### diversity-through-time

Today we will use paleotree to plot diversity through time for stratigraphic range data from paelodb. First lets get some occurrence data. Paleotree can work with all of the occurrences.

```
## Loading required package: raster
## Loading required package: sp
## Loading required package: maps
## Loading required package: ape
## Warning: package 'ape' was built under R version 3.3.2
##
## Attaching package: 'ape'
  The following objects are masked from 'package:raster':
##
       rotate, zoom
data(graptPBDB)
head(graptOccPBDB)
##
     occurrence_no record_type reid_no obsolete collection_no
## 1
                                     NA
                                                            215
              1669 occurrence
                                              NA
## 2
              2186 occurrence
                                     NA
                                              NA
                                                            256
## 3
              2216 occurrence
                                     NA
                                              NA
                                                            258
## 4
              2217
                                     NA
                                              NA
                                                            258
                    occurrence
## 5
              2318 occurrence
                                     NA
                                              NA
                                                            270
## 6
              2319 occurrence
                                     NA
                                              NA
##
        identified_name identified_rank identified_no taxonomic_reason
## 1
      Chaunograptus sp.
                                   genus
                                                  33800
      Dendrograptus sp.
                                                  33551
                                   genus
## 3 Acanthograptus sp.
                                   genus
                                                  33536
     Dendrograptus sp.
                                   genus
                                                  33551
## 5
     Dendrograptus sp.
                                   genus
                                                  33551
## 6
                                                  33673
       Hallograptus sp.
                                   genus
##
      accepted_name accepted_rank accepted_no early_interval late_interval
      Chaunograptus
                                         33800
                                                     St Davids
                                                                   St Davids
                             genus
     Dendrograptus
                                         33551
                                                Trempealeauan Trempealeauan
                             genus
## 3 Acanthograptus
                             genus
                                         33536
                                                      Cambrian
                                                                    Cambrian
                                                      Cambrian
                                                                    Cambrian
     Dendrograptus
                                         33551
                             genus
## 5
      Dendrograptus
                                         33551
                                                      Tremadoc
                                                                    Tremadoc
                             genus
                                                      Tremadoc
                                                                    Tremadoc
## 6
       Hallograptus
                             genus
                                         33673
     early_age late_age reference_no
                                        primary_name primary_reso
## 1
         513.0
                  501.0
                                   13 Chaunograptus
```

13 Dendrograptus

13 Acanthograptus

## 2

## 3

501.0

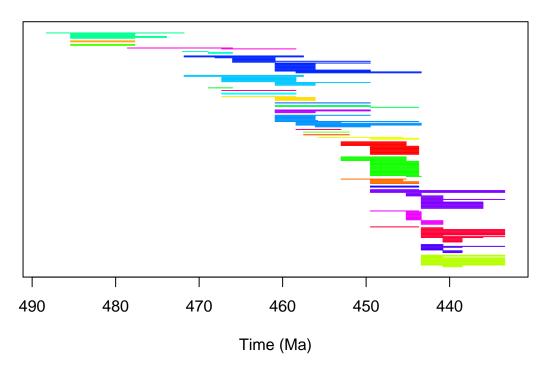
541.0

485.4

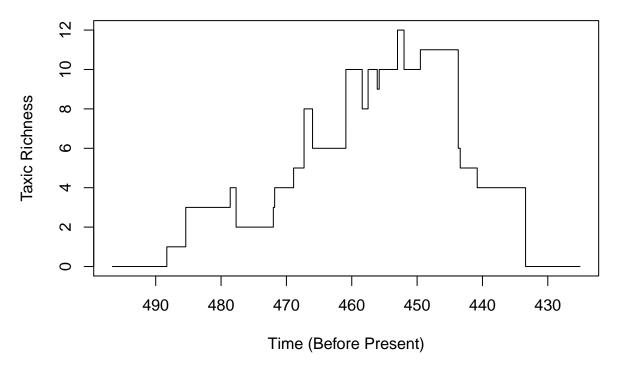
485.4

```
## 4
         541.0
                  485.4
                                   13 Dendrograptus
## 5
         485.4
                  477.7
                                   13 Dendrograptus
         485.4
                  477.7
                                        Hallograptus
## 6
                                   13
##
     subgenus_name subgenus_reso species_name species_reso subgenus
## 1
                                           sp.
## 2
                                                                   NA
                                           sp.
## 3
                                                                   NA
                                           sp.
## 4
                                                                   NΑ
                                           sp.
## 5
                                                                   NA
                                           sp.
## 6
                                                                   NA
                                           sp.
     subgenus_no
                          genus genus_no family family_no
                                                                   order
## 1
                                    33800
              NA
                  Chaunograptus
                                                         ΝA
                                                              Dendroidea
## 2
              NA Dendrograptus
                                    33551
                                                         NA
## 3
                                    33536
                                                              Dendroidea
              NA Acanthograptus
                                                         NA
## 4
              NA Dendrograptus
                                    33551
                                                         NA
                                                              Dendroidea
## 5
              NA Dendrograptus
                                    33551
                                                         NA
                                                              Dendroidea
## 6
              NA
                                    33673
                   Hallograptus
                                                         NA Graptoloidea
     order no
                      class class no
                                            phylum phylum_no
                                                                authorizer
## 1
                                33534 Hemichordata
                                                       33518 Sepkoski, J.
           NA Graptolithina
## 2
        33535 Graptolithina
                                33534 Hemichordata
                                                        33518 Sepkoski, J.
## 3
        33535 Graptolithina
                                33534 Hemichordata
                                                       33518 Sepkoski, J.
## 4
        33535 Graptolithina
                                33534 Hemichordata
                                                        33518 Sepkoski, J.
## 5
        33535 Graptolithina
                                33534 Hemichordata
                                                       33518 Sepkoski, J.
## 6
        33606 Graptolithina
                                33534 Hemichordata
                                                       33518 Sepkoski, J.
##
         enterer modifier
## 1 Sommers, M.
                  unknown
## 2 Sommers, M.
                  unknown
## 3 Sommers, M.
                  unknown
## 4 Sommers, M.
                  unknown
## 5 Sommers, M.
                  unknown
## 6 Sommers, M. unknown
# lets look at uncertainty for species and genera
# graptOccPBDB <- canids ### does not work, canid data set is formatted differently but not sure why.
#qraptOccPBDB <- canids</pre>
#dev.new()
#get data
data(graptPBDB)
#get species sorted occurrences
occSpecies <- taxonSortPBDBocc(graptOccPBDB, rank="species")
#plot species occurrences
plotOccData(occSpecies,groupLabel = "Species")
```

# **Age Uncertainty of Occurrence Data for Species**



# convert occurrence data to "timelist" format
graptTimeSpecies<-occData2timeList(occList=occSpecies)
#plot diversity trhough time
taxicDivDisc(graptTimeSpecies)</pre>



#### head(graptTimeSpecies)

startTime endTime

## \$intTimes

##

```
## [1,]
            488.3
                     477.7
## [2,]
             485.4
                     477.7
## [3,]
             485.4
                     471.8
## [4,]
            478.6
                     466.0
## [5,]
            472.0
                     468.9
            471.8
## [6,]
                     460.9
## [7,]
             471.8
                     458.4
## [8,]
            468.9
                     466.0
## [9,]
            467.3
                     458.4
            460.9
## [10,]
                     456.1
## [11,]
            460.9
                     449.5
## [12,]
            458.4
                     453.0
## [13,]
            458.4
                     443.4
## [14,]
             457.5
                     452.0
## [15,]
             456.1
                     443.4
## [16,]
            455.8
                     445.6
            453.0
## [17,]
                     445.6
## [18,]
             453.0
                     445.2
## [19,]
            449.5
                     443.7
## [20,]
             445.2
                     443.4
## [21,]
             443.4
                     440.8
## [22,]
             443.4
                     433.4
## [23,]
             440.8
                     433.4
##
## $taxonTimes
##
                                firstInt lastInt
## Adelograptus antiquus
                                               3
                                       1
## Adelograptus clarki
                                       2
                                               2
## Amplexograptus rugosus
                                      14
                                              14
## Azygograptus novozealandicus
                                       9
                                              10
## Climacograptus bicornis
                                      10
                                              15
## Climacograptus scalaris
                                      19
                                              23
## Corynoides incurvus
                                      14
                                              14
## Corynoides tricornis
                                      10
                                              11
                                      7
## Cryptograptus schaferi
                                              11
## Cryptograptus tricornis
                                      6
                                              13
## Dicellograptus anceps
                                      16
                                              19
## Dicellograptus complanatus
                                      17
                                              19
## Dicellograptus ornatus
                                      18
                                              20
                                              12
## Dicranograptus ramosus
                                      12
## Dictyonema pulchellum
                                       2
                                               2
## Didymograptus nicholsoni
                                      4
                                               9
## Diplograptus hughesi
                                      21
                                              23
## Geniculograptus pygmaeus
                                              19
                                      11
## Goniograptus macer
                                       5
                                               8
## Goniograptus speciosus
                                       8
                                               8
## Metabolograptus persculptus
                                      19
                                              21
                                              22
## Normalograptus normalis
                                      19
## Parabrograptus tribrachiatus
                                              11
```

```
## Pleurograptus linearis 19 19
## Pleurograptus lui 18 19
## Pterograptus elegans 9 9
## Rhaphidograptus toernquisti 21 23
## Tetragraptus insuetus 9 9
```

#### head(occSpecies)

##	\$`Ade	elograptus antid	ານນຣີ					
##	Ψ 1140	occurrence_no i	_	e reid no	obsolet	ce coll	ection n	0
	3609	596430	occurrenc			JA	6318	
	3612	596434	occurrenc		N	JA	6319	
	3627	596451	occurrenc		N	JA	6319	
##	3630	596454	occurrenc		N	JA	6319	
##	3632	596458	occurrenc	e NA	N	JA	6319	
##	3667	596498	occurrenc	e NA	N	JA	6320	
##	4223	826761	occurrenc	e NA	N	JA	9117	2
##		identified_name identified_rank identified_no						
##	3609	Adelograptus ?	antiquus	S	pecies		84007	
##	3612	Adelograptus ?	antiquus	s	pecies		84007	
##	3627	Adelograptus ?	antiquus	s	pecies		84007	
##	3630	Adelograptus ?	antiquus	S	pecies		84007	
##	3632	Adelograptus ?	antiquus	S	pecies		84007	
##	3667	Adelograptus ?	antiquus	S	pecies		84007	
##	4223	Adelograptus	antiquus		pecies		84007	
##		taxonomic_reaso				ccepted	_rank ac	cepted_no
	3609		A> Adelogr			sp	ecies	84007
	3612		A> Adelogr	_	_	sp	ecies	84007
	3627		A> Adelogr	_	_	sp	ecies	84007
	3630		A> Adelogr	_	_	-	ecies	84007
	3632		A> Adelogr	_	_	-	ecies	84007
	3667		A> Adelogr	_	_	-	ecies	84007
	4223		A> Adelogr	-	-	-	ecies	84007
##		early_interval			_	_		
	3609	Tremadocian	Tremado		485.4	477.7		18179
	3612	Lancefieldian	Bendigo		485.4	473.9		18179
	3627		Bendigo		485.4	473.9		18179
	3630	Tremadocian	Tremado		485.4	477.7		18179
	3632	Tremadocian	Tremado		485.4	477.7		18179 18170
	3667 4223	Tremadocian	Tremado		485.4 488.3	477.7 471.8		18179 24434
##	4223	Ibexian primary_name pr						
	3600	Adelograptus	-	o subgenu ?	S_Hame s	subgenu	s_reso s <sub>.</sub> <na></na>	antiquus
		Adelograptus		?	<na></na>		<na></na>	antiquus
		Adelograptus		?	<na></na>		<na></na>	antiquus
		Adelograptus		?	<na></na>		<na></na>	antiquus
		Adelograptus		?	<na></na>		<na></na>	antiquus
		Adelograptus		?	<na></na>		<na></na>	antiquus
		Adelograptus	<na< th=""><th></th><th><na></na></th><th></th><th><na></na></th><th>antiquus</th></na<>		<na></na>		<na></na>	antiquus
##		species_reso su				genus	genus_no	-
	3609	<na></na>	NA		Adelogr		33537	<na></na>
	3612	<na></na>	NA		Adelogr	-	33537	<na></na>
	3627	<na></na>	NA		Adelogr	_	33537	<na></na>
##	3630	<na></na>	NA		Adelogr	-	33537	<na></na>

```
## 3632
                <NA>
                            NA
                                        NA Adelograptus
                                                            33537
                                                                    <NA>
## 3667
                <NA>
                            NΑ
                                                                     <NA>
                                        NA Adelograptus
                                                            33537
## 4223
                <NA>
                            NA
                                        NA Adelograptus
                                                            33537
                                                                    <NA>
##
                                               class class_no
        family_no
                        order order_no
                                                                     phylum
## 3609
               NA Dendroidea
                                 33535 Graptolithina
                                                         33534 Hemichordata
## 3612
               NA Dendroidea
                                                         33534 Hemichordata
                                 33535 Graptolithina
## 3627
               NA Dendroidea
                                 33535 Graptolithina
                                                         33534 Hemichordata
## 3630
                                                         33534 Hemichordata
               NA Dendroidea
                                 33535 Graptolithina
## 3632
               NA Dendroidea
                                 33535 Graptolithina
                                                         33534 Hemichordata
## 3667
                                                         33534 Hemichordata
               NA Dendroidea
                                 33535 Graptolithina
## 4223
               NA Dendroidea
                                 33535 Graptolithina
                                                         33534 Hemichordata
##
                                   enterer modifier
        phylum_no
                   authorizer
## 3609
            33518
                    Hendy, A.
                                 Hendy, A. Hendy, A.
## 3612
            33518
                    Hendy, A.
                                 Hendy, A.
                                             unknown
## 3627
            33518
                    Hendy, A.
                                 Hendy, A.
                                             unknown
## 3630
            33518
                    Hendy, A.
                                 Hendy, A. Hendy, A.
## 3632
            33518
                                             unknown
                    Hendy, A.
                                 Hendy, A.
## 3667
            33518
                    Hendy, A.
                                 Hendy, A.
                                             unknown
## 4223
            33518 Villier, L. Villier, L.
                                             unknown
##
## $ Adelograptus clarki
        occurrence_no record_type reid_no obsolete collection_no
               596431 occurrence
                                        NA
                                                             63189
## 3610
                                                 NA
## 3633
               596459 occurrence
                                        NA
                                                             63195
                                                 NA
##
            identified name identified rank identified no taxonomic reason
## 3610 Adelograptus clarki
                                     species
                                                      84009
                                                                         <NA>
  3633 Adelograptus clarki
                                     species
                                                      84009
                                                                         <NA>
              accepted_name accepted_rank accepted_no early_interval
## 3610 Adelograptus clarki
                                                 84009
                                                           Tremadocian
                                   species
                                   species
  3633 Adelograptus clarki
                                                  84009
                                                           Tremadocian
##
        late_interval early_age late_age reference_no primary_name
## 3610
          Tremadocian
                           485.4
                                    477.7
                                                  18179 Adelograptus
   3633
          Tremadocian
                           485.4
                                    477.7
                                                  18179 Adelograptus
##
        primary_reso subgenus_name subgenus_reso species_name species_reso
## 3610
                <NA>
                               <NA>
                                             <NA>
                                                         clarki
                                                                         <NA>
##
  3633
                <NA>
                               <NA>
                                             <NA>
                                                         clarki
                                                                         <NA>
##
        subgenus subgenus no
                                     genus genus no family family no
## 3610
                          NA Adelograptus
                                              33537
                                                       <NA>
                                                                   NΔ
              NΑ
## 3633
              NA
                          NA Adelograptus
                                              33537
                                                       <NA>
##
             order order_no
                                     class class_no
                                                           phylum phylum_no
## 3610 Dendroidea
                      33535 Graptolithina
                                              33534 Hemichordata
  3633 Dendroidea
                      33535 Graptolithina
                                              33534 Hemichordata
                                                                      33518
        authorizer
                     enterer modifier
  3610 Hendy, A. Hendy, A. Hendy, A.
  3633 Hendy, A. Hendy, A.
                                unknown
##
## $`Amplexograptus rugosus`
        occurrence_no record_type reid_no obsolete collection_no
## 5893
              1256955 occurrence
                                        NA
                                                 NΑ
                                                            166800
##
               identified_name identified_rank identified_no taxonomic_reason
## 5893 Amplexograptus rugosus
                                                        315895
                                        species
                                                                            <NA>
                 accepted name accepted rank accepted no early interval
## 5893 Amplexograptus rugosus
                                      species
                                                    315895
                                                              Longvillian
##
        late interval early age late age reference no primary name
```

```
## 5893 Marshbrookian
                           457.5
                                       452
                                                    102 Amplexograptus
##
        primary_reso subgenus_name subgenus_reso species_name species_reso
## 5893
                               <NA>
                                              < NA >
                                                         rugosus
##
        subgenus subgenus_no
                                        genus genus_no family family_no
##
   5893
                           NA Amplexograptus
                                                 33615
                                                          <NA>
##
                                                              phylum phylum no
               order order no
                                        class class no
                         33606 Graptolithina
                                                 33534 Hemichordata
   5893 Graptoloidea
##
        authorizer
                       enterer modifier
## 5893 Wagner, P. Wagner, P. unknown
##
   $`Azygograptus novozealandicus`
##
        occurrence_no record_type reid_no obsolete collection_no
               601800 occurrence
## 3898
                                         NΑ
                                                  NA
## 3960
               601885 occurrence
                                         NA
                                                  NA
                                                              63960
## 3964
               601889 occurrence
                                         NA
                                                  NA
                                                              63961
## 3993
               601921
                        occurrence
                                         NA
                                                  NA
                                                              63963
## 4014
               601945 occurrence
                                                  NA
                                                              63965
                                         NA
##
                             identified name identified rank identified no
## 3898
                                                                       84630
               Azygograptus novozealandicus
                                                      species
                                                                       84630
## 3960
               Azygograptus novozealandicus
                                                      species
## 3964
               Azygograptus novozealandicus
                                                      species
                                                                       84630
## 3993 Azygograptus novozealandicus n. sp.
                                                      species
                                                                       84630
## 4014
               Azygograptus novozealandicus
                                                      species
                                                                       84630
        taxonomic reason
                                          accepted name accepted rank
                     <NA> Azygograptus novozealandicus
## 3898
                                                               species
## 3960
                     <NA> Azygograptus novozealandicus
                                                               species
## 3964
                     <NA> Azygograptus novozealandicus
                                                               species
## 3993
                     <NA> Azygograptus novozealandicus
                                                               species
## 4014
                     <NA> Azygograptus novozealandicus
                                                               species
        accepted_no early_interval late_interval early_age late_age
                                                       460.9
## 3898
              84630
                         Gisbornian
                                        Gisbornian
                                                                 456.1
## 3960
              84630
                         Gisbornian
                                        Gisbornian
                                                        460.9
                                                                 456.1
## 3964
                                                       460.9
              84630
                         Gisbornian
                                        Gisbornian
                                                                 456.1
## 3993
              84630
                        Darriwilian
                                                        467.3
                                                                 458.4
                                      Darriwilian
##
   4014
              84630
                         Gisbornian
                                        Gisbornian
                                                        460.9
                                                                 456.1
##
        reference_no primary_name primary_reso subgenus_name subgenus_reso
## 3898
               18428 Azygograptus
                                            <NA>
                                                           <NA>
                                                                          <NA>
## 3960
               18428 Azygograptus
                                            <NA>
                                                           <NA>
                                                                          <NA>
## 3964
               18428 Azygograptus
                                            <NA>
                                                           <NA>
                                                                          <NA>
## 3993
               18428 Azygograptus
                                            <NA>
                                                           <NA>
                                                                          <NA>
## 4014
               18428 Azygograptus
                                            <NA>
                                                           <NA>
                                                                          <NA>
           species_name species_reso subgenus subgenus_no
##
                                                                    genus
## 3898 novozealandicus
                                 <NA>
                                             NA
                                                          NA Azygograptus
## 3960 novozealandicus
                                 <NA>
                                             NΑ
                                                          NA Azygograptus
## 3964 novozealandicus
                                 <NA>
                                             NA
                                                          NA Azygograptus
## 3993 novozealandicus
                               n. sp.
                                                          NA Azygograptus
                                             NA
   4014 novozealandicus
                                 <NA>
                                             NA
                                                          NA Azygograptus
##
        genus_no family family_no
                                           order order_no
                                                                   class
## 3898
           33628
                    <NA>
                                NA Graptoloidea
                                                    33606 Graptolithina
## 3960
           33628
                    <NA>
                                NA Graptoloidea
                                                    33606 Graptolithina
## 3964
           33628
                    <NA>
                                NA Graptoloidea
                                                    33606 Graptolithina
## 3993
                    <NA>
                                NA Graptoloidea
                                                    33606 Graptolithina
           33628
## 4014
           33628
                    <NA>
                                NA Graptoloidea
                                                    33606 Graptolithina
##
        class no
                        phylum phylum no authorizer
                                                       enterer modifier
```

```
## 3898
           33534 Hemichordata
                                    33518
                                           Hendy, A. Hendy, A.
                                                                 unknown
## 3960
           33534 Hemichordata
                                    33518
                                           Hendy, A. Hendy, A.
                                                                 unknown
## 3964
           33534 Hemichordata
                                    33518
                                           Hendy, A. Hendy, A.
                                                                 unknown
                                           Hendy, A. Hendy, A.
## 3993
           33534 Hemichordata
                                    33518
                                                                 unknown
##
  4014
           33534 Hemichordata
                                    33518
                                           Hendy, A. Hendy, A.
                                                                 unknown
##
## $`Climacograptus bicornis`
        occurrence_no record_type reid_no obsolete collection_no
##
## 2399
               246238
                        occurrence
                                         NA
                                                   NA
                                                              24117
## 4166
               748935
                        occurrence
                                         NA
                                                   NA
                                                              80104
## 4320
               955088
                        occurrence
                                         NA
                                                   NA
                                                             111711
## 4325
               955095
                        occurrence
                                         NA
                                                   NA
                                                             111713
## 4332
               955103
                                         NA
                                                   NA
                                                             111718
                        occurrence
## 4516
                        occurrence
                                                             120528
               996584
                                         NA
                                                   NA
## 4685
                                                             145233
              1139721
                        occurrence
                                         NA
                                                   NA
## 4695
              1139731
                                         NA
                                                   NA
                                                             145236
                        occurrence
## 4703
              1139741
                                         NA
                                                   NA
                        occurrence
                                                             145237
## 4713
              1139751
                                                             145238
                        occurrence
                                         NA
                                                   NA
## 4725
                                                             145240
              1139763
                       occurrence
                                         NA
                                                   NA
## 4773
               1141828
                        occurrence
                                         NA
                                                   NA
                                                             145463
## 4774
              1141829
                        occurrence
                                         NA
                                                   MΔ
                                                             145464
## 5330
               1144012 occurrence
                                         NA
                                                   NA
                                                             145615
##
                 identified_name identified_rank identified_no
## 2399 Climacograptus bicornis
                                          species
                                                          306375
## 4166 Climacograptus bicornis
                                          species
                                                          306375
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## 4332 Climacograptus bicornis
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## 4325 Late Ordovician Late Ordovician
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   4332 Late Ordovician Late Ordovician
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                                               460.9
              Gisbornian
                                                         456.1
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## 4695
                                               460.9
              Gisbornian
                               Gisbornian
                                                         456.1
                                                                       46966
## 4703
             Gisbornian
                               Gisbornian
                                               460.9
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## 4713
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                                                    33606 Graptolithina
                                                                             33534
   5365 Diplograptidae
                           150197 Graptoloidea
                                                    33606 Graptolithina
                                                                             33534
   5385 Diplograptidae
                                                    33606 Graptolithina
                           150197 Graptoloidea
                                                                             33534
   5871 Diplograptidae
                           150197 Graptoloidea
                                                    33606 Graptolithina
                                                                             33534
  5896 Diplograptidae
                           150197 Graptoloidea
                                                    33606 Graptolithina
                                                                             33534
##
##
               phylum phylum_no
                                    authorizer
                                                    enterer
                                                               modifier
## 233
        Hemichordata
                          33518
                                     Alroy, J. Sommers, M.
                                                                unknown
   236
        Hemichordata
                          33518
                                     Alroy, J.
                                               Sommers, M.
                                                                unknown
   2530
        Hemichordata
                          33518
                                   Holland, S.
                                                 Hanson, T.
                                                                unknown
   2884
        Hemichordata
                                                  Foote, M.
                          33518
                                     Foote, M.
                                                                unknown
## 2948 Hemichordata
                          33518
                                     Foote, M.
                                                  Foote, M.
                                                                unknown
## 3173 Hemichordata
                          33518
                                     Foote, M.
                                                  Foote, M.
                                                                unknown
## 3246 Hemichordata
                          33518
                                     Foote, M.
                                                  Foote, M.
                                                                unknown
```

```
## 5115 Hemichordata
                          33518 Kiessling, W.
                                                Krause, M.
                                                               unknown
## 5122 Hemichordata
                          33518 Kiessling, W.
                                                Krause, M.
                                                               unknown
                                                               unknown
## 5132 Hemichordata
                          33518 Kiessling, W.
                                                Krause, M.
## 5154 Hemichordata
                          33518 Kiessling, W.
                                                Krause, M.
                                                               unknown
## 5204 Hemichordata
                          33518 Kiessling, W.
                                                Krause, M.
                                                               unknown
## 5344 Hemichordata
                          33518 Kiessling, W.
                                                Krause, M.
                                                               unknown
## 5355 Hemichordata
                          33518 Kiessling, W.
                                                Krause, M.
                                                               unknown
## 5365 Hemichordata
                                                Krause, M. Krause, M.
                          33518 Kiessling, W.
## 5385 Hemichordata
                          33518 Kiessling, W.
                                                Krause, M. Krause, M.
## 5871 Hemichordata
                          33518
                                   Kroger, B.
                                                Kroger, B.
                                                               unknown
## 5896 Hemichordata
                          33518
                                   Wagner, P.
                                                Wagner, P.
                                                               unknown
occGenera <- taxonSortPBDBocc(graptOccPBDB, rank="genus")
occFamily <- taxonSortPBDBocc(graptOccPBDB, rank=("family"))</pre>
head(occSpecies)
## $ Adelograptus antiquus
        occurrence no record type reid no obsolete collection no
## 3609
               596430 occurrence
                                        NA
                                                  NA
                                                             63189
## 3612
               596434 occurrence
                                         NA
                                                  MΔ
                                                             63190
## 3627
               596451 occurrence
                                        NA
                                                  NA
                                                             63192
## 3630
               596454 occurrence
                                        NA
                                                             63194
                                                  NΑ
## 3632
               596458 occurrence
                                         NA
                                                  NA
                                                             63195
## 3667
               596498 occurrence
                                         NA
                                                  NA
                                                             63204
## 4223
               826761 occurrence
                                         NA
                                                  NA
                                                             91172
##
                identified_name identified_rank identified_no
## 3609 Adelograptus ? antiquus
                                          species
                                                           84007
  3612 Adelograptus ? antiquus
                                          species
                                                          84007
## 3627 Adelograptus ? antiquus
                                          species
                                                          84007
## 3630 Adelograptus ? antiquus
                                                          84007
                                          species
                                          species
## 3632 Adelograptus ? antiquus
                                                          84007
## 3667
        Adelograptus ? antiquus
                                          species
                                                          84007
## 4223
          Adelograptus antiquus
                                                          84007
                                          species
##
                                  accepted_name accepted_rank accepted_no
        taxonomic_reason
## 3609
                     <NA> Adelograptus antiquus
                                                       species
                                                                      84007
## 3612
                     <NA> Adelograptus antiquus
                                                       species
                                                                      84007
                     <NA> Adelograptus antiquus
## 3627
                                                       species
                                                                      84007
## 3630
                     <NA> Adelograptus antiquus
                                                       species
                                                                      84007
## 3632
                     <NA> Adelograptus antiquus
                                                       species
                                                                      84007
## 3667
                     <NA> Adelograptus antiquus
                                                       species
                                                                      84007
## 4223
                     <NA> Adelograptus antiquus
                                                       species
                                                                      84007
        early_interval late_interval early_age late_age reference_no
##
## 3609
           Tremadocian
                          Tremadocian
                                           485.4
                                                    477.7
                                                                  18179
## 3612
        Lancefieldian
                          Bendigonian
                                           485.4
                                                    473.9
                                                                  18179
## 3627
         Lancefieldian
                                                    473.9
                                                                  18179
                          Bendigonian
                                           485.4
## 3630
           Tremadocian
                          Tremadocian
                                           485.4
                                                    477.7
                                                                  18179
## 3632
                                                    477.7
           Tremadocian
                          Tremadocian
                                           485.4
                                                                  18179
## 3667
           Tremadocian
                          Tremadocian
                                           485.4
                                                    477.7
                                                                  18179
## 4223
                                           488.3
                                                    471.8
                                                                  24434
               Ibexian
                              Ibexian
##
        primary name primary reso subgenus name subgenus reso species name
## 3609 Adelograptus
                                 ?
                                             <NA>
                                                            <NA>
                                                                     antiquus
## 3612 Adelograptus
                                 ?
                                             <NA>
                                                            <NA>
                                                                     antiquus
## 3627 Adelograptus
                                 ?
                                                            <NA>
                                             <NA>
                                                                     antiquus
```

```
## 3630 Adelograptus
                                             <NA>
                                                            <NA>
                                                                      antiquus
## 3632 Adelograptus
                                  ?
                                                            <NA>
                                                                      antiquus
                                             <NA>
## 3667 Adelograptus
                                             <NA>
                                                            <NA>
                                                                      antiquus
  4223 Adelograptus
                                             < N A >
                                                            <NA>
                                                                      antiquus
                              <NA>
        species_reso subgenus subgenus_no
                                                    genus genus_no family
## 3609
                 <NA>
                            NA
                                                             33537
                                         NA Adelograptus
                                                                      <NA>
## 3612
                 <NA>
                                         NA Adelograptus
                                                                      <NA>
                            NΑ
                                                             33537
## 3627
                                         NA Adelograptus
                 <NA>
                            NΑ
                                                             33537
                                                                      <NA>
## 3630
                 <NA>
                            NA
                                         NA Adelograptus
                                                             33537
                                                                      <NA>
## 3632
                 <NA>
                            NA
                                         NA Adelograptus
                                                             33537
                                                                      <NA>
## 3667
                 <NA>
                            NA
                                         NA Adelograptus
                                                             33537
                                                                      <NA>
##
  4223
                 <NA>
                            NA
                                         NA Adelograptus
                                                             33537
                                                                      <NA>
        family_no
                                                                       phylum
##
                        order order_no
                                                class class no
                NA Dendroidea
                                                          33534 Hemichordata
## 3609
                                  33535 Graptolithina
## 3612
               NA Dendroidea
                                  33535 Graptolithina
                                                          33534 Hemichordata
## 3627
               NA Dendroidea
                                  33535 Graptolithina
                                                          33534 Hemichordata
## 3630
               NA Dendroidea
                                  33535 Graptolithina
                                                          33534 Hemichordata
## 3632
               NA Dendroidea
                                  33535 Graptolithina
                                                          33534 Hemichordata
                                  33535 Graptolithina
## 3667
               NA Dendroidea
                                                          33534 Hemichordata
                                                          33534 Hemichordata
## 4223
               NA Dendroidea
                                  33535 Graptolithina
##
        phylum_no
                    authorizer
                                    enterer modifier
## 3609
            33518
                     Hendy, A.
                                 Hendy, A. Hendy, A.
                     Hendy, A.
## 3612
            33518
                                 Hendy, A.
                                              unknown
                                 Hendy, A.
## 3627
            33518
                     Hendy, A.
                                              unknown
## 3630
                     Hendy, A.
                                  Hendy, A. Hendy, A.
            33518
## 3632
            33518
                     Hendy, A.
                                  Hendy, A.
                                              unknown
## 3667
            33518
                     Hendy, A.
                                  Hendy, A.
                                              unknown
            33518 Villier, L. Villier, L.
##
  4223
                                              unknown
##
  $`Adelograptus clarki`
##
        occurrence_no record_type reid_no obsolete collection_no
## 3610
               596431 occurrence
                                         NA
                                                   NA
                                                              63189
   3633
                                                              63195
##
               596459 occurrence
                                         NA
                                                   NA
##
            identified_name identified_rank identified_no taxonomic_reason
   3610 Adelograptus clarki
                                      species
                                                       84009
                                                                          <NA>
   3633 Adelograptus clarki
                                      species
                                                       84009
                                                                          <NA>
##
##
              accepted name accepted rank accepted no early interval
  3610 Adelograptus clarki
                                    species
                                                  84009
                                                            Tremadocian
   3633 Adelograptus clarki
                                    species
                                                   84009
                                                            Tremadocian
##
        late_interval early_age late_age reference_no primary_name
          Tremadocian
                           485.4
                                                   18179 Adelograptus
  3610
                                     477.7
##
   3633
          Tremadocian
                           485.4
                                     477.7
                                                   18179 Adelograptus
        primary_reso subgenus_name subgenus_reso species_name species_reso
                                                          clarki
##
  3610
                 <NA>
                                <NA>
                                              <NA>
                                                                          <NA>
                 <NA>
                                <NA>
                                              <NA>
##
   3633
                                                          clarki
                                                                          <NA>
##
        subgenus subgenus_no
                                      genus genus_no family family_no
##
  3610
              NA
                           NA Adelograptus
                                               33537
                                                        <NA>
                                                                     NA
##
   3633
              NA
                           NA Adelograptus
                                                        <NA>
                                                                     NA
                                                33537
             order order_no
                                      class class_no
                                                            phylum phylum_no
##
  3610 Dendroidea
                       33535 Graptolithina
                                               33534 Hemichordata
                                                                        33518
                       33535 Graptolithina
   3633 Dendroidea
                                               33534 Hemichordata
                                                                        33518
##
        authorizer
                      enterer modifier
## 3610 Hendy, A. Hendy, A. Hendy, A.
## 3633 Hendy, A. Hendy, A.
                                unknown
```

```
##
## $ Amplexograptus rugosus
        occurrence_no record_type reid_no obsolete collection_no
              1256955 occurrence
## 5893
                                        NA
                                                            166800
                                            NA
##
               identified name identified rank identified no taxonomic reason
##
  5893 Amplexograptus rugosus
                                        species
                                                       315895
                 accepted name accepted rank accepted no early interval
##
  5893 Amplexograptus rugosus
                                                   315895
##
                                      species
                                                              Longvillian
##
        late_interval early_age late_age reference_no primary_name
   5893 Marshbrookian
                                      452
##
                          457.5
                                                   102 Amplexograptus
        primary_reso subgenus_name subgenus_reso species_name species_reso
   5893
##
                                                        rugosus
                <NA>
                               <NA>
                                             <NA>
                                                                        <NA>
##
        subgenus subgenus_no
                                       genus genus_no family family_no
                                                33615
                                                         <NA>
##
  5893
                          NA Amplexograptus
##
               order order_no
                                       class class_no
                                                             phylum phylum_no
   5893 Graptoloidea
                        33606 Graptolithina
                                                33534 Hemichordata
                                                                        33518
##
        authorizer
                      enterer modifier
   5893 Wagner, P. Wagner, P. unknown
##
##
  $`Azygograptus novozealandicus`
##
        occurrence_no record_type reid_no obsolete collection_no
## 3898
               601800 occurrence
                                        NA
               601885 occurrence
## 3960
                                        NA
                                                 NΔ
                                                             63960
## 3964
               601889 occurrence
                                        NA
                                                 NA
                                                             63961
               601921 occurrence
## 3993
                                        NΑ
                                                             63963
                                                 NA
## 4014
               601945 occurrence
                                        NA
                                                 NA
                                                             63965
##
                             identified_name identified_rank identified_no
## 3898
               Azygograptus novozealandicus
                                                     species
                                                                      84630
## 3960
                                                                      84630
               Azygograptus novozealandicus
                                                     species
## 3964
               Azygograptus novozealandicus
                                                     species
                                                                      84630
## 3993 Azygograptus novozealandicus n. sp.
                                                     species
                                                                      84630
## 4014
               Azygograptus novozealandicus
                                                     species
                                                                      84630
##
        taxonomic_reason
                                         accepted_name accepted_rank
## 3898
                    <NA> Azygograptus novozealandicus
                                                              species
## 3960
                    <NA> Azygograptus novozealandicus
                                                              species
## 3964
                    <NA> Azygograptus novozealandicus
                                                              species
## 3993
                    <NA> Azygograptus novozealandicus
                                                              species
## 4014
                    <NA> Azygograptus novozealandicus
                                                              species
##
        accepted_no early_interval late_interval early_age late_age
## 3898
              84630
                        Gisbornian
                                       Gisbornian
                                                      460.9
                                                                456.1
## 3960
              84630
                        Gisbornian
                                       Gisbornian
                                                       460.9
                                                                456.1
## 3964
                                                      460.9
              84630
                        Gisbornian
                                       Gisbornian
                                                                456.1
## 3993
              84630
                       Darriwilian
                                      Darriwilian
                                                      467.3
                                                                458.4
  4014
                                                      460.9
##
              84630
                        Gisbornian
                                       Gisbornian
                                                                456.1
        reference_no primary_name primary_reso subgenus_name subgenus_reso
## 3898
               18428 Azygograptus
                                           <NA>
                                                          <NA>
                                                                        <NA>
## 3960
               18428 Azygograptus
                                           <NA>
                                                          <NA>
                                                                        <NA>
## 3964
               18428 Azygograptus
                                                          <NA>
                                           <NA>
                                                                        <NA>
## 3993
               18428 Azygograptus
                                           <NA>
                                                          <NA>
                                                                        <NA>
## 4014
               18428 Azygograptus
                                           <NA>
                                                          <NA>
                                                                        <NA>
##
           species_name species_reso subgenus subgenus_no
                                                                   genus
## 3898 novozealandicus
                                 <NA>
                                            NA
                                                         NA Azygograptus
## 3960 novozealandicus
                                 <NA>
                                            NΑ
                                                         NA Azygograptus
## 3964 novozealandicus
                                 <NA>
                                            NA
                                                         NA Azygograptus
```

```
## 3993 novozealandicus
                               n. sp.
                                             NA
                                                          NA Azygograptus
## 4014 novozealandicus
                                  <NA>
                                             NΑ
                                                          NA Azygograptus
        genus no family family no
##
                                           order order no
                                                                    class
## 3898
           33628
                    <NA>
                                                     33606 Graptolithina
                                NA Graptoloidea
  3960
           33628
                    <NA>
                                NA Graptoloidea
                                                     33606 Graptolithina
## 3964
                                                     33606 Graptolithina
           33628
                    <NA>
                                NA Graptoloidea
## 3993
                                NA Graptoloidea
                                                     33606 Graptolithina
           33628
                    <NA>
## 4014
           33628
                    <NA>
                                NA Graptoloidea
                                                     33606 Graptolithina
                        phylum phylum_no authorizer
##
        class no
                                                        enterer modifier
## 3898
           33534 Hemichordata
                                    33518 Hendy, A. Hendy, A.
                                                                  unknown
## 3960
           33534 Hemichordata
                                    33518
                                           Hendy, A. Hendy, A.
                                                                  unknown
## 3964
           33534 Hemichordata
                                    33518
                                           Hendy, A. Hendy, A.
                                                                  unknown
## 3993
           33534 Hemichordata
                                    33518
                                           Hendy, A. Hendy, A.
                                                                  unknown
           33534 Hemichordata
## 4014
                                    33518
                                           Hendy, A. Hendy, A.
                                                                  unknown
##
   $`Climacograptus bicornis`
##
        occurrence_no record_type reid_no obsolete collection_no
## 2399
                246238
                       occurrence
                                                              24117
                                         NA
                                                   NA
## 4166
               748935
                                                              80104
                       occurrence
                                         NΑ
                                                   NΑ
## 4320
               955088
                        occurrence
                                         NA
                                                   NA
                                                             111711
## 4325
               955095
                        occurrence
                                         NA
                                                   NA
                                                             111713
## 4332
                955103
                        occurrence
                                         NA
                                                   NΑ
                                                             111718
## 4516
                                                             120528
               996584
                        occurrence
                                         NA
                                                  NA
## 4685
              1139721
                        occurrence
                                         NA
                                                   NA
                                                             145233
## 4695
                        occurrence
              1139731
                                         NA
                                                  NΑ
                                                             145236
## 4703
              1139741
                        occurrence
                                         NA
                                                  NA
                                                             145237
## 4713
              1139751
                                         NA
                                                             145238
                        occurrence
                                                   NA
## 4725
              1139763
                        occurrence
                                         NA
                                                   NA
                                                             145240
## 4773
              1141828
                        occurrence
                                         ΝA
                                                   NA
                                                             145463
## 4774
              1141829
                        occurrence
                                         NA
                                                   NA
                                                             145464
## 5330
              1144012
                        occurrence
                                         NA
                                                   NA
                                                             145615
##
                 identified_name identified_rank identified_no
  2399 Climacograptus bicornis
                                          species
                                                          306375
## 4166 Climacograptus bicornis
                                                          306375
                                          species
## 4320 Climacograptus bicornis
                                          species
                                                          306375
## 4325 Climacograptus bicornis
                                          species
                                                          306375
## 4332 Climacograptus bicornis
                                          species
                                                          306375
## 4516 Climacograptus bicornis
                                                          306375
                                          species
## 4685 Climacograptus bicornis
                                          species
                                                          306375
## 4695 Climacograptus bicornis
                                          species
                                                          306375
## 4703 Climacograptus bicornis
                                          species
                                                          306375
## 4713 Climacograptus bicornis
                                          species
                                                          306375
## 4725 Climacograptus bicornis
                                          species
                                                          306375
## 4773 Climacograptus bicornis
                                          species
                                                          306375
## 4774 Climacograptus bicornis
                                          species
                                                          306375
## 5330 Climacograptus bicornis
                                          species
                                                          306375
##
        taxonomic_reason
                                     accepted_name accepted_rank accepted_no
## 2399
                     <NA> Climacograptus bicornis
                                                          species
                                                                        306375
## 4166
                     <NA> Climacograptus bicornis
                                                          species
                                                                        306375
## 4320
                     <NA> Climacograptus bicornis
                                                          species
                                                                        306375
## 4325
                     <NA> Climacograptus bicornis
                                                          species
                                                                        306375
## 4332
                     <NA> Climacograptus bicornis
                                                          species
                                                                        306375
## 4516
                     <NA> Climacograptus bicornis
                                                          species
                                                                        306375
## 4685
                     <NA> Climacograptus bicornis
                                                          species
                                                                        306375
```

```
## 4695
                     <NA> Climacograptus bicornis
                                                           species
                                                                          306375
## 4703
                     <NA> Climacograptus bicornis
                                                                          306375
                                                           species
## 4713
                     <NA> Climacograptus bicornis
                                                           species
                                                                          306375
## 4725
                     <NA> Climacograptus bicornis
                                                           species
                                                                         306375
## 4773
                     <NA> Climacograptus bicornis
                                                           species
                                                                          306375
                     <NA> Climacograptus bicornis
## 4774
                                                           species
                                                                          306375
## 5330
                     <NA> Climacograptus bicornis
                                                           species
                                                                          306375
         early_interval
##
                            late_interval early_age late_age reference_no
## 2399
              Trentonian
                              Richmondian
                                               460.9
                                                         443.7
                                                                        6817
## 4166
                 Idavere
                                  Idavere
                                               460.9
                                                         455.8
                                                                       26936
## 4320 Late Ordovician Late Ordovician
                                               458.4
                                                         443.4
                                                                       36540
## 4325 Late Ordovician Late Ordovician
                                               458.4
                                                         443.4
                                                                       36540
        Late Ordovician Late Ordovician
                                               458.4
                                                         443.4
                                                                       36540
                                                                       38521
## 4516
                Sandbian
                                 Sandbian
                                               458.4
                                                         453.0
## 4685
                                               460.9
                                                         456.1
              Gisbornian
                               Gisbornian
                                                                       46966
## 4695
              Gisbornian
                               Gisbornian
                                               460.9
                                                         456.1
                                                                       46966
## 4703
              Gisbornian
                               Gisbornian
                                               460.9
                                                         456.1
                                                                       46966
## 4713
              Gisbornian
                               Gisbornian
                                               460.9
                                                         456.1
                                                                       46966
## 4725
                               Gisbornian
                                               460.9
                                                         456.1
              Gisbornian
                                                                       46966
## 4773
               Eastonian
                                Eastonian
                                               456.1
                                                         449.5
                                                                       46966
## 4774
               Eastonian
                                Eastonian
                                               456.1
                                                         449.5
                                                                       46966
## 5330
              Caradocian
                               Caradocian
                                               460.9
                                                         449.5
                                                                       47089
##
          primary_name primary_reso subgenus_name subgenus_reso species_name
## 2399 Climacograptus
                                 <NA>
                                                 <NA>
                                                                <NA>
                                                                          bicornis
  4166 Climacograptus
                                 <NA>
                                                 < NA >
                                                                <NA>
                                                                          bicornis
## 4320 Climacograptus
                                 <NA>
                                                 <NA>
                                                                <NA>
                                                                          bicornis
                                 <NA>
                                                 <NA>
                                                                <NA>
## 4325 Climacograptus
                                                                          bicornis
## 4332 Climacograptus
                                 <NA>
                                                 <NA>
                                                                <NA>
                                                                          bicornis
## 4516 Climacograptus
                                 <NA>
                                                 <NA>
                                                                <NA>
                                                                         bicornis
                                 <NA>
                                                 <NA>
                                                                <NA>
                                                                          bicornis
## 4685 Climacograptus
## 4695 Climacograptus
                                 <NA>
                                                 <NA>
                                                                <NA>
                                                                          bicornis
## 4703 Climacograptus
                                 <NA>
                                                 <NA>
                                                                <NA>
                                                                          bicornis
## 4713 Climacograptus
                                 <NA>
                                                 <NA>
                                                                <NA>
                                                                          bicornis
## 4725 Climacograptus
                                 <NA>
                                                 <NA>
                                                                <NA>
                                                                          bicornis
## 4773 Climacograptus
                                 <NA>
                                                 <NA>
                                                                <NA>
                                                                          bicornis
                                                                          bicornis
## 4774 Climacograptus
                                 <NA>
                                                 <NA>
                                                                <NA>
  5330 Climacograptus
                                 <NA>
                                                 <NA>
                                                                <NA>
                                                                         bicornis
##
        species_reso subgenus subgenus_no
                                                       genus genus_no
## 2399
                 <NA>
                             NA
                                                                 33636
                                          NA Climacograptus
## 4166
                 <NA>
                             NA
                                          NA Climacograptus
                                                                 33636
## 4320
                 <NA>
                             NΑ
                                          NA Climacograptus
                                                                 33636
## 4325
                 <NA>
                             NA
                                                                 33636
                                          NA Climacograptus
## 4332
                 <NA>
                             NA
                                          NA Climacograptus
                                                                 33636
## 4516
                 <NA>
                             NA
                                          NA Climacograptus
                                                                 33636
## 4685
                 <NA>
                             NA
                                          NA Climacograptus
                                                                 33636
## 4695
                 <NA>
                             NA
                                          NA Climacograptus
                                                                 33636
## 4703
                 <NA>
                             NA
                                          NA Climacograptus
                                                                 33636
## 4713
                 <NA>
                             NA
                                          NA Climacograptus
                                                                 33636
## 4725
                 <NA>
                             NA
                                          NA Climacograptus
                                                                 33636
## 4773
                 <NA>
                             NA
                                          NA Climacograptus
                                                                 33636
## 4774
                 <NA>
                             NA
                                                                 33636
                                          NA Climacograptus
## 5330
                 <NA>
                             NA
                                          NA Climacograptus
                                                                 33636
##
                 family family_no
                                           order order_no
                                                                    class class_no
## 2399 Diplograptidae
                            150197 Graptoloidea
                                                     33606 Graptolithina
                                                                              33534
```

```
## 4166 Diplograptidae
                           150197 Graptoloidea
                                                    33606 Graptolithina
                                                                            33534
                                                                            33534
## 4320 Diplograptidae
                           150197 Graptoloidea
                                                    33606 Graptolithina
                                                                            33534
## 4325 Diplograptidae
                           150197 Graptoloidea
                                                    33606 Graptolithina
## 4332 Diplograptidae
                           150197 Graptoloidea
                                                    33606 Graptolithina
                                                                            33534
## 4516 Diplograptidae
                           150197 Graptoloidea
                                                    33606 Graptolithina
                                                                            33534
  4685 Diplograptidae
                           150197 Graptoloidea
                                                    33606 Graptolithina
                                                                            33534
## 4695 Diplograptidae
                           150197 Graptoloidea
                                                    33606 Graptolithina
                                                                            33534
## 4703 Diplograptidae
                           150197 Graptoloidea
                                                    33606 Graptolithina
                                                                            33534
## 4713 Diplograptidae
                           150197 Graptoloidea
                                                    33606 Graptolithina
                                                                            33534
## 4725 Diplograptidae
                           150197 Graptoloidea
                                                    33606 Graptolithina
                                                                            33534
## 4773 Diplograptidae
                           150197 Graptoloidea
                                                    33606 Graptolithina
                                                                            33534
  4774 Diplograptidae
                           150197 Graptoloidea
                                                    33606 Graptolithina
                                                                            33534
   5330 Diplograptidae
                           150197 Graptoloidea
                                                    33606 Graptolithina
                                                                            33534
##
              phylum phylum_no
                                           authorizer
                                                          enterer
                                                                     modifier
## 2399 Hemichordata
                          33518
                                          Holland, S. Hanson, T.
                                                                      unknown
## 4166 Hemichordata
                          33518 Novack-Gottshall, P.
                                                        Hearn, P. Wagner, P.
## 4320 Hemichordata
                          33518
                                           Miller, A.
                                                        Kolbe, S.
                                                                    Kolbe, S.
## 4325 Hemichordata
                          33518
                                           Miller, A.
                                                        Kolbe, S.
                                                                      unknown
## 4332 Hemichordata
                          33518
                                           Miller, A.
                                                        Kolbe, S.
                                                                      unknown
## 4516 Hemichordata
                          33518
                                        Kiessling, W. Merkel, U.
                                                                      unknown
## 4685 Hemichordata
                          33518
                                        Kiessling, W. Krause, M.
                                                                      unknown
## 4695 Hemichordata
                          33518
                                        Kiessling, W. Krause, M. Krause, M.
## 4703 Hemichordata
                                        Kiessling, W. Krause, M.
                          33518
                                                                      unknown
## 4713 Hemichordata
                                        Kiessling, W. Krause, M.
                          33518
                                                                      unknown
## 4725 Hemichordata
                                        Kiessling, W. Krause, M.
                          33518
                                                                      unknown
## 4773 Hemichordata
                          33518
                                        Kiessling, W. Krause, M. Krause, M.
## 4774 Hemichordata
                          33518
                                        Kiessling, W. Krause, M. Krause, M.
   5330 Hemichordata
                                        Kiessling, W. Krause, M.
                          33518
                                                                      unknown
##
   $`Climacograptus scalaris`
##
        occurrence_no record_type reid_no obsolete collection_no
## 233
                 41894
                        occurrence
                                         NA
                                                   NA
                                                               3281
## 236
                 41899
                        occurrence
                                         NA
                                                   NA
                                                               3282
## 2530
                260374
                                                              25168
                                         NΑ
                                                   NA
                        occurrence
## 2884
                285928
                                         NA
                                                   NA
                                                              27197
                        occurrence
## 2948
                287240
                                         NA
                        occurrence
                                                   NΑ
                                                              27388
## 3173
                291182
                        occurrence
                                         NA
                                                   NA
                                                              27782
## 3246
                292390
                        occurrence
                                         NA
                                                   NA
                                                              27838
## 5115
              1143763
                        occurrence
                                         NA
                                                             145587
                                                   NΑ
## 5122
                                         NA
              1143780
                        occurrence
                                                   NA
                                                             145589
## 5132
              1143790
                        occurrence
                                         NA
                                                   NA
                                                             145590
## 5154
              1143812
                        occurrence
                                         NA
                                                             145591
                                                   NA
## 5204
              1143865
                        occurrence
                                         NA
                                                   NA
                                                             145598
## 5344
              1144116
                                         NA
                                                   NA
                        occurrence
                                                             145653
## 5355
              1144128
                        occurrence
                                         NA
                                                   NA
                                                             145654
## 5365
              1144142
                                         NA
                                                   NA
                        occurrence
                                                             145655
## 5385
              1144162
                        occurrence
                                         NA
                                                   NA
                                                             145656
## 5871
              1218886
                        occurrence
                                         NA
                                                   NA
                                                             159343
##
  5896
               1257991
                        occurrence
                                         NA
                                                   NA
                                                             166909
##
                   identified_name identified_rank identified_no
## 233
          Climacograptus scalaris
                                            species
                                                            316364
## 236
          Climacograptus scalaris
                                            species
                                                            316364
## 2530
          Climacograptus scalaris
                                            species
                                                            316364
## 2884
          Climacograptus scalaris
                                            species
                                                            316364
```

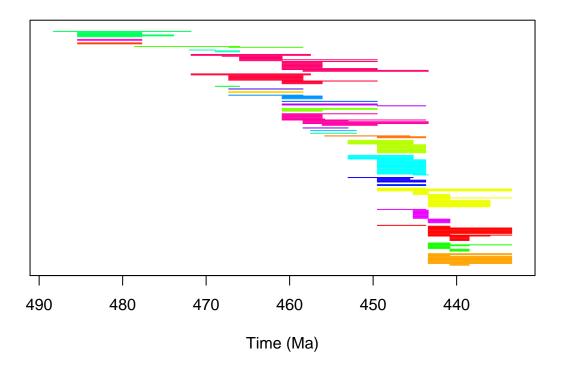
```
## 2948
          Climacograptus scalaris
                                                             316364
                                             species
## 3173
          Climacograptus scalaris
                                             species
                                                             316364
                                             species
## 3246
          Climacograptus scalaris
                                                             316364
## 5115
          Climacograptus scalaris
                                             species
                                                             316364
## 5122
        Climacograptus ? scalaris
                                             species
                                                             316364
## 5132
          Climacograptus scalaris
                                             species
                                                             316364
## 5154
          Climacograptus scalaris
                                             species
                                                             316364
## 5204
          Climacograptus scalaris
                                             species
                                                             316364
## 5344
          Climacograptus scalaris
                                             species
                                                             316364
## 5355
          Climacograptus scalaris
                                             species
                                                             316364
## 5365
          Climacograptus scalaris
                                                             316364
                                             species
## 5385
          Climacograptus scalaris
                                             species
                                                             316364
##
  5871
          Climacograptus scalaris
                                                             316364
                                             species
## 5896
          Climacograptus scalaris
                                             species
                                                             316364
##
        taxonomic_reason
                                     accepted_name accepted_rank accepted_no
## 233
                          Climacograptus scalaris
                                                           species
                                                                         316364
  236
##
                     <NA> Climacograptus scalaris
                                                                         316364
                                                           species
## 2530
                     <NA> Climacograptus scalaris
                                                                         316364
                                                           species
## 2884
                     <NA> Climacograptus scalaris
                                                           species
                                                                         316364
## 2948
                     <NA> Climacograptus scalaris
                                                           species
                                                                         316364
## 3173
                     <NA> Climacograptus scalaris
                                                           species
                                                                         316364
## 3246
                     <NA> Climacograptus scalaris
                                                           species
                                                                         316364
## 5115
                     <NA> Climacograptus scalaris
                                                           species
                                                                         316364
## 5122
                     <NA> Climacograptus scalaris
                                                           species
                                                                         316364
## 5132
                     <NA> Climacograptus scalaris
                                                           species
                                                                         316364
## 5154
                     <NA> Climacograptus scalaris
                                                           species
                                                                         316364
## 5204
                     <NA> Climacograptus scalaris
                                                           species
                                                                         316364
## 5344
                     <NA> Climacograptus scalaris
                                                           species
                                                                         316364
## 5355
                     <NA> Climacograptus scalaris
                                                           species
                                                                         316364
## 5365
                     <NA> Climacograptus scalaris
                                                                         316364
                                                           species
## 5385
                     <NA> Climacograptus scalaris
                                                           species
                                                                         316364
## 5871
                     <NA> Climacograptus scalaris
                                                                         316364
                                                           species
## 5896
                     <NA> Climacograptus scalaris
                                                                         316364
                                                           species
##
        early_interval late_interval early_age late_age reference_no
## 233
               Aeronian
                              Aeronian
                                            440.8
                                                     438.5
                                                                      155
## 236
                              Aeronian
                                            440.8
                                                     438.5
                                                                      155
               Aeronian
## 2530
            Alexandrian
                          Alexandrian
                                            443.4
                                                     436.0
                                                                    7063
## 2884
            Llandovery
                           Llandovery
                                            443.4
                                                     433.4
                                                                    7455
## 2948
            Rhuddanian
                            Rhuddanian
                                            443.4
                                                     440.8
                                                                    7455
## 3173
            Llandovery
                           Llandovery
                                            443.4
                                                     433.4
                                                                    7624
## 3246
            Llandovery
                           Llandovery
                                            443.4
                                                     433.4
                                                                    7624
## 5115
            Llandovery
                           Llandovery
                                            443.4
                                                     433.4
                                                                    47076
## 5122
            Llandovery
                           Llandovery
                                            443.4
                                                     433.4
                                                                    47076
## 5132
            Llandovery
                            Llandovery
                                            443.4
                                                     433.4
                                                                   47076
## 5154
                                            443.4
            Llandovery
                            Llandovery
                                                     433.4
                                                                    47076
## 5204
                                            443.4
                                                     433.4
                                                                    47083
            Llandovery
                            Llandovery
## 5344
            Rhuddanian
                            Rhuddanian
                                            443.4
                                                     440.8
                                                                    47103
## 5355
            Rhuddanian
                            Rhuddanian
                                            443.4
                                                     440.8
                                                                    47103
## 5365
               Aeronian
                              Aeronian
                                            440.8
                                                     438.5
                                                                    47103
## 5385
               Aeronian
                              Aeronian
                                            440.8
                                                     438.5
                                                                    47103
## 5871
                                            440.8
               Aeronian
                              Aeronian
                                                     438.5
                                                                    52096
                                            449.5
## 5896
              Bolindian
                            Bolindian
                                                     443.7
                                                                      78
##
          primary_name primary_reso subgenus_name subgenus_reso species_name
## 233
        Climacograptus
                                 <NA>
                                                <NA>
                                                               <NA>
                                                                         scalaris
```

```
<NA>
                                                               <NA>
                                                                         scalaris
## 236
        Climacograptus
                                                <NA>
## 2530 Climacograptus
                                 <NA>
                                                <NA>
                                                               <NA>
                                                                         scalaris
                                                                         scalaris
  2884 Climacograptus
                                 <NA>
                                                <NA>
                                                               <NA>
                                 <NA>
                                                                         scalaris
  2948 Climacograptus
                                                <NA>
                                                               <NA>
  3173 Climacograptus
                                 <NA>
                                                <NA>
                                                               <NA>
                                                                         scalaris
  3246 Climacograptus
                                                               <NA>
                                                                         scalaris
                                 <NA>
                                                <NA>
## 5115 Climacograptus
                                 <NA>
                                                <NA>
                                                               <NA>
                                                                         scalaris
## 5122 Climacograptus
                                    ?
                                                <NA>
                                                               <NA>
                                                                         scalaris
## 5132 Climacograptus
                                 <NA>
                                                <NA>
                                                               <NA>
                                                                         scalaris
                                                                         scalaris
## 5154 Climacograptus
                                 <NA>
                                                <NA>
                                                               <NA>
## 5204 Climacograptus
                                 <NA>
                                                <NA>
                                                               <NA>
                                                                         scalaris
## 5344 Climacograptus
                                 <NA>
                                                <NA>
                                                               <NA>
                                                                         scalaris
                                 <NA>
                                                <NA>
                                                               <NA>
                                                                         scalaris
  5355 Climacograptus
   5365 Climacograptus
                                 <NA>
                                                <NA>
                                                               <NA>
                                                                         scalaris
                                                                         scalaris
  5385 Climacograptus
                                 <NA>
                                                <NA>
                                                               <NA>
   5871 Climacograptus
                                 <NA>
                                                <NA>
                                                               <NA>
                                                                         scalaris
##
   5896 Climacograptus
                                 <NA>
                                                <NA>
                                                               <NA>
                                                                         scalaris
##
        species_reso subgenus subgenus_no
                                                       genus genus_no
## 233
                                                                33636
                 <NA>
                             NA
                                          NA Climacograptus
##
  236
                 <NA>
                             NA
                                          NA Climacograptus
                                                                33636
## 2530
                 <NA>
                             NA
                                          NA Climacograptus
                                                                33636
## 2884
                 <NA>
                             NΑ
                                          NA Climacograptus
                                                                33636
## 2948
                 <NA>
                                          NA Climacograptus
                                                                33636
                             NA
## 3173
                 <NA>
                             NA
                                          NA Climacograptus
                                                                33636
## 3246
                 < NA >
                             NΑ
                                          NA Climacograptus
                                                                33636
## 5115
                 <NA>
                             NA
                                          NA Climacograptus
                                                                33636
## 5122
                 <NA>
                             NA
                                          NA Climacograptus
                                                                33636
## 5132
                 <NA>
                             NA
                                          NA Climacograptus
                                                                33636
## 5154
                 <NA>
                             NA
                                          NA Climacograptus
                                                                33636
## 5204
                 <NA>
                             NA
                                                                33636
                                          NA Climacograptus
## 5344
                 <NA>
                             NA
                                          NA Climacograptus
                                                                33636
## 5355
                 <NA>
                             NΑ
                                            Climacograptus
                                                                33636
## 5365
                 <NA>
                             NA
                                          NA Climacograptus
                                                                33636
## 5385
                 <NA>
                             NA
                                                                33636
                                          NA Climacograptus
  5871
                 <NA>
                             NA
                                                                33636
##
                                          NA Climacograptus
  5896
                                          NA Climacograptus
                                                                33636
##
                 <NA>
                             NA
##
                 family family no
                                           order order no
                                                                    class class no
## 233
                                                                             33534
        Diplograptidae
                            150197 Graptoloidea
                                                    33606 Graptolithina
        Diplograptidae
                                                                             33534
   236
                            150197 Graptoloidea
                                                    33606 Graptolithina
  2530 Diplograptidae
                            150197 Graptoloidea
                                                    33606 Graptolithina
                                                                             33534
  2884 Diplograptidae
                            150197 Graptoloidea
                                                    33606 Graptolithina
                                                                             33534
  2948 Diplograptidae
                            150197 Graptoloidea
                                                    33606 Graptolithina
                                                                             33534
   3173 Diplograptidae
                            150197 Graptoloidea
                                                    33606 Graptolithina
                                                                             33534
  3246 Diplograptidae
                            150197 Graptoloidea
                                                    33606 Graptolithina
                                                                             33534
## 5115 Diplograptidae
                            150197 Graptoloidea
                                                    33606 Graptolithina
                                                                             33534
## 5122 Diplograptidae
                            150197 Graptoloidea
                                                    33606 Graptolithina
                                                                             33534
## 5132 Diplograptidae
                            150197 Graptoloidea
                                                    33606 Graptolithina
                                                                             33534
## 5154 Diplograptidae
                            150197 Graptoloidea
                                                    33606 Graptolithina
                                                                             33534
  5204 Diplograptidae
                            150197 Graptoloidea
                                                    33606 Graptolithina
                                                                             33534
  5344 Diplograptidae
                            150197 Graptoloidea
                                                    33606 Graptolithina
                                                                             33534
  5355 Diplograptidae
                            150197 Graptoloidea
                                                    33606 Graptolithina
                                                                             33534
## 5365 Diplograptidae
                            150197 Graptoloidea
                                                    33606 Graptolithina
                                                                             33534
## 5385 Diplograptidae
                            150197 Graptoloidea
                                                    33606 Graptolithina
                                                                             33534
## 5871 Diplograptidae
                            150197 Graptoloidea
                                                    33606 Graptolithina
                                                                             33534
```

```
## 5896 Diplograptidae
                           150197 Graptoloidea
                                                   33606 Graptolithina
                                                                           33534
##
              phylum phylum_no
                                   authorizer
                                                   enterer
                                                             modifier
## 233
        Hemichordata
                          33518
                                    Alroy, J. Sommers, M.
                                                              unknown
## 236
                          33518
        Hemichordata
                                    Alroy, J. Sommers, M.
                                                              unknown
## 2530 Hemichordata
                          33518
                                  Holland, S.
                                               Hanson, T.
                                                              unknown
## 2884 Hemichordata
                          33518
                                    Foote, M.
                                                Foote, M.
                                                              unknown
## 2948 Hemichordata
                          33518
                                    Foote, M.
                                                Foote, M.
                                                              unknown
## 3173 Hemichordata
                                    Foote, M.
                                                Foote, M.
                          33518
                                                              unknown
## 3246 Hemichordata
                          33518
                                    Foote, M.
                                                Foote, M.
                                                              unknown
## 5115 Hemichordata
                          33518 Kiessling, W.
                                                Krause, M.
                                                              unknown
## 5122 Hemichordata
                          33518 Kiessling, W.
                                               Krause, M.
                                                              unknown
## 5132 Hemichordata
                          33518 Kiessling, W.
                                                Krause, M.
                                                              unknown
## 5154 Hemichordata
                          33518 Kiessling, W.
                                               Krause, M.
                                                              unknown
## 5204 Hemichordata
                          33518 Kiessling, W.
                                                Krause, M.
                                                              unknown
## 5344 Hemichordata
                          33518 Kiessling, W.
                                               Krause, M.
                                                              unknown
## 5355 Hemichordata
                          33518 Kiessling, W.
                                                Krause, M.
                                                              unknown
## 5365 Hemichordata
                          33518 Kiessling, W.
                                               Krause, M. Krause, M.
## 5385 Hemichordata
                          33518 Kiessling, W.
                                               Krause, M. Krause, M.
## 5871 Hemichordata
                          33518
                                               Kroger, B.
                                   Kroger, B.
                                                              unknown
## 5896 Hemichordata
                          33518
                                   Wagner, P.
                                                Wagner, P.
                                                              unknown
```

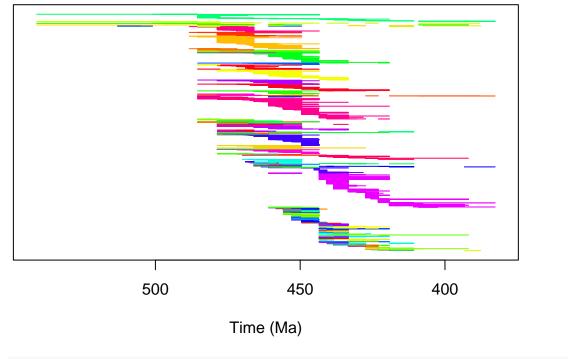
plotOccData(occSpecies,groupLabel = "Species")

### Age Uncertainty of Occurrence Data for Species



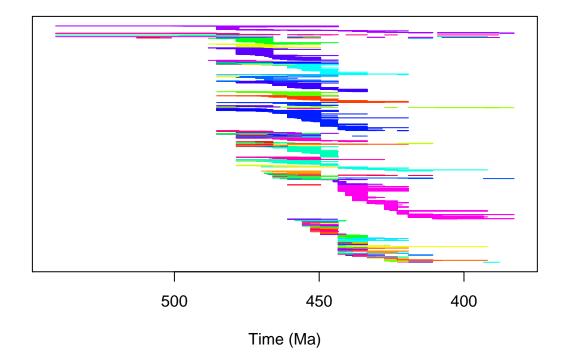
plotOccData(occGenera, groupLabel = "Genera")

### Age Uncertainty of Occurrence Data for Genera



plotOccData(occGenera, groupLabel = "Families")

## **Age Uncertainty of Occurrence Data for Families**



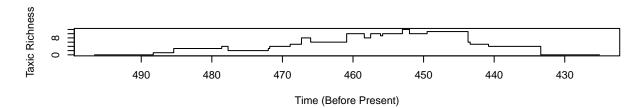
```
pdf(file= "ranges.pdf")
plotOccData(occSpecies,groupLabel = "Species")
plotOccData(occGenera, groupLabel = "Genera")
plotOccData(occGenera, groupLabel = "Families")
dev.off()
```

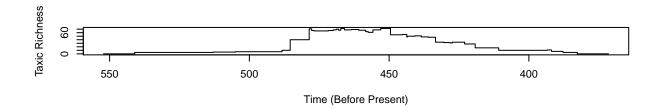
## pdf ## 2

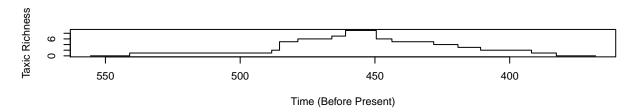
Now lets look at the diversity through time for various ranks

```
graptTimeSpecies<-occData2timeList(occList=occSpecies)
graptTimeGenus<-occData2timeList(occList=occGenera)
graptTimeFamily<-occData2timeList(occList=occFamily)

layout(1:3)
taxicDivDisc(graptTimeSpecies)
taxicDivDisc(graptTimeGenus)
taxicDivDisc(graptTimeFamily)</pre>
```







```
dev.off()
```

```
## null device
## 1
```

```
pdf(file="dtt.pdf")
taxicDivDisc(graptTimeSpecies)
taxicDivDisc(graptTimeGenus)
taxicDivDisc(graptTimeFamily)
dev.off()
```

```
## null device
## 1
```

We can use the paleobioDB package to directly query the PBDB and work with data. Try repeating the analyses above with the canid data set.

```
library(paleobioDB)
canids <- pbdb_occurrences (limit="all", vocab= "pbdb", base_name="Canidae", show=c('phylo', 'ident'))
head(canids)</pre>
```

```
##
       occurrence_no record_type collection_no
                                                                 taxon_name
## 1:1
              117266 occurrence
                                            9070
                                                      Cynodictis lacustris
## 1:2
              150070
                                          13293
                                                                   Cuon sp.
                      occurrence
## 1:3
              176227
                                          16626
                                                           Hesperocyon sp.
                      occurrence
## 1:4
              176384
                                          16647
                                                          Miacis washakius
                      occurrence
                                                         Hesperocyon ? sp.
## 1:5
              177551
                                          16840
                      occurrence
## 1:6
              177611
                      occurrence
                                          16845 Hesperocyon gregarius cf.
##
       taxon_rank taxon_no
                                     matched_name matched_rank matched_no
## 1:1
          species
                    349281
                             Cynodictis lacustris
                                                        species
                                                                     349281
## 1:2
                      41204
                                                                      41204
            genus
                                             Cuon
                                                          genus
## 1:3
            genus
                                      Hesperocyon
                                                          genus
                      41217
                                                                      41217
                      48498 Neovulpavus washakius
## 1:4
          species
                                                        species
                                                                      49147
            genus
                                                          genus
## 1:5
                     41217
                                      Hesperocyon
                                                                      41217
## 1:6
                      46911 Hesperocyon gregarius
                                                                      46911
          species
                                                        species
           early_interval early_age late_age reference_no
##
                                                                   genus
                              37.200 33.9000
              Late Eocene
                                                11154;11154
## 1:1
                                                             Cynodictis
## 1:2 Middle Pleistocene
                               0.781
                                       0.0117
                                                  4412;4412
                                                                    Cuon
## 1:3
              Late Uintan
                              46.200
                                     40.4000
                                                  1139;1139 Hesperocyon
## 1:4
                   Uintan
                              46.200
                                      40.4000
                                                  2495;2495 Neovulpavus
## 1:5
                                                  3359;3359 Hesperocyon
               Duchesnean
                              40.400
                                      33.9000
## 1:6
               Duchesnean
                              40.400
                                      37.2000
                                                  6226;6226 Hesperocyon
       genus_no family family_no
                                       order order_no
                                                          class class_no
## 1:1
          41276 Canidae
                                                 36905 Mammalia
                                                                    36651
                             41189 Carnivora
## 1:2
          41204 Canidae
                             41189 Carnivora
                                                 36905 Mammalia
                                                                    36651
## 1:3
          41217 Canidae
                             41189 Carnivora
                                                 36905 Mammalia
                                                                    36651
## 1:4
          49146 Canidae
                             41189 Carnivora
                                                 36905 Mammalia
                                                                    36651
          41217 Canidae
                                                 36905 Mammalia
## 1:5
                             41189 Carnivora
                                                                    36651
          41217 Canidae
                             41189 Carnivora
                                                 36905 Mammalia
                                                                    36651
## 1:6
         phylum phylum_no
                            genus_name species_name
##
                                                        late interval reid no
## 1:1 Chordata
                            Cynodictis
                    33815
                                          lacustris
                                                                  <NA>
                                                                            NA
## 1:2 Chordata
                    33815
                                  Cuon
                                                 sp. Late Pleistocene
                                                                            NA
## 1:3 Chordata
                    33815 Hesperocyon
                                                                          3083
                                                                  <NA>
                                                 sp.
## 1:4 Chordata
                    33815
                                Miacis
                                                                  <NA>
                                                                            NA
                                          washakius
## 1:5 Chordata
                    33815 Hesperocyon
                                                 sp.
                                                           Chadronian
                                                                            NA
## 1:6 Chordata
                    33815 Hesperocyon
                                          gregarius
                                                                  <NA>
                                                                          3336
```

##		genus_reso	species_reso	subgenus_name	subgenus_reso
##	1:1	<na></na>	<na></na>	<na></na>	<na></na>
##	1:2	<na></na>	<na></na>	<na></na>	<na></na>
##	1:3	<na></na>	<na></na>	<na></na>	<na></na>
##	1:4	<na></na>	<na></na>	<na></na>	<na></na>
##	1:5	?	<na></na>	<na></na>	<na></na>
##	1:6	<na></na>	cf.	<na></na>	<na></na>

How would you repeat the analyses?