coelacanth ageing data

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Input data

- Each individual is identified by CCC number
- TL : total length in cm
- Sex: f for female, m for male and na for undetermined
- weight : Total weight in g
- circuli : number of circuli observed under polarized ligth
- macrocirculi : number of macroscopic circuli observed under transmitted ligth
- miaCir : marginal increment analysis for circuli observed under polarized ligth
- miaMC : marginal increment analysis for circuli observed under polarized ligth

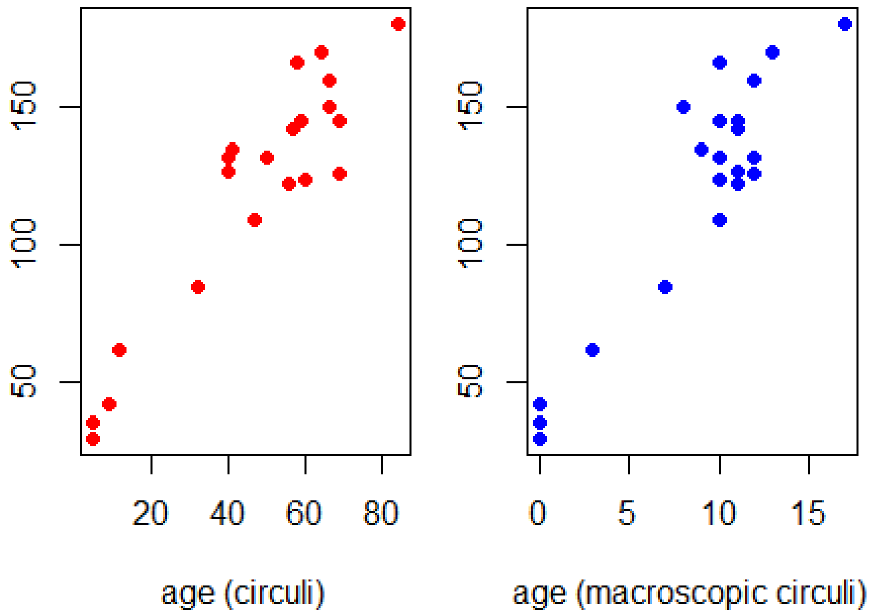
```
coel=read.table(file="coelacanthdata.csv",header=TRUE,as.is=T,sep=";",quote="
",dec=".")
coel
```

```
##    CCCnumber Inventory.number catchyear catchmonth  TL Sex weight circuli
## 1    CCC29.5  MNHN AC 2012-22      1962          1  30  na  0.530       5
## 2  CCC162.21        ZSM 28409      1991          8  36  na  0.417       5
## 3      CCC94  MNHN AC 2012-27      1974          8  42   f  0.800       9
## 4     CCC160        ZSM 28410      1989          9  62  na  3.000      12
## 5      CCC76      MNHN AC C64      1971          4  85   f 10.000      32
## 6       CCC4   MNHN AC 2012-2      1954          1 109   f 20.000      47
## 7      CCC12   MNHN AC 2012-9      1955          4 122   m 23.000      56
## 8      CCC30  MNHN AC 2012-23      1962          2 124   m 30.000      60
## 9       CCC5   MNHN AC 2012-3      1954         11 126   m 34.000      69
## 10      CCC6   MNHN AC 2012-4      1954          1 127   m 33.000      40
## 11     CCC19  MNHN AC 2012-15      1956          6 132   m 35.000      40
## 12     CCC27  MNHN AC 2012-21      1961          8 132   m 38.000      50
## 13     CCC26  MNHN AC 2012-20      1961          4 135   m 33.000      41
## 14      CCC8   MNHN AC 2012-6      1954         11 142   f 41.000      57
## 15     CCC21  MNHN AC 2012-17      1960          2 145   f 40.000      59
## 16     CCC24  MNHN AC 2012-19      1960          7 145   f 64.000      69
## 17     CCC31  MNHN AC 2012-24      1962          3 150   f 45.000      66
## 18     CCC71  MNHN AC 2012-25      1970         11 160   f 73.000      66
## 19     CCC10   MNHN AC 2012-6      1955          3 166   f 79.000      58
## 20     CCC13  MNHN AC 2012-10      1956          5 170   f 70.000      64
## 21     CCC20  MNHN AC 2012-16      1960          1 180   f 95.000      84
## 22      CCC3   MNHN AC 2012-1      1953          9 129   m 40.000      NA
## 23     CCC22  MNHN AC 2012-18      1960          6 130   m 31.000      NA
## 24      CCC7   MNHN AC 2012-5      1954          9 130   m 30.000      NA
## 25     CCC11   MNHN AC 2012-8      1955          3 131   f 26.000      NA
```

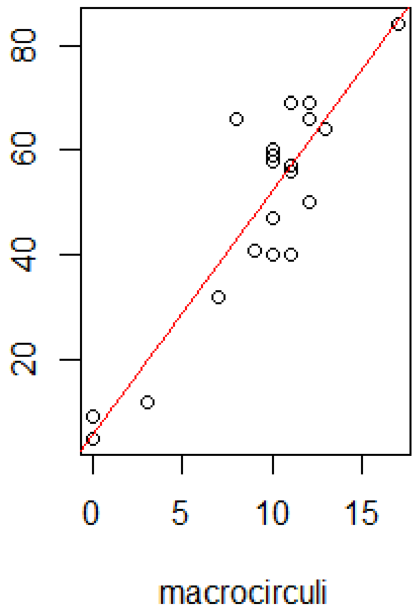
```
## 26     CCC17  MNHN AC 2012-13      1958          9 135    f 37.000       NA
## 27     CCC79  MNHN AC 2012-26      1972          1 163    f 78.000       NA
##    macrocirculi     miaCir     miaMC
## 1             0 0.74662062 0.8053409
## 2             0 0.05882282 0.5126670
## 3             0 0.21218313 0.6745513
## 4             3 0.07073698 0.5508276
## 5             7 0.21216076 0.8800253
## 6            10 0.39728796 0.3163341
## 7            11 0.47060019 0.3908354
## 8            10 0.83107223 0.4347932
## 9            12 0.38631301 0.9673497
## 10           11 0.44309133 0.8038768
## 11           10 0.36862397 0.6163091
## 12           12 0.17719806 0.6666637
## 13            9 0.66402687 0.5098630
## 14           11 0.69615900 1.1647532
## 15           10 0.54651855 1.0603691
## 16           11 0.36480832 0.8794958
## 17            8 0.66965097 1.1476950
## 18           12 0.74417836 0.2953734
## 19           10 0.95307761 0.6985523
## 20           13 0.44555359 0.8676350
## 21           17 0.89936359 0.4999875
## 22           NA         NA        NA
## 23           NA         NA        NA
## 24           NA         NA        NA
## 25           NA         NA        NA
## 26           NA         NA        NA
## 27           NA         NA        NA
```

Ageing data view

- red data : circuli
- blue data : macroscopic circuli




```
##
## Call:
## lm(formula = circuli ~ macrocirculi, data = coel)
##
## Coefficients:
##  (Intercept)  macrocirculi
##        5.747         4.643
```



Marginal Increment Analysis

Monthly trend of average marginal increment (mm) on scales of L. chalumnae. The marginal ciculi showed a trend with a maximum growth between November and March. Conversely, in the case of macroscopic circuli, no optimum growth period was detected during the year. For two specimens, only circuli could be estimated and for the months 10 and 12 presented no data.

```
## Loading required package: carData

##    catchmonth        MIA               type
## 1           1 0.39728796            Circuli
## 2           1 0.44309133            Circuli
## 3           1 0.89936359            Circuli
## 4           1 0.74662062            Circuli
## 5           2 0.54651855            Circuli
## 6           2 0.83107223            Circuli
## 7           3 0.95307761            Circuli
## 8           3 0.66965097            Circuli
## 9           4 0.47060019            Circuli
## 10          4 0.66402687            Circuli
## 11          4 0.21216076            Circuli
## 12          5 0.44555359            Circuli
## 13          6 0.38292836            Circuli
## 14          6 0.36862397            Circuli
## 15          7 0.36480832            Circuli
```

```
## 16          8 0.17719806             Circuli
## 17          8 0.21218313             Circuli
## 18          8 0.05882282             Circuli
## 19          9 0.07073698             Circuli
## 20          9 0.14073698             Circuli
## 21         11 0.38631301             Circuli
## 22         11 0.69615900             Circuli
## 23         11 0.74417836             Circuli
## 24          1 0.31633406 Macroscopic circuli
## 25          1 0.80387683 Macroscopic circuli
## 26          1 0.49998746 Macroscopic circuli
## 27          1 0.80534087 Macroscopic circuli
## 28          2 1.06036906 Macroscopic circuli
## 29          2 0.43479323 Macroscopic circuli
## 30          3 0.69855226 Macroscopic circuli
## 31          3 1.14769497 Macroscopic circuli
## 32          4 0.39083535 Macroscopic circuli
## 33          4 0.50986300 Macroscopic circuli
## 34          4 0.88002532 Macroscopic circuli
## 35          5 0.86763501 Macroscopic circuli
## 36          6 0.61630909 Macroscopic circuli
## 37          6 0.42483876 Macroscopic circuli
## 38          7 0.87949575 Macroscopic circuli
## 39          8 0.66666367 Macroscopic circuli
## 40          8 0.67455128 Macroscopic circuli
## 41          8 0.51266696 Macroscopic circuli
## 42          9 0.06465919 Macroscopic circuli
## 43          9 0.55082763 Macroscopic circuli
## 44         11 0.96734972 Macroscopic circuli
## 45         11 1.16475320 Macroscopic circuli
## 46         11 0.29537340 Macroscopic circuli
## 47         10         NA             Circuli
## 48         12         NA             Circuli
## 49         10         NA Macroscopic circuli
## 50         12         NA Macroscopic circuli
```

``{r, echo=FALSE} bp <- ggplot(data=mia, aes(x=factor(catchmonth), y=MIA, fill=factor(type))) + geom_boxplot()+ theme(legend.position = "none")+ labs(x="Month", y="Marginal Increment Analysis") + facet_wrap(~type,scales="free",nrow=11) bp + theme(axis.title.x = element_text(size=14, face="bold"), axis.title.y = element_text(size=14, face="bold"))

#selection species2<-coel[coel$espece=='marmoratus',]

#Compute Kruskal-Wallis test

kruskal.test(am ~ mois, data = species2)

#Multiple pairwise-comparison between groups pairwise.wilcox.test(species2$am, species$2mois, p.adjust.method = "BH")

```
## Growth models applied to **circuli** data ("slow groth")
- 1) the von Bertalanffy model without constraint :vbp
- 2) the von Bertalanffy model forced TL1:vbL1p
- 3) the Gompertz model: gp.p
- 4) the logistic model: log.p
```

Formula: TL ~ Linf * (1 - exp(-k * (circuli - t0)))

Parameters:

Estimate Std. Error t value Pr(>|t|)

Linf 203.781000 45.306165 4.498 0.000278 * ## k 0.019187 0.009362 2.050 0.055272 .**
t0 -4.423684 4.451530 -0.994 0.333519
— ## Signif. codes: 0 ‘’ *0.001 ’’ 0.01 ”* 0.05 ‘.’ 0.1 ’ ’ 1 ## ## Residual standard error: 15.32 on 18 degrees of freedom ## ## Number of iterations to convergence: 7 ## Achieved convergence tolerance: 8.251e-06 ## (6 observations deleted due to missingness)

It. 1, fac= 1, eval (no.,total): (1, 1): new dev = 192934

It. 1, fac= 0.5, eval (no.,total): (2, 2): new dev = 18593.7

It. 2, fac= 1, eval (no.,total): (1, 3): new dev = 49819.3

It. 2, fac= 0.5, eval (no.,total): (2, 4): new dev = 5596.6

It. 3, fac= 1, eval (no.,total): (1, 5): new dev = 6440.75

It. 3, fac= 0.5, eval (no.,total): (2, 6): new dev = 4506.2

It. 4, fac= 1, eval (no.,total): (1, 7): new dev = 4368.39

It. 5, fac= 1, eval (no.,total): (1, 8): new dev = 4226.49

It. 6, fac= 1, eval (no.,total): (1, 9): new dev = 4226.49

It. 7, fac= 1, eval (no.,total): (1, 10): new dev = 4226.49

Formula: TL ~ Linf - (Linf - l1) * exp(-k * (circuli - 1))

Parameters:

Estimate Std. Error t value Pr(>|t|)

Linf 2.038e+02 4.531e+01 4.498 0.000278 * ## l1 2.014e+01 1.171e+01 1.720 0.102616**
k 1.919e-02 9.362e-03 2.049 0.055276 .
— ## Signif. codes: 0 ‘’ *0.001 ’’ 0.01 ”* 0.05 ‘.’ 0.1 ’ ’ 1 ## ## Residual standard error: 15.32 on 18 degrees of freedom ## ## Number of iterations to convergence: 7 ## Achieved convergence tolerance: 1.128e-06 ## (6 observations deleted due to missingness)

Formula: TL ~ Linf * exp(log(L1/Linf) * exp(-k * (circuli - 1)))

Parameters:

Estimate Std. Error t value Pr(>|t|)

Linf 175.64175 20.00282 8.781 6.35e-08 * ## L1 27.81956 8.53060 3.261 0.00434 ## k 0.03855 0.01062 3.629 0.00192 ** ## — ## Signif. codes: 0 ‘’ *0.001* ’’ *0.01* ” 0.05 ‘.’ 0.1 ’ ’ 1 ## ## Residual standard error: 15.54 on 18 degrees of freedom ## ## Number of iterations to convergence: 7 ## Achieved convergence tolerance: 1.543e-06 ## (6 observations deleted due to missingness)

Formula: TL ~ Linf/(1 + ((Linf/L1) - 1) * exp(-k * circuli))

Parameters:

Estimate Std. Error t value Pr(>|t|)

Linf 164.26307 12.82134 12.812 1.75e-10 ***## L1 30.00618 7.80131 3.846 0.001183 ## k 0.05962 0.01306 4.564 0.000241*** **** ## — ## Signif. codes: 0 ‘’ *0.001* ’’ *0.01* ” 0.05 ‘.’ 0.1 ’ ’ 1 ## ## Residual standard error: 15.82 on 18 degrees of freedom ## ## Number of iterations to convergence: 7 ## Achieved convergence tolerance: 2.799e-06 ## (6 observations deleted due to missingness)**

df AIC

vbp 4 178.9921

vbL1p 4 178.9921

gp.p 4 179.5915

log.p 4 180.3352

```
## Growth models applied to __macroscopic circuli__ data ("fast growth")
- 1) the von Bertalanffy model without constraint :vbnp
- 2) the von Bertalanffy model forced TL1:vbL1np
- 3) the Gompertz model: gp.np
- 4) the logistic model: log.np
```

Formula: TL ~ Linf * (1 - exp(-k * (macrocirculi - t0)))

Parameters:

Estimate Std. Error t value Pr(>|t|)

Linf 296.11734 181.51757 1.631 0.1202

k 0.04679 0.04404 1.062 0.3021

t0 -2.68591 1.38407 -1.941 0.0681 .

—

Signif. codes: 0 ‘’ *0.001 ’’ 0.01 ”* 0.05 ‘.’ 0.1 ’ ’ 1

Residual standard error: 17.33 on 18 degrees of freedom

Number of iterations to convergence: 5

Achieved convergence tolerance: 1.351e-07

(6 observations deleted due to missingness)

It. 1, fac= 1, eval (no.,total): (1, 1): new dev = 7536.66

It. 2, fac= 1, eval (no.,total): (1, 2): new dev = 5498.25

It. 3, fac= 1, eval (no.,total): (1, 3): new dev = 5406.51

It. 4, fac= 1, eval (no.,total): (1, 4): new dev = 5406.5

Formula: TL ~ Linf - (Linf - l1) * exp(-k * (macrocirculi - 1))

Parameters:

Estimate Std. Error t value Pr(>|t|)

Linf 296.11752 181.51793 1.631 0.120

l1 46.91138 7.91620 5.926 1.31e-05 * ## k 0.04679 0.04404 1.062 0.302**
— ## Signif. codes: 0 ‘’ *0.001 ’’ 0.01 ”* 0.05 ‘.’ 0.1 ’ ’ 1 ## ## Residual standard error: 17.33 on 18 degrees of freedom ## ## Number of iterations to convergence: 4 ## Achieved convergence tolerance: 1.071e-06 ## (6 observations deleted due to missingness)

Formula: TL ~ Linf * exp(log(L1/Linf) * exp(-k * (macrocirculi - 1)))

Parameters:

Estimate Std. Error t value Pr(>|t|)

Linf 206.62539 45.19184 4.572 0.000236 ***## L1 45.07300 8.61802 5.230 5.66e-05***

k 0.13781 0.04791 2.876 0.010046 *
—

Signif. codes: 0 ‘’ ***0.001 ’’ 0.01 ”*** **0.05 ‘.’ 0.1 ’ ’ 1**

Residual standard error: 17.35 on 18 degrees of freedom

Number of iterations to convergence: 4

Achieved convergence tolerance: 8.371e-06

(6 observations deleted due to missingness)

Formula: TL ~ Linf/(1 + ((Linf/L1) - 1) * exp(-k * macrocirculi))

Parameters:

Estimate Std. Error t value Pr(>|t|)

Linf 184.3906 26.4863 6.962 1.67e-06 ***## L1 37.6088 8.8319 4.258 0.000473***

k 0.2320 0.0574 4.042 0.000765 * ## — ## Signif. codes: 0 ‘’** ***0.001 ”*** ***0.01 ”*** **0.05 ‘.’ 0.1 ’ ’ 1 ## ## Residual standard error: 17.52 on 18 degrees of freedom ## ## Number of iterations to convergence: 8 ## Achieved convergence tolerance: 7.113e-06 ## (6 observations deleted due to missingness)**

df AIC

vbnp 4 184.1630

vbL1np 4 184.1630

gp.np 4 184.2078

log.np 4 184.6122

```
```