

Survival analysis

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2025-03-24

```
data$colony <- as.factor(data$colony)
data$type <- as.factor(data$type)
data$type_eggs <- as.factor (data$type_eggs)

library(dplyr)
library(survival)
library(coxme)
library(survminer)
library(ggplot2)
library(gridExtra)
library(tidyr)
library(sjPlot)

surv1 <- coxme(Surv(time,censor) ~ type * type_eggs + (1|colony), data =
data)
summary(surv1)

## Mixed effects coxme model
## Formula: Surv(time, censor) ~ type * type_eggs + (1 | colony)
## Data: data
##
## events, n = 2676, 3234
##
## Random effects:
## group variable sd variance
## 1 colony Intercept 0.4310816 0.1858314
## Chisq df p AIC BIC
## Integrated loglik 2176 4.00 0 2168 2144
## Penalized loglik 2188 4.99 0 2178 2149
##
## Fixed effects:
## coef exp(coef) se(coef) z p
## typeC 0.64373 1.90358 0.09548 6.74 1.56e-11
## type_eggsW 2.42902 11.34777 0.08778 27.67 < 2e-16
## typeC:type_eggsW -0.52002 0.59451 0.10438 -4.98 6.29e-07

surv1

## Cox mixed-effects model fit by maximum likelihood
## Data: data
## events, n = 2676, 3234
## Iterations= 6 40
## NULL Integrated Fitted
## Log-likelihood -19931.38 -18843.34 -18837.27
```

```

##
##              Chisq  df p      AIC      BIC
## Integrated loglik 2176.06 4.00 0 2168.06 2144.50
## Penalized loglik 2188.22 4.99 0 2178.24 2148.86
##
## Model: Surv(time, censor) ~ type * type_eggs + (1 | colony)
## Fixed coefficients
##              coef exp(coef) se(coef)      z      p
## typeC          0.6437342  1.9035760 0.09548458  6.74 1.6e-11
## type_eggsW     2.4290210 11.3477668 0.08778163 27.67 0.0e+00
## typeC:type_eggsW -0.5200168  0.5945105 0.10437916 -4.98 6.3e-07
##
## Random effects
## Group Variable Std Dev Variance
## colony Intercept 0.4310816 0.1858314

cox.zph(surv1)

##              chisq df      p
## type          0.00676  1 0.93447
## type_eggs     34.20253  1 5.0e-09
## type:type_eggs 11.00936  1 0.00091
## GLOBAL        36.10658  3 7.1e-08

ranef(surv1)

## $colony
##      1      2      3
## 0.4942601 -0.2087281 -0.2855320

VarCorr(surv1)

## $colony
## Intercept
## 0.1858314

surv0 <- coxph(Surv(time, censor) ~ type * type_eggs, data = data)

anova(surv0, surv1)

## Analysis of Deviance Table
## Cox model: response is Surv(time, censor)
## Model 1: ~type * type_eggs
## Model 2: ~type * type_eggs + (1 | colony)
## loglik Chisq Df P(>|Chi|)
## 1 -18963
## 2 -18843 240.07  1 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

AIC (surv0, surv1)

```

```
##           df      AIC
## surv0 3.00000 37932.75
## surv1 4.98709 37684.51
```

analysis for worker-laid eggs

```
surv_T <- coxme(Surv(time, censor) ~ type + (1 | colony), data = subset(data,
type_eggs == "W"))
summary(surv_T)
```

```
## Mixed effects coxme model
## Formula: Surv(time, censor) ~ type + (1 | colony)
## Data: subset(data, type_eggs == "W")
##
## events, n = 2155, 2184
##
## Random effects:
## group variable      sd variance
## 1 colony Intercept 0.4310294 0.1857863
##              Chisq  df p  AIC  BIC
## Integrated loglik 212.1 2.00 0 208.1 196.8
## Penalized loglik 223.8 2.98 0 217.8 200.9
##
## Fixed effects:
##      coef exp(coef) se(coef)  z      p
## typeC 0.10228 1.10769 0.04425 2.31 0.0208
```

```
cox.zph(surv_T)
```

```
##      chisq df      p
## type 2.72 1 0.099
## GLOBAL 2.72 1 0.099
```

```
surv_T_without_random <- coxph(Surv(time, censor) ~ type, data = subset(data,
type_eggs == "W"))
```

```
anova(surv_T, surv_T_without_random)
```

```
## Analysis of Deviance Table
## Cox model: response is Surv(time, censor)
## Model 1: ~type + (1 | colony)
## Model 2: ~type
## loglik Chisq Df P(>|Chi|)
## 1 -14436
## 2 -14530 187.26 1 < 2.2e-16 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
AIC (surv_T, surv_T_without_random)
```

```
##                df      AIC
## surv_T         2.98369 28866.35
## surv_T_without_random 1.00000 29061.31
```

separate analysis of worker-laid eggs for each colony

colony 1

```
surv_T1 <- coxph(Surv(time, censor) ~ type, data = subset(data, type_eggs ==
"W" & colony == "1"))
summary(surv_T1)
```

```
## Call:
## coxph(formula = Surv(time, censor) ~ type, data = subset(data,
##   type_eggs == "W" & colony == "1"))
##
##   n= 551, number of events= 550
##
##           coef exp(coef) se(coef)      z Pr(>|z|)
## typeC -0.34572  0.70771  0.08868 -3.898 9.68e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##           exp(coef) exp(-coef) lower .95 upper .95
## typeC    0.7077      1.413    0.5948    0.8421
##
## Concordance= 0.607 (se = 0.026 )
## Likelihood ratio test= 15.14 on 1 df,  p=1e-04
## Wald test               = 15.2 on 1 df,  p=1e-04
## Score (logrank) test = 15.34 on 1 df,  p=9e-05
```

```
confint(surv_T1)
```

```
##           2.5 %      97.5 %
## typeC -0.5195288 -0.1719025
```

colony 2

```
surv_T2 <- coxph(Surv(time, censor) ~ type, data = subset(data, type_eggs ==
"W" & colony == "2"))
summary(surv_T2)
```

```
## Call:
## coxph(formula = Surv(time, censor) ~ type, data = subset(data,
##   type_eggs == "W" & colony == "2"))
##
##   n= 789, number of events= 788
##
##           coef exp(coef) se(coef)      z Pr(>|z|)
## typeC -0.03416  0.96641  0.07132 -0.479  0.632
##
##           exp(coef) exp(-coef) lower .95 upper .95
```

```
## typeC    0.9664    1.035    0.8403    1.111
##
## Concordance= 0.518 (se = 0.014 )
## Likelihood ratio test= 0.23 on 1 df, p=0.6
## Wald test = 0.23 on 1 df, p=0.6
## Score (logrank) test = 0.23 on 1 df, p=0.6
```

```
confint(surv_T2)
```

```
##          2.5 %    97.5 %
## typeC -0.1739501 0.1056251
```

colony 3

```
surv_T3 <- coxph(Surv(time, censor) ~ type, data = subset(data, type_eggs ==
"W" & colony == "3"))
summary(surv_T3)
```

```
## Call:
## coxph(formula = Surv(time, censor) ~ type, data = subset(data,
##   type_eggs == "W" & colony == "3"))
##
## n= 844, number of events= 817
##
##          coef exp(coef) se(coef)    z Pr(>|z|)
## typeC 0.67339  1.96087  0.07187  9.37 <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##          exp(coef) exp(-coef) lower .95 upper .95
## typeC      1.961      0.51    1.703    2.257
##
## Concordance= 0.629 (se = 0.012 )
## Likelihood ratio test= 87.56 on 1 df, p=<2e-16
## Wald test = 87.8 on 1 df, p=<2e-16
## Score (logrank) test = 90.76 on 1 df, p=<2e-16
```

```
confint(surv_T3)
```

```
##          2.5 %    97.5 %
## typeC 0.5325331 0.814243
```

analysis for queen-laid eggs

```
surv_M <- coxme(Surv(time, censor) ~ type + (1 | colony), data = subset(data,
type_eggs == "Q"))
summary(surv_M)
```

```
## Mixed effects coxme model
## Formula: Surv(time, censor) ~ type + (1 | colony)
## Data: subset(data, type_eggs == "Q")
##
## events, n = 521, 1050
```

```

##
## Random effects:
##   group variable      sd variance
## 1 colony Intercept 0.7294155 0.532047
##               Chisq  df p    AIC    BIC
## Integrated loglik 207.5 2.00 0 203.5 195.0
## Penalized loglik 218.4 2.98 0 212.4 199.8
##
## Fixed effects:
##      coef exp(coef) se(coef)      z      p
## typeC 0.70823    2.03039  0.09862  7.18 6.91e-13

cox.zph(surv_M)

##      chisq df      p
## type    5.03  1 0.025
## GLOBAL  5.03  1 0.025

surv_M_without_random <- coxph(Surv(time, censor) ~ type, data = subset(data,
type_eggs == "Q"))

anova(surv_M, surv_M_without_random)

## Analysis of Deviance Table
## Cox model: response is Surv(time, censor)
## Model 1: ~type + (1 | colony)
## Model 2: ~type
##   loglik  Chisq Df P(>|Chi|)
## 1 -3362.6
## 2 -3431.7 138.28  1 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

AIC (surv_M, surv_M_without_random)

##              df      AIC
## surv_M          2.97502 6720.307
## surv_M_without_random 1.00000 6865.495

```

separate analysis of queen-laid eggs for each colony

colony 1

```

surv_M1 <- coxph(Surv(time, censor) ~ type, data = subset(data, type_eggs ==
"Q" & colony == "1"))
summary(surv_M1)

## Call:
## coxph(formula = Surv(time, censor) ~ type, data = subset(data,
##   type_eggs == "Q" & colony == "1"))
##
## n= 221, number of events= 186

```

```
##
##          coef exp(coef) se(coef)      z Pr(>|z|)
## typeC -0.7101  0.4916  0.1545 -4.596  4.3e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##          exp(coef) exp(-coef) lower .95 upper .95
## typeC  0.4916      2.034    0.3631    0.6654
##
## Concordance= 0.682 (se = 0.028 )
## Likelihood ratio test= 20 on 1 df,  p=8e-06
## Wald test              = 21.13 on 1 df,  p=4e-06
## Score (logrank) test = 21.9 on 1 df,  p=3e-06
```

colony 2

```
surv_M2 <- coxph(Surv(time, censor) ~ type, data = subset(data, type_eggs ==
"Q" & colony == "2"))
summary(surv_M2)
```

```
## Call:
## coxph(formula = Surv(time, censor) ~ type, data = subset(data,
##   type_eggs == "Q" & colony == "2"))
##
## n= 342, number of events= 101
##
##          coef exp(coef) se(coef)      z Pr(>|z|)
## typeC 0.2963  1.3449  0.2066  1.435  0.151
##
##          exp(coef) exp(-coef) lower .95 upper .95
## typeC  1.345    0.7435    0.8971    2.016
##
## Concordance= 0.536 (se = 0.028 )
## Likelihood ratio test= 2.11 on 1 df,  p=0.1
## Wald test              = 2.06 on 1 df,  p=0.2
## Score (logrank) test = 2.07 on 1 df,  p=0.1
```

colony 3

```
surv_M3 <- coxph(Surv(time, censor) ~ type, data = subset(data, type_eggs ==
"Q" & colony == "3"))
summary(surv_M3)
```

```
## Call:
## coxph(formula = Surv(time, censor) ~ type, data = subset(data,
##   type_eggs == "Q" & colony == "3"))
##
## n= 487, number of events= 234
##
##          coef exp(coef) se(coef)      z Pr(>|z|)
## typeC 1.7076  5.5158  0.1631 10.47  <2e-16 ***
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##      exp(coef) exp(-coef) lower .95 upper .95
## typeC      5.516      0.1813      4.006      7.594
##
## Concordance= 0.707 (se = 0.015 )
## Likelihood ratio test= 139.8 on 1 df,  p=<2e-16
## Wald test              = 109.6 on 1 df,  p=<2e-16
## Score (logrank) test = 137.1 on 1 df,  p=<2e-16
```