

# Onlinebeispiel 11.10. Ringfundanalysen zur Mortalitätsschätzung von juvenilen und adulten Stockenten (*Anas platyrhynchos*)

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Hier stellen wir einen Ringfund-Datensatz von Stockenten im San Luis Valley in Colorado vor. Bei diesem Datensatz werden Jung- und Alttiere unterschieden [Modell H1 von Brownie et al. (1985)]. Dazu nutzen wir den Datensatz `brownie`, der im R-Paket `RMark` enthalten ist (Laake 2013). Erläuterungen finden sich in Laake und Rexstad (2013).

```
# check.packages function: install and load multiple R packages.
# Function from: https://gist.github.com/smithdanielle/9913897
check.packages <- function(pkg){
  new.pkg <- pkg[!(pkg %in% installed.packages()[, "Package"])]
  if (length(new.pkg))
    install.packages(new.pkg, dependencies = TRUE, type = "source")
  sapply(pkg, require, character.only = TRUE)
}

# benoetigte R pakete
pakete <- c("RMark", "ggplot2", "scales")

# Pruefe und installiere
check.packages(pakete)
```

```
##   RMark ggplot2  scales
##   TRUE   TRUE   TRUE
```

Weitere Informationen zur Nutzung des Paketes finden sich hier:

<https://cran.r-project.org/web/packages/RMark/RMark.pdf>

Die Annahmen des Modells entsprechen denjenigen von Kap. 11.11 Modell 1, außer, dass Jungvögel im ersten Lebensjahr und adulte Vögel eine unterschiedliche Überlebens- und Rückmelderate aufweisen. Damit kann dem Umstand Rechnung getragen werden, dass Jungvögel häufig eine erheblich höhere Mortalität aufweisen als Altvögel.

Der Datensatz ist im `RMark`-Paket (Laake 2013) als Beispiel integriert.

```
data("brownie")
head(brownie)
```

```
##               ch freq ReleaseAge
## 1 1000000000000000000 194      Adult
## 2 1100000000000000000  10      Adult
## 3 1001000000000000000  13      Adult
## 4 1000010000000000000   6      Adult
## 5 1000000100000000000   1      Adult
## 6 1000000001000000000   1      Adult
```

Die Standardsortierreihenfolge von `RealeaseAge` (also Alter der Beringung) ist alphabetisch, folglich: Adult, Young. Daher ist `initial.ages=c(1,0)`.

## Seber-Modell

Das Modell wird indiziert mit `model = "Recovery"` und geht auf Seber (1982) zurück. Details finden sich in Kap. 11.11 des Buches.

```
br <- process.data(brownie,model="Recovery",groups="ReleaseAge",
                  age.var=1,initial.ages=c(1,0))
br.ddl <- make.design.data(br,parameters=list(S=list(age.bins=c(0,1,10)),
                                                    r=list(age.bins=c(0,1,10))),right=FALSE)
mod <- mark(br,br.ddl,
            model.parameters=list(S=list(formula=~-1+age:time,link="sin"),
                                    r=list(formula=~-1+age:time,link="sin")),delete=TRUE)
```

```
##
## Output summary for Recovery model
## Name : S(~-1 + age:time)r(~-1 + age:time)
##
## Npar : 36 (unadjusted=34)
## -2lnL: 20650.4
## AICc : 20722.57 (unadjusted=20718.554)
##
## Beta
##               estimate      se      lcl      ucl
## S:age[0,1]:time1 -0.0524422 0.1197360 -0.2871248 0.1822404
## S:age[1,10]:time1 0.1587910 0.2310324 -0.2940325 0.6116145
## S:age[0,1]:time2 0.0179450 0.1404892 -0.2574139 0.2933039
## S:age[1,10]:time2 0.2819136 0.1581189 -0.0279994 0.5918267
## S:age[0,1]:time3 0.1068958 0.1348956 -0.1574996 0.3712912
## S:age[1,10]:time3 0.2546993 0.1520851 -0.0433876 0.5527862
## S:age[0,1]:time4 0.1901312 0.1467219 -0.0974438 0.4777062
## S:age[1,10]:time4 0.8299177 0.3112315 0.2199040 1.4399313
## S:age[0,1]:time5 -0.0396180 0.1226790 -0.2800688 0.2008328
## S:age[1,10]:time5 0.3112329 0.1528194 0.0117068 0.6107591
## S:age[0,1]:time6 0.3152910 0.1527867 0.0158290 0.6147530
## S:age[1,10]:time6 0.1102410 0.1174256 -0.1199132 0.3403952
## S:age[0,1]:time7 -0.0661525 0.1368479 -0.3343743 0.2020694
## S:age[1,10]:time7 0.1528413 0.1352256 -0.1122010 0.4178835
## S:age[0,1]:time8 -0.1810555 0.2405947 -0.6526212 0.2905102
## S:age[1,10]:time8 0.1312970 0.2709540 -0.3997730 0.6623669
## S:age[0,1]:time9 -0.9704075 0.0000000 -0.9704075 -0.9704075
## S:age[1,10]:time9 0.6348851 0.0000000 0.6348851 0.6348851
```

```

## r:age[0,1]:time1 -0.7370072 0.0657534 -0.8658839 -0.6081306
## r:age[1,10]:time1 -0.9178808 0.1342331 -1.1809776 -0.6547839
## r:age[0,1]:time2 -0.4141168 0.1048338 -0.6195911 -0.2086426
## r:age[1,10]:time2 -0.5535649 0.1401776 -0.8283130 -0.2788168
## r:age[0,1]:time3 -0.7418334 0.0782929 -0.8952874 -0.5883793
## r:age[1,10]:time3 -0.7539230 0.1036715 -0.9571191 -0.5507268
## r:age[0,1]:time4 -0.3808179 0.1262967 -0.6283593 -0.1332764
## r:age[1,10]:time4 0.0279097 0.8754164 -1.6879064 1.7437259
## r:age[0,1]:time5 -0.7078708 0.0662433 -0.8377075 -0.5780340
## r:age[1,10]:time5 -0.7753296 0.1107999 -0.9924973 -0.5581618
## r:age[0,1]:time6 -0.4475529 0.1393160 -0.7206123 -0.1744935
## r:age[1,10]:time6 -0.7975261 0.0750974 -0.9447170 -0.6503352
## r:age[0,1]:time7 -0.6293785 0.0755380 -0.7774330 -0.4813241
## r:age[1,10]:time7 -0.6785647 0.0940936 -0.8629882 -0.4941412
## r:age[0,1]:time8 -0.7004668 0.1019671 -0.9003222 -0.5006114
## r:age[1,10]:time8 -0.6326258 0.1738164 -0.9733059 -0.2919456
## r:age[0,1]:time9 -0.8696024 0.0000000 -0.8696024 -0.8696024
## r:age[1,10]:time9 -0.3451764 0.0000000 -0.3451764 -0.3451764
##
##
## Real Parameter S
## Group:ReleaseAgeAdult
##      1      2      3      4      5      6      7      8
## 1 0.5790623 0.6390971 0.6259772 0.8689379 0.6531163 0.5550089 0.5761235 0.56546
## 2      0.6390971 0.6259772 0.8689379 0.6531163 0.5550089 0.5761235 0.56546
## 3      0.6259772 0.8689379 0.6531163 0.5550089 0.5761235 0.56546
## 4      0.8689379 0.6531163 0.5550089 0.5761235 0.56546
## 5      0.6531163 0.5550089 0.5761235 0.56546
## 6      0.5550089 0.5761235 0.56546
## 7      0.5761235 0.56546
## 8      0.56546
## 9
##      9
## 1 0.7965425
## 2 0.7965425
## 3 0.7965425
## 4 0.7965425
## 5 0.7965425
## 6 0.7965425
## 7 0.7965425
## 8 0.7965425
## 9 0.7965425
##
## Group:ReleaseAgeYoung
##      1      2      3      4      5      6      7
## 1 0.4737909 0.6390971 0.6259772 0.8689379 0.6531163 0.5550089 0.5761235
## 2      0.5089720 0.6259772 0.8689379 0.6531163 0.5550089 0.5761235
## 3      0.5533462 0.8689379 0.6531163 0.5550089 0.5761235
## 4      0.5944939 0.6531163 0.5550089 0.5761235
## 5      0.4801962 0.5550089 0.5761235
## 6      0.6550466 0.5761235
## 7      0.4669479
## 8
## 9

```

```

##           8           9
## 1 0.565460 0.7965425
## 2 0.565460 0.7965425
## 3 0.565460 0.7965425
## 4 0.565460 0.7965425
## 5 0.565460 0.7965425
## 6 0.565460 0.7965425
## 7 0.565460 0.7965425
## 8 0.409966 0.7965425
## 9           0.0874420
##
##
## Real Parameter r
## Group:ReleaseAgeAdult
##           1           2           3           4           5           6           7
## 1 0.102842 0.2371385 0.1577481 0.5139531 0.1500243 0.1421849 0.1861618
## 2           0.2371385 0.1577481 0.5139531 0.1500243 0.1421849 0.1861618
## 3           0.1577481 0.5139531 0.1500243 0.1421849 0.1861618
## 4           0.5139531 0.1500243 0.1421849 0.1861618
## 5           0.1500243 0.1421849 0.1861618
## 6           0.1421849 0.1861618
## 7           0.1861618
## 8
## 9
##           8           9
## 1 0.2043678 0.3308187
## 2 0.2043678 0.3308187
## 3 0.2043678 0.3308187
## 4 0.2043678 0.3308187
## 5 0.2043678 0.3308187
## 6 0.2043678 0.3308187
## 7 0.2043678 0.3308187
## 8 0.2043678 0.3308187
## 9           0.3308187
##
## Group:ReleaseAgeYoung
##           1           2           3           4           5           6           7
## 1 0.1639626 0.2371385 0.1577481 0.5139531 0.1500243 0.1421849 0.1861618
## 2           0.2988092 0.1577481 0.5139531 0.1500243 0.1421849 0.1861618
## 3           0.1621797 0.5139531 0.1500243 0.1421849 0.1861618
## 4           0.3141601 0.1500243 0.1421849 0.1861618
## 5           0.1748912 0.1421849 0.1861618
## 6           0.2836196 0.1861618
## 7           0.2056788
## 8
## 9
##           8           9
## 1 0.2043678 0.3308187
## 2 0.2043678 0.3308187
## 3 0.2043678 0.3308187
## 4 0.2043678 0.3308187
## 5 0.2043678 0.3308187
## 6 0.2043678 0.3308187
## 7 0.2043678 0.3308187

```

```
## 8 0.1777127 0.3308187
## 9 0.1179638
```

```
summary(mod)
```

```
## Output summary for Recovery model
## Name : S(~-1 + age:time)r(~-1 + age:time)
##
## Npar : 36 (unadjusted=34)
## -2lnL: 20650.4
## AICc : 20722.57 (unadjusted=20718.554)
##
## Beta
##
## estimate se lcl ucl
## S:age[0,1]:time1 -0.0524422 0.1197360 -0.2871248 0.1822404
## S:age[1,10]:time1 0.1587910 0.2310324 -0.2940325 0.6116145
## S:age[0,1]:time2 0.0179450 0.1404892 -0.2574139 0.2933039
## S:age[1,10]:time2 0.2819136 0.1581189 -0.0279994 0.5918267
## S:age[0,1]:time3 0.1068958 0.1348956 -0.1574996 0.3712912
## S:age[1,10]:time3 0.2546993 0.1520851 -0.0433876 0.5527862
## S:age[0,1]:time4 0.1901312 0.1467219 -0.0974438 0.4777062
## S:age[1,10]:time4 0.8299177 0.3112315 0.2199040 1.4399313
## S:age[0,1]:time5 -0.0396180 0.1226790 -0.2800688 0.2008328
## S:age[1,10]:time5 0.3112329 0.1528194 0.0117068 0.6107591
## S:age[0,1]:time6 0.3152910 0.1527867 0.0158290 0.6147530
## S:age[1,10]:time6 0.1102410 0.1174256 -0.1199132 0.3403952
## S:age[0,1]:time7 -0.0661525 0.1368479 -0.3343743 0.2020694
## S:age[1,10]:time7 0.1528413 0.1352256 -0.1122010 0.4178835
## S:age[0,1]:time8 -0.1810555 0.2405947 -0.6526212 0.2905102
## S:age[1,10]:time8 0.1312970 0.2709540 -0.3997730 0.6623669
## S:age[0,1]:time9 -0.9704075 0.0000000 -0.9704075 -0.9704075
## S:age[1,10]:time9 0.6348851 0.0000000 0.6348851 0.6348851
## r:age[0,1]:time1 -0.7370072 0.0657534 -0.8658839 -0.6081306
## r:age[1,10]:time1 -0.9178808 0.1342331 -1.1809776 -0.6547839
## r:age[0,1]:time2 -0.4141168 0.1048338 -0.6195911 -0.2086426
## r:age[1,10]:time2 -0.5535649 0.1401776 -0.8283130 -0.2788168
## r:age[0,1]:time3 -0.7418334 0.0782929 -0.8952874 -0.5883793
## r:age[1,10]:time3 -0.7539230 0.1036715 -0.9571191 -0.5507268
## r:age[0,1]:time4 -0.3808179 0.1262967 -0.6283593 -0.1332764
## r:age[1,10]:time4 0.0279097 0.8754164 -1.6879064 1.7437259
## r:age[0,1]:time5 -0.7078708 0.0662433 -0.8377075 -0.5780340
## r:age[1,10]:time5 -0.7753296 0.1107999 -0.9924973 -0.5581618
## r:age[0,1]:time6 -0.4475529 0.1393160 -0.7206123 -0.1744935
## r:age[1,10]:time6 -0.7975261 0.0750974 -0.9447170 -0.6503352
## r:age[0,1]:time7 -0.6293785 0.0755380 -0.7774330 -0.4813241
## r:age[1,10]:time7 -0.6785647 0.0940936 -0.8629882 -0.4941412
## r:age[0,1]:time8 -0.7004668 0.1019671 -0.9003222 -0.5006114
## r:age[1,10]:time8 -0.6326258 0.1738164 -0.9733059 -0.2919456
## r:age[0,1]:time9 -0.8696024 0.0000000 -0.8696024 -0.8696024
## r:age[1,10]:time9 -0.3451764 0.0000000 -0.3451764 -0.3451764
##
##
## Real Parameter S
## Group:ReleaseAgeAdult
```

```

##          1          2          3          4          5          6          7          8
## 1 0.5790623 0.6390971 0.6259772 0.8689379 0.6531163 0.5550089 0.5761235 0.56546
## 2          0.6390971 0.6259772 0.8689379 0.6531163 0.5550089 0.5761235 0.56546
## 3          0.6259772 0.8689379 0.6531163 0.5550089 0.5761235 0.56546
## 4          0.8689379 0.6531163 0.5550089 0.5761235 0.56546
## 5          0.6531163 0.5550089 0.5761235 0.56546
## 6          0.5550089 0.5761235 0.56546
## 7          0.5761235 0.56546
## 8          0.56546
## 9
##          9
## 1 0.7965425
## 2 0.7965425
## 3 0.7965425
## 4 0.7965425
## 5 0.7965425
## 6 0.7965425
## 7 0.7965425
## 8 0.7965425
## 9 0.7965425
##
## Group:ReleaseAgeYoung
##          1          2          3          4          5          6          7
## 1 0.4737909 0.6390971 0.6259772 0.8689379 0.6531163 0.5550089 0.5761235
## 2          0.5089720 0.6259772 0.8689379 0.6531163 0.5550089 0.5761235
## 3          0.5533462 0.8689379 0.6531163 0.5550089 0.5761235
## 4          0.5944939 0.6531163 0.5550089 0.5761235
## 5          0.4801962 0.5550089 0.5761235
## 6          0.6550466 0.5761235
## 7          0.4669479
## 8
## 9
##          8          9
## 1 0.565460 0.7965425
## 2 0.565460 0.7965425
## 3 0.565460 0.7965425
## 4 0.565460 0.7965425
## 5 0.565460 0.7965425
## 6 0.565460 0.7965425
## 7 0.565460 0.7965425
## 8 0.409966 0.7965425
## 9          0.0874420
##
##
## Real Parameter r
## Group:ReleaseAgeAdult
##          1          2          3          4          5          6          7
## 1 0.102842 0.2371385 0.1577481 0.5139531 0.1500243 0.1421849 0.1861618
## 2          0.2371385 0.1577481 0.5139531 0.1500243 0.1421849 0.1861618
## 3          0.1577481 0.5139531 0.1500243 0.1421849 0.1861618
## 4          0.5139531 0.1500243 0.1421849 0.1861618
## 5          0.1500243 0.1421849 0.1861618
## 6          0.1421849 0.1861618
## 7          0.1861618

```

```
## 8
## 9
##           8           9
## 1 0.2043678 0.3308187
## 2 0.2043678 0.3308187
## 3 0.2043678 0.3308187
## 4 0.2043678 0.3308187
## 5 0.2043678 0.3308187
## 6 0.2043678 0.3308187
## 7 0.2043678 0.3308187
## 8 0.2043678 0.3308187
## 9           0.3308187
##
## Group:ReleaseAgeYoung
##           1           2           3           4           5           6           7
## 1 0.1639626 0.2371385 0.1577481 0.5139531 0.1500243 0.1421849 0.1861618
## 2           0.2988092 0.1577481 0.5139531 0.1500243 0.1421849 0.1861618
## 3           0.1621797 0.5139531 0.1500243 0.1421849 0.1861618
## 4           0.3141601 0.1500243 0.1421849 0.1861618
## 5           0.1748912 0.1421849 0.1861618
## 6           0.2836196 0.1861618
## 7           0.2056788
## 8
## 9
##           8           9
## 1 0.2043678 0.3308187
## 2 0.2043678 0.3308187
## 3 0.2043678 0.3308187
## 4 0.2043678 0.3308187
## 5 0.2043678 0.3308187
## 6 0.2043678 0.3308187
## 7 0.2043678 0.3308187
## 8 0.1777127 0.3308187
## 9           0.1179638
```

```
# konkret die Schätzwerte aufrufen
mod.seber <- mod$results$real
```

Die Überlebensraten der adulten beringten Vögel ist höher als der jung beringten Vögel.

## Brownie-Modell

Das Modell wird indiziert mit `model = "Brownie"` und geht auf Brownie et al. (1985) zurück. Details finden sich in Kap. 11.11 des Buches.

```
br=process.data(brownie,model="Brownie",groups="ReleaseAge",
               age.var=1,initial.ages=c(1,0))
br.ddl=make.design.data(br,
                       parameters=list(S=list(age.bins=c(0,1,10)),

f=list(age.bins=c(0,1,10))),right=FALSE)
mod=mark(br,br.ddl,
```

```

model.parameters=list(S=list(formula=~-1+age:time,link="sin"),
f=list(formula=~-1+age:time,link="sin")),delete=TRUE)

```

```

##
## Output summary for Brownie model
## Name : S(~-1 + age:time)f(~-1 + age:time)
##
## Npar : 34
## -2lnL: 20650.4
## AICc : 20718.55
##
## Beta
##
##      estimate      se      lcl      ucl
## S:age[0,1]:time1 3.1940361 0.1197356 2.9593543 3.4287179
## S:age[1,10]:time1 0.1587910 0.2310319 -0.2940315 0.6116134
## S:age[0,1]:time2 0.0179447 0.1404886 -0.2574131 0.2933024
## S:age[1,10]:time2 0.2819125 0.1581177 -0.0279981 0.5918231
## S:age[0,1]:time3 0.1068979 0.1348936 -0.1574936 0.3712895
## S:age[1,10]:time3 0.2547035 0.1520826 -0.0433783 0.5527853
## S:age[0,1]:time4 2.9514637 0.1467209 2.6638907 3.2390366
## S:age[1,10]:time4 0.8299056 0.3112136 0.2199269 1.4398843
## S:age[0,1]:time5 -0.0396188 0.1226786 -0.2800688 0.2008312
## S:age[1,10]:time5 0.3112357 0.1528187 0.0117109 0.6107604
## S:age[0,1]:time6 0.3152913 0.1527863 0.0158301 0.6147524
## S:age[1,10]:time6 3.0313521 0.1174255 2.8011981 3.2615061
## S:age[0,1]:time7 -0.0661532 0.1368475 -0.3343743 0.2020679
## S:age[1,10]:time7 2.9887504 0.1352259 2.7237077 3.2537931
## S:age[0,1]:time8 3.3226488 0.2405932 2.8510862 3.7942115
## S:age[1,10]:time8 0.1312947 0.2709513 -0.3997700 0.6623593
## f:age[0,1]:time1 -0.9745385 0.0322413 -1.0377315 -0.9113456
## f:age[1,10]:time1 -1.1516087 0.0657952 -1.2805672 -1.0226502
## f:age[0,1]:time2 -0.7846149 0.0377426 -0.8585903 -0.7106395
## f:age[1,10]:time2 -0.9770169 0.0328456 -1.0413943 -0.9126396
## f:age[0,1]:time3 -1.0257894 0.0297219 -1.0840443 -0.9675344
## f:age[1,10]:time3 -1.0800837 0.0259161 -1.1308792 -1.0292882
## f:age[0,1]:time4 -0.8408532 0.0288555 -0.8974100 -0.7842964
## f:age[1,10]:time4 -1.0457101 0.0287228 -1.1020067 -0.9894134
## f:age[0,1]:time5 -0.9582416 0.0288795 -1.0148455 -0.9016377
## f:age[1,10]:time5 -2.0310995 0.0226914 -2.0755746 -1.9866244
## f:age[0,1]:time6 -0.9345453 0.0294245 -0.9922173 -0.8768733
## f:age[1,10]:time6 -2.0793329 0.0225826 -2.1235947 -2.0350710
## f:age[0,1]:time7 -0.8958253 0.0297351 -0.9541060 -0.8375446
## f:age[1,10]:time7 -2.1402778 0.0224472 -2.1842743 -2.0962813
## f:age[0,1]:time8 -0.9112772 0.0332228 -0.9763939 -0.8461606
## f:age[1,10]:time8 -2.1759968 0.0282601 -2.2313867 -2.1206070
## f:age[0,1]:time9 -0.9022162 0.0532246 -1.0065364 -0.7978959
## f:age[1,10]:time9 -1.0459176 0.0566136 -1.1568803 -0.9349549
##
##
## Real Parameter S
## Group:ReleaseAgeAdult
##      1      2      3      4      5      6      7

```



```

## 1 0.5790622 0.6390966 0.6259792 0.8689338 0.6531176 0.5550087 0.576124
## 2          0.6390966 0.6259792 0.8689338 0.6531176 0.5550087 0.576124
## 3          0.6259792 0.8689338 0.6531176 0.5550087 0.576124
## 4          0.8689338 0.6531176 0.5550087 0.576124
## 5          0.6531176 0.5550087 0.576124
## 6          0.5550087 0.576124
## 7          0.576124
## 8
##          8
## 1 0.5654589
## 2 0.5654589
## 3 0.5654589
## 4 0.5654589
## 5 0.5654589
## 6 0.5654589
## 7 0.5654589
## 8 0.5654589
##
## Group:ReleaseAgeYoung
##          1          2          3          4          5          6          7
## 1 0.4737903 0.6390966 0.6259792 0.8689338 0.6531176 0.5550087 0.5761240
## 2          0.5089718 0.6259792 0.8689338 0.6531176 0.5550087 0.5761240
## 3          0.5533472 0.8689338 0.6531176 0.5550087 0.5761240
## 4          0.5944928 0.6531176 0.5550087 0.5761240
## 5          0.4801958 0.5550087 0.5761240
## 6          0.6550467 0.5761240
## 7          0.4669475
## 8
##          8
## 1 0.5654589
## 2 0.5654589
## 3 0.5654589
## 4 0.5654589
## 5 0.5654589
## 6 0.5654589
## 7 0.5654589
## 8 0.4099657
##
##
## Real Parameter f
## Group:ReleaseAgeAdult
##          1          2          3          4          5          6          7          8
## 1 0.04329 0.085584 0.0590014 0.0673596 0.0520411 0.063271 0.0789097 0.088806
## 2          0.085584 0.0590014 0.0673596 0.0520411 0.063271 0.0789097 0.088806
## 3          0.0590014 0.0673596 0.0520411 0.063271 0.0789097 0.088806
## 4          0.0673596 0.0520411 0.063271 0.0789097 0.088806
## 5          0.0520411 0.063271 0.0789097 0.088806
## 6          0.063271 0.0789097 0.088806
## 7          0.0789097 0.088806
## 8          0.088806
## 9
##          9
## 1 0.0673076
## 2 0.0673076

```

```

## 3 0.0673076
## 4 0.0673076
## 5 0.0673076
## 6 0.0673076
## 7 0.0673076
## 8 0.0673076
## 9 0.0673076
##
## Group:ReleaseAgeYoung
##      1      2      3      4      5      6      7
## 1 0.0862786 0.0855840 0.0590014 0.0673596 0.0520411 0.0632710 0.0789097
## 2      0.1467236 0.0590014 0.0673596 0.0520411 0.0632710 0.0789097
## 3      0.0724382 0.0673596 0.0520411 0.0632710 0.0789097
## 4      0.1273938 0.0520411 0.0632710 0.0789097
## 5      0.0909091 0.0632710 0.0789097
## 6      0.0978355 0.0789097
## 7      0.1096375
## 8
## 9
##      8      9
## 1 0.0888060 0.0673076
## 2 0.0888060 0.0673076
## 3 0.0888060 0.0673076
## 4 0.0888060 0.0673076
## 5 0.0888060 0.0673076
## 6 0.0888060 0.0673076
## 7 0.0888060 0.0673076
## 8 0.1048565 0.0673076
## 9      0.1076487

```

```

#mod=mark(br,br.ddl,model.parameters=list(S=list(formula=~-1+age,link="sin"),
#
#f=list(formula=~-1+age,link="sin")),delete=TRUE)
summary(mod)

```

```

## Output summary for Brownie model
## Name : S(~-1 + age:time)f(~-1 + age:time)
##
## Npar : 34
## -2lnL: 20650.4
## AICc : 20718.55
##
## Beta
##      estimate      se      lcl      ucl
## S:age[0,1]:time1 3.1940361 0.1197356 2.9593543 3.4287179
## S:age[1,10]:time1 0.1587910 0.2310319 -0.2940315 0.6116134
## S:age[0,1]:time2 0.0179447 0.1404886 -0.2574131 0.2933024
## S:age[1,10]:time2 0.2819125 0.1581177 -0.0279981 0.5918231
## S:age[0,1]:time3 0.1068979 0.1348936 -0.1574936 0.3712895
## S:age[1,10]:time3 0.2547035 0.1520826 -0.0433783 0.5527853
## S:age[0,1]:time4 2.9514637 0.1467209 2.6638907 3.2390366
## S:age[1,10]:time4 0.8299056 0.3112136 0.2199269 1.4398843
## S:age[0,1]:time5 -0.0396188 0.1226786 -0.2800688 0.2008312
## S:age[1,10]:time5 0.3112357 0.1528187 0.0117109 0.6107604

```

```

## S:age[0,1):time6  0.3152913 0.1527863 0.0158301 0.6147524
## S:age[1,10]:time6 3.0313521 0.1174255 2.8011981 3.2615061
## S:age[0,1):time7 -0.0661532 0.1368475 -0.3343743 0.2020679
## S:age[1,10]:time7 2.9887504 0.1352259 2.7237077 3.2537931
## S:age[0,1):time8  3.3226488 0.2405932 2.8510862 3.7942115
## S:age[1,10]:time8 0.1312947 0.2709513 -0.3997700 0.6623593
## f:age[0,1):time1 -0.9745385 0.0322413 -1.0377315 -0.9113456
## f:age[1,10]:time1 -1.1516087 0.0657952 -1.2805672 -1.0226502
## f:age[0,1):time2 -0.7846149 0.0377426 -0.8585903 -0.7106395
## f:age[1,10]:time2 -0.9770169 0.0328456 -1.0413943 -0.9126396
## f:age[0,1):time3 -1.0257894 0.0297219 -1.0840443 -0.9675344
## f:age[1,10]:time3 -1.0800837 0.0259161 -1.1308792 -1.0292882
## f:age[0,1):time4 -0.8408532 0.0288555 -0.8974100 -0.7842964
## f:age[1,10]:time4 -1.0457101 0.0287228 -1.1020067 -0.9894134
## f:age[0,1):time5 -0.9582416 0.0288795 -1.0148455 -0.9016377
## f:age[1,10]:time5 -2.0310995 0.0226914 -2.0755746 -1.9866244
## f:age[0,1):time6 -0.9345453 0.0294245 -0.9922173 -0.8768733
## f:age[1,10]:time6 -2.0793329 0.0225826 -2.1235947 -2.0350710
## f:age[0,1):time7 -0.8958253 0.0297351 -0.9541060 -0.8375446
## f:age[1,10]:time7 -2.1402778 0.0224472 -2.1842743 -2.0962813
## f:age[0,1):time8 -0.9112772 0.0332228 -0.9763939 -0.8461606
## f:age[1,10]:time8 -2.1759968 0.0282601 -2.2313867 -2.1206070
## f:age[0,1):time9 -0.9022162 0.0532246 -1.0065364 -0.7978959
## f:age[1,10]:time9 -1.0459176 0.0566136 -1.1568803 -0.9349549
##
##
## Real Parameter S
## Group:ReleaseAgeAdult
##      1      2      3      4      5      6      7
## 1 0.5790622 0.6390966 0.6259792 0.8689338 0.6531176 0.5550087 0.576124
## 2      0.6390966 0.6259792 0.8689338 0.6531176 0.5550087 0.576124
## 3      0.6259792 0.8689338 0.6531176 0.5550087 0.576124
## 4      0.8689338 0.6531176 0.5550087 0.576124
## 5      0.6531176 0.5550087 0.576124
## 6      0.5550087 0.576124
## 7      0.576124
## 8
##      8
## 1 0.5654589
## 2 0.5654589
## 3 0.5654589
## 4 0.5654589
## 5 0.5654589
## 6 0.5654589
## 7 0.5654589
## 8 0.5654589
##
## Group:ReleaseAgeYoung
##      1      2      3      4      5      6      7
## 1 0.4737903 0.6390966 0.6259792 0.8689338 0.6531176 0.5550087 0.5761240
## 2      0.5089718 0.6259792 0.8689338 0.6531176 0.5550087 0.5761240
## 3      0.5533472 0.8689338 0.6531176 0.5550087 0.5761240
## 4      0.5944928 0.6531176 0.5550087 0.5761240
## 5      0.4801958 0.5550087 0.5761240

```

```

## 6                                0.6550467 0.5761240
## 7                                0.4669475
## 8
##          8
## 1 0.5654589
## 2 0.5654589
## 3 0.5654589
## 4 0.5654589
## 5 0.5654589
## 6 0.5654589
## 7 0.5654589
## 8 0.4099657
##
##
## Real Parameter f
## Group:ReleaseAgeAdult
##          1          2          3          4          5          6          7          8
## 1 0.04329 0.085584 0.0590014 0.0673596 0.0520411 0.063271 0.0789097 0.088806
## 2          0.085584 0.0590014 0.0673596 0.0520411 0.063271 0.0789097 0.088806
## 3          0.0590014 0.0673596 0.0520411 0.063271 0.0789097 0.088806
## 4          0.0673596 0.0520411 0.063271 0.0789097 0.088806
## 5          0.0520411 0.063271 0.0789097 0.088806
## 6          0.063271 0.0789097 0.088806
## 7          0.0789097 0.088806
## 8          0.088806
## 9
##          9
## 1 0.0673076
## 2 0.0673076
## 3 0.0673076
## 4 0.0673076
## 5 0.0673076
## 6 0.0673076
## 7 0.0673076
## 8 0.0673076
## 9 0.0673076
##
## Group:ReleaseAgeYoung
##          1          2          3          4          5          6          7
## 1 0.0862786 0.0855840 0.0590014 0.0673596 0.0520411 0.0632710 0.0789097
## 2          0.1467236 0.0590014 0.0673596 0.0520411 0.0632710 0.0789097
## 3          0.0724382 0.0673596 0.0520411 0.0632710 0.0789097
## 4          0.1273938 0.0520411 0.0632710 0.0789097
## 5          0.0909091 0.0632710 0.0789097
## 6          0.0978355 0.0789097
## 7          0.1096375
## 8
## 9
##          8          9
## 1 0.0888060 0.0673076
## 2 0.0888060 0.0673076
## 3 0.0888060 0.0673076
## 4 0.0888060 0.0673076
## 5 0.0888060 0.0673076

```

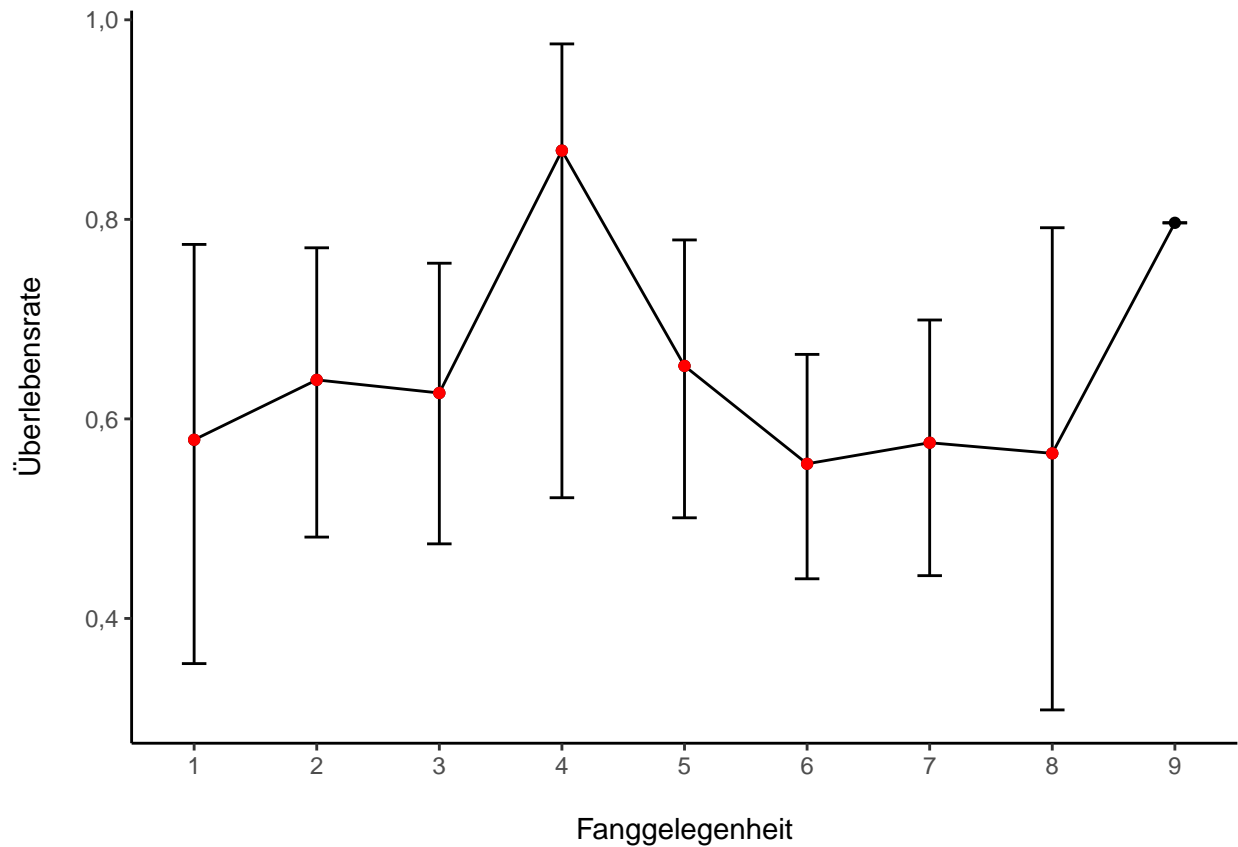
```
## 6 0.0888060 0.0673076
## 7 0.0888060 0.0673076
## 8 0.1048565 0.0673076
## 9          0.1076487
```

```
# konkret die Schätzwerte aufrufen
mod.brownie <- mod$results$real
```

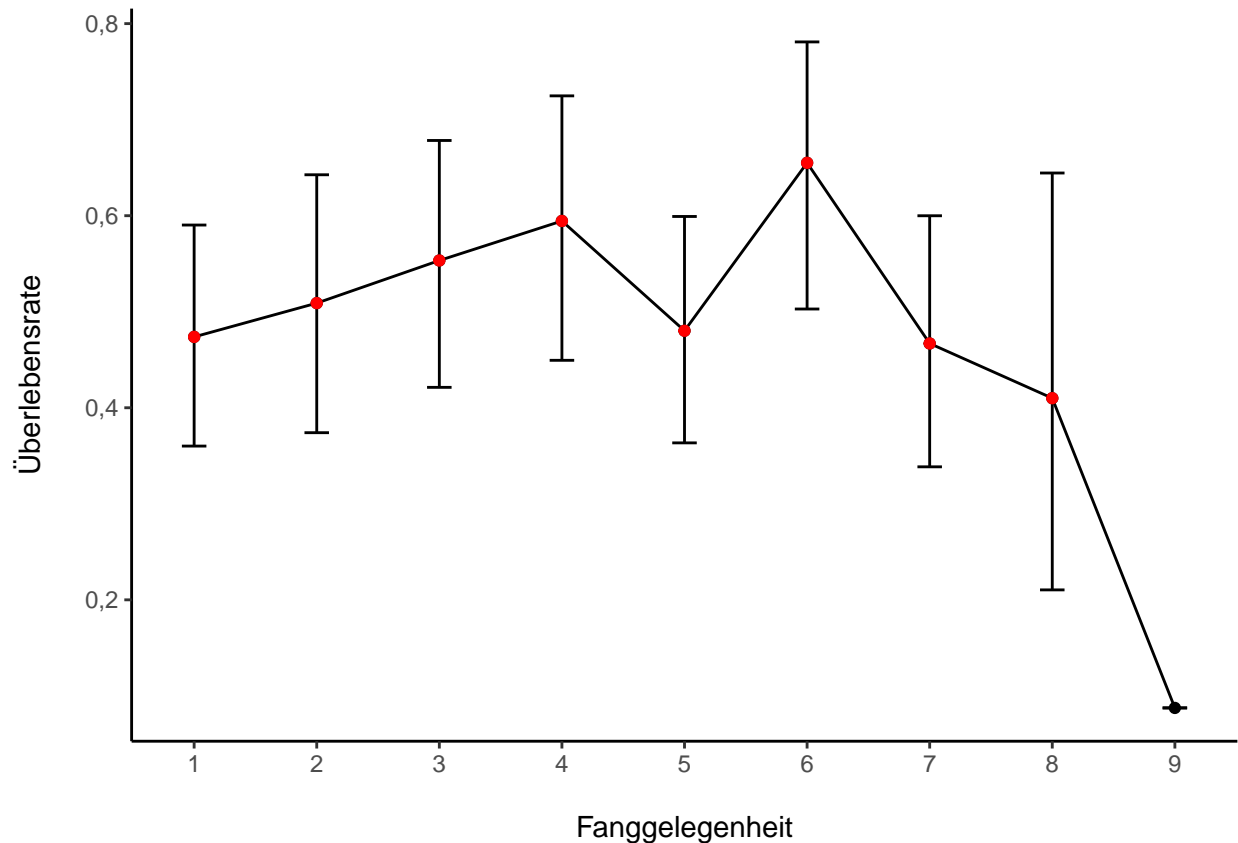
Vergleichen wir die Daten aus beiden Modellen miteinander. Dazu nutzen wir das Paket ggplot2 (Wickham 2016).

```
mod.seber.adult <- mod.seber[1:9,]
mod.seber.adult$Occasion <- 1:9
mod.seber.young <- mod.seber[10:18,]
mod.seber.young$Occasion <- 1:9
mod.brownie.adult <- mod.brownie[1:8,]
mod.brownie.adult$Occasion <- 1:8
mod.brownie.young <- mod.brownie[9:16,]
mod.brownie.young$Occasion <- 1:8

# Adult markierte Tiere
ggplot(mod.seber.adult, aes(Occasion, estimate,
                           ymin=lcl, ymax=ucl)) +
  geom_errorbar(width=0.2) + geom_point() + geom_line() +
  geom_point(data=mod.brownie.adult,
             aes(Occasion, estimate, ymin=lcl, ymax=ucl, color="red")) +
  scale_y_continuous(labels = label_number(decimal.mark = ",")) +
  scale_x_continuous(breaks = function(x) seq(floor(min(x)), ceiling(max(x)), by = 1),
                    labels = number_format(accuracy = 1)) +
  theme_classic() +
  xlab("\nFanggelegenhheit") + ylab("Überlebensrate\n")
```



```
# Juvenil markierte Tiere
ggplot(mod.seber.young,aes(Occasion,estimate,
                           ymin=lcl,ymax=ucl))+
  geom_errorbar(width=0.2)+geom_point()+geom_line()+
  geom_point(data=mod.brownie.young,
             aes(Occasion, estimate, ymin=lcl,ymax=ucl), color="red") +
  scale_y_continuous(labels = label_number(decimal.mark = ",")) +
  scale_x_continuous(breaks = function(x) seq(floor(min(x)), ceiling(max(x)), by = 1),
                    labels = number_format(accuracy = 1)) +
  theme_classic() +
  xlab("\nFanggelegenheit")+ylab("Überlebensrate\n")
```



Die schwarzen verbundenen Punkte stellen die Schätzungen von Seber (und deren 95 %-Konfidenzintervall) dar, die roten Punkte die Schätzungen von Brownie. Die berechneten Überlebensraten sind folglich nahezu identisch.

## Literaturverzeichnis

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- Seber, G.A.F. (1982): The estimation of animal abundance and related parameters, Second Edition. — Griffin, London.
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