Comparing von Bertalanffy Growth Functions

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Preliminaries

```
> library(FSA)
> library(FSAdata)               # for Croaker2 data
> library(dplyr)                 # for mutate()
```

Loading the Data and Some Preparations

```
> data(Croaker2)
> str(Croaker2)
'data.frame':   318 obs. of  3 variables:
 $ age: int  1 1 1 2 2 2 2 2 2 2 ...
 $ tl : int  243 247 248 330 320 285 280 265 260 248 ...
 $ sex: Factor w/ 2 levels "F","M": 1 1 2 1 1 1 1 1 1 1 ...

> Croaker2 <- mutate(Croaker2,logTL=log(tl))
```

Fitting Most Complex Model and Checking Assumptions

```
> ( svOm <- vbStarts(tl~age,data=Croaker2,meth0="yngAge") )
$Linf
[1] 434.697

$K
[1] 0.1837369

$t0
[1] -3.541856

> ( svLKt <- Map(rep,svOm,c(2,2,2)) )
$Linf
[1] 434.697 434.697

$K
[1] 0.1837369 0.1837369

$t0
[1] -3.541856 -3.541856

> vbLKt <- tl~Linf[sex]*(1-exp(-K[sex]*(age-t0[sex])))
> fitLKt <- nls(vbLKt,data=Croaker2,start=svLKt)
> residPlot(fitLKt,col=rgb(0,0,0,1/3))
```
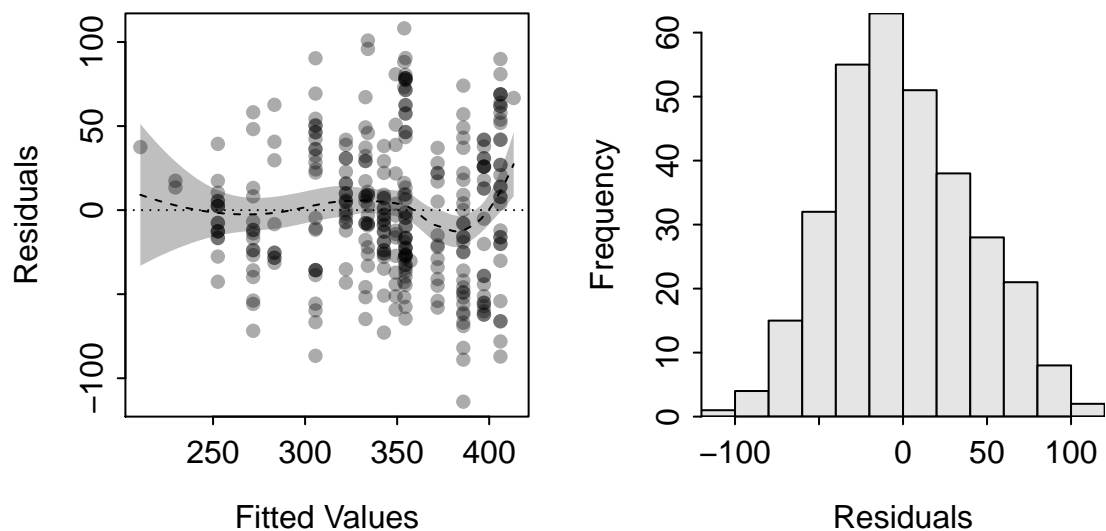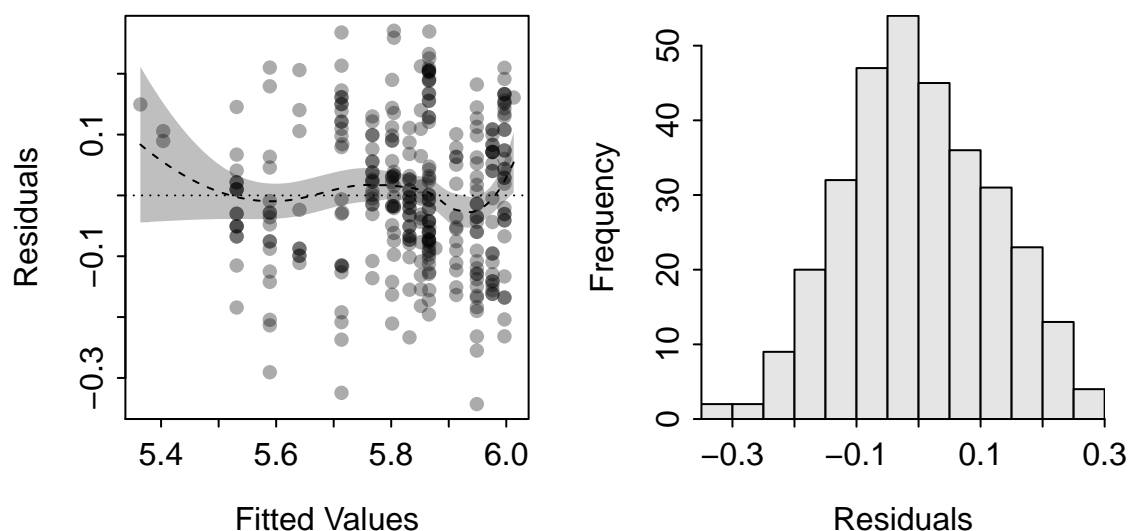
```
> vbLKt <- logTL~log(Linf[sex]*(1-exp(-K[sex]*(age-t0[sex]))))
> fitLKt <- nls(vbLKt,data=Croaker2,start=svLKt)
> residPlot(fitLKt,col=rgb(0,0,0,1/3))
```


Are There Any Differences?

```
> vbOm <- logTL~log(Linf*(1-exp(-K*(age-t0))))
> fitOm <- nls(vbOm,data=Croaker2,start=svOm)

> extraSS(fitOm,com=fitLKt,sim.name="{Omega}",com.name="{Linf,K,t0}")
Model 1: {Omega}
Model A: {Linf,K,t0}

    DfO    RSSO DfA    RSSA Df      SS      F    Pr(>F)
1vA 315 5.23971 312 4.44264  3 0.79707 18.659 3.705e-11

> lrt(fitOm,com=fitLKt,sim.name="{Omega}",com.name="{Linf,K,t0}")
Model 1: {Omega}
Model A: {Linf,K,t0}

    DfO logLikO DfA logLikA Df  logLik  Chisq Pr(>Chisq)
1vA 315 201.597 312 227.835  3 -26.238 52.476  2.372e-11
```

Is the Most Complex Model Warranted?

```
> vbLK <- logTL~log(Linf[sex]*(1-exp(-K[sex]*(age-t0))))
> ( svLK <- Map(rep,svOm,c(2,2,1)) )
$Linf
[1] 434.697 434.697

$K
[1] 0.1837369 0.1837369

$t0
[1] -3.541856


> fitLK <- nls(vbLK,data=Croaker2,start=svLK)
> vbLt <- logTL~log(Linf[sex]*(1-exp(-K*(age-t0[sex]))))
> svLt <- Map(rep,svOm,c(2,1,2))
> fitLt <- nls(vbLt,data=Croaker2,start=svLt)
> vbKt <- logTL~log(Linf*(1-exp(-K[sex]*(age-t0[sex]))))
> svKt <- Map(rep,svOm,c(1,2,2))
> fitKt <- nls(vbKt,data=Croaker2,start=svKt)
> extraSS(fitLK,fitLt,fitKt,com=fitLKt,com.name="{Linf,K,t0}",
          sim.names=c("{Linf,K}","{Linf,t0}","{K,t0}"))
Model 1: {Linf,K}
Model 2: {Linf,t0}
Model 3: {K,t0}
Model A: {Linf,K,t0}
```

	DfO	RSSO	DfA	RSSA	Df	SS	F	Pr(>F)
1vA	313	4.442641	312	4.442639	1	0.000002	0.0001	0.9916
2vA	313	4.444957	312	4.442639	1	0.002318	0.1628	0.6869
3vA	313	4.476736	312	4.442639	1	0.034097	2.3946	0.1228

Can the Model be Reduced to Only One Parameter that Differs?

```
> vbL <- logTL~log(Linf[sex]*(1-exp(-K*(age-t0))))
> ( svL <- Map(rep,svOm,c(2,1,1)) )
$Linf
[1] 434.697 434.697

$K
[1] 0.1837369

$t0
[1] -3.541856


> fitL <- nls(vbL,data=Croaker2,start=svL)
> vbK <- logTL~log(Linf*(1-exp(-K[sex]*(age-t0))))
> svK <- Map(rep,svOm,c(1,2,1))
> fitK <- nls(vbK,data=Croaker2,start=svK)
> extraSS(fitL,fitK,com=fitLK,com.name="{Linf,K}",sim.names=c("{Linf}","{K}"))
Model 1: {Linf}
Model 2: {K}
Model A: {Linf,K}
```

	DfO	RSSO	DfA	RSSA	Df	SS	F	Pr(>F)
1vA	314	4.484252	313	4.442641	1	0.041612	2.9317	0.087847
2vA	314	4.621667	313	4.442641	1	0.179027	12.6131	0.000442

Summarize Final Model

```
> summary(fitL,correlation=TRUE)


Formula: logTL ~ log(Linf[sex] * (1 - exp(-K * (age - t0))))


Parameters:
       Estimate Std. Error t value Pr(>|t|)
Linf1 425.37154   17.13519  24.824  < 2e-16
Linf2 384.21646   15.65097  24.549  < 2e-16
K       0.24825    0.05315   4.671 4.45e-06
t0     -2.12303    0.66226  -3.206  0.00149


Residual standard error: 0.1195 on 314 degrees of freedom


Correlation of Parameter Estimates:
      Linf1 Linf2 K
Linf2  0.94
K     -0.95 -0.93
t0    -0.87 -0.85  0.97


Number of iterations to convergence: 4
Achieved convergence tolerance: 1.84e-06


> round(cbind(coef(fitL),confint(fitL)),3)
Waiting for profiling to be done...
                2.5%    97.5%
Linf1 425.372 400.090 481.671
Linf2 384.216 360.721 435.082
K       0.248   0.144   0.357
t0     -2.123  -3.986  -1.108


> vb <- vbFuns("typical")
> # Females
> crF <- filterD(Croaker2,sex=="F")
> svF <- list(Linf=425,K=0.25,t0=-2)
> fitF <- nls(logTL~log(vb(age,Linf,K,t0)),data=crF,start=svF)
> # Males
> crM <- filterD(Croaker2,sex=="M")
> svM <- list(Linf=385,K=0.25,t0=-2)
> fitM <- nls(logTL~log(vb(age,Linf,K,t0)),data=crM,start=svM)


> clr1 <- c(rgb(0,0,0,1/5),rgb(1,0,0,1/5))
> clr2 <- c("black","red")
> offset <- 0.04
> # Females
> plot(tl~I(age-offset),data=crF,pch=19,col=clr1[1],ylim=c(200,500),
      xlab="Age (yrs)",ylab="Total Lengt (mm)")
> curve(vb(x-offset,coef(fitF)),from=1,to=10,col=clr2[1],lwd=2,add=TRUE)
> # Males
> points(tl~I(age+offset),data=crM,pch=19,col=clr1[2])
> curve(vb(x+offset,coef(fitM)),from=1,to=10,col=clr2[2],lwd=2,add=TRUE)
> legend("topleft",c("Female","Male"),pch=19,col=clr2,bty="n")
```
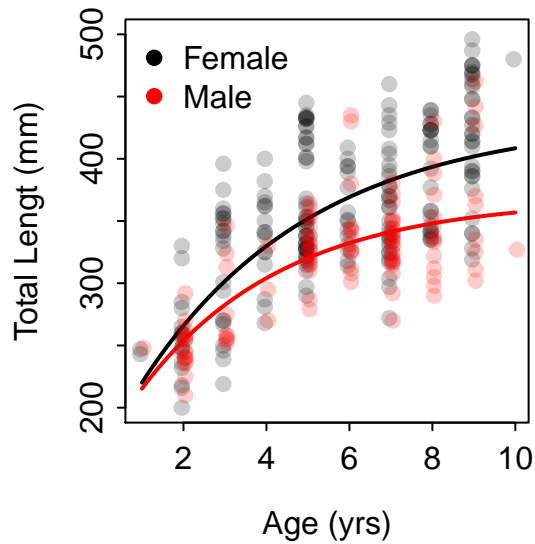
Using Information Criterion

Fit the Only Other Model not Fit Above

```
> vbt <- logTL~log(Linf*(1-exp(-K*(age-t0[sex]))))
> svt <- Map(rep,svOm,c(1,1,2))
> fitt <- nls(vbt,data=Croaker2,start=svt)
```

AICc Table

```
> library(AICcmodavg)
> ms <- list(fitOm,fitL,fitK,fitt,fitLK,fitLt,fitKt,fitLKt)
> mnames <- c("{Omega}","{Linf}","{K}","{t0}","{Linf,K}","{Linf,t0}","{K,t0}","{Linf,K,t0}")
> aictab(ms,mnames)

Model selection based on AICc :

             K      AICc Delta_AICc AICcWt Cum.Wt      LL
{Linf,K}     6  -443.40       0.00   0.31   0.31  227.84
{Linf,t0}    6  -443.23       0.17   0.29   0.60  227.75
{Linf}       5  -442.51       0.89   0.20   0.80  226.35
{Linf,K,t0}  7  -441.31       2.09   0.11   0.91  227.84
{K,t0}       6  -440.97       2.43   0.09   1.00  226.62
{K}          5  -432.91      10.49   0.00   1.00  221.55
{t0}         5  -422.44      20.96   0.00   1.00  216.31
{Omega}      4  -395.07      48.33   0.00   1.00  201.60
```