# Survival Models Fitted

Loïc Pages

2025-06-17

## Introduction

```
rm(list=ls())
library(knitr)
library(spaMM)
library(tidyverse)
library(splines)
library(foreach)
library(doParallel)
library(patchwork)

setwd("/media/loic/Commun/0Travail/Stage 2025 ISEM/Code")

IPM_data <- read.csv("newdata.csv")

centauree_data <- IPM_data[!is.na(IPM_data$SizeOMars) & !is.na(IPM_data$Age),]
centauree_data$Age[centauree_data$Age > 8] <- 8

spaMM.options(separation_max=70)
```

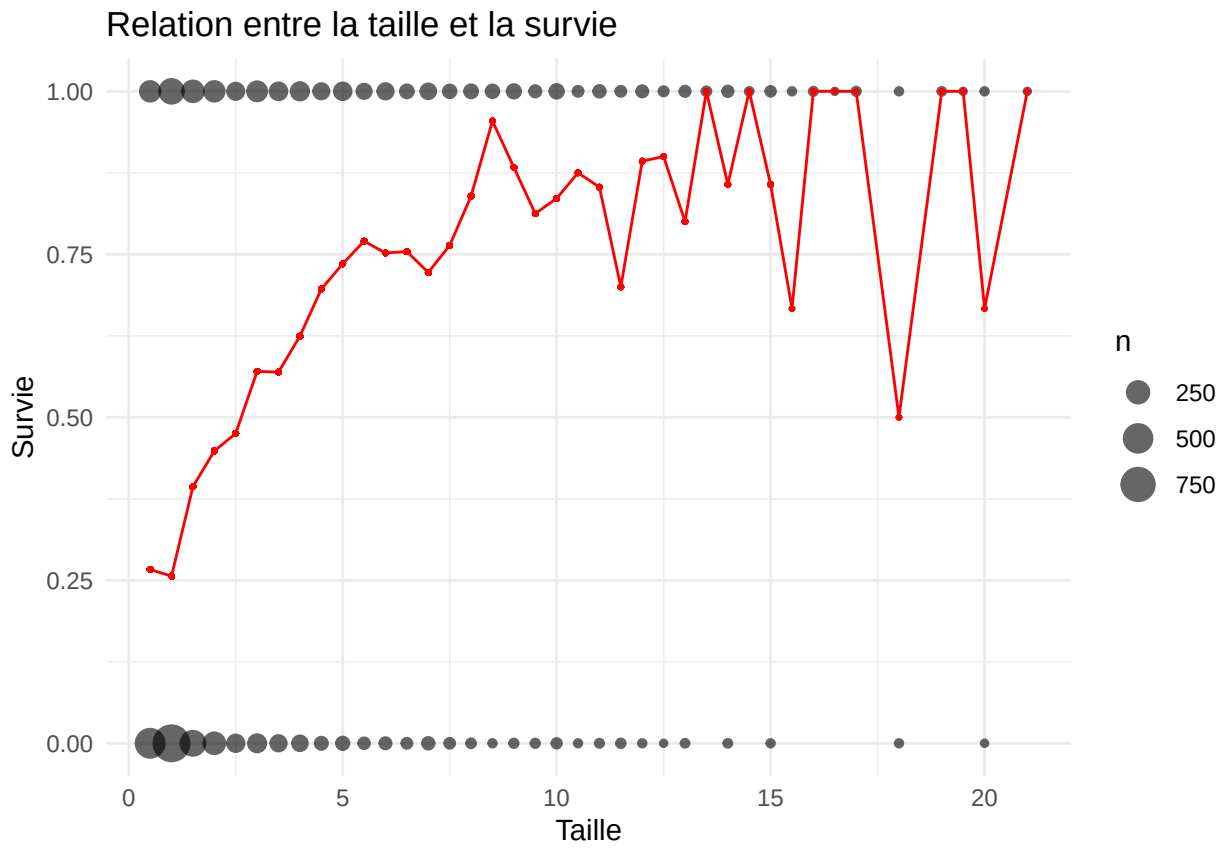
BIC

## Survival probability

```
survdata <- centauree_data[centauree_data$Flowering!=1,]
# survdata$Survie[survdata$Age==7][1:15] <- 0

survdata %>%
  group_by(SizeOMars) %>%
  mutate(survivalProba = sum(Survie, na.rm = TRUE) / n()) %>%
  ggplot(aes(x = SizeOMars, y = Survie)) +
  geom_count(alpha = 0.6) +  # Points dimensionnés selon la fréquence
  geom_point(aes(y = survivalProba), color = "red", size = 0.5) +
  geom_line(aes(y = survivalProba), color = "red") +
  labs(title = "Relation entre la taille et la survie",
       x = "Taille",
       y = "Survie") +
```

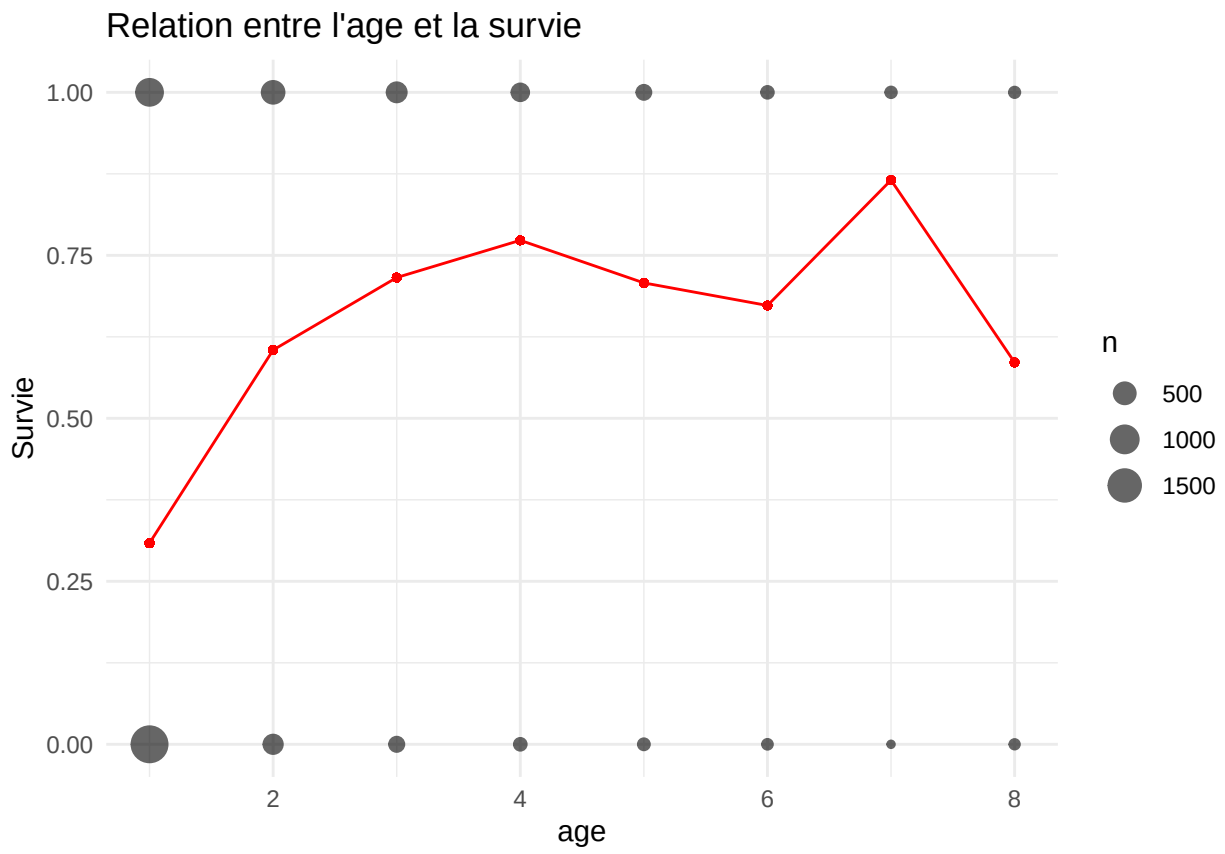
```
  ylim(0, 1) +
  theme_minimal()
```

```
## Warning: Removed 101 rows containing non-finite outside the scale range
## (`stat_sum()`).
```




```
survdata %>%
  group_by(Age) %>%
  mutate(survivalProba = sum(Survie, na.rm = TRUE) / n()) %>%
  ggplot(aes(x = Age, y = Survie)) +
  geom_count(alpha = 0.6) +  # Points dimensionnés selon la fréquence
  geom_point(aes(x = Age, y = survivalProba), color = "red", size = 1) +
  geom_line(aes(x = Age, y = survivalProba), color = "red") +
  labs(title = "Relation entre l'age et la survie",
       x = "age",
       y = "Survie") +
  ylim(0, 1) +
  theme_minimal()
```

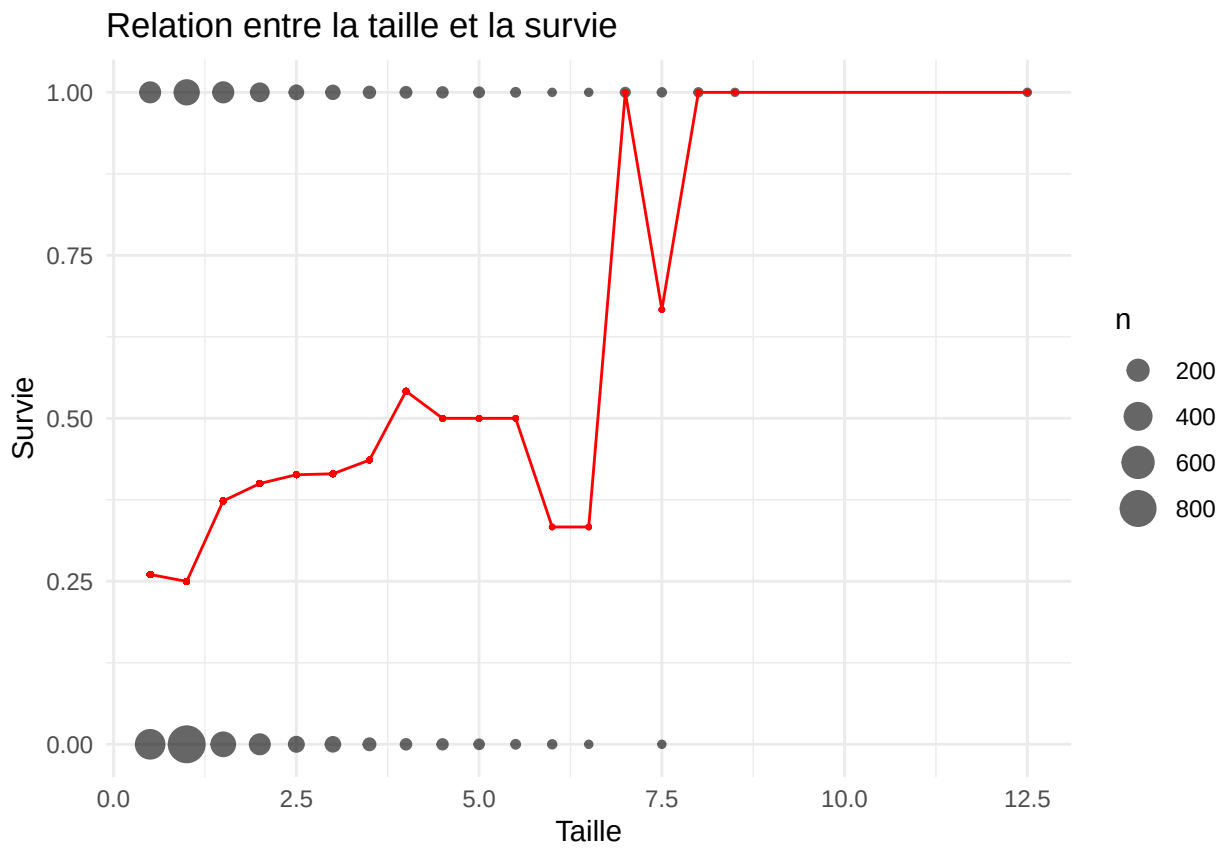
```
## Warning: Removed 101 rows containing non-finite outside the scale range
## (`stat_sum()`).
```




## Seedlings survival

```
survdata1 <- survdata[survdata$Age==1,]

survdata1 %>%
  group_by(SizeOMars) %>%
  mutate(survivalProba = sum(Survie, na.rm = TRUE) / n()) %>%
  ggplot(aes(x = SizeOMars, y = Survie)) +
  geom_count(alpha = 0.6) +  # Points dimensionnés selon la fréquence
  geom_point(aes(y = survivalProba), color = "red", size = 0.5) +
  geom_line(aes(y = survivalProba), color = "red") +
  labs(title = "Relation entre la taille et la survie",
       x = "Taille",
       y = "Survie") +
  ylim(0, 1) +
  theme_minimal()
```

```
## Warning: Removed 61 rows containing non-finite outside the scale range
## (`stat_sum()`).
```




AIC

```
ASurvglm11 <- fitme(Survie ~ 1+ bs(SizeOMars,df=4,degree=2) + (SizeOMars|year),
                    family=binomial,
                    data=survdata1,
                    method="PQL/L")

ASurvglm12 <- fitme(Survie ~ 1+ bs(SizeOMars,df=4,degree=2) + (SizeOMars|year)+ (1|Pop),
                    family=binomial,
                    data=survdata1,
                    method="PQL/L")

ASurvglm13 <- fitme(Survie ~ 1+ bs(SizeOMars,df=4,degree=2) + (1|year) + (1|Pop),
                    family=binomial,
                    data=survdata1,
                    method="PQL/L")

ASurvglm14 <- fitme(Survie ~ 1+ bs(SizeOMars,df=4,degree=2) + (1|year),
                    family=binomial,
                    data=survdata1,
                    method="PQL/L")

ASurvglm15 <- fitme(Survie ~ 1+ bs(SizeOMars,df=5,degree=3) + (SizeOMars|year),
                    family=binomial,
                    data=survdata1,
                    method="PQL/L")
```

BIC

```
BSurvglm11 <- fitme(Survie ~ 1+ SizeOMars + (1|year) + (1|Pop),
                  family=binomial,
                  data=survdata1,
                  method="PQL/L")

BSurvglm12 <- fitme(Survie ~ 1+ SizeOMars + (1|year),
                  family=binomial,
                  data=survdata1,
                  method="PQL/L")

BSurvglm13 <- fitme(Survie ~ 1 + SizeOMars + (SizeOMars|year) + (1|Pop),
                  family=binomial,
                  data=survdata1,
                  method="PQL/L")

BSurvglm14 <- fitme(Survie ~ 1+ SizeOMars + (SizeOMars|year),
                  family=binomial,
                  data=survdata1,
                  method="PQL/L")

BSurvglm15 <- fitme(Survie ~ 1+ SizeOMars + (1|year) + (SizeOMars|Pop),
                  family=binomial,
                  data=survdata1,
                  method="PQL/L")
```

```
summary(ASurvglm11)
```

```
## formula: Survie ~ 1 + bs(SizeOMars, df = 4, degree = 2) + (SizeOMars |
##     year)
## Estimation of ranCoefs by ML (p_v approximation of logL).
## Estimation of fixed effects by h-likelihood approximation.
## family: binomial( link = logit )
##  ------------ Fixed effects (beta) ------------
##                                    Estimate Cond. SE t-value
## (Intercept)                         -1.3258   0.2560  -5.179
## bs(SizeOMars, df = 4, degree = 2)1  -0.4160   0.2095  -1.986
## bs(SizeOMars, df = 4, degree = 2)2   0.7485   0.1590   4.709
## bs(SizeOMars, df = 4, degree = 2)3   0.9162   0.8042   1.139
## bs(SizeOMars, df = 4, degree = 2)4   7.1514   3.0511   2.344
##  --------------- Random effects ---------------
## Family: gaussian( link = identity )
##          --- Random-coefficients Cov matrices:
##  Group        Term    Var.   Corr.
##   year (Intercept)   1.582
##   year   SizeOMars 0.02833 -0.9827
## # of obs: 2842; # of groups: year, 27
##  ------------- Likelihood values  -------------
##                         logLik
##        h-likelihood: -1620.909
## logL       (p_v(h)): -1606.418
```

```
summary(ASurvglm12)
```

```
## formula: Survie ~ 1 + bs(SizeOMars, df = 4, degree = 2) + (SizeOMars |
##     year) + (1 | Pop)
## Estimation of lambda and ranCoefs by ML (p_v approximation of logL).
## Estimation of fixed effects by h-likelihood approximation.
## family: binomial( link = logit )
##  ------------ Fixed effects (beta) ------------
##                                    Estimate Cond. SE t-value
## (Intercept)                         -1.3279   0.2587  -5.132
## bs(SizeOMars, df = 4, degree = 2)1  -0.3992   0.2103  -1.898
## bs(SizeOMars, df = 4, degree = 2)2   0.7414   0.1592   4.658
## bs(SizeOMars, df = 4, degree = 2)3   1.0188   0.8056   1.265
## bs(SizeOMars, df = 4, degree = 2)4   7.1285   3.0490   2.338
##  --------------- Random effects ---------------
## Family: gaussian( link = identity )
##          --- Random-coefficients Cov matrices:
##  Group        Term    Var.   Corr.
##   year (Intercept)   1.562
##   year   SizeOMars 0.02607 -0.9798
##            --- Variance parameters ('lambda'):
## lambda = var(u) for u ~ Gaussian;
##    Pop  :  0.009413
##              --- Coefficients for log(lambda):
##  Group        Term Estimate Cond.SE
##    Pop (Intercept)   -4.666  0.9804
## # of obs: 2842; # of groups: year, 27; Pop, 6
##  ------------- Likelihood values  -------------
##                         logLik
##        h-likelihood: -1610.258
## logL       (p_v(h)): -1605.648
```

```
summary(ASurvglm13)
```

```
## formula: Survie ~ 1 + bs(SizeOMars, df = 4, degree = 2) + (1 | year) +
##     (1 | Pop)
## Estimation of fixed effects by h-likelihood approximation.
## Estimation of lambda by 'outer' ML, maximizing logL.
## family: binomial( link = logit )
##  ------------ Fixed effects (beta) ------------
##                                    Estimate Cond. SE t-value
## (Intercept)                         -1.2924   0.2291  -5.641
## bs(SizeOMars, df = 4, degree = 2)1  -0.4172   0.2101  -1.986
## bs(SizeOMars, df = 4, degree = 2)2   0.6812   0.1579   4.315
## bs(SizeOMars, df = 4, degree = 2)3   0.8527   0.8136   1.048
## bs(SizeOMars, df = 4, degree = 2)4   7.1211   3.2920   2.163
##  --------------- Random effects ---------------
## Family: gaussian( link = identity )
##            --- Variance parameters ('lambda'):
## lambda = var(u) for u ~ Gaussian;
##    year  :  1.009
##    Pop  :  0.01178
```

```
## # of obs: 2842; # of groups: year, 27; Pop, 6
##  ------------- Likelihood values  -------------
##                          logLik
##        h-likelihood: -1588.931
## logL       (p_v(h)): -1607.753
```

```
summary(ASurvglm14)
```

```
## formula: Survie ~ 1 + bs(SizeOMars, df = 4, degree = 2) + (1 | year)
## Estimation of fixed effects by h-likelihood approximation.
## Estimation of lambda by 'outer' ML, maximizing logL.
## family: binomial( link = logit )
##  ------------ Fixed effects (beta) ------------
##                                    Estimate Cond. SE t-value
## (Intercept)                         -1.2855   0.2232 -5.7604
## bs(SizeOMars, df = 4, degree = 2)1  -0.4381   0.2092 -2.0941
## bs(SizeOMars, df = 4, degree = 2)2   0.6842   0.1575  4.3441
## bs(SizeOMars, df = 4, degree = 2)3   0.7134   0.8112  0.8794
## bs(SizeOMars, df = 4, degree = 2)4   7.1565   3.3098  2.1622
##  --------------- Random effects ---------------
## Family: gaussian( link = identity )
##            --- Variance parameters ('lambda'):
## lambda = var(u) for u ~ Gaussian;
##    year  :  0.999
## # of obs: 2842; # of groups: year, 27
##  ------------- Likelihood values  -------------
##                          logLik
##        h-likelihood: -1599.370
## logL       (p_v(h)): -1608.823
```

```
summary(ASurvglm15)
```

```
## formula: Survie ~ 1 + bs(SizeOMars, df = 5, degree = 3) + (SizeOMars |
##     year)
## Estimation of ranCoefs by ML (p_v approximation of logL).
## Estimation of fixed effects by h-likelihood approximation.
## family: binomial( link = logit )
##  ------------ Fixed effects (beta) ------------
##                                    Estimate Cond. SE t-value
## (Intercept)                         -1.3294   0.2571 -5.1710
## bs(SizeOMars, df = 5, degree = 3)1  -1.2562   0.6692 -1.8772
## bs(SizeOMars, df = 5, degree = 3)2   0.6150   0.2580  2.3837
## bs(SizeOMars, df = 5, degree = 3)3   1.5967   1.2102  1.3194
## bs(SizeOMars, df = 5, degree = 3)4  -0.4639   4.6227 -0.1003
## bs(SizeOMars, df = 5, degree = 3)5  16.3925  13.0674  1.2545
##  --------------- Random effects ---------------
## Family: gaussian( link = identity )
##          --- Random-coefficients Cov matrices:
##  Group        Term    Var.   Corr.
##   year (Intercept)   1.602
##   year   SizeOMars 0.02916 -0.9927
## # of obs: 2842; # of groups: year, 27
##  ------------- Likelihood values  -------------
```

```
##                          logLik
##        h-likelihood: -1620.756
## logL       (p_v(h)): -1606.117
```

```
summary(BSurvglm11)
```

```
## formula: Survie ~ 1 + SizeOMars + (1 | year) + (1 | Pop)
## Estimation of fixed effects by h-likelihood approximation.
## Estimation of lambda by 'outer' ML, maximizing logL.
## family: binomial( link = logit )
##  ------------ Fixed effects (beta) ------------
##             Estimate Cond. SE t-value
## (Intercept)  -1.4349  0.22455  -6.390
## SizeOMars     0.3669  0.04839   7.582
##  ---------------- Random effects ----------------
## Family: gaussian( link = identity )
##             --- Variance parameters ('lambda'):
## lambda = var(u) for u ~ Gaussian;
##    year  :  1.009
##    Pop  :  0.01442
## # of obs: 2842; # of groups: year, 27; Pop, 6
##  ------------- Likelihood values  -------------
##                          logLik
##        h-likelihood: -1594.987
## logL       (p_v(h)): -1613.482
```

```
summary(BSurvglm12)
```

```
## formula: Survie ~ 1 + SizeOMars + (1 | year)
## Estimation of fixed effects by h-likelihood approximation.
## Estimation of lambda by 'outer' ML, maximizing logL.
## family: binomial( link = logit )
##  ------------ Fixed effects (beta) ------------
##             Estimate Cond. SE t-value
## (Intercept)  -1.4246  0.21711  -6.562
## SizeOMars     0.3551  0.04756   7.465
##  ---------------- Random effects ----------------
## Family: gaussian( link = identity )
##             --- Variance parameters ('lambda'):
## lambda = var(u) for u ~ Gaussian;
##    year  :  0.9977
## # of obs: 2842; # of groups: year, 27
##  ------------- Likelihood values  -------------
##                          logLik
##        h-likelihood: -1605.475
## logL       (p_v(h)): -1614.962
```

```
summary(BSurvglm13)
```

```
## formula: Survie ~ 1 + SizeOMars + (SizeOMars | year) + (1 | Pop)
## Estimation of lambda and ranCoefs by ML (p_v approximation of logL).
## Estimation of fixed effects by h-likelihood approximation.
```

```
## family: binomial( link = logit )
##  ------------ Fixed effects (beta) ------------
##             Estimate Cond. SE t-value
## (Intercept)  -1.4487  0.26110  -5.548
## SizeOMars     0.3847  0.05671   6.783
##  --------------- Random effects ---------------
## Family: gaussian( link = identity )
##          --- Random-coefficients Cov matrices:
##  Group        Term    Var.   Corr.
##   year (Intercept)   1.456
##   year   SizeOMars 0.02092 -0.9322
##            --- Variance parameters ('lambda'):
## lambda = var(u) for u ~ Gaussian;
##    Pop  :  0.01255
##              --- Coefficients for log(lambda):
##  Group        Term Estimate Cond.SE
##    Pop (Intercept)   -4.378  0.9071
## # of obs: 2842; # of groups: year, 27; Pop, 6
##  ------------- Likelihood values  -------------
##                         logLik
##        h-likelihood: -1616.888
## logL       (p_v(h)): -1612.081
```

```
summary(BSurvglm14)
```

```
## formula: Survie ~ 1 + SizeOMars + (SizeOMars | year)
## Estimation of ranCoefs by ML (p_v approximation of logL).
## Estimation of fixed effects by h-likelihood approximation.
## family: binomial( link = logit )
##  ------------ Fixed effects (beta) ------------
##             Estimate Cond. SE t-value
## (Intercept)  -1.4428  0.25795  -5.594
## SizeOMars     0.3762  0.05687   6.614
##  --------------- Random effects ---------------
## Family: gaussian( link = identity )
##          --- Random-coefficients Cov matrices:
##  Group        Term    Var.   Corr.
##   year (Intercept)   1.476
##   year   SizeOMars 0.02321 -0.9389
## # of obs: 2842; # of groups: year, 27
##  ------------- Likelihood values  -------------
##                         logLik
##        h-likelihood: -1627.435
## logL       (p_v(h)): -1613.306
```

```
summary(BSurvglm15)
```

```
## formula: Survie ~ 1 + SizeOMars + (1 | year) + (SizeOMars | Pop)
## Estimation of lambda and ranCoefs by ML (p_v approximation of logL).
## Estimation of fixed effects by h-likelihood approximation.
## family: binomial( link = logit )
##  ------------ Fixed effects (beta) ------------
##             Estimate Cond. SE t-value
```

```
## (Intercept)  -1.4281  0.22026  -6.483
## SizeOMars     0.3632  0.04844   7.498
##  --------------- Random effects ---------------
## Family: gaussian( link = identity )
##          --- Random-coefficients Cov matrices:
##  Group        Term      Var. Corr.
##    Pop (Intercept)   0.01842
##    Pop   SizeOMars 0.0001291    -1
##            --- Variance parameters ('lambda'):
## lambda = var(u) for u ~ Gaussian;
##    year  :  0.9413
##             --- Coefficients for log(lambda):
##  Group        Term Estimate Cond.SE
##   year (Intercept)  -0.0605  0.2926
## # of obs: 2842; # of groups: year, 27; Pop, 6
##  ------------- Likelihood values  -------------
##                          logLik
##        h-likelihood: -1613.032
## logL       (p_v(h)): -1613.473
```

```
ASurvpredict1 <- predict(ASurvglm11, newdata = fake_data1)[,1]
ASurvpredict2 <- predict(ASurvglm12, newdata = fake_data1)[,1]
ASurvpredict3 <- predict(ASurvglm13, newdata = fake_data1)[,1]
ASurvpredict4 <- predict(ASurvglm14, newdata = fake_data1)[,1]
ASurvpredict5 <- predict(ASurvglm15, newdata = fake_data1)[,1]

BSurvpredict1 <- predict(BSurvglm11, newdata = fake_data1)[,1]
BSurvpredict2 <- predict(BSurvglm12, newdata = fake_data1)[,1]
BSurvpredict3 <- predict(BSurvglm13, newdata = fake_data1)[,1]
BSurvpredict4 <- predict(BSurvglm14, newdata = fake_data1)[,1]
BSurvpredict5 <- predict(BSurvglm15, newdata = fake_data1)[,1]
```

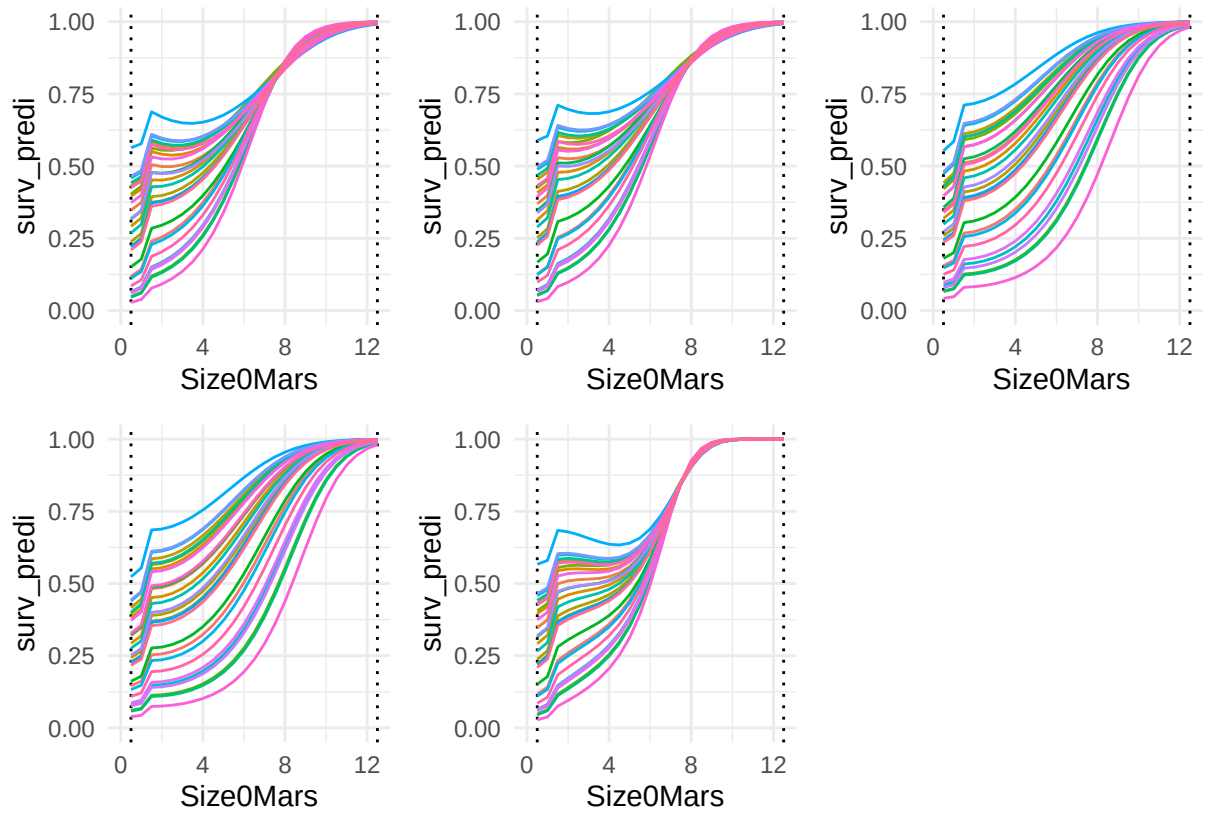
```
plot_survie1 <- function(data = fake_data1, prediction, var, c1, valc1, fact, mindat, maxdat) {
  data %>%
    mutate(surv_predi = prediction) %>%
    filter(!!sym(c1) == valc1) %>%
    ggplot(aes(x = .data[[var]], y = surv_predi)) +
    geom_vline(xintercept=maxdat, lty="dotted")+
    geom_vline(xintercept=mindat, lty="dotted")+
    geom_line(aes(color = as.factor(.data[[fact]])),show.legend = FALSE) +
    theme_minimal() +
    ylim(0, 1)+
    xlim(0,maxdat)
}
```

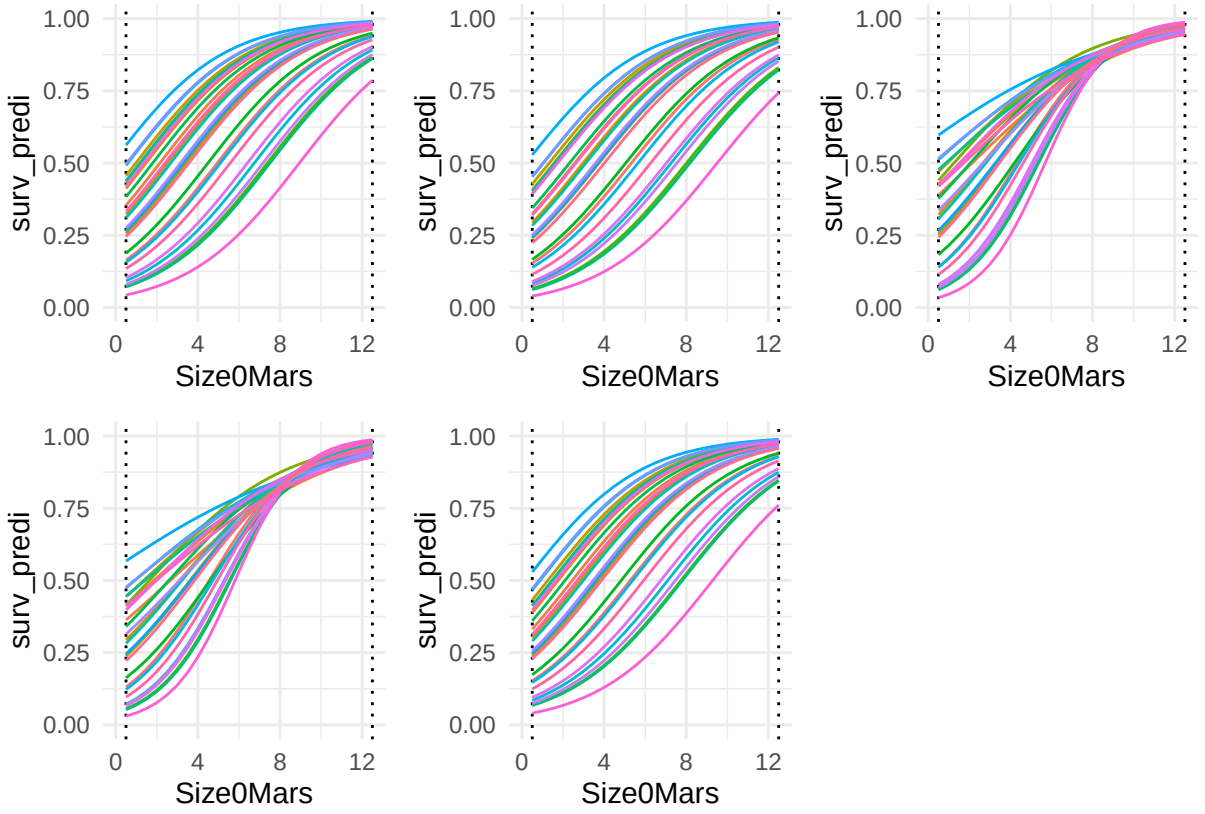
## Survie en fonction de la taille

### En fixant la population : voir l'effet année

```
var <- "SizeOMars"
c1 <- "Pop"
```

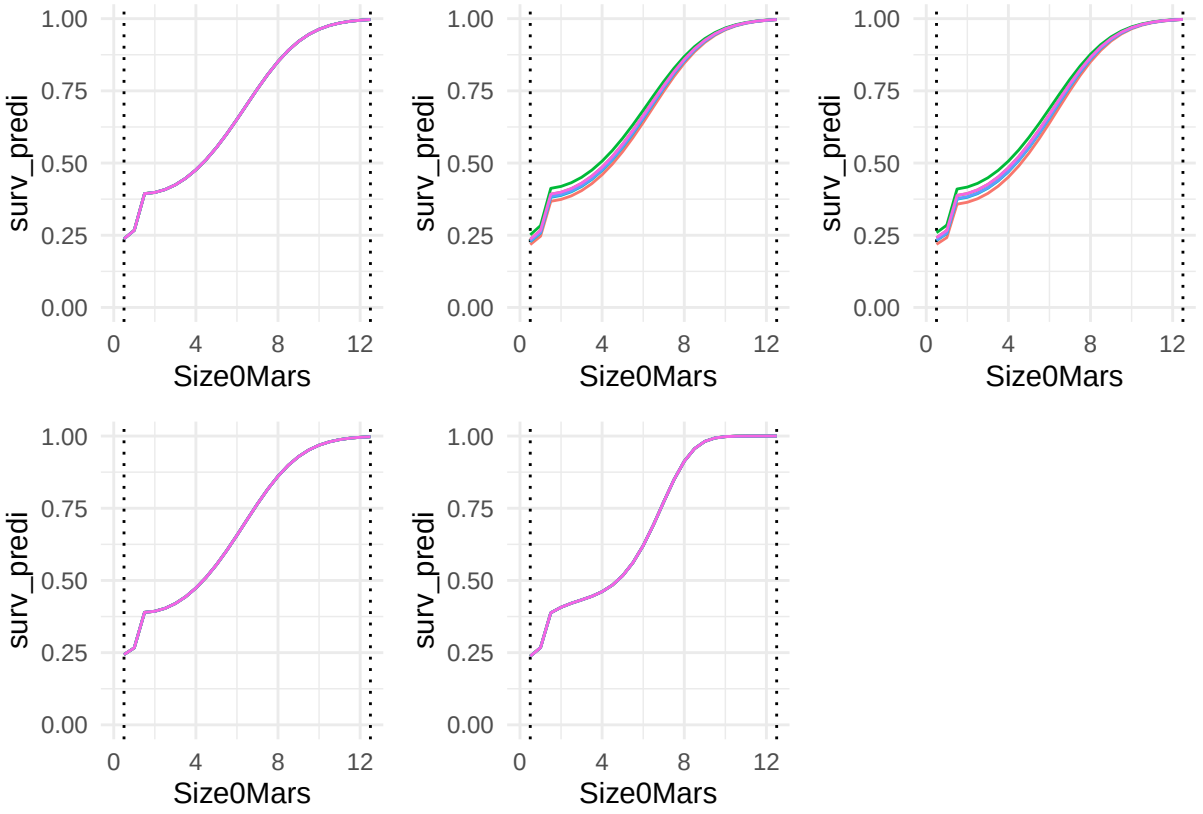
```
valc1 <- "Au"
fact <- "year"

maxdat <- max(survdata1$Size0Mars)
mindat <- min(survdata1$Size0Mars)
```

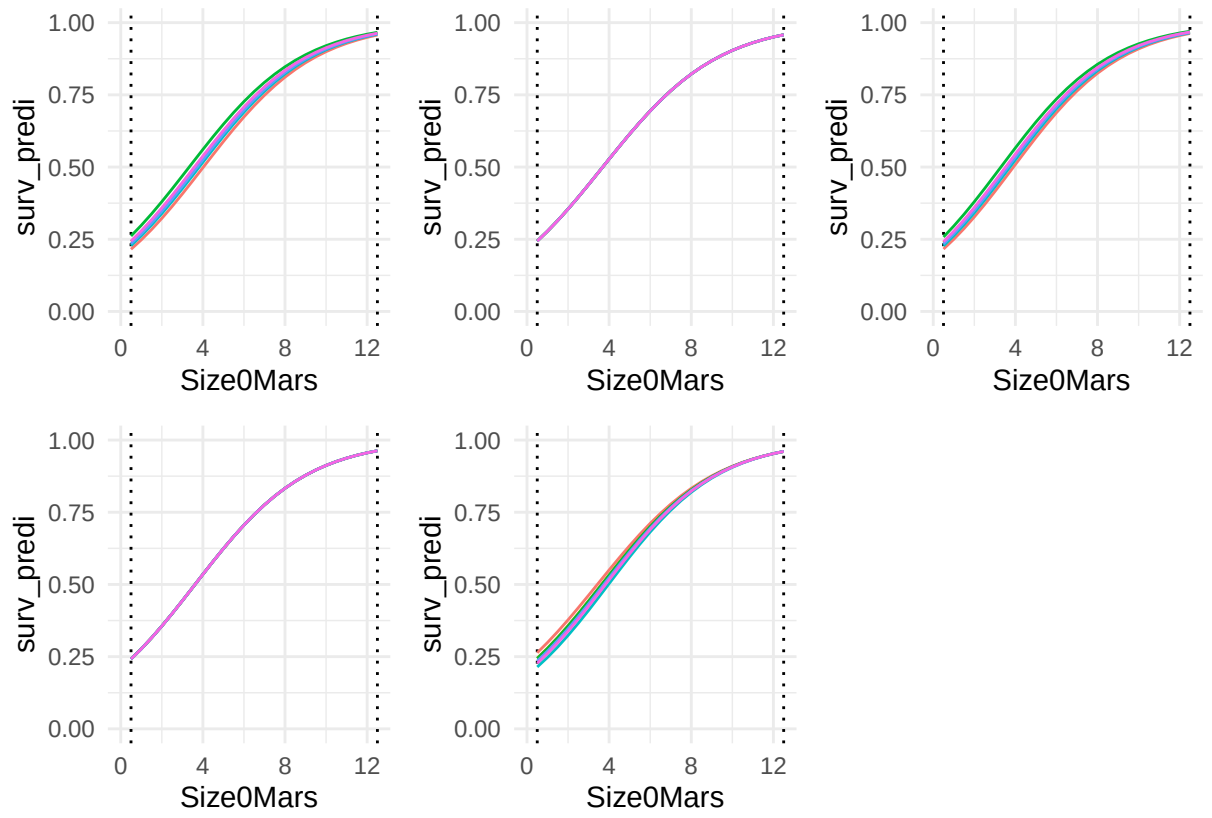





**En fixant l'année : voir l'effet population**

```
var <- "Size0Mars"
c1 <- "year"
valc1 <- 2000
fact <- "Pop"
```

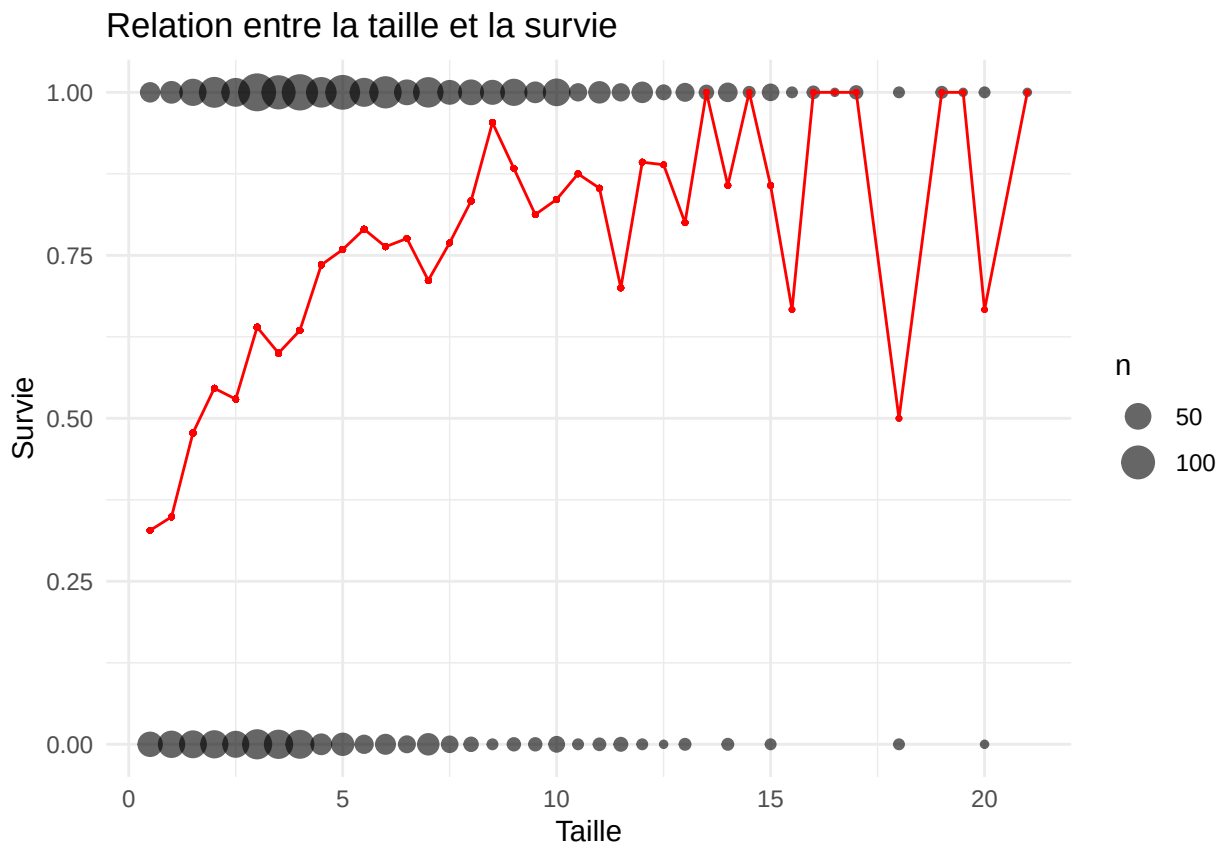

surv_predi
1.00
0.75
0.50
0.25
0.00
0
4
8
12
Size0Mars




## Rosette survival

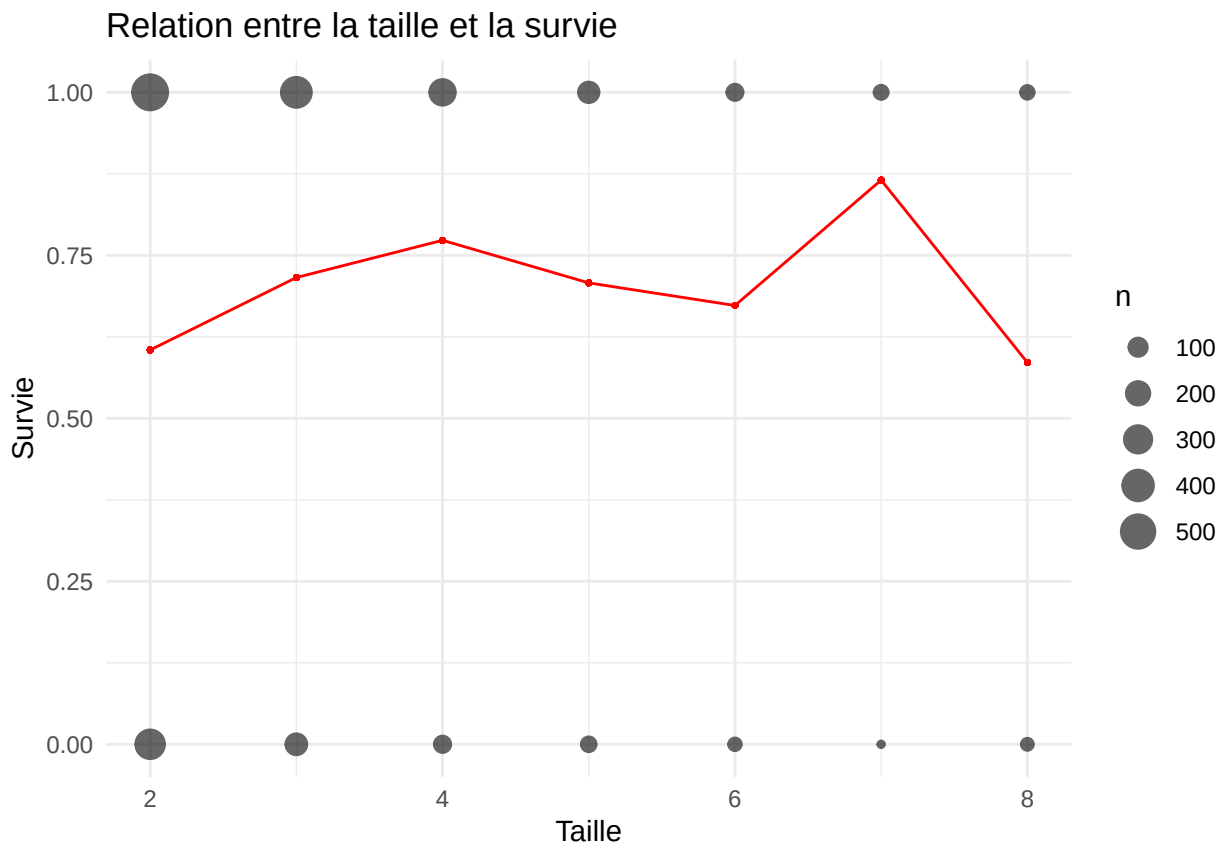
```
survdata2 <- survdata[survdata$Age>1,]

survdata2 %>%
  group_by(Size0Mars) %>%
  mutate(survivalProba = sum(Survie, na.rm = TRUE) / n()) %>%
  ggplot(aes(x = Size0Mars, y = Survie)) +
  geom_count(alpha = 0.6) +  # Points dimensionnés selon la fréquence
  geom_point(aes(y = survivalProba), color = "red", size = 0.5) +
  geom_line(aes(y = survivalProba), color = "red") +
  labs(title = "Relation entre la taille et la survie",
       x = "Taille",
       y = "Survie") +
  ylim(0, 1) +
  theme_minimal()
```

```
## Warning: Removed 40 rows containing non-finite outside the scale range
## (`stat_sum()`).
```




```
survdata2 %>%
  group_by(Age) %>%
  mutate(survivalProba = sum(Survie, na.rm = TRUE) / n()) %>%
  ggplot(aes(x = Age, y = Survie)) +
  geom_count(alpha = 0.6) +  # Points dimensionnés selon la fréquence
  geom_point(aes(y = survivalProba), color = "red", size = 0.5) +
  geom_line(aes(y = survivalProba), color = "red") +
  labs(title = "Relation entre la taille et la survie",
       x = "Taille",
       y = "Survie") +
  ylim(0, 1) +
  theme_minimal()
```

```
## Warning: Removed 40 rows containing non-finite outside the scale range
## (`stat_sum()`).
```




AIC

```
ASurvglm21 <- fitme(Survie ~ 1+ bs(SizeOMars,df=3,degree=2) + bs(Age,degree=3,knots=6.5) + (Age|year) +
                    family=binomial,
                    data=survdata2,
                    method="PQL/L")

ASurvglm22 <- fitme(Survie ~ 1+  bs(SizeOMars,df=3,degree=2) + bs(Age,degree=3,knots=6.5) + (1|year) +
                    family=binomial,
                    data=survdata2,
                    method="PQL/L")

ASurvglm23 <- fitme(Survie ~ 1+ bs(SizeOMars,df=4,degree=2) + bs(Age,degree=3,knots=6.5) + (Age|year) +
                    family=binomial,
                    data=survdata2,
                    method="PQL/L")

ASurvglm24 <- fitme(Survie ~ 1 + poly(SizeOMars,4) + bs(Age,degree=3,knots=6.5) + (Age|year) + (1|Pop),
                    family=binomial,
                    data=survdata2,
                    method="PQL/L")

ASurvglm25 <- fitme(Survie ~ 1+ bs(SizeOMars,df=4,degree=2) + bs(Age,degree=3,knots=6.5) + (1|year) + (
                    family=binomial,
                    data=survdata2,
                    method="PQL/L")
```

BIC

```
BSurvglm21 <- fitme(Survie ~ 1+ bs(SizeOMars,df=3,degree=2) + (Age|year) + (1|Pop),
                  family=binomial,
                  data=survdata2,
                  method="PQL/L")

BSurvglm22 <- fitme(Survie ~ 1+ poly(SizeOMars,3) + (Age|year) + (1|Pop),
                  family=binomial,
                  data=survdata2,
                  method="PQL/L")

BSurvglm23 <- fitme(Survie ~ 1 + bs(SizeOMars,df=3,degree=2) + (Age|year) + (SizeOMars|Pop),
                  family=binomial,
                  data=survdata2,
                  method="PQL/L")

BSurvglm24 <- fitme(Survie ~ 1+ bs(SizeOMars,df=3,degree=2) + (Age|year) + (Age|Pop),
                  family=binomial,
                  data=survdata2,
                  method="PQL/L")

BSurvglm25 <- fitme(Survie ~ 1+ poly(SizeOMars,2) + (Age|year) + (1|Pop),
                  family=binomial,
                  data=survdata2,
                  method="PQL/L")
```

```
summary(ASurvglm21)
```

```
## formula: Survie ~ 1 + bs(SizeOMars, df = 3, degree = 2) + bs(Age, degree = 3,
##     knots = 6.5) + (Age | year) + (1 | Pop)
## Estimation of lambda and ranCoefs by ML (p_v approximation of logL).
## Estimation of fixed effects by h-likelihood approximation.
## family: binomial( link = logit )
##  ------------ Fixed effects (beta) ------------
##                                    Estimate Cond. SE t-value
## (Intercept)                          -1.426   0.3201  -4.455
## bs(SizeOMars, df = 3, degree = 2)1    2.024   0.2895   6.991
## bs(SizeOMars, df = 3, degree = 2)2    4.546   0.3978  11.429
## bs(SizeOMars, df = 3, degree = 2)3    3.385   0.8440   4.010
## bs(Age, degree = 3, knots = 6.5)1     1.070   0.3859   2.772
## bs(Age, degree = 3, knots = 6.5)2    -1.802   0.6620  -2.722
## bs(Age, degree = 3, knots = 6.5)3     1.083   0.6949   1.559
## bs(Age, degree = 3, knots = 6.5)4    -1.050   0.3301  -3.180
##  --------------- Random effects ---------------
## Family: gaussian( link = identity )
##          --- Random-coefficients Cov matrices:
##  Group        Term    Var.   Corr.
##   year (Intercept)   1.443
##   year         Age 0.01105 -0.8682
##            --- Variance parameters ('lambda'):
## lambda = var(u) for u ~ Gaussian;
##    Pop   :  0.07594
```

```
##              --- Coefficients for log(lambda):
##  Group        Term Estimate Cond.SE
##    Pop (Intercept)   -2.578  0.6928
## # of obs: 2156; # of groups: year, 26; Pop, 6
##  ------------- Likelihood values  -------------
##                          logLik
##        h-likelihood: -1100.556
## logL       (p_v(h)): -1088.777
```

```
summary(ASurvglm22)
```

```
## formula: Survie ~ 1 + bs(SizeOMars, df = 3, degree = 2) + bs(Age, degree = 3,
##     knots = 6.5) + (1 | year) + (1 | Pop)
## Estimation of fixed effects by h-likelihood approximation.
## Estimation of lambda by 'outer' ML, maximizing logL.
## family: binomial( link = logit )
##  ------------ Fixed effects (beta) ------------
##                                    Estimate Cond. SE t-value
## (Intercept)                         -1.3969   0.3045  -4.587
## bs(SizeOMars, df = 3, degree = 2)1   1.9606   0.2858   6.859
## bs(SizeOMars, df = 3, degree = 2)2   4.5024   0.3985  11.297
## bs(SizeOMars, df = 3, degree = 2)3   3.3509   0.8525   3.931
## bs(Age, degree = 3, knots = 6.5)1    1.0974   0.3813   2.878
## bs(Age, degree = 3, knots = 6.5)2   -1.7469   0.6657  -2.624
## bs(Age, degree = 3, knots = 6.5)3    1.3478   0.6950   1.939
## bs(Age, degree = 3, knots = 6.5)4   -0.9679   0.3059  -3.164
##  --------------- Random effects ---------------
## Family: gaussian( link = identity )
##            --- Variance parameters ('lambda'):
## lambda = var(u) for u ~ Gaussian;
##    year  :  0.8379
##    Pop   :  0.08086
## # of obs: 2156; # of groups: year, 26; Pop, 6
##  ------------- Likelihood values  -------------
##                          logLik
##        h-likelihood: -1078.227
## logL       (p_v(h)): -1090.973
```

```
summary(ASurvglm23)
```

```
## formula: Survie ~ 1 + bs(SizeOMars, df = 4, degree = 2) + bs(Age, degree = 3,
##     knots = 6.5) + (Age | year) + (1 | Pop)
## Estimation of lambda and ranCoefs by ML (p_v approximation of logL).
## Estimation of fixed effects by h-likelihood approximation.
## family: binomial( link = logit )
##  ------------ Fixed effects (beta) ------------
##                                    Estimate Cond. SE t-value
## (Intercept)                          -1.425   0.3401  -4.190
## bs(SizeOMars, df = 4, degree = 2)1    1.503   0.3564   4.217
## bs(SizeOMars, df = 4, degree = 2)2    2.704   0.2610  10.361
## bs(SizeOMars, df = 4, degree = 2)3    4.166   0.5393   7.724
## bs(SizeOMars, df = 4, degree = 2)4    3.705   0.9293   3.987
## bs(Age, degree = 3, knots = 6.5)1     1.071   0.3859   2.775
```

```
## bs(Age, degree = 3, knots = 6.5)2    -1.811   0.6618  -2.737
## bs(Age, degree = 3, knots = 6.5)3     1.073   0.6942   1.546
## bs(Age, degree = 3, knots = 6.5)4    -1.053   0.3294  -3.196
##  --------------- Random effects ---------------
## Family: gaussian( link = identity )
##          --- Random-coefficients Cov matrices:
##  Group        Term    Var.   Corr.
##   year (Intercept)   1.452
##   year         Age 0.01097 -0.8758
##            --- Variance parameters ('lambda'):
## lambda = var(u) for u ~ Gaussian;
##    Pop  :  0.07606
##              --- Coefficients for log(lambda):
##  Group        Term Estimate Cond.SE
##    Pop (Intercept)   -2.576  0.6925
## # of obs: 2156; # of groups: year, 26; Pop, 6
##  ------------- Likelihood values  -------------
##                         logLik
##        h-likelihood: -1099.954
## logL       (p_v(h)): -1088.112
```

```
summary(ASurvglm24)
```

```
## formula: Survie ~ 1 + poly(SizeOMars, 4) + bs(Age, degree = 3, knots = 6.5) +
##     (Age | year) + (1 | Pop)
## Estimation of lambda and ranCoefs by ML (p_v approximation of logL).
## Estimation of fixed effects by h-likelihood approximation.
## family: binomial( link = logit )
##  ------------ Fixed effects (beta) ------------
##                                  Estimate Cond. SE t-value
## (Intercept)                        0.9307   0.2563   3.631
## poly(SizeOMars, 4)1               38.6596   3.2489  11.899
## poly(SizeOMars, 4)2              -18.0598   2.8389  -6.362
## poly(SizeOMars, 4)3                8.1763   2.6915   3.038
## poly(SizeOMars, 4)4               -4.2457   2.7178  -1.562
## bs(Age, degree = 3, knots = 6.5)1   1.0735   0.3858   2.783
## bs(Age, degree = 3, knots = 6.5)2  -1.8129   0.6618  -2.739
## bs(Age, degree = 3, knots = 6.5)3   1.0676   0.6943   1.538
## bs(Age, degree = 3, knots = 6.5)4  -1.0562   0.3291  -3.209
##  --------------- Random effects ---------------
## Family: gaussian( link = identity )
##          --- Random-coefficients Cov matrices:
##  Group        Term    Var.   Corr.
##   year (Intercept)   1.443
##   year         Age 0.01075 -0.8749
##            --- Variance parameters ('lambda'):
## lambda = var(u) for u ~ Gaussian;
##    Pop  :  0.07573
##              --- Coefficients for log(lambda):
##  Group        Term Estimate Cond.SE
##    Pop (Intercept)   -2.581  0.6929
## # of obs: 2156; # of groups: year, 26; Pop, 6
##  ------------- Likelihood values  -------------
##                         logLik
```

```
##        h-likelihood: -1100.149
## logL       (p_v(h)): -1088.269
```

```
summary(ASurvglm25)
```

```
## formula: Survie ~ 1 + bs(SizeOMars, df = 4, degree = 2) + bs(Age, degree = 3,
##     knots = 6.5) + (1 | year) + (1 | Pop)
## Estimation of fixed effects by h-likelihood approximation.
## Estimation of lambda by 'outer' ML, maximizing logL.
## family: binomial( link = logit )
##  ------------ Fixed effects (beta) ------------
##                                    Estimate Cond. SE t-value
## (Intercept)                         -1.4028   0.3249  -4.317
## bs(SizeOMars, df = 4, degree = 2)1   1.4724   0.3531   4.170
## bs(SizeOMars, df = 4, degree = 2)2   2.6402   0.2572  10.267
## bs(SizeOMars, df = 4, degree = 2)3   4.1543   0.5410   7.679
## bs(SizeOMars, df = 4, degree = 2)4   3.6523   0.9373   3.896
## bs(Age, degree = 3, knots = 6.5)1    1.0973   0.3815   2.876
## bs(Age, degree = 3, knots = 6.5)2   -1.7530   0.6660  -2.632
## bs(Age, degree = 3, knots = 6.5)3    1.3423   0.6950   1.931
## bs(Age, degree = 3, knots = 6.5)4   -0.9672   0.3060  -3.161
##  --------------- Random effects ---------------
## Family: gaussian( link = identity )
##            --- Variance parameters ('lambda'):
## lambda = var(u) for u ~ Gaussian;
##    year  :  0.8401
##    Pop   :  0.08102
## # of obs: 2156; # of groups: year, 26; Pop, 6
##  ------------- Likelihood values  -------------
##                         logLik
##        h-likelihood: -1077.622
## logL       (p_v(h)): -1090.352
```

```
summary(BSurvglm21)
```

```
## formula: Survie ~ 1 + bs(SizeOMars, df = 3, degree = 2) + (Age | year) +
##     (1 | Pop)
## Estimation of lambda and ranCoefs by ML (p_v approximation of logL).
## Estimation of fixed effects by h-likelihood approximation.
## family: binomial( link = logit )
##  ------------ Fixed effects (beta) ------------
##                                    Estimate Cond. SE t-value
## (Intercept)                          -1.408   0.3087  -4.560
## bs(SizeOMars, df = 3, degree = 2)1    2.042   0.2894   7.056
## bs(SizeOMars, df = 3, degree = 2)2    4.522   0.3874  11.673
## bs(SizeOMars, df = 3, degree = 2)3    3.370   0.8463   3.982
##  --------------- Random effects ---------------
## Family: gaussian( link = identity )
##          --- Random-coefficients Cov matrices:
##  Group        Term    Var.   Corr.
##   year (Intercept)   1.411
##   year         Age 0.03893 -0.6445
##            --- Variance parameters ('lambda'):
```

```
## lambda = var(u) for u ~ Gaussian;
##    Pop  :  0.07958
##              --- Coefficients for log(lambda):
##  Group        Term Estimate Cond.SE
##    Pop (Intercept)   -2.531  0.6913
## # of obs: 2156; # of groups: year, 26; Pop, 6
##  ------------- Likelihood values  -------------
##                         logLik
##        h-likelihood: -1102.616
## logL       (p_v(h)): -1097.194
```

```
summary(BSurvglm22)
```

```
## formula: Survie ~ 1 + poly(SizeOMars, 3) + (Age | year) + (1 | Pop)
## Estimation of lambda and ranCoefs by ML (p_v approximation of logL).
## Estimation of fixed effects by h-likelihood approximation.
## family: binomial( link = logit )
##  ------------ Fixed effects (beta) ------------
##                     Estimate Cond. SE t-value
## (Intercept)           0.9604   0.2267   4.236
## poly(SizeOMars, 3)1  37.9503   3.1038  12.227
## poly(SizeOMars, 3)2 -18.4898   2.9627  -6.241
## poly(SizeOMars, 3)3   8.7676   2.9049   3.018
##  --------------- Random effects ---------------
## Family: gaussian( link = identity )
##          --- Random-coefficients Cov matrices:
##  Group        Term    Var.   Corr.
##   year (Intercept)   1.369
##   year         Age 0.03817 -0.6367
##            --- Variance parameters ('lambda'):
## lambda = var(u) for u ~ Gaussian;
##    Pop  :  0.07759
##              --- Coefficients for log(lambda):
##  Group        Term Estimate Cond.SE
##    Pop (Intercept)   -2.556  0.6931
## # of obs: 2156; # of groups: year, 26; Pop, 6
##  ------------- Likelihood values  -------------
##                         logLik
##        h-likelihood: -1103.553
## logL       (p_v(h)): -1097.901
```

```
summary(BSurvglm23)
```

```
## formula: Survie ~ 1 + bs(SizeOMars, df = 3, degree = 2) + (Age | year) +
##     (SizeOMars | Pop)
## Estimation of ranCoefs by ML (p_v approximation of logL).
## Estimation of fixed effects by h-likelihood approximation.
## family: binomial( link = logit )
##  ------------ Fixed effects (beta) ------------
##                                     Estimate Cond. SE t-value
## (Intercept)                           -1.364   0.2920  -4.672
## bs(SizeOMars, df = 3, degree = 2)1     2.003   0.2898   6.912
## bs(SizeOMars, df = 3, degree = 2)2     4.497   0.4092  10.990
```

```
## bs(SizeOMars, df = 3, degree = 2)3    3.500   0.9002   3.888
##  --------------- Random effects ---------------
## Family: gaussian( link = identity )
##          --- Random-coefficients Cov matrices:
##  Group        Term      Var.   Corr.
##   year (Intercept)     1.408
##   year         Age      0.04 -0.6377
##    Pop (Intercept)   0.02391
##    Pop   SizeOMars 0.0007286       1
## # of obs: 2156; # of groups: year, 26; Pop, 6
##  ------------- Likelihood values  -------------
##                         logLik
##        h-likelihood: -1114.438
## logL       (p_v(h)): -1096.462
```

```
summary(BSurvglm24)
```

```
## formula: Survie ~ 1 + bs(SizeOMars, df = 3, degree = 2) + (Age | year) +
##     (Age | Pop)
## Estimation of ranCoefs by ML (p_v approximation of logL).
## Estimation of fixed effects by h-likelihood approximation.
## family: binomial( link = logit )
##  ------------ Fixed effects (beta) ------------
##                                    Estimate Cond. SE t-value
## (Intercept)                          -1.416   0.3096  -4.573
## bs(SizeOMars, df = 3, degree = 2)1    2.044   0.2897   7.055
## bs(SizeOMars, df = 3, degree = 2)2    4.551   0.3892  11.693
## bs(SizeOMars, df = 3, degree = 2)3    3.377   0.8468   3.988
##  --------------- Random effects ---------------
## Family: gaussian( link = identity )
##          --- Random-coefficients Cov matrices:
##  Group        Term     Var.   Corr.
##   year (Intercept)    1.409
##   year         Age  0.03799 -0.6446
##    Pop (Intercept)  0.09702
##    Pop         Age 0.001534 -0.3934
## # of obs: 2156; # of groups: year, 26; Pop, 6
##  ------------- Likelihood values  -------------
##                         logLik
##        h-likelihood: -1115.225
## logL       (p_v(h)): -1097.128
```

```
summary(BSurvglm25)
```

```
## formula: Survie ~ 1 + poly(SizeOMars, 2) + (Age | year) + (1 | Pop)
## Estimation of lambda and ranCoefs by ML (p_v approximation of logL).
## Estimation of fixed effects by h-likelihood approximation.
## family: binomial( link = logit )
##  ------------ Fixed effects (beta) ------------
##                     Estimate Cond. SE t-value
## (Intercept)           0.9873    0.224   4.408
## poly(SizeOMars, 2)1  39.0546    3.093  12.628
## poly(SizeOMars, 2)2 -18.7113    2.607  -7.177
```

```
##  --------------- Random effects ---------------
## Family: gaussian( link = identity )
##          --- Random-coefficients Cov matrices:
##  Group        Term    Var.   Corr.
##   year (Intercept)    1.25
##   year         Age 0.03738 -0.6126
##            --- Variance parameters ('lambda'):
## lambda = var(u) for u ~ Gaussian;
##    Pop  :  0.0792
##              --- Coefficients for log(lambda):
##  Group        Term Estimate Cond.SE
##    Pop (Intercept)   -2.536  0.6908
## # of obs: 2156; # of groups: year, 26; Pop, 6
##  ------------- Likelihood values  -------------
##                          logLik
##        h-likelihood: -1109.354
## logL       (p_v(h)): -1103.102
```

```
ASurvpredict1 <- predict(ASurvglm21, newdata = fake_data2)[,1]
ASurvpredict2 <- predict(ASurvglm22, newdata = fake_data2)[,1]
ASurvpredict3 <- predict(ASurvglm23, newdata = fake_data2)[,1]
ASurvpredict4 <- predict(ASurvglm24, newdata = fake_data2)[,1]
ASurvpredict5 <- predict(ASurvglm25, newdata = fake_data2)[,1]

BSurvpredict1 <- predict(BSurvglm21, newdata = fake_data2)[,1]
BSurvpredict2 <- predict(BSurvglm22, newdata = fake_data2)[,1]
BSurvpredict3 <- predict(BSurvglm23, newdata = fake_data2)[,1]
BSurvpredict4 <- predict(BSurvglm24, newdata = fake_data2)[,1]
BSurvpredict5 <- predict(BSurvglm25, newdata = fake_data2)[,1]
```

```
plot_survie <- function(data = fake_data2, prediction, var, c1, valc1 = 1, c2, valc2 = "Au", fact, minda
  data %>%
    mutate(surv_predi = prediction) %>%
    filter(!!sym(c1) == valc1, !!sym(c2) == valc2) %>%
    ggplot(aes(x = .data[[var]], y = surv_predi)) +
    geom_vline(xintercept=maxdat, lty="dotted")+
    geom_vline(xintercept=mindat, lty="dotted")+
    geom_line(aes(color = as.factor(.data[[fact]])),show.legend=FALSE) +
    theme_minimal() +
    ylim(0, 1)
}

plot_survie2 <- function(data = fake_data2, prediction, var, c1, valc1 = 1, c2, valc2 = "Au", fact) {
  data %>%
    mutate(surv_predi = prediction) %>%
    filter(!!sym(c1) == valc1, !!sym(c2) == valc2) %>%
    ggplot(aes(x = .data[[var]], y = surv_predi)) +
    geom_line(aes(color = as.factor(.data[[fact]])),show.legend = FALSE) +
    theme_minimal() +
    ylim(0, 1)+
      scale_color_brewer(palette = "Spectral", direction = -1)
}
```

## Survie en fonction de la taille

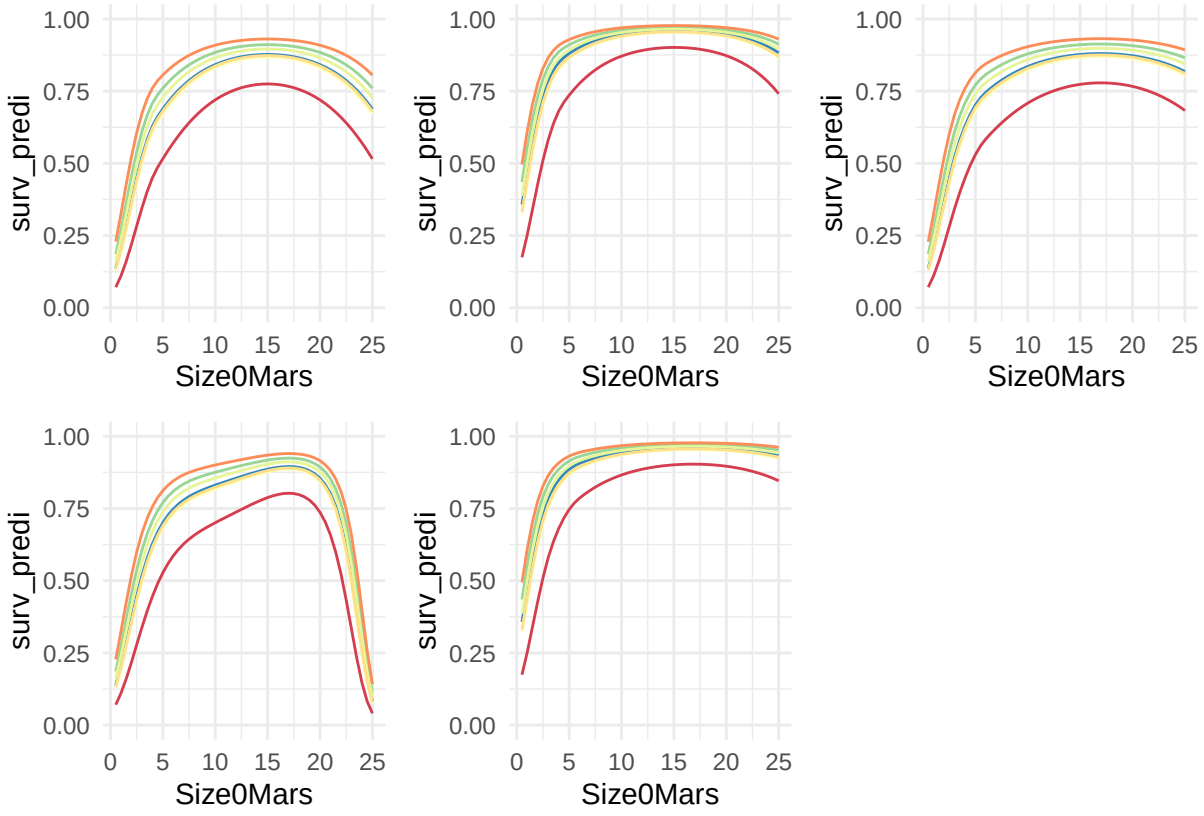
### En fixant la population et l'année : voir l'effet age

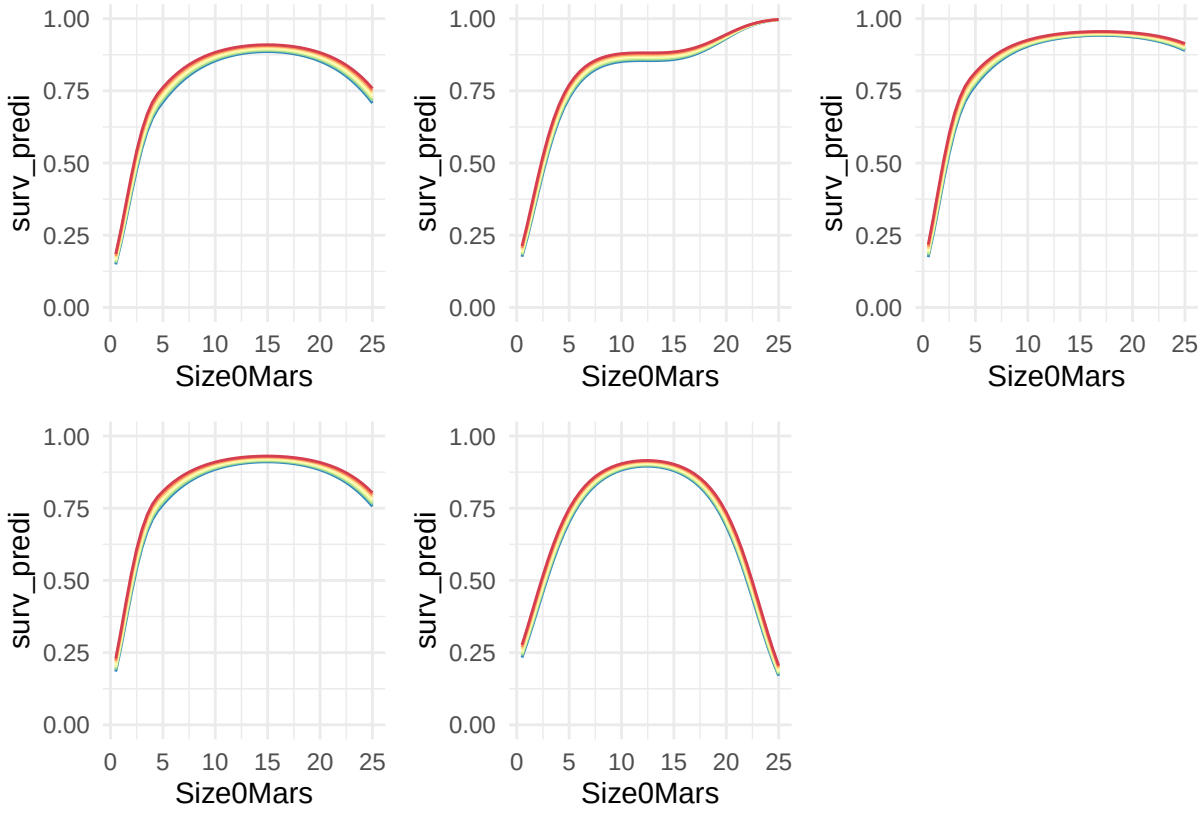
```
var <- "SizeOMars"
c1 <- "year"
c2 <- "Pop"
valc2 <- "Au"
fact <- "Age"
valc1 <- 2000
maxdat <- max(centauree_data$SizeOMars[centauree_data$Age==valc1])
```

```
## Warning in max(centauree_data$SizeOMars[centauree_data$Age == valc1]): no
## non-missing arguments to max; returning -Inf
```

```
mindat <- min(centauree_data$SizeOMars[centauree_data$Age==valc1])
```

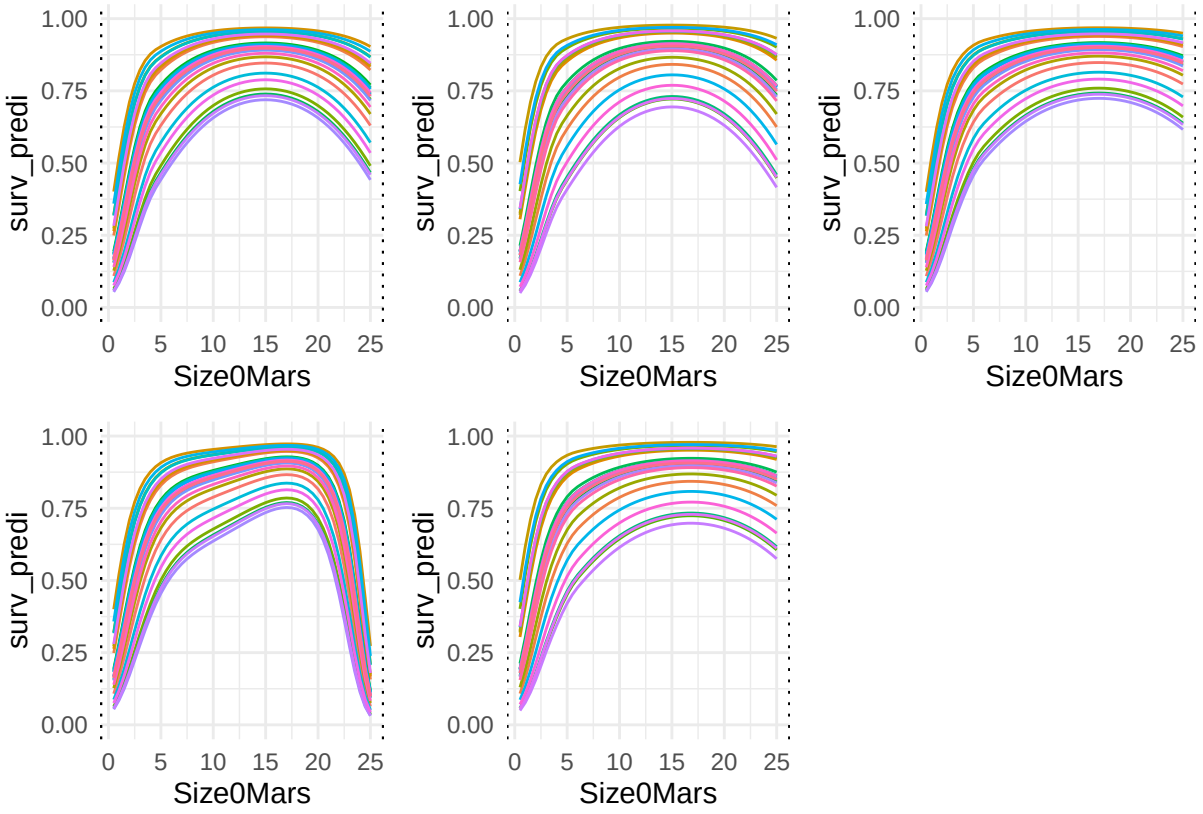
```
## Warning in min(centauree_data$SizeOMars[centauree_data$Age == valc1]): no
## non-missing arguments to min; returning Inf
```

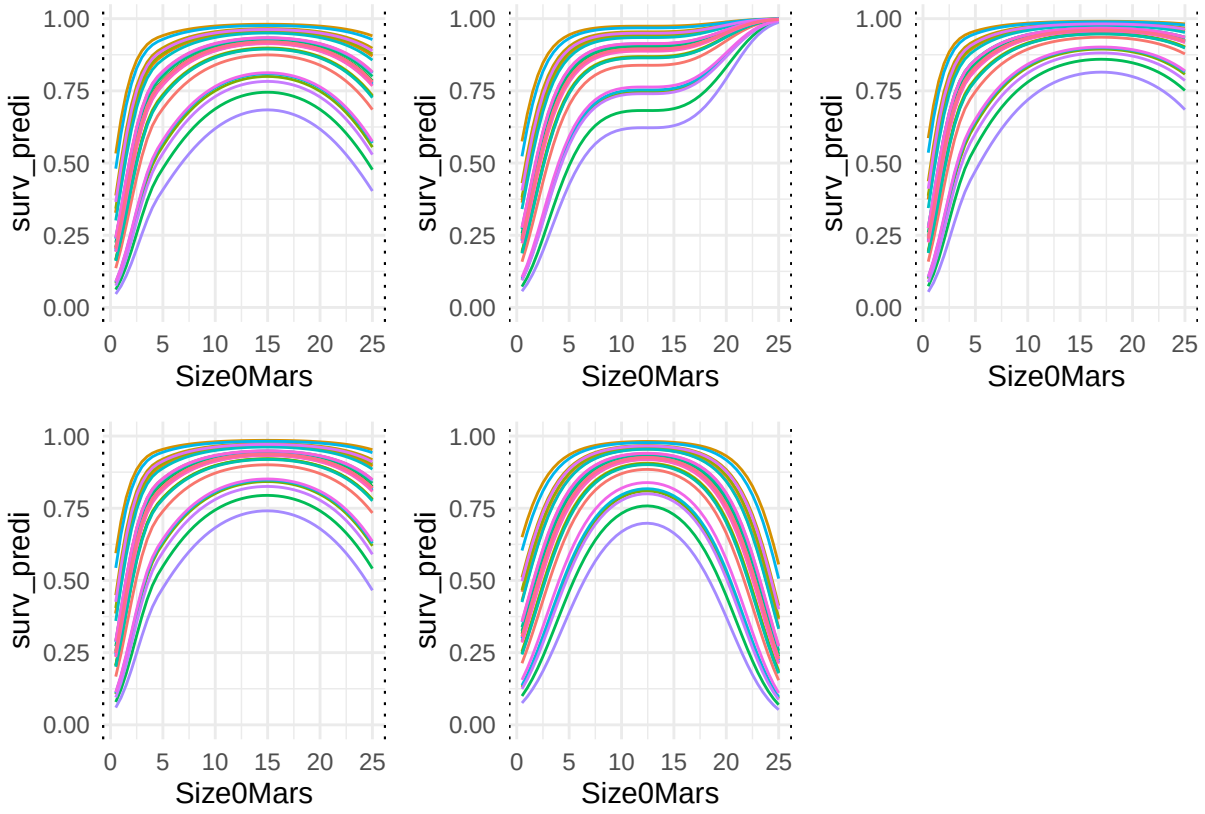





**En fixant la population : voir l'effet année**

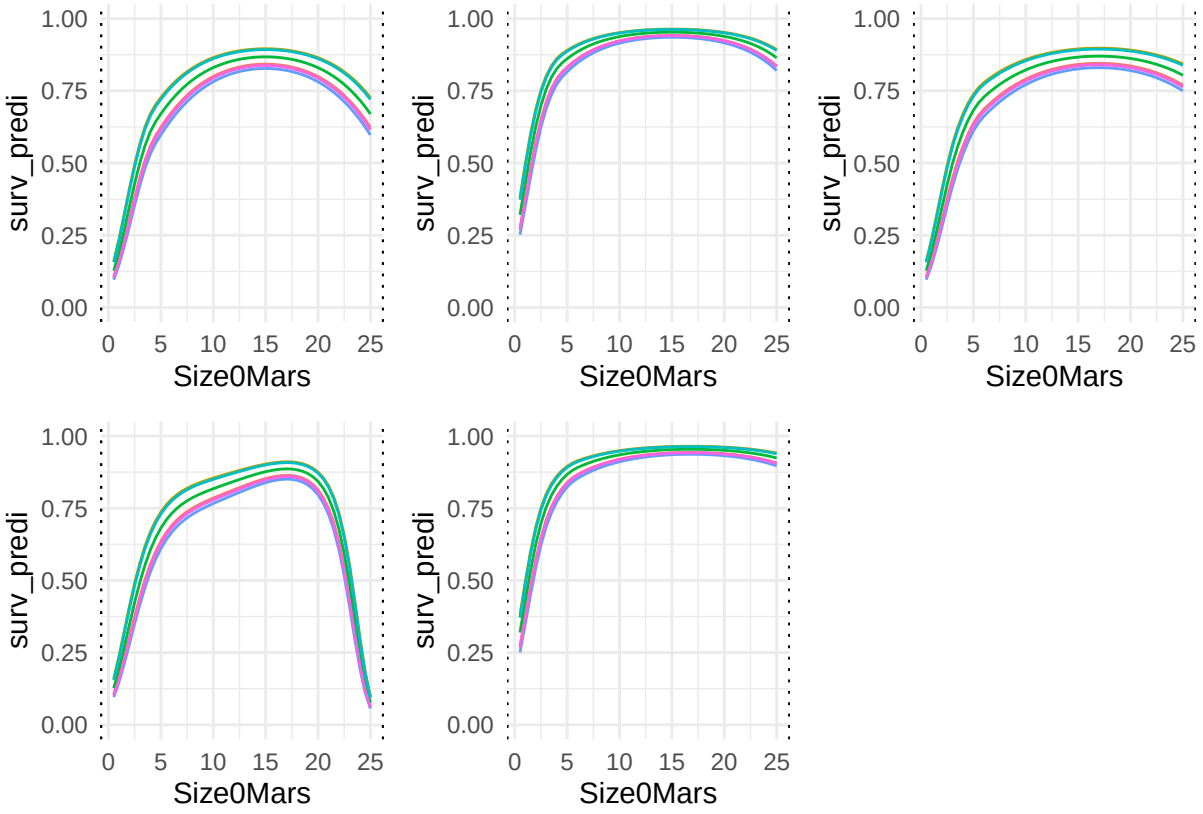
```
var <- "Size0Mars"
c1 <- "Age"
c2 <- "Pop"
valc2 <- "Au"
fact <- "year"
valc1 <- 5
```

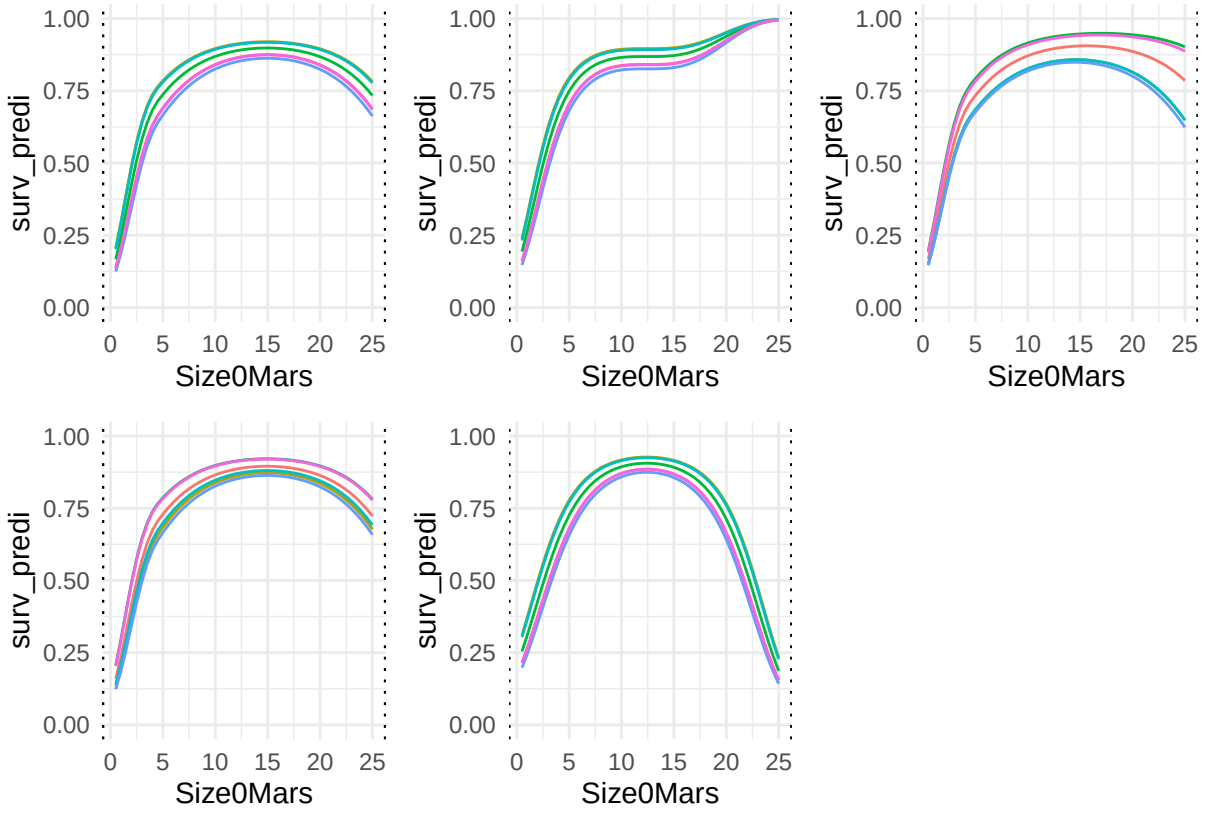

surv_predi
1.00
0.75
0.50
0.25
0.00
0
5
10
15
20
25
Size0Mars




**En fixant l'année : voir l'effet population**

```
var <- "Size0Mars"
c1 <- "Age"
c2 <- "year"
valc2 <- 2000
fact <- "Pop"
```

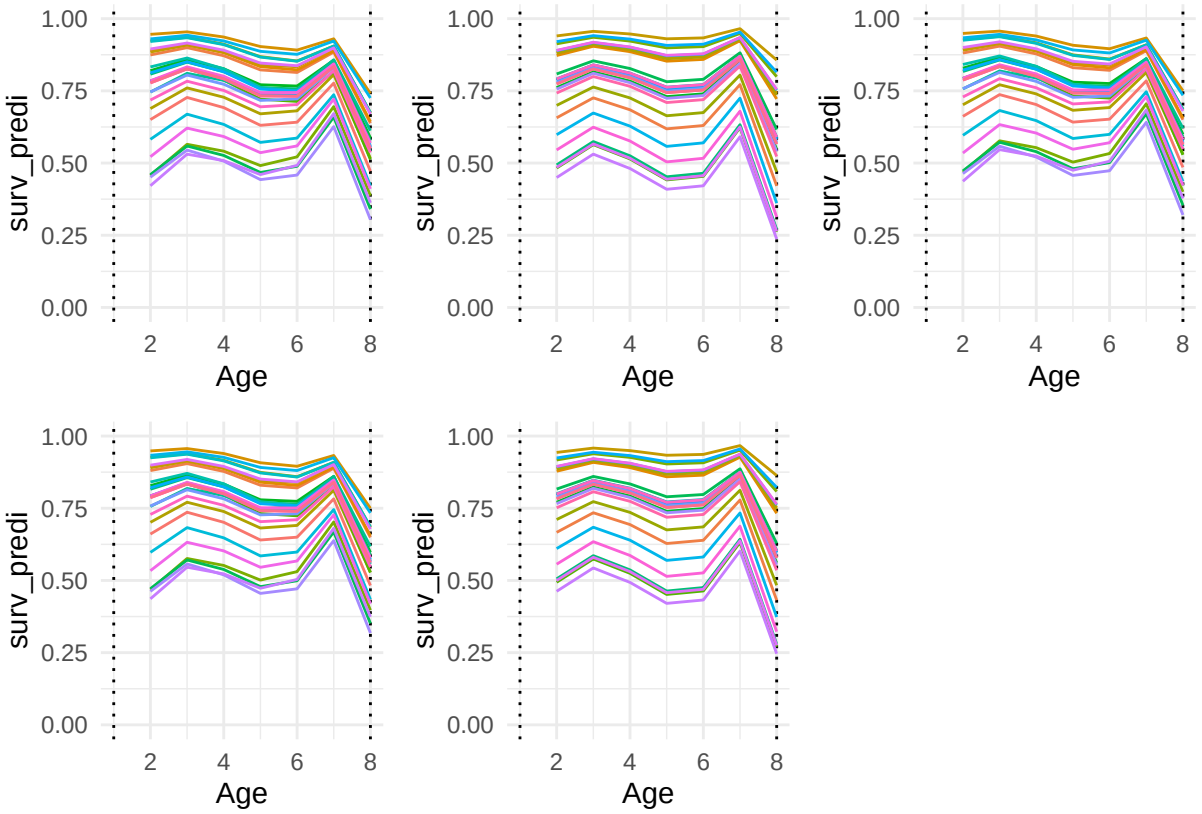

surv_predi
1.00
0.75
0.50
0.25
0.00
0
5
10
15
20
25
Size0Mars

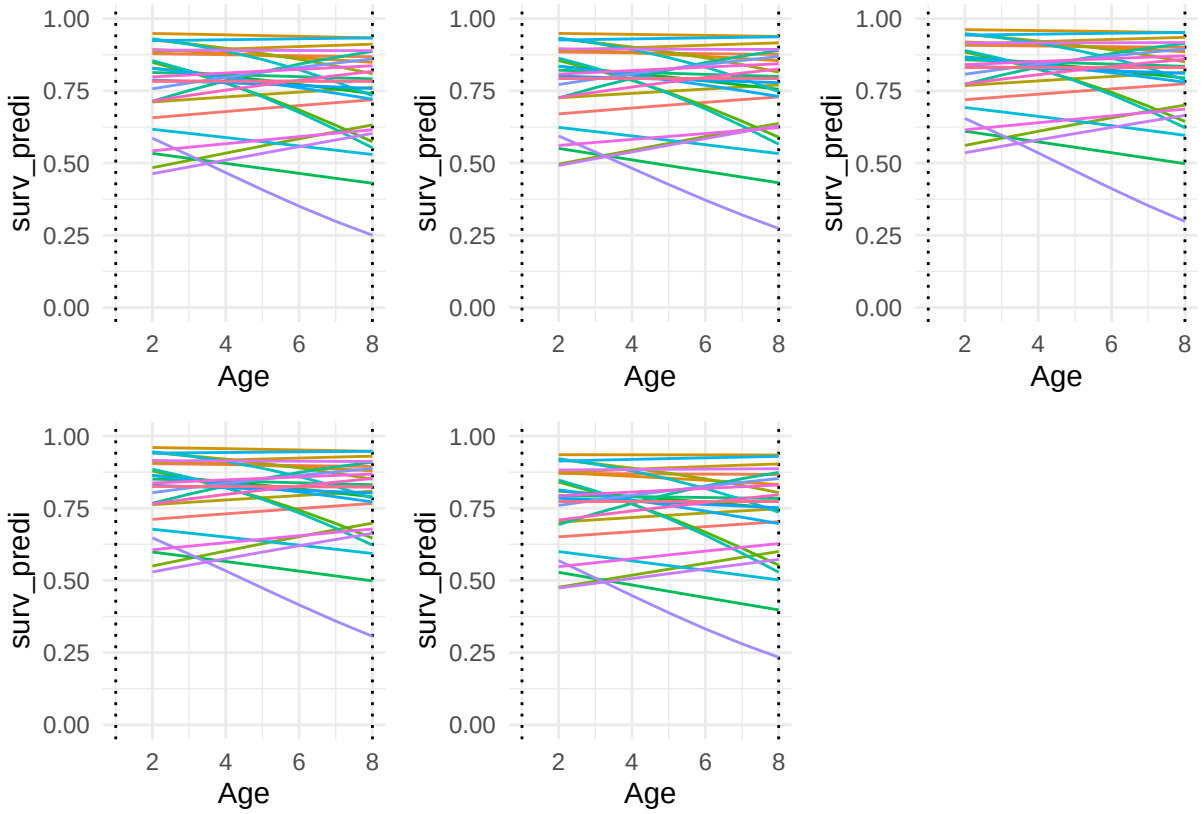



## Survie en fonction de l'age (taille fixé)

**En fixant la population : voir l'effet année**

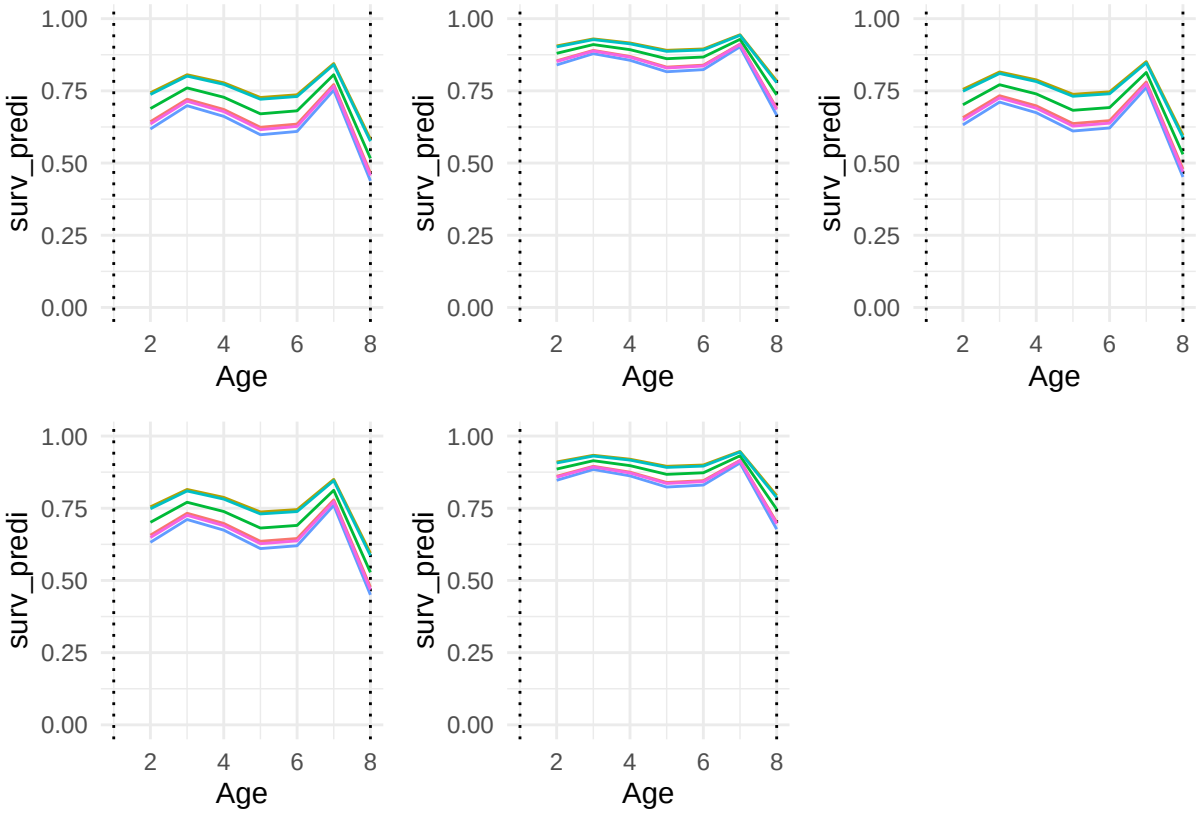
```
var <- "Age"
c1 <- "Size0Mars"
c2 <- "Pop"
valc2 <- "Au"
fact <- "year"
valc1 <- 5
maxdat <- max(centauree_data$Age[centauree_data$Size0Mars==valc1])
mindat <- min(centauree_data$Age[centauree_data$Size0Mars==valc1])
```

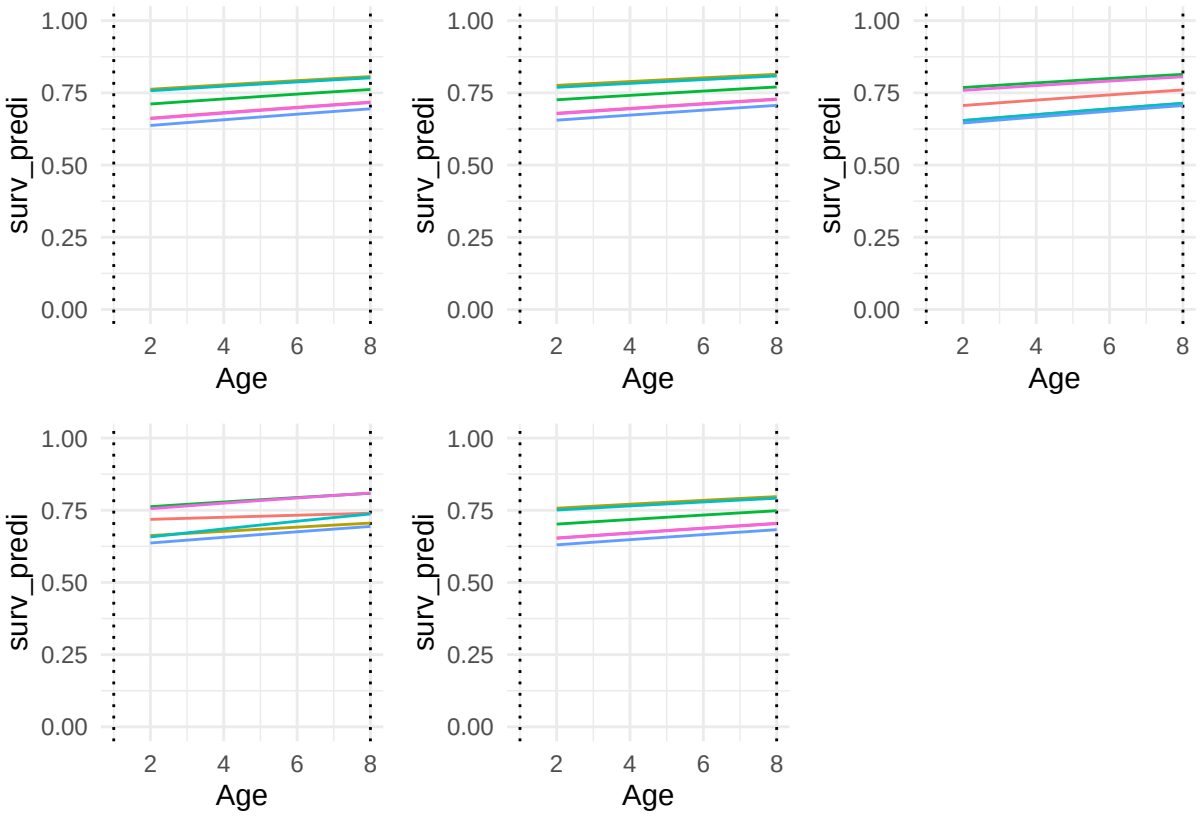

surv_predi
1.00
0.75
0.50
0.25
0.00
2
4
6
8
Age




**En fixant l'année : voir l'effet population**

```
var <- "Age"
c1 <- "SizeOMars"
c2 <- "year"
valc2 <- 2000
fact <- "Pop"
```


surv_predi
1.00
0.75
0.50
0.25
0.00
2
4
6
8
Age


surv_predi
1.00
0.75
0.50
0.25
0.00
2
4
6
8
Age