studbookR: Natural history analyses

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Introduction

The following natural history analyses are available:

- Lifespan and longevity
- Reproductive lifespan
- Interbirth interval
- Litter size
- Litter survival
- Seasonality

Lifespan

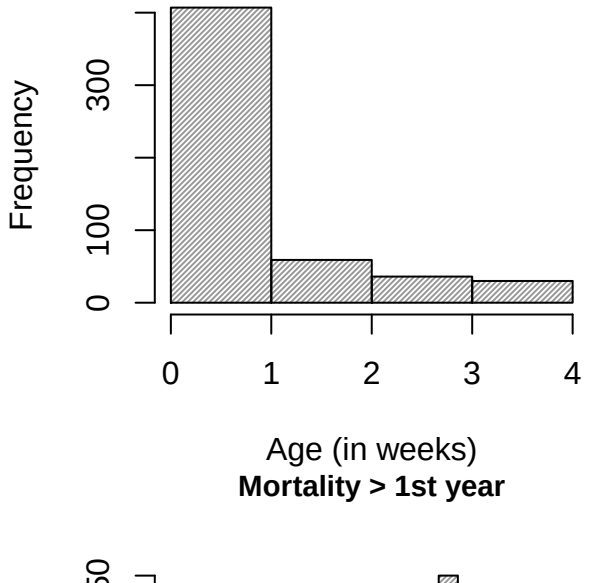
Lifespan is estimated from uncensored data i.e. ages at death only. Analyses are carried out all individuals, females and males, separately.

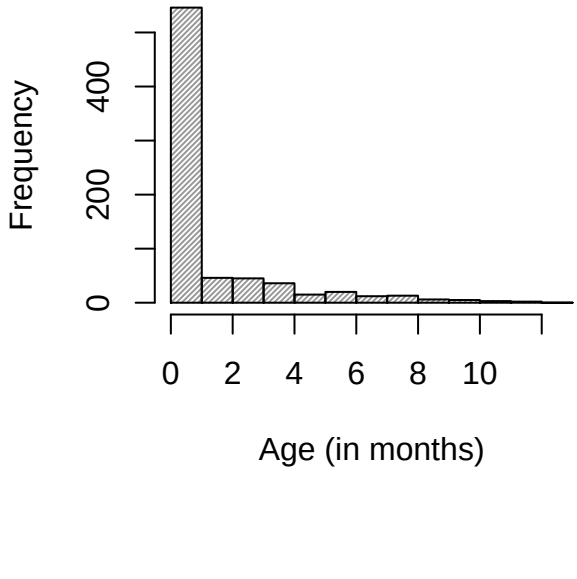
```
studbook.lifespan()
```

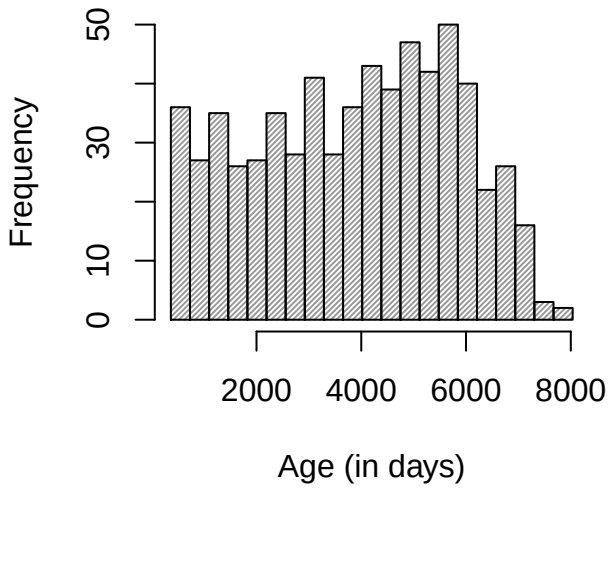
```
## ================================================
## Lifespan (age at death)
## ================================================
##
## ------------------------------------------------
## Group: all
## ------------------------------------------------
##               N min.  p25 median   mean  p75 max.
## all ages   1398    0    4    168 1813.0 3770 7738
## 1st week    407    0    0      1    1.6    3    7
## 1st month   546    0    0      2    5.7    8   30
## 1st year    749    0    0      5   36.8   41  362
## > 1st year  649  367 2280   4066 3863.0 5449 7738
```


Mortality − age at death (all)
Frequency
0
200
600
0
2000
4000
6000
8000
Age (in days)

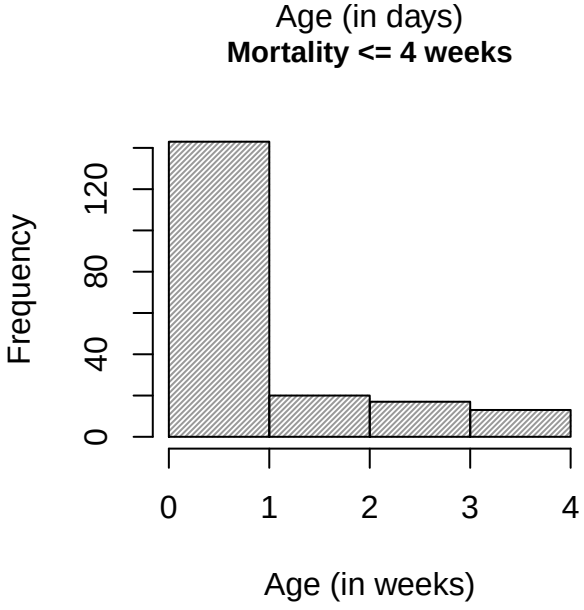

Mortality in first week
Frequency
0
50
150
250
0
1
2
3
4
5
6
7
Age (in days)

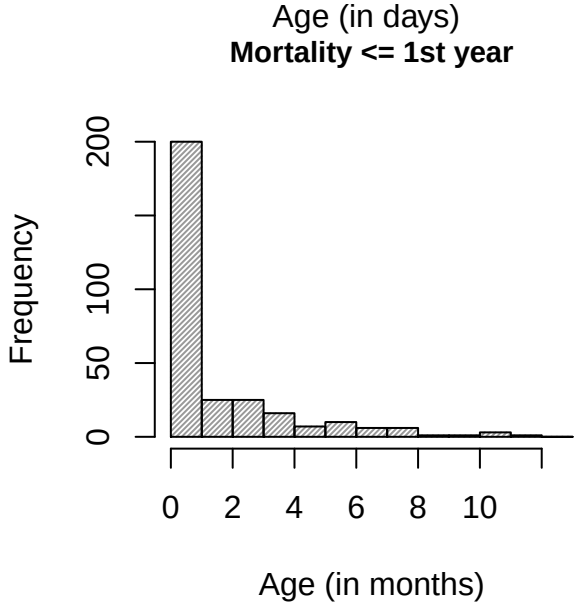

Mortality <= 4 weeks
Frequency
0
100
300
0
1
2
3
4
Age (in weeks)

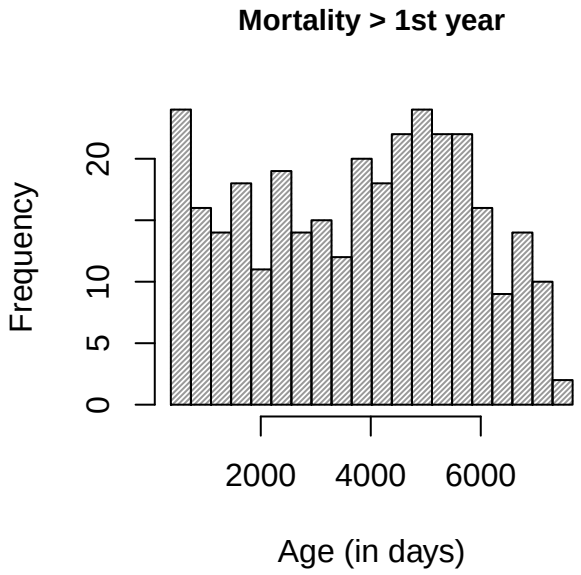

Mortality <= 1st year
Frequency
0
200
400
0
2
4
6
8
10
Age (in months)


Mortality > 1st year
Frequency
0
10
30
50
2000
4000
6000
8000
Age (in days)

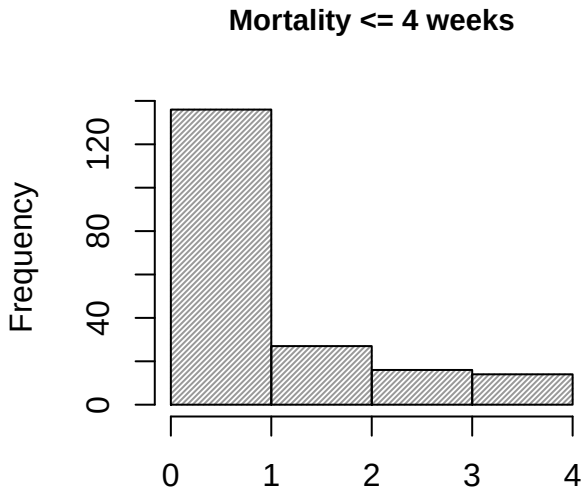
```
## ------------------------------------------------
## Group: male
## ------------------------------------------------
##                N min.  p25 median   mean  p75 max.
## all ages     623    0   12    499 1968.0 4075 7523
## 1st week     143    0    0      1    1.8    3    7
## 1st month    200    0    0      3    6.6   10   30
## 1st year     301    0    1     11   43.3   63  351
## > 1st year   322  367 2055   3968 3766.0 5300 7523
```

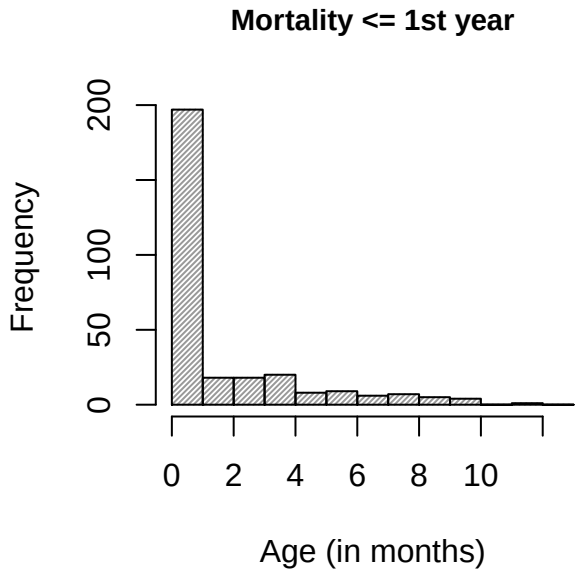


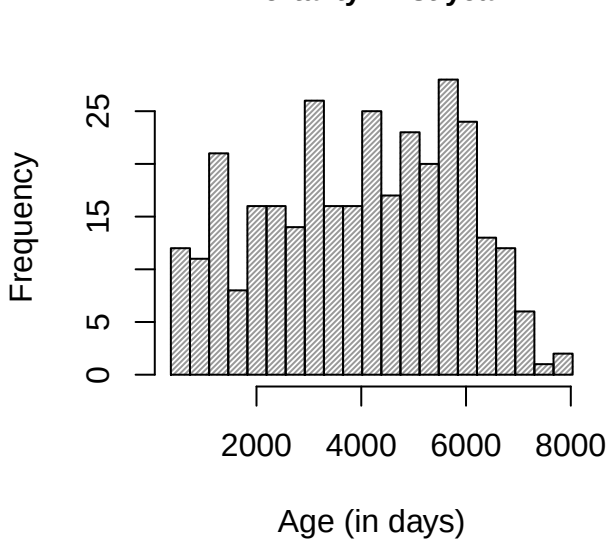




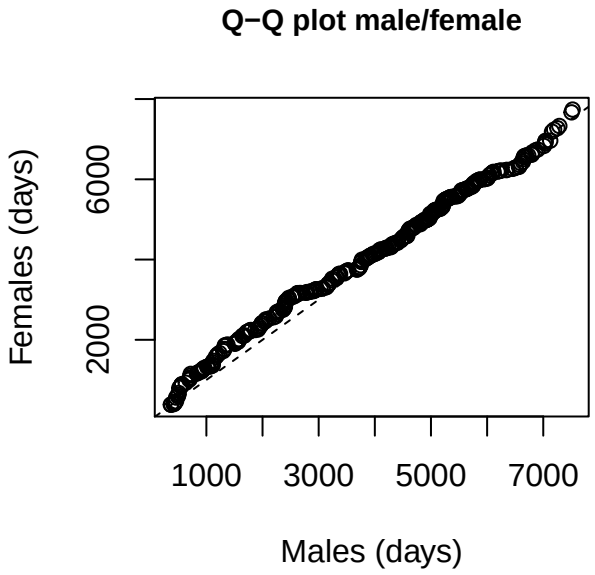

```
## ------------------------------------------------
## Group: female
## ------------------------------------------------
##              N min.  p25 median   mean    p75 max.
## all ages   620    0   13    884 2110.0 4277.0 7738
## 1st week   136    0    0      1    1.4    2.2    7
## 1st month  197    0    0      2    6.3   10.0   30
## 1st year   293    0    1     10   46.2   74.0  362
## > 1st year 327  383 2480   4141 3959.0 5512.0 7738
```








```
## ------------------------------------------------
## Compare sexes
## ------------------------------------------------
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  sample1 and sample2
## W = 49723, p-value = 0.2209
## alternative hypothesis: true location shift is not equal to 0
##
## H0: equal distributions is not rejected
```




```
## [1] FALSE
```

Longevity

Longevities (oldest observed age) are estimated for all individuals, males and females.

```
studbook.longevity()
```

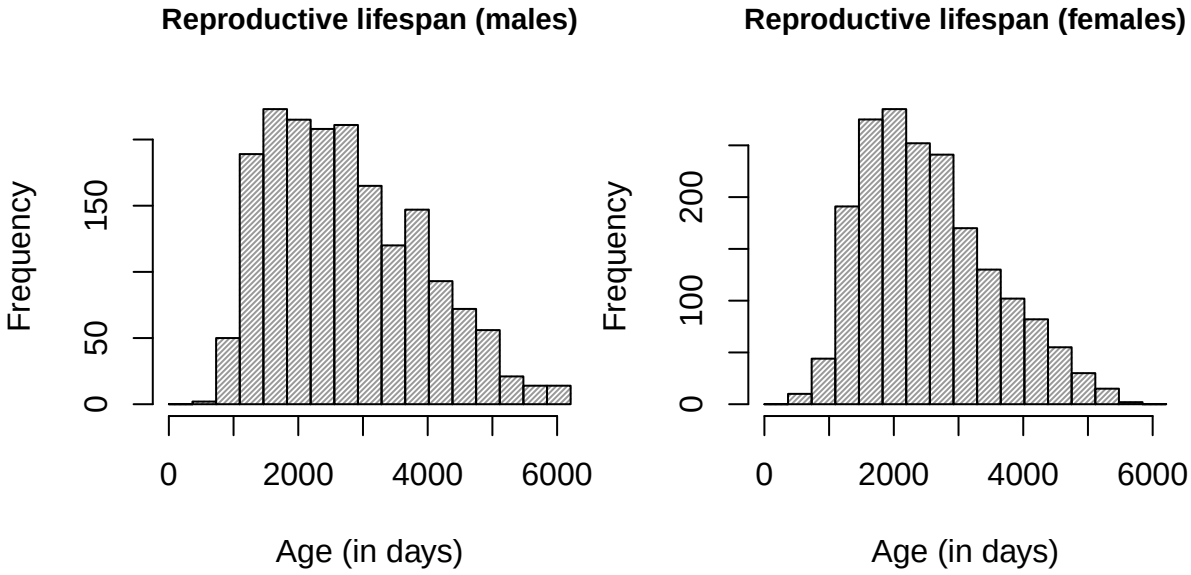
```
## ================================================
## Longevity and percentiles
## ================================================
##
##          ALL    MALE  FEMALE
## 90%  5579.60 5637.60 5772.20
## 95%  6205.60 6329.50 6234.05
## 99%  7038.09 7105.74 6962.43
## 100% 7738.00 7523.00 7738.00
```

Reproductive life-span

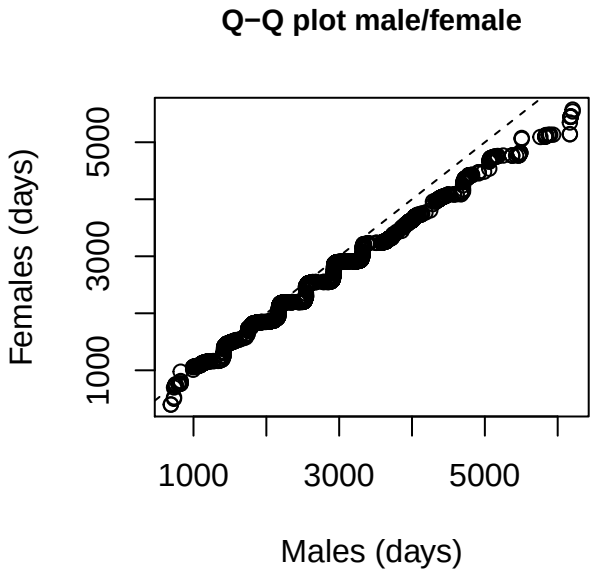
The number of births in male and female age classes are calculated with the function

```
studbook.breeding()
```

```
## ================================================
## Reproductive lifespan
## ================================================
##
## males  [ n =  1800 ]
## ------------------------------------------------
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     689    1821    2564    2736    3607    6205
## ------------------------------------------------
##
## females  [ n =  1884 ]
## ------------------------------------------------
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     397    1816    2500    2546    3253    5573
## ------------------------------------------------
```




```
## ------------------------------------------------
## Compare sexes
## ------------------------------------------------
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  sample1 and sample2
## W = 1835600, p-value = 1.436e-05
## alternative hypothesis: true location shift is not equal to 0
##
## H0: equal distributions is rejected
```




```
## [1] FALSE
```

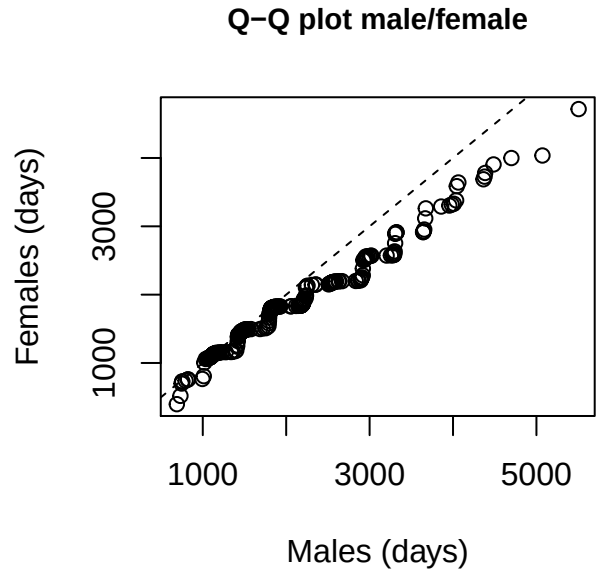
Age at first reproduction

Age at first reproduction is estimated in days for both males and females.

```
studbook.firstBreeding()
```

```
## ================================================
## Age at first reproduction
## ================================================
##
## Age at 1st reproduction (males)  [ n =  284 ]
## ------------------------------------------------
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     689    1408    1810    1992    2540    5506
## ------------------------------------------------
##
## Percentiles 2.5-97.5%   : 836.825 4062.575
## Sampling variance       : 802631.1
## Standard deviation      : 895.8968
## Standard error of mean  : 53.1617
## Age at 1st reproduction (females)  [ n =  312 ]
## ------------------------------------------------
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     397    1226    1755    1787    2170    4716
## ------------------------------------------------
##
## Percentiles 2.5-97.5%   : 761.325 3638.975
## Sampling variance       : 476880.5
## Standard deviation      : 690.5654
## Standard error of mean  : 39.09557
```


```
## ------------------------------------------------
## Compare sexes
## ------------------------------------------------
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  sample1 and sample2
## W = 48690, p-value = 0.03675
## alternative hypothesis: true location shift is not equal to 0
##
## H0: equal distributions is rejected
```

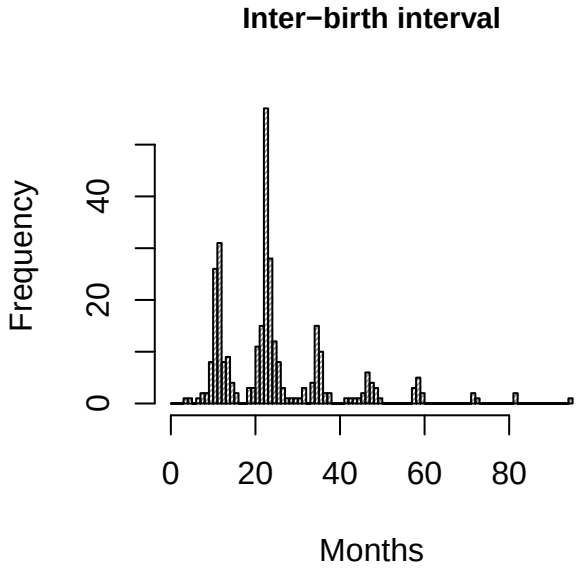



```
## [1] TRUE
```

Interbirth interval

```
studbook.birthInterval()
```

```
## ================================================
## Inter-birth interval
## ================================================
##
## Inter-birth interval  [ n =  311 ]
## ------------------------------------------------------
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   125.0   420.0   716.0   774.3   828.5  2923.0
## ------------------------------------------------------
```



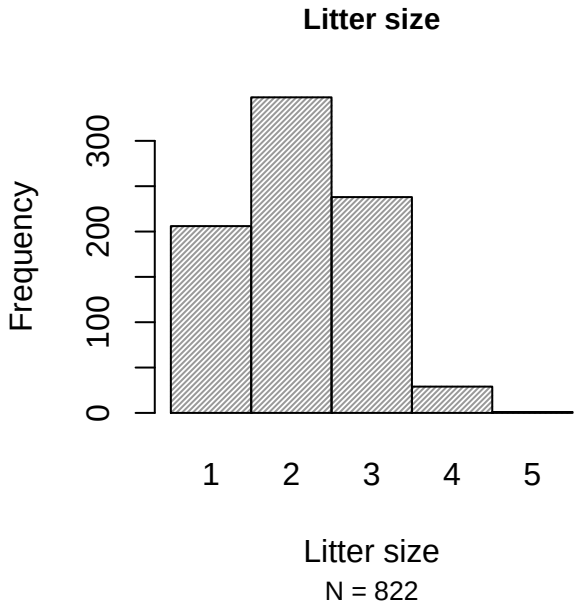

```
## [1] FALSE
```

Litter size

```
studbook.litterSize()
```

```
## ================================================
## Litter size
## ================================================
##
## Litter  [ n =  822 ]
## ------------------------------------------------------
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   1.000   1.250   2.000   2.113   3.000   5.000
## ------------------------------------------------------
##
## Unweighted  [ n =  822 ]
## ------------------------------------------------------
## Arithmetic mean          : 2.113139  [sd = 0.8247674 ]
## Median                   : 2
```

```
## Geometric mean           : 1.939451  [ 1.883216 , 1.997365 ]
## --------------------------------------------------
##
## raw.data
##   1   2   3   4   5
## 206 348 238  29   1
```




```
## [1] TRUE
```

Litter survival

```
studbook.litterSurvival()
```

```
## ================================================
## Litter size and neonatal survival
## ================================================
##
## Total litters: 923
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: binomial  ( logit )
## Formula: cbind(SURVIVED, DEATHS) ~ SIZE + F + (1 | animal)
##    Data: litter.data
##
##      AIC      BIC   logLik deviance df.resid
##   1813.6   1832.9   -902.8   1805.6      919
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.2777 -0.7575  0.4506  0.6690  1.9221
##
## Random effects:
##  Groups Name        Variance Std.Dev.
```

```
##  animal (Intercept) 1.883    1.372
## Number of obs: 923, groups:  animal, 330
##
## Fixed effects:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)   0.9588     0.2313   4.146 3.39e-05 ***
## SIZE          0.1435     0.0858   1.672   0.0945 .
## F            -2.2751     2.2277  -1.021   0.3071
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##      (Intr) SIZE
## SIZE -0.863
## F    -0.172  0.013
```

Seasonality

The package `circular` is used to analyse seasonality in dates of birth (litter) and death. Individual dates are plotted as stacked bars on a circle. The same figure includes a rose diagram with dates grouped per month.

The following circular tests are applied to test whether dates are distributed uniformly over the year: *Rayleigh's test*, *Kuiper's test*, *Rao's spacing test of uniformity* and *Watson's test*.

Birth season

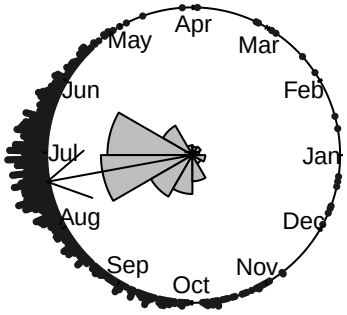
Seasonality in births is estimated, depending on the species' reproduction, from individual dates or litter dates. The following example is for a species that produces litters. Only the *Rayleigh's test* is applied in this example. In addition, the effect of maternal generation on seasonality is analysed.

```
studbook.season(analysis='litter',test='rayleigh',effects='generation')
```

```
## ================================================
## Seasonality in litters
## ================================================
##
## Litters  [ n= 923 ]
## [Range]
## Season       : 11 Jan - 24 Dec
## Season (99%) : 28 Feb - 9 Dec
## Season (95%) : 17 May - 15 Oct
## Median season: 8 Jul
##
## Mean angle   : 190.3985 degrees ( -2.960105 radians)
## Variance     : 0.1811009
## Mean day     : 12 Jul  [-172.428188203896]
## CI 2.5%      : 10 Jul
## CI 97.5%     : 14 Jul
##
## [Rayleigh's test]
## Group        : Litters (n = 923 )
## Resultant r  : 0.8188991
## Rayleigh's R : 755.8439
```

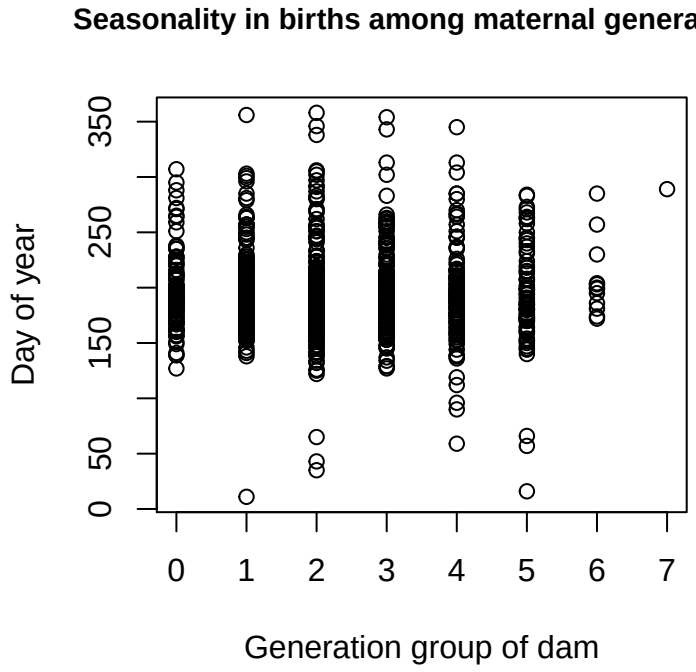
```
## p            : 1.545696e-269
## H0: uniform distribution is rejected
```

Seasonality in litters (all)




```
## [Rayleigh's test]
## Group        : Males in litter (n = 878 )
## Resultant r  : 0.7980477
## Rayleigh's R : 700.6859
## p            : 5.05999e-256
## H0: uniform distribution is rejected
##
## [Rayleigh's test]
## Group        : Females in litter (n = 902 )
## Resultant r  : 0.8147672
## Rayleigh's R : 734.92
## p            : 7.851958e-267
## H0: uniform distribution is rejected
##
## [Rayleigh's test]
## Group        : Unknown in litter (n = 151 )
## Resultant r  : 0.1228831
## Rayleigh's R : 18.55535
## p            : 8.851223e-07
## H0: uniform distribution is rejected
##
## [ Seasonality in births among maternal generations ]
## Table generation groups
##
##   0   1   2   3   4   5   6   7
## 103 190 237 183 118  79  12   1
##
##  Pairwise comparisons using Rao test for equal mean
##
## data:  season.data$DAY and season.data$G
##
##   0 1 2 3 4 5 6
## 1 1 - - - - - -
## 2 1 1 - - - - -
## 3 1 1 1 - - - -
## 4 1 1 1 1 - - -
```

```
## 5 1 1 1 1 1 - -
## 6 1 1 1 1 1 1 -
## 7 - - - - - - -
##
## P value adjustment method: holm
##
##  Pairwise comparisons using Rao test for equal dispersion
##
## data:  season.data$DAY and season.data$G
##
##   0    1    2    3    4    5    6
## 1 1.00 -    -    -    -    -    -
## 2 1.00 1.00 -    -    -    -    -
## 3 1.00 1.00 1.00 -    -    -    -
## 4 1.00 1.00 1.00 1.00 -    -    -
## 5 1.00 0.89 1.00 1.00 1.00 -    -
## 6 1.00 1.00 1.00 1.00 1.00 1.00 -
## 7 -    -    -    -    -    -    -
##
## P value adjustment method: holm
## [p < 0.05 indicate significant differences between groups]
```




```
## [1] FALSE
```

Death season

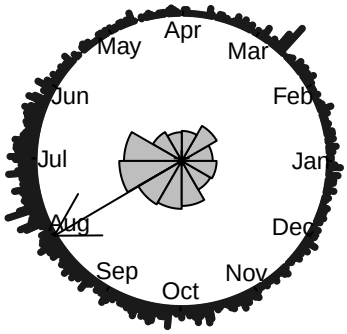
Seasonality in deaths is estimated in the entire population and/or for males and females, separately.

```
studbook.season(analysis='death',sex='all',test='rayleigh')
```

```
## ================================================
## Seasonality in deaths
## ================================================
```

```
##
## all  [ n= 1454 ]
## [Range]
## Season       : 22 Jan - 19 Jan
## Season (99%) : 23 Jan - 16 Jan
## Season (95%) : 5 Feb - 4 Jan
## Median season: 22 Jul
##
## Mean angle   : 210.4317 degrees ( -2.610459 radians)
## Variance     : 0.7002022
## Mean day     : 1 Aug  [-152.061068318624]
## CI 2.5%      : 27 Jul
## CI 97.5%     : 8 Aug
##
## [Rayleigh's test]
## Group        : all (n = 1454 )
## Resultant r  : 0.2997978
## Rayleigh's R : 435.906
## p            : 1.757116e-57
## H0: uniform distribution is rejected
```

Seasonality in deaths (all)




```
## [1] FALSE
```