R Handout - Growth

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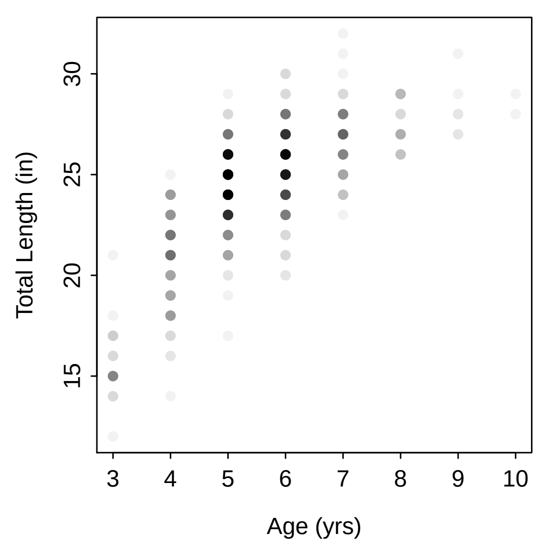
```
> library(FSA)       # Subset, fitPlot, vbModels, vbStart, vbFuns
> library(nlstools) # overview
```

Brule River Rainbow Trout

```
> setwd("C:/aaaWork/Web/fishR/courses/MNAFS2013/CourseMaterial/")
> d <- read.csv("TroutBR.csv",header=TRUE)
> str(d)

'data.frame': 851 obs. of  3 variables:
 $ tl     : int  16 16 17 17 17 17 17 17 17 17 ...
 $ age    : int  4 4 2 3 3 3 3 3 3 4 ...
 $ species: Factor w/ 2 levels "Brown","Rainbow": 1 1 1 1 1 1 1 1 1 1 ...

> rbt <- Subset(d,species=="Rainbow")
> str(rbt)

'data.frame': 627 obs. of  3 variables:
 $ tl     : int  12 14 14 14 14 15 15 15 15 15 ...
 $ age    : int  3 3 3 3 4 3 3 3 3 3 ...
 $ species: Factor w/ 1 level "Rainbow": 1 1 1 1 1 1 1 1 1 1 ...
```

```
> xlbl <- "Age (yrs)"
> ylbl <- "Total Length (in)"
> clr <- rgb(0,0,0,0.05)
```

```
> plot(tl~age,data=rbt,xlab=xlbl,ylab=ylbl,pch=16,col=clr)
```



Fit Typical Model

```
> vbModels()
```

FSA von Bertalanffy Parametrizations

Original: $E(L_t) = L_\infty - (L_\infty - L_0)\, e^{-Kt}$

Typical: $E(L_t) = L_\infty\left(1 - e^{-K(t - t_0)}\right)$

GalucciQuinn: $E(L_t) = \frac{\omega}{K}\left(1 - e^{-K(t - t_0)}\right)$

Mooij: $E(L_t) = L_\infty - (L_\infty - L_0)\, e^{-\frac{\omega}{L_\infty} t}$

Schnute: $E(L_t) = L_1 + (L_2 - L_1)\,\frac{1 - e^{-K(t - t_1)}}{1 - e^{-K(t_2 - t_1)}}$

Francis: $E(L_t) = L_1 + (L_3 - L_1)\,\frac{1 - r^{2\frac{t - t_1}{t_3 - t_1}}}{1 - r^2}$

where $r = \frac{L_3 - L_2}{L_2 - L_1}$

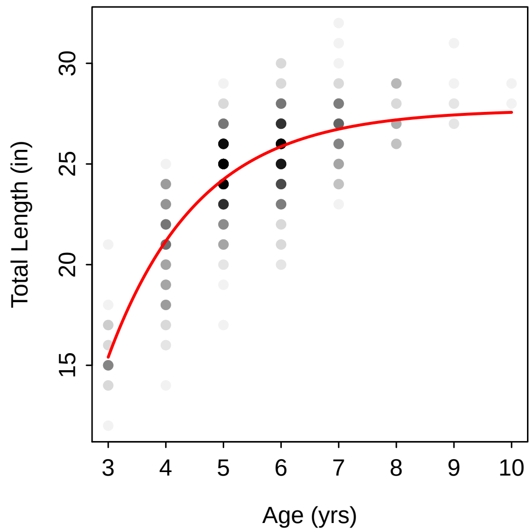
```
> ( svb1 <- vbStarts(tl~age,data=rbt,type="typical") )
$Linf
[1] 28.67

$K
[1] 0.5242

$t0
[1] -1.429

> fit1 <- nls(tl~Linf*(1-exp(-K*(age-t0))),data=rbt,start=svb1)
> overview(fit1)

------
Formula: tl ~ Linf * (1 - exp(-K * (age - t0)))

Parameters:
     Estimate Std. Error t value Pr(>|t|)
Linf  27.7118     0.2838    97.6   <2e-16
K      0.6324     0.0425    14.9   <2e-16
t0     1.7169     0.1016    16.9   <2e-16

Residual standard error: 1.78 on 624 degrees of freedom

Number of iterations to convergence: 5
Achieved convergence tolerance: 5.38e-08

------
Residual sum of squares: 1970

------
Asymptotic confidence interval:
        2.5%   97.5%
Linf 27.154 28.2692
```

```
K      0.549  0.7159
t0     1.517  1.9164

------
Correlation matrix:
        Linf       K      t0
Linf  1.0000 -0.9074 -0.7114
K    -0.9074  1.0000  0.9191
t0   -0.7114  0.9191  1.0000
```

```
> ( cf <- coef(fit1) )
```

```
   Linf       K      t0
27.7118  0.6324  1.7169
```

```
> plot(tl~age,data=rbt,xlab=xlbl,ylab=ylbl,pch=16,col=clr)
> curve(cf["Linf"]*(1-exp(-cf["K"]*(x-cf["t0"]))),from=3,to=10,n=500,lwd=2,col="red",add=TRUE)
```




```
> boot1 <- nlsBoot(fit1,niter=200)    # niter should be nearer 1000
> confint(boot1)
```

```
     95% LCI 95% UCI
Linf 27.2045 28.3411
K     0.5582  0.7115
t0    1.5470  1.8801
```

```
> new <- data.frame(age=8)
> predict(fit1, new)
```

```
[1] 27.19
```

```
> ests1 <- boot1$coefboot
> pv <- ests1[,"Linf"]*(1-exp(-ests1[,"K"]*(8-ests1[,"t0"])))
> quantile(pv,c(0.025,0.975))
```

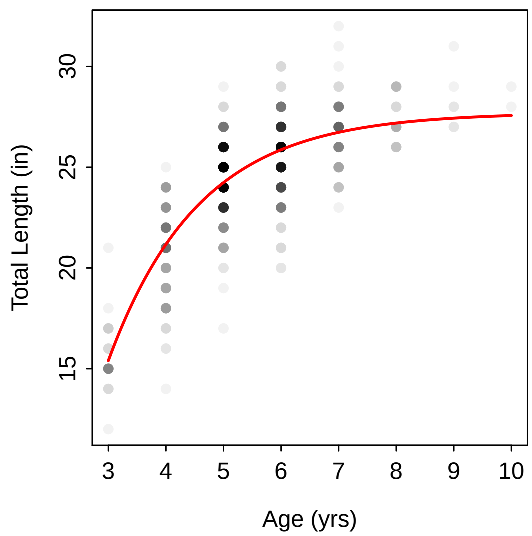
```
 2.5% 97.5%
26.86 27.59
```

Fit Francis Parameterization

```
> ages <- c(3,8)
> ( vb2 <- vbFuns("Francis") )

function(t,L1,L2=NULL,L3=NULL,t1,t3=NULL) {
         if (length(L1)==3) {
           L2 <- L1[2]
           L3 <- L1[3]
           L1 <- L1[1]
         } else if (length(L1)!=1 | is.null(L2) | is.null(L3)) {
           stop("One or more model parameters (L1, L2, L3) are missing or incorrect.",call.=FALSE)
         }
         if (length(t1)==2) {
           t3 <- t1[2]
           t1 <- t1[1]
         } else if (length(t1)!=1 | is.null(t3)) {
           stop("One or more model definitions (t1, t3) are missing or incorrect.",call.=FALSE)
         }
         r <- (L3-L2)/(L2-L1)
         L1+(L3-L1)*((1-r^(2*((t-t1)/(t3-t1))))/(1-r^2))
  }
<environment: 0x0593e194>

> ( sv2 <- vbStarts(tl~age,data=rbt,type="Francis",tFrancis=ages) )

$L1
[1] 15.56

$L2
[1] 25.04

$L3
[1] 27.48

> fit2 <- nls(tl~vb2(age,L1,L2,L3,t1=ages[1],t3=ages[2]),data=rbt,start=sv2)
> overview(fit2)

------
Formula: tl ~ vb2(age, L1, L2, L3, t1 = ages[1], t3 = ages[2])

Parameters:
   Estimate Std. Error t value Pr(>|t|)
L1  15.4023     0.3325    46.3   <2e-16
L2  25.1791     0.0783   321.8   <2e-16
L3  27.1907     0.1801   151.0   <2e-16

Residual standard error: 1.78 on 624 degrees of freedom

Number of iterations to convergence: 2
Achieved convergence tolerance: 2.09e-06

------
Residual sum of squares: 1970

------
Asymptotic confidence interval:
    2.5% 97.5%
```

```
L1 14.75 16.06
L2 25.03 25.33
L3 26.84 27.54

------
Correlation matrix:
        L1      L2     L3
L1  1.0000 -0.2171 0.2164
L2 -0.2171  1.0000 0.2502
L3  0.2164  0.2502 1.0000
```

```
> plot(tl~age,data=rbt,xlab=xlbl,ylab=ylbl,pch=16,col=clr)
> curve(vb2(x,L1=coef(fit2),t1=ages),from=3,to=10,n=500,lwd=2,col="red",add=TRUE)
```




```
> boot2 <- nlsBoot(fit2,niter=200)    # niter should be nearer 1000
> confint(boot2)
```

```
   95% LCI 95% UCI
L1   14.77   16.11
L2   25.04   25.34
L3   26.87   27.57
```