Pleistocene
## 6   4.800  5.200             Pliocene           Zanclean
## 7   1.800  3.600 Pleistocene/Pliocene           Gelasian
## 8   1.000  1.500          Pleistocene  Lower Pleistocene
## 9   3.000  3.000             Pliocene         Piacencian
## 10 10.900 11.000              Miocene          Tortonian
## 11  0.012  0.126          Pleistocene  Upper Pleistocene
## 12  2.600  5.300             Pliocene         Piacencian
## 13  2.600  5.300             Pliocene         Piacencian
## 14 13.000 13.000              Miocene       Serravallian
## 15 13.000 13.000              Miocene       Serravallian
## 16 13.000 13.000              Miocene       Serravallian
## 17 13.000 13.000              Miocene       Serravallian
## 18 13.000 13.000              Miocene       Serravallian
## 19 13.000 13.000              Miocene       Serravallian
## 20 13.000 13.000              Miocene       Serravallian
## 21 13.000 13.000              Miocene       Serravallian
## 22 13.000 13.000              Miocene       Serravallian
## 23  2.600  5.300             Pliocene         Piacencian
## 24  2.600  5.300             Pliocene         Piacencian
## 25  3.000  3.000             Pliocene         Piacencian
## 26  3.000  3.000             Pliocene         Piacencian
## 27 33.900 34.000               Eocene         Priabonian
## 28 23.030 23.200            Oligocene           Chattian
## 29  1.770  1.770          Pleistocene  Lower Pleistocene
## 30  4.000  5.000             Pliocene           Zanclean
## 31 11.200 12.500              Miocene          Tortonian
## 32  9.000 11.200              Miocene          Tortonian
## 33  9.000 11.200              Miocene          Tortonian
## 34 18.000 19.000              Miocene        Burdigalian
## 35 18.000 19.000              Miocene        Burdigalian
## 36  6.000 11.000              Miocene          Messinian
## 37  2.000  2.000          Pleistocene           Gelasian
## 38 16.500 16.800              Miocene        Burdigalian
## 39 13.500 14.500              Miocene       Serravallian
## 40 19.000 20.000              Miocene        Burdigalian
## 41 19.000 20.000              Miocene        Burdigalian
## 42 18.000 18.000              Miocene        Burdigalian
## 43 18.000 18.000              Miocene        Burdigalian
## 44 18.000 18.000              Miocene        Burdigalian
## 45 18.000 18.000              Miocene        Burdigalian
## 46 17.000 17.500              Miocene        Burdigalian
## 47 17.000 17.500              Miocene        Burdigalian
## 48 17.000 17.500              Miocene        Burdigalian
## 49 17.000 17.500              Miocene        Burdigalian
## 50 17.000 17.500              Miocene        Burdigalian
## 51 17.000 17.500              Miocene        Burdigalian
```

```
## 52 17.000 17.500              Miocene        Burdigalian
## 53 17.000 17.500              Miocene        Burdigalian
## 54  5.300  7.200              Miocene          Messinian
## 55  3.600  4.200             Pliocene           Zanclean
## 56  0.005  0.127 Holocene/Pleistocene           Holocene
## 57  9.500 11.000              Miocene          Tortonian
## 58  1.800  1.900          Pleistocene  Lower Pleistocene
## 59  1.800  2.200          Pleistocene           Gelasian
## 60  1.800  2.200          Pleistocene           Gelasian
## 61  1.000  5.000 Pleistocene/Pliocene  Lower Pleistocene
## 62  1.000  5.000 Pleistocene/Pliocene  Lower Pleistocene
## 63  2.600  5.300             Pliocene         Piacencian
## 64  2.600  5.300             Pliocene         Piacencian
## 65 16.270 16.470              Miocene        Burdigalian
## 66 16.270 16.470              Miocene        Burdigalian
## 67 11.600 12.700              Miocene       Serravallian
## 68 11.600 12.700              Miocene       Serravallian
## 69 11.600 12.700              Miocene       Serravallian
## 70 13.000 13.000              Miocene       Serravallian
## 71 13.000 13.000              Miocene       Serravallian
## 72 12.500 13.500              Miocene       Serravallian
## 73  3.600  4.200             Pliocene           Zanclean
## 74     NA     NA
##           lower.stage          Genus          Species
## 1           Messinian Hesperotestudo       orthopygia
## 2           Tortonian Hesperotestudo              sp.
## 3           Messinian Hesperotestudo       orthopygia
## 4            Langhian     Floridemys            hurdi
## 5  Middle Pleistocene Hesperotestudo        equicomes
## 6             Zanclean     Geochelone              sp.
## 7           Piacencian       Gopherus      canyonensis
## 8   Lower Pleistocene Hesperotestudo    crassiscutata
## 9           Piacencian Hesperotestudo         oelrichi
## 10          Tortonian Hesperotestudo           alleni
## 11  Upper Pleistocene Hesperotestudo           incisa
## 12            Zanclean   Titanochelon      bacharidisi
## 13            Zanclean   Titanochelon      bacharidisi
## 14       Serravallian   Paleotestudo          antiqua
## 15       Serravallian   Paleotestudo          antiqua
## 16       Serravallian   Paleotestudo          antiqua
## 17       Serravallian   Paleotestudo          antiqua
## 18       Serravallian   Paleotestudo          antiqua
## 19       Serravallian   Paleotestudo          antiqua
## 20       Serravallian   Paleotestudo          antiqua
## 21       Serravallian   Paleotestudo          antiqua
## 22       Serravallian   Paleotestudo          antiqua
## 23            Zanclean      Ergilemys       oskarkuhni
## 24            Zanclean      Ergilemys       oskarkuhni
## 25          Piacencian Hesperotestudo           riggsi
## 26          Piacencian Hesperotestudo           riggsi
## 27          Priabonian   Cheirogaster          maurini
## 28            Chattian      Ergilemys          bruneti
## 29  Lower Pleistocene        Testudo            graeca
## 30            Zanclean     Geochelone              sp.
```

```
## 31       Serravallian       Gopherus            ? sp.
## 32          Tortonian     Geochelone              sp.
## 33          Tortonian       Gopherus            ? sp.
## 34         Burdigalian     Geochelone         tedwhitei
## 35         Burdigalian     Geochelone         tedwhitei
## 36          Tortonian     Geochelone          hesterna
## 37            Gelasian   Titanochelon   aff. schafferi
## 38         Burdigalian     Geochelone              sp.
## 39            Langhian      Ergilemys              sp.
## 40         Burdigalian   Namibchersus       namaquensis
## 41         Burdigalian   Namibchersus       namaquensis
## 42         Burdigalian   Namibchersus       namaquensis
## 43         Burdigalian   Namibchersus       namaquensis
## 44         Burdigalian   Namibchersus       namaquensis
## 45         Burdigalian   Namibchersus       namaquensis
## 46         Burdigalian     Mesocherus          orangeus
## 47         Burdigalian     Mesocherus          orangeus
## 48         Burdigalian     Mesocherus          orangeus
## 49         Burdigalian     Mesocherus          orangeus
## 50         Burdigalian     Mesocherus          orangeus
## 51         Burdigalian   Namibchersus aff. namaquensis
## 52         Burdigalian   Namibchersus aff. namaquensis
## 53         Burdigalian   Namibchersus aff. namaquensis
## 54           Messinian   Titanochelon        schafferi
## 55            Zanclean   Titanochelon       perpiniana
## 56  Upper Pleistocene        Testudo            graeca
## 57          Tortonian   Cheirogaster              sp.
## 58  Lower Pleistocene   Titanochelon              sp.
## 59            Gelasian     Geochelone              sp.
## 60            Gelasian     Geochelone              sp.
## 61            Zanclean  Aldabrachelys            ? sp.
## 62            Zanclean  Aldabrachelys            ? sp.
## 63            Zanclean   Titanochelon      bacharidisi
## 64            Zanclean   Titanochelon      bacharidisi
## 65         Burdigalian        Testudo     rectogularis
## 66         Burdigalian   Titanochelon   cf. perpiniana
## 67        Serravallian   Paleotestudo          antiqua
## 68        Serravallian   Paleotestudo          antiqua
## 69        Serravallian        Testudo   steinheimensis
## 70        Serravallian   Paleotestudo          antiqua
## 71        Serravallian   Paleotestudo          antiqua
## 72        Serravallian        Testudo   steinheimensis
## 73            Zanclean        Testudo              sp.
## 74
##                            Taxon                           Author
## 1      Hesperotestudo orthopygia                       (Cope, 1878)
## 2            Hesperotestudo sp.                     Williams, 1950
## 3      Hesperotestudo orthopygia                       (Cope, 1878)
## 4              Floridemys hurdi                 Weems & George, 2013
## 5       Hesperotestudo equicomes                          (Hay, 1917)
## 6                Geochelone sp.                    Fitzinger, 1835
## 7           Gopherus canyonensis                   (Johnston, 1937)
## 8   Hesperotestudo crassiscutata                      (Leidy, 1889)
## 9        Hesperotestudo oelrichi                       Holman, 1972
```

```
## 10         Hesperotestudo alleni                (Auffenbgerg, 1996)
## 11         Hesperotestudo incisa                        (Hay, 1916)
## 12      Titanochelon bacharidisi (Vlachos, Tsoukala & Corsini, 2014)
## 13      Titanochelon bacharidisi (Vlachos, Tsoukala & Corsini, 2014)
## 14          Paleotestudo antiqua                     (Bronn, 1831)
## 15          Paleotestudo antiqua                     (Bronn, 1831)
## 16          Paleotestudo antiqua                     (Bronn, 1831)
## 17          Paleotestudo antiqua                     (Bronn, 1831)
## 18          Paleotestudo antiqua                     (Bronn, 1831)
## 19          Paleotestudo antiqua                     (Bronn, 1831)
## 20          Paleotestudo antiqua                     (Bronn, 1831)
## 21          Paleotestudo antiqua                     (Bronn, 1831)
## 22          Paleotestudo antiqua                     (Bronn, 1831)
## 23          Ergilemys oskarkuhni                M?ynarski(, 1968)
## 24          Ergilemys oskarkuhni                M?ynarski(, 1968)
## 25         Hesperotestudo riggsi                   (Hibbard, 1944)
## 26         Hesperotestudo riggsi                   (Hibbard, 1944)
## 27          Cheirogaster maurini                Bergounioux, 1935
## 28             Ergilemys bruneti                      Broin, 1977
## 29                Testudo graeca                   Linnaeus, 1758
## 30                Geochelone sp.                  Fitzinger, 1835
## 31                Gopherus ? sp.                 Rafinesque, 1832
## 32                Geochelone sp.                  Fitzinger, 1835
## 33                Gopherus ? sp.                 Rafinesque, 1832
## 34          Geochelone tedwhitei                   (Williams, 1953)
## 35          Geochelone tedwhitei                   (Williams, 1953)
## 36           Geochelone hesterna                   Auffenberg, 1971
## 37   Titanochelon aff. schafferi                     (Szalai, 1931)
## 38                Geochelone sp.                  Fitzinger, 1835
## 39                 Ergilemys sp.                 Ckhikvadze, 1972
## 40      Namibchersus namaquensis                    (Stromer, 1926)
## 41      Namibchersus namaquensis                    (Stromer, 1926)
## 42      Namibchersus namaquensis                    (Stromer, 1926)
## 43      Namibchersus namaquensis                    (Stromer, 1926)
## 44      Namibchersus namaquensis                    (Stromer, 1926)
## 45      Namibchersus namaquensis                    (Stromer, 1926)
## 46           Mesocherus orangeus          Lapparent de Broin, 2003
## 47           Mesocherus orangeus          Lapparent de Broin, 2003
## 48           Mesocherus orangeus          Lapparent de Broin, 2003
## 49           Mesocherus orangeus          Lapparent de Broin, 2003
## 50           Mesocherus orangeus          Lapparent de Broin, 2003
## 51 Namibchersus aff. namaquensis                    (Stromer, 1926)
## 52 Namibchersus aff. namaquensis                    (Stromer, 1926)
## 53 Namibchersus aff. namaquensis                    (Stromer, 1926)
## 54        Titanochelon schafferi                     (Szalai, 1931)
## 55       Titanochelon perpiniana                    (Depéret, 1885)
## 56                Testudo graeca                   Linnaeus, 1758
## 57              Cheirogaster sp.                Bergounioux, 1935
## 58              Titanochelon sp.     Pérez-García and Vlachos, 2014
## 59                Geochelone sp.                  Fitzinger, 1835
## 60                Geochelone sp.                  Fitzinger, 1835
## 61           Aldabrachelys ? sp.         Loveridge & Williams, 1975
## 62           Aldabrachelys ? sp.         Loveridge & Williams, 1975
## 63      Titanochelon bacharidisi (Vlachos, Tsoukala & Corsini, 2014)
```

```
## 64      Titanochelon bacharidisi (Vlachos, Tsoukala & Corsini, 2014)
## 65          Testudo rectogularis                        Schleich, 1981
## 66   Titanochelon cf. perpiniana                      (Depéret, 1885)
## 67          Paleotestudo antiqua                        (Bronn, 1831)
## 68          Paleotestudo antiqua                        (Bronn, 1831)
## 69        Testudo steinheimensis                     (Staesche, 1931)
## 70          Paleotestudo antiqua                        (Bronn, 1831)
## 71          Paleotestudo antiqua                        (Bronn, 1831)
## 72        Testudo steinheimensis                      Staesche, 1931
## 73                   Testudo sp.                      Linnaeus, 1758
## 74
##
## 1
## 2
## 3
## 4
## 5                   Holotypus: NMNH 10944 (cast UMMP V31427) right epiplastron, left hyoplastral fra
## 6
## 7
## 8                                                                  UF 64395, 65005, 80593, 84300, 
## 9  Holotypus: UMMP V56298 almost complete specimen, Paratypes: UMMP V59919 one fragmentary nuchal, 59
## 10
## 11
## 12
## 13
## 14                                                                  Neotypus: MT PAL 2012.0.10 r
## 15                                                                  Neotypus: MT PAL 2012.0.10 r
## 16                                                                  Neotypus: MT PAL 2012.0.10 r
## 17                                                                  Neotypus: MT PAL 2012.0.10 r
## 18                                                                  Neotypus: MT PAL 2012.0.10 r
## 19                                                                  Neotypus: MT PAL 2012.0.10 r
## 20                                                                  Neotypus: MT PAL 2012.0.10 r
## 21                                                                  Neotypus: MT PAL 2012.0.10 r
## 22                                                                  Neotypus: MT PAL 2012.0.10 r
## 23                                                                       Holotypus: ZI
## 24                                                                       Holotypus: ZI
## 25                                                                Holotypus: KUMVP 6789 nearly
## 26
## 27
## 28
## 29                                                          DM-H-14 nearly complete shell, asso
## 30
## 31
## 32
## 33
## 34
## 35
## 36
## 37
## 38
## 39
## 40
## 41
## 42                                                                                        MSGN
```

```
## 43                                                                                                  MSGN
## 44                                                                                                  MSGN
## 45                                                                                                  MSGN
## 46
## 47
## 48
## 49
## 50
## 51                                         MSGN old collections: PQ AD 73, PQ AD 1293, PQ AD 2789
## 52                                         MSGN old collections: PQ AD 73, PQ AD 1293, PQ AD 2789
## 53                                         MSGN old collections: PQ AD 73, PQ AD 1293, PQ AD 2789
## 54
## 55
## 56
## 57
## 58
## 59                                                                UMMP V60631 distal phalange (UM-
## 60                                                                UMMP V60631 distal phalange (UM-
## 61
## 62
## 63
## 64
## 65
## 66
## 67
## 68
## 69
## 70
## 71
## 72
## 73
## 74
##                                                          CollNo   CL
## 1                                                   UCMP 95918 1200
## 2                                                   UCMP 36080 1200
## 3                                                  UCMP 131794   NA
## 4                                                   CMM-V-4666   NA
## 5                                                   NMNH 10944   NA
## 6                                               Santee Type B    NA
## 7                                                  TPPHM 1534    NA
## 8                                                        80593   NA
## 9                                                  UMMP V56298   NA
## 10                                                     UF 9370   NA
## 11                      7 specimens: 192.0-264.0 mm (mean=211.6 mm)   NA
## 12                                         LGPUT EPN I 100-199 1196
## 13                                        LGPUT EPN II 200-287 1164
## 14                                           MT PAL 2012.0.10   185
## 15                                                  FFSM3446.1  229
## 16                                                 FFSM 3446.2  220
## 17                                                 FFSM 3446.3  195
## 18                                                 FFSM 3446.4  206
## 19                                      SMNS 4450 (incomplete)  195
## 20                                                  SMNS 51467   NA
## 21                                                  SMNS 51469  180
```

```
## 22                                                        UFGC 9  145
## 23                                                       MgCH/15   NA
## 24                                                       MgCH/17  220
## 25                                                     KUMVP 6789  176
## 26                                                     KUMVP 6790  185
## 27                                                             -  400
## 28                                                         MP 29  400
## 29                                                       DM-H-14  195
## 30                                          CL: 88 cm, PL: 70 cm  880
## 31                          several specimens, no exact number given  500
## 32                          several specimens, no exact number given  500
## 33                          several specimens, no exact number given  500
## 34                                                       MCZ 2020  370
## 35                                                       MCZ 2021   NA
## 36                                                     UCMP 40200  278
## 37                                                             - 1860
## 38                                                             - 1000
## 39                                                             - 1000
## 40 Holotype (Stromer, 1926) --> was destroyed during World War II   NA
## 41                                             ca. 30 cm (wsl CL)  300
## 42                                                         AM 1'99  254
## 43                                                         AM 9'93  470
## 44                                                          OMS x1  470
## 45                                                           Am xf  815
## 46                                                       Holotypus  180
## 47                                                       Holotypus  160
## 48                                                       Holotypus  180
## 49                                                       Holotypus  200
## 50                                                       Holotypus  180
## 51                                                             -   NA
## 52                                                             -   NA
## 53                                                             -  110
## 54                                            NHMW 2009z0103/0001 1850
## 55                                                  type locality 1140
## 56                                                             -  850
## 57                                                             - 1170
## 58                                                             - 1420
## 59                                                             -   NA
## 60                                                             -   NA
## 61                                                             - 1500
## 62                                                             - 1500
## 63                                                LGPUT KLK 501-528  900
## 64                                                LGPUT MIC 300-303  900
## 65                                     Holotypus: BSP 1959 II 1172  213
## 66                                                  1959 II 2033   NA
## 67                                                BSP 1954 I 539a  203
## 68                                                BSP 1954 I 539b   NA
## 69                                                  BSP 1932 I 50  111
## 70                                                             -  152
## 71                                                             -  240
## 72                                                         Tüb. 1   NA
## 73                                                            264  500
## 74                                                                 NA
##        PL            size
```

```
## 1      NA            <NA>
## 2      NA            <NA>
## 3   620.0            <NA>
## 4      NA            <NA>
## 5      NA medium to large
## 6   160.0            <NA>
## 7   805.0            <NA>
## 8   510.0           small
## 9   258.0           large
## 10  219.0            <NA>
## 11  211.6            <NA>
## 12 1150.0            <NA>
## 13 1120.0            <NA>
## 14     NA            <NA>
## 15     NA            <NA>
## 16     NA            <NA>
## 17     NA            <NA>
## 18     NA            <NA>
## 19  186.0            <NA>
## 20  145.0            <NA>
## 21     NA            <NA>
## 22     NA            <NA>
## 23  180.0            <NA>
## 24     NA            <NA>
## 25  189.0            <NA>
## 26     NA            <NA>
## 27     NA            <NA>
## 28     NA            <NA>
## 29     NA            <NA>
## 30  700.0           large
## 31     NA            <NA>
## 32     NA            <NA>
## 33     NA            <NA>
## 34     NA            <NA>
## 35  400.0            <NA>
## 36     NA            <NA>
## 37     NA            <NA>
## 38     NA            <NA>
## 39     NA            <NA>
## 40  240.0            <NA>
## 41  244.0            <NA>
## 42  225.0            <NA>
## 43  406.0            <NA>
## 44     NA            <NA>
## 45     NA            <NA>
## 46  155.0          medium
## 47     NA          medium
## 48     NA          medium
## 49     NA          medium
## 50     NA          medium
## 51  400.0           large
## 52  500.0           large
## 53     NA           large
## 54     NA           giant
```

```
## 55     NA           giant
## 56     NA           large
## 57     NA           giant
## 58     NA           giant
## 59     NA          larrge
## 60     NA           small
## 61     NA            <NA>
## 62     NA            <NA>
## 63     NA            <NA>
## 64     NA            <NA>
## 65  180.0            <NA>
## 66  910.0            <NA>
## 67  178.0            <NA>
## 68  167.0            <NA>
## 69  110.0            <NA>
## 70  134.0            <NA>
## 71     NA            <NA>
## 72  207.0            <NA>
## 73  450.0            <NA>
## 74     NA
##
## 1
## 2
## 3
## 4
## 5
## 6
## 7
## 8
## 9
## 10
## 11
## 12
## 13
## 14
## 15
## 16
## 17
## 18
## 19
## 20
## 21
## 22
## 23
## 24
## 25                                                                  Holotype KUMVP (
## 26
## 27
## 28
## 29
## 30
## 31                                                        Tortoises (Geochelone sp. and
## 32                                                        Tortoises (Geochelone sp. and
## 33                                                        Tortoises (Geochelone sp. and
```

```
## 34
## 35
## 36
## 37
## 38
## 39
## 40
## 41
## 42
## 43
## 44
## 45
## 46
## 47
## 48
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## 50
## 51
## 52
## 53
## 54
## 55
## 56
## 57
## 58
## 59
## 60
## 61
## 62
## 63
## 64
## 65 der leider nur fragmentär überlieferte Panzer des Typusexemplares misst eine rekonstruierbare Läng
## 66
## 67
## 68
## 69
## 70
## 71
## 72
## 73
## 74
##    estimated..e..from.verbal.description..ev..from.plastron..ep..or.measured..m..measured.from.figur
## 1
## 2
## 3
## 4
## 5
## 6
## 7
## 8
## 9
## 10
## 11
## 12
```

```
## 13
## 14
## 15
## 16
## 17
## 18
## 19
## 20
## 21
## 22
## 23
## 24
## 25
## 26
## 27
## 28
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## 53
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## 55
## 56
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## 59
## 60
## 61
## 62
## 63
## 64
## 65
## 66
```

```
## 67
## 68
## 69
## 70
## 71
## 72
## 73
## 74
##
## 1
## 2
## 3
## 4
## 5
## 6
## 7
## 8  Meylan P.A., 1995: Pleistocene amphibians and reptiles from the Leisey Shell Pit, Hillsborough Co
## 9
## 10
## 11
## 12
## 13
## 14
## 15
## 16
## 17
## 18
## 19
## 20
## 21
## 22
## 23
## 24
## 25
## 26
## 27
## 28
## 29
## 30
## 31
## 32
## 33
## 34
## 35
## 36
## 37
## 38
## 39
## 40
## 41
## 42
## 43
## 44
## 45
```

```
## 46
## 47
## 48
## 49
## 50
## 51
## 52
## 53
## 54
## 55
## 56
## 57
## 58
## 59
## 60
## 61
## 62
## 63
## 64
## 65
## 66
## 67
## 68
## 69
## 70
## 71
## 72
## 73
## 74
##    in.fossil.checklist.    Age
## 1                    NA  5.500
## 2                    NA  9.500
## 3                    NA  5.500
## 4                    NA 15.400
## 5                    NA  0.300
## 6                    NA  5.000
## 7                    NA  2.700
## 8                    NA  1.250
## 9                    NA  3.000
## 10                   NA 10.950
## 11                   NA  0.069
## 12                   NA  3.950
## 13                   NA  3.950
## 14                   NA 13.000
## 15                   NA 13.000
## 16                   NA 13.000
## 17                   NA 13.000
## 18                   NA 13.000
## 19                   NA 13.000
## 20                   NA 13.000
## 21                   NA 13.000
## 22                   NA 13.000
## 23                   NA  3.950
## 24                   NA  3.950
```

```
## 25                   NA  3.000
## 26                   NA  3.000
## 27                   NA 33.950
## 28                   NA 23.115
## 29                   NA  1.770
## 30                   NA  4.500
## 31                   NA 11.850
## 32                   NA 10.100
## 33                   NA 10.100
## 34                   NA 18.500
## 35                   NA 18.500
## 36                   NA  8.500
## 37                   NA  2.000
## 38                   NA 16.650
## 39                   NA 14.000
## 40                   NA 19.500
## 41                   NA 19.500
## 42                   NA 18.000
## 43                   NA 18.000
## 44                   NA 18.000
## 45                   NA 18.000
## 46                   NA 17.250
## 47                   NA 17.250
## 48                   NA 17.250
## 49                   NA 17.250
## 50                   NA 17.250
## 51                   NA 17.250
## 52                   NA 17.250
## 53                   NA 17.250
## 54                   NA  6.250
## 55                   NA  3.900
## 56                   NA  0.066
## 57                   NA 10.250
## 58                   NA  1.850
## 59                   NA  2.000
## 60                   NA  2.000
## 61                   NA  3.000
## 62                   NA  3.000
## 63                   NA  3.950
## 64                   NA  3.950
## 65                   NA 16.370
## 66                   NA 16.370
## 67                   NA 12.150
## 68                   NA 12.150
## 69                   NA 12.150
## 70                   NA 13.000
## 71                   NA 13.000
## 72                   NA 13.000
## 73                   NA  3.900
## 74                   NA     NA
```

Prepare data for conversion to paleoTS-object:

```
SampleSize <- tidyCL %>%
  dplyr::select(MAmin, Mamax, CL) %>%
```

```
  filter(CL != "NA")

length(SampleSize$CL)
```

```
## [1] 53
```

```
TidyCL <- tidyCL %>%
  dplyr::select(MAmin, Mamax, CL) %>%
  dplyr::filter(CL != "NA") %>%
  mutate(tt= (MAmin+Mamax)/2) %>% # create mean age
  group_by(tt) %>% #create time bins
  summarise(mm=mean(CL), vv=var(CL), nn=n()) #create means etc. for each time bin

TidyCL[is.na(TidyCL)]<-0 #subset NAs with 0 for

TidyCL
```

```
## # A tibble: 26 × 4
##       tt      mm       vv    nn
##    <dbl>   <dbl>    <dbl> <int>
## 1  0.066  850.00      0.0     1
## 2  1.770  195.00      0.0     1
## 3  1.850 1420.00      0.0     1
## 4  2.000 1860.00      0.0     1
## 5  3.000  840.25 580373.6     4
## 6  3.900  820.00 204800.0     2
## 7  3.950  876.00 154208.0     5
## 8  4.500  880.00      0.0     1
## 9  5.500 1200.00      0.0     1
## 10 6.250 1850.00      0.0     1
## # ... with 16 more rows
```

```
bins <- tidyCL %>%
#  select(MAmin, Mamax, CL) %>%
  filter(CL != "NA") %>%
  mutate(tt= (MAmin+Mamax)/2) %>% # create mean age
  group_by(tt)

bins
```

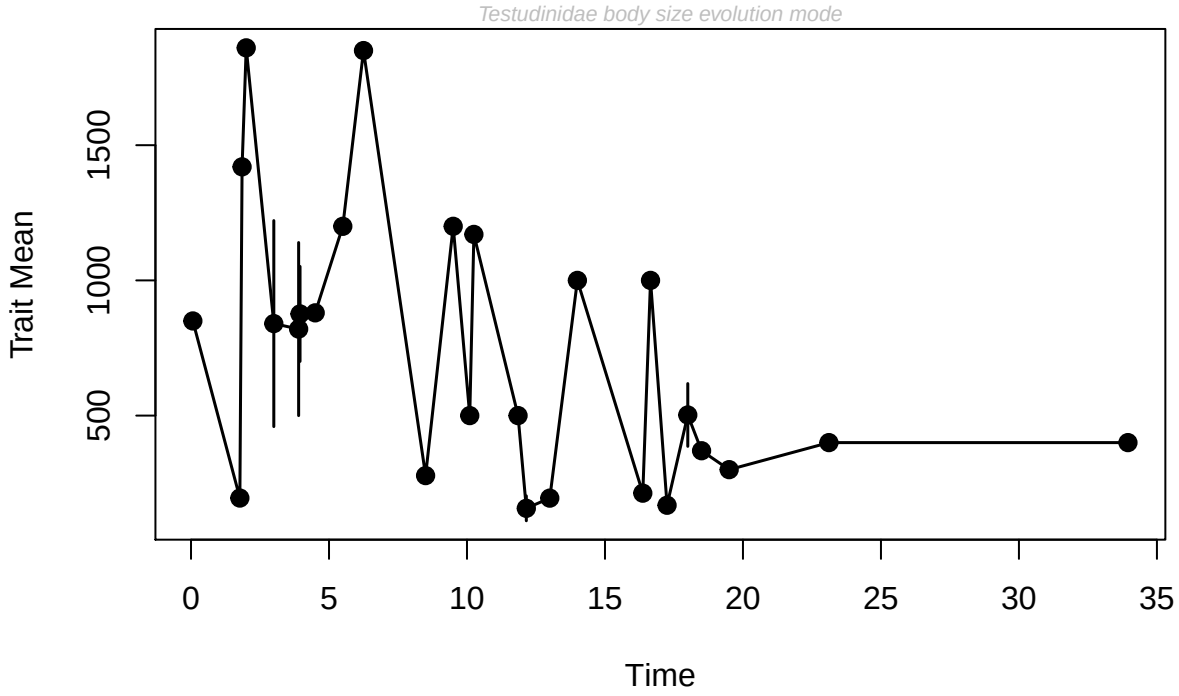
```
## Source: local data frame [53 x 25]
## Groups: tt [26]
##
##                                                                  Locality
##                                                                    <fctr>
## 1        UCMP V71137, Turlock Lake 10, Stanislaus County, California
## 2    UCMP V-3952, Ingram Creek site 8, Stanislaus County, California
## 3   Epanomi (EPN I), western Chalkidiki Peninsula, Thessaloniki area
## 4  Epanomi (EPN II), western Chalkidiki Peninsula, Thessaloniki area
## 5                     Hohenhöwen, Engen, Hegau, southwestern Germany
## 6                     Hohenhöwen, Engen, Hegau, southwestern Germany
## 7                     Hohenhöwen, Engen, Hegau, southwestern Germany
## 8                     Hohenhöwen, Engen, Hegau, southwestern Germany
## 9                     Hohenhöwen, Engen, Hegau, southwestern Germany
## 10                    Hohenhöwen, Engen, Hegau, southwestern Germany
```

```
## # ... with 43 more rows, and 24 more variables: Country <fctr>,
## #   Latitude <dbl>, Longitude <dbl>, Formation.Location.comment <fctr>,
## #   MAmin <dbl>, Mamax <dbl>, Epoch <fctr>, upper.stage <fctr>,
## #   lower.stage <fctr>, Genus <fctr>, Species <fctr>, Taxon <fctr>,
## #   Author <fctr>, comment <fctr>, CollNo <fctr>, CL <int>, PL <dbl>,
## #   size <fctr>, verbal.description <fctr>,
## #   estimated..e..from.verbal.description..ev..from.plastron..ep..or.measured..m..measured.from.figu
## #   Reference <fctr>, in.fossil.checklist. <lgl>, Age <dbl>, tt <dbl>
```

```
library(paleoTS)
paleoTidyCL <-as.paleoTS(TidyCL$mm, TidyCL$vv, TidyCL$nn, TidyCL$tt, MM = NULL, genpars = NULL, label =
paleoTidyCL
```

```
## $mm
##  [1]  850.0000  195.0000 1420.0000 1860.0000  840.2500  820.0000  876.0000
##  [8]  880.0000 1200.0000 1850.0000  278.0000 1200.0000  500.0000 1170.0000
## [15]  500.0000  157.0000  194.7000 1000.0000  213.0000 1000.0000  168.3333
## [22]  502.2500  370.0000  300.0000  400.0000  400.0000
##
## $vv
##  [1]      0.0000      0.0000      0.0000      0.0000 580373.5833
##  [6] 204800.0000 154208.0000      0.0000      0.0000      0.0000
## [11]      0.0000      0.0000      0.0000      0.0000      0.0000
## [16]   4232.0000    955.5667      0.0000      0.0000      0.0000
## [21]    976.6667  53840.2500      0.0000      0.0000      0.0000
## [26]      0.0000
##
## $nn
##  [1]  1  1  1  1  4  2  5  1  1  1  1  1  2  1  1  2 10  1  1  1  6  4  1
## [24]  1  1  1
##
## $tt
##  [1]  0.000  1.704  1.784  1.934  2.934  3.834  3.884  4.434  5.434  6.184
## [11]  8.434  9.434 10.034 10.184 11.784 12.084 12.934 13.934 16.304 16.584
## [21] 17.184 17.934 18.434 19.434 23.049 33.884
##
## $MM
## NULL
##
## $genpars
## NULL
##
## $label
## [1] "Testudinidae body size evolution mode"
##
## $start.age
## [1] 0.066
##
## $timeDir
## [1] "increasing"
##
## attr(,"class")
## [1] "paleoTS"
```

```
plot(paleoTidyCL)
```




```
fit3models(paleoTidyCL, silent=FALSE, method="AD", pool=FALSE)   #not working with Test1, because no va
```

```
##
## Comparing 3 models [n = 25, method = AD]
##
##             logL K     AICc Akaike.wt
## GRW    -207.9992 2 420.5439         0
## URW    -261.5456 1 525.2652         0
## Stasis -192.9638 2 390.4730         1
```

15.06.2017

Use paleoTS with data from the past 10 Mya (today - Pliocene, beginning of Miocene)

```
unique(tidyCL$Epoch)
```

```
## [1] Pliocene/Miocene     Miocene              Pleistocene
## [4] Pliocene             Pleistocene/Pliocene Eocene
## [7] Oligocene            Holocene/Pleistocene
## 9 Levels:  Eocene Holocene/Pleistocene Miocene Oligocene ... Pliocene/Miocene
```

```
PleiPlioCL <- tidyCL %>%
  filter(Age < 10.000)
```

```
length(PleiPlioCL$CL)
```

```
## [1] 30
```

```
PPCL <- PleiPlioCL %>%
  select(MAmin, Mamax, CL) %>%
  filter(CL != "NA") %>%
  mutate(tt= (MAmin+Mamax)/2) %>% # create mean age
  group_by(tt) %>% #create time bins
  summarise(mm=mean(CL), vv=var(CL), nn=n()) #create means etc. for each time bin

PPCL[is.na(PPCL)]<-0 #subset NAs with 0 for

PPCL
```

```
## # A tibble: 12 × 4
##       tt      mm       vv    nn
##    <dbl>   <dbl>    <dbl> <int>
## 1  0.066  850.00      0.0     1
## 2  1.770  195.00      0.0     1
## 3  1.850 1420.00      0.0     1
## 4  2.000 1860.00      0.0     1
## 5  3.000  840.25 580373.6     4
## 6  3.900  820.00 204800.0     2
## 7  3.950  876.00 154208.0     5
## 8  4.500  880.00      0.0     1
## 9  5.500 1200.00      0.0     1
## 10 6.250 1850.00      0.0     1
## 11 8.500  278.00      0.0     1
## 12 9.500 1200.00      0.0     1
```

```
bins <- PleiPlioCL %>%
  #  select(MAmin, Mamax, CL) %>%
  filter(CL != "NA") %>%
  mutate(tt= (MAmin+Mamax)/2) %>% # create mean age
  group_by(tt)

bins
```

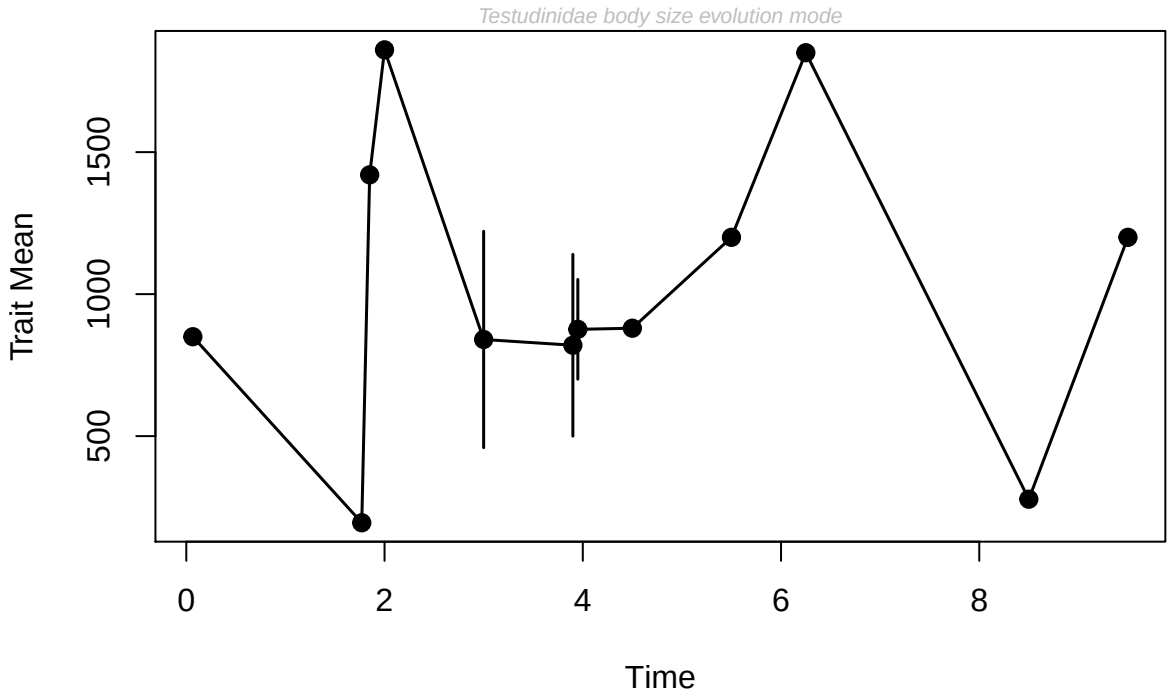
```
## Source: local data frame [20 x 25]
## Groups: tt [12]
##
##                                                                  Locality
##                                                                    <fctr>
## 1            UCMP V71137, Turlock Lake 10, Stanislaus County, California
## 2         UCMP V-3952, Ingram Creek site 8, Stanislaus County, California
## 3       Epanomi (EPN I), western Chalkidiki Peninsula, Thessaloniki area
## 4      Epanomi (EPN II), western Chalkidiki Peninsula, Thessaloniki area
## 5                       Altan-Teli main fossiliferous bed (Dzereg valley)
## 6                       Sawrock Canyon local fauna, Seward County, Kansas
## 7                       Sawrock Canyon local fauna, Seward County, Kansas
## 8                                                                 Dmanisi
## 9       Lee Creek Mine, Yorktown Sample, Beaufort County, North Carolina
## 10                                    San Nicolas, UCMP locality V4536
## 11                                              Lesbos Island, F-Site
```

```
## 12                                                                 Samos 1
## 13              Serrat-d´en-Vacquer near Perpignan, Pyrénées-Orientales
## 14                                  Zebbug and Gahr Dalam Cave deposits
## 15                                                Fonelas P-1, Guadix Basin
## 16 Tha Chang area, Chaloem Pra Kiat district, Nakhon Ratchasima Province
## 17 Tha Chang area, Chaloem Pra Kiat district, Nakhon Ratchasima Province
## 18      Nea Kallikratia, western Chalkidiki Peninsula, Thessaloniki area
## 19       Nea Michaniona, western Chalkidiki Peninsula, Thessaloniki area
## 20                                                                 W??e 1
## # ... with 24 more variables: Country <fctr>, Latitude <dbl>,
## #   Longitude <dbl>, Formation.Location.comment <fctr>, MAmin <dbl>,
## #   Mamax <dbl>, Epoch <fctr>, upper.stage <fctr>, lower.stage <fctr>,
## #   Genus <fctr>, Species <fctr>, Taxon <fctr>, Author <fctr>,
## #   comment <fctr>, CollNo <fctr>, CL <int>, PL <dbl>, size <fctr>,
## #   verbal.description <fctr>,
## #   estimated..e..from.verbal.description..ev..from.plastron..ep..or.measured..m..measured.from.figu
## #   Reference <fctr>, in.fossil.checklist. <lgl>, Age <dbl>, tt <dbl>
```

```
paleoPPCL <-as.paleoTS(PPCL$mm, PPCL$vv, PPCL$nn, PPCL$tt, MM = NULL, genpars = NULL, label = "Testudin
paleoPPCL
```

```
## $mm
##  [1]  850.00  195.00 1420.00 1860.00  840.25  820.00  876.00  880.00
##  [9] 1200.00 1850.00  278.00 1200.00
##
## $vv
##  [1]      0.0      0.0      0.0      0.0 580373.6 204800.0 154208.0
##  [8]      0.0      0.0      0.0      0.0      0.0
##
## $nn
##  [1] 1 1 1 1 4 2 5 1 1 1 1 1
##
## $tt
##  [1] 0.000 1.704 1.784 1.934 2.934 3.834 3.884 4.434 5.434 6.184 8.434
## [12] 9.434
##
## $MM
## NULL
##
## $genpars
## NULL
##
## $label
## [1] "Testudinidae body size evolution mode"
##
## $start.age
## [1] 0.066
##
## $timeDir
## [1] "increasing"
##
## attr(,"class")
## [1] "paleoTS"
```

```
plot(paleoPPCL)
```

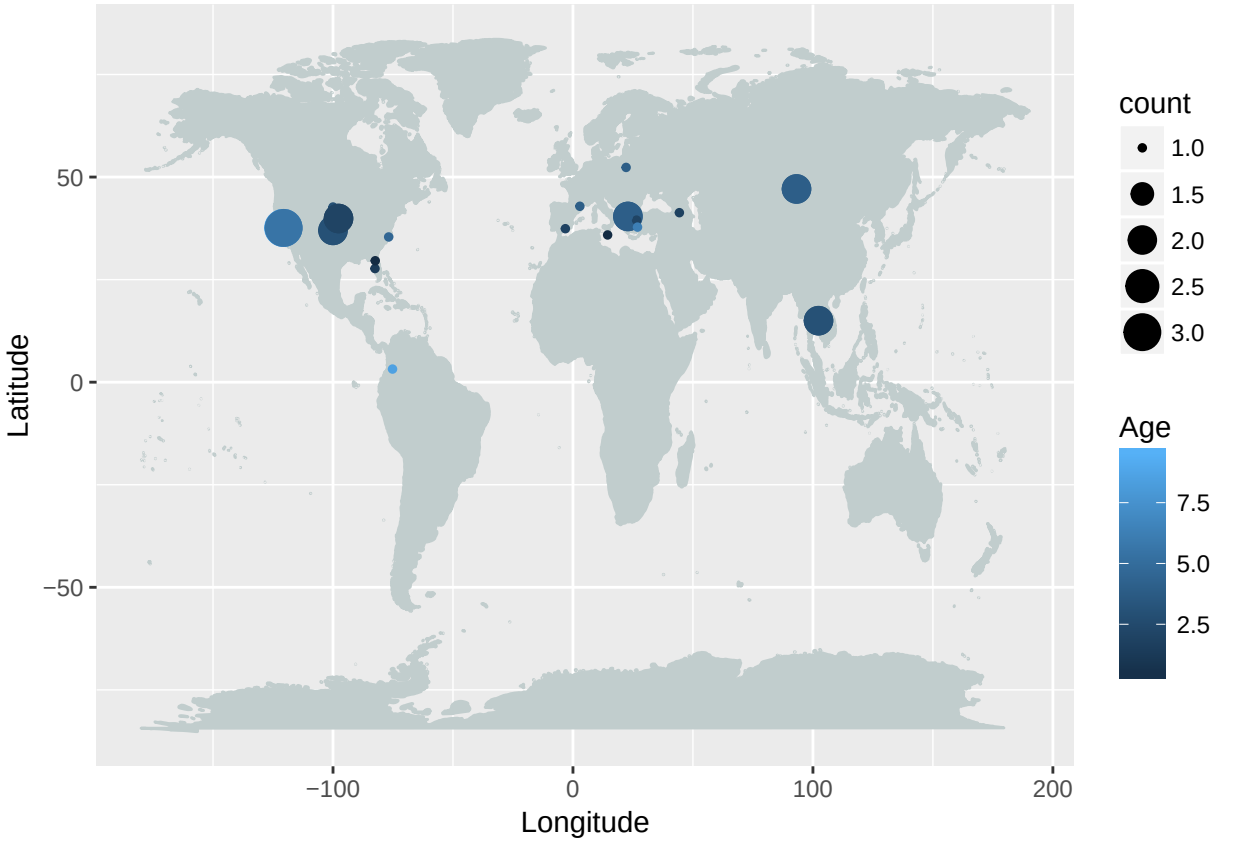



```
fit3models(paleoPPCL, silent=FALSE, method="AD", pool=FALSE)   #not working with Test1, because no vari
```

```
##
## Comparing 3 models [n = 11, method = AD]
##
##             logL K     AICc Akaike.wt
## GRW    -140.0303 2 285.5606         0
## URW    -151.9229 1 306.2902         0
## Stasis -102.1288 2 209.7576         1
```

```
PPmap <- PleiPlioCL %>%
  select(Genus, Taxon, Latitude, Longitude, Country, CL, PL, Age) %>%
  group_by(Latitude) %>%
  mutate(count= n()) %>%
  ggplot(aes(Longitude, Latitude)) + mapWorld +
  geom_point(aes(Longitude, Latitude,colour=Age, size=count))

PPmap
```




```
ggplotly(PPmap)
```

```
## We recommend that you use the dev version of ggplot2 with `ggplotly()`
## Install it with: `devtools::install_github('hadley/ggplot2')`
```

TO DO:

- finish data set
-

This is an R Markdown Notebook. When you execute code within the notebook, the results appear beneath the code.

Try executing this chunk by clicking the *Run* button within the chunk or by placing your cursor inside it and pressing *Ctrl+Shift+Enter*.

Add a new chunk by clicking the *Insert Chunk* button on the toolbar or by pressing *Ctrl+Alt+I*.

When you save the notebook, an HTML file containing the code and output will be saved alongside it (click the *Preview* button or press *Ctrl+Shift+K* to preview the HTML file).