```
library(tidyverse)
library(cmdstanr)
source("scripts/functions.R")
df <- read.csv("data/main.csv")
set.seed(12042014)
```

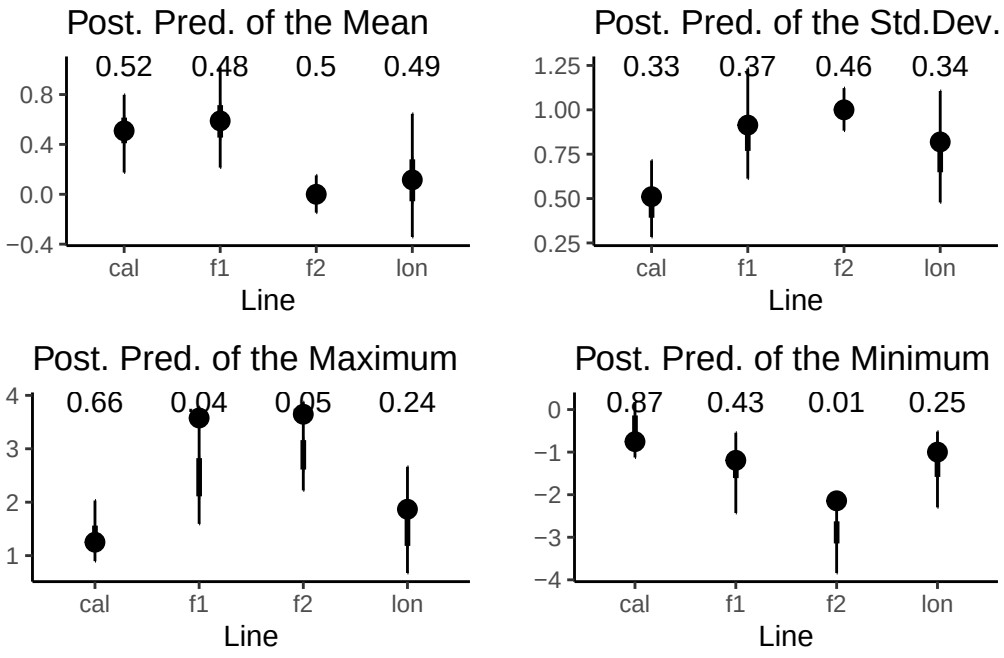
The Bayesian Bootstrap

$$
\begin{aligned}
w &\sim Dirichlet(\alpha) \\
\mu &= \sum_{i=1}^{n} w_i x_i \\
\sigma &= \sqrt{\sum_{i=1}^{n} w_i (x_i - \sum_{i=1}^{n} w_i x_i)^2}
\end{aligned}
$$

Posterior Predictive Checks

1DAG

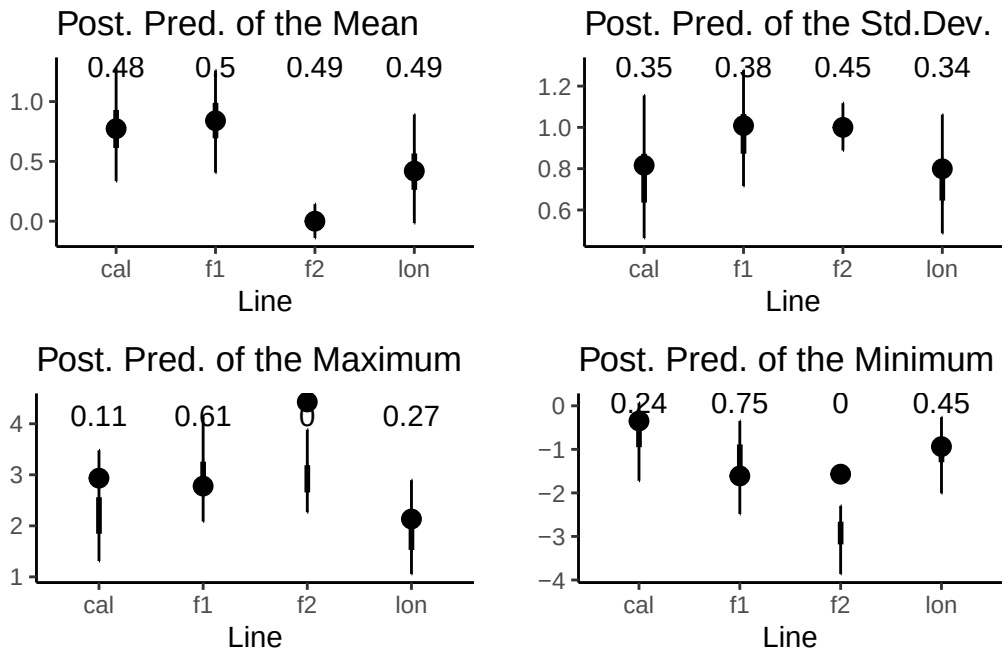
```
post_pred_check(df, "day_4", lik = "normal")
```



```
# post_pred_check(df, "day_4", lik = "gamma")
# post_pred_check(df, "day_4", lik = "log-normal")
```

14DAG

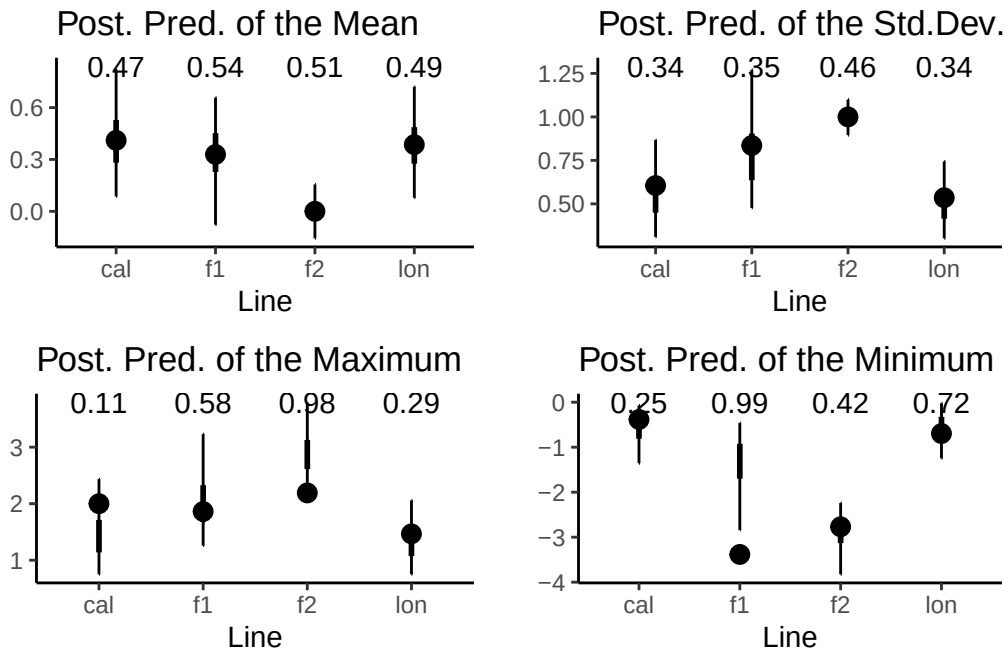
```
post_pred_check(df, "day_17", "normal")
```




```
# post_pred_check(df, "day_17", "gamma")
# post_pred_check(df, "day_17", "log-normal")
```

RGR

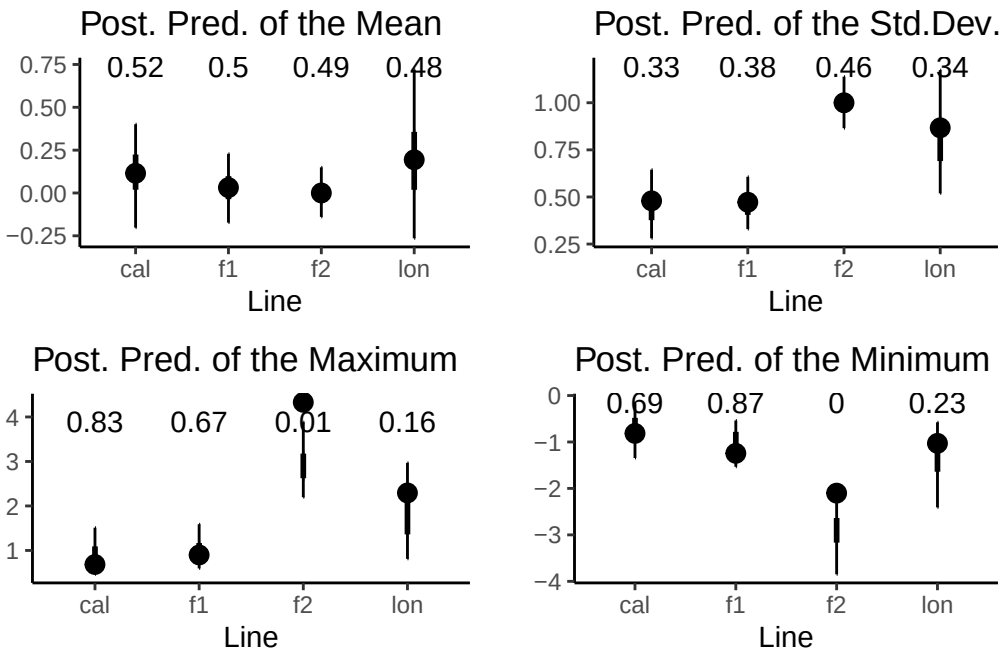
```
post_pred_check(df, "rgr", "normal")
```




```
# post_pred_check(df, "rgr", "gamma")
# post_pred_check(df, "rgr", "log-normal")
```

Height

```
post_pred_check(df, "height_122", "normal")
```

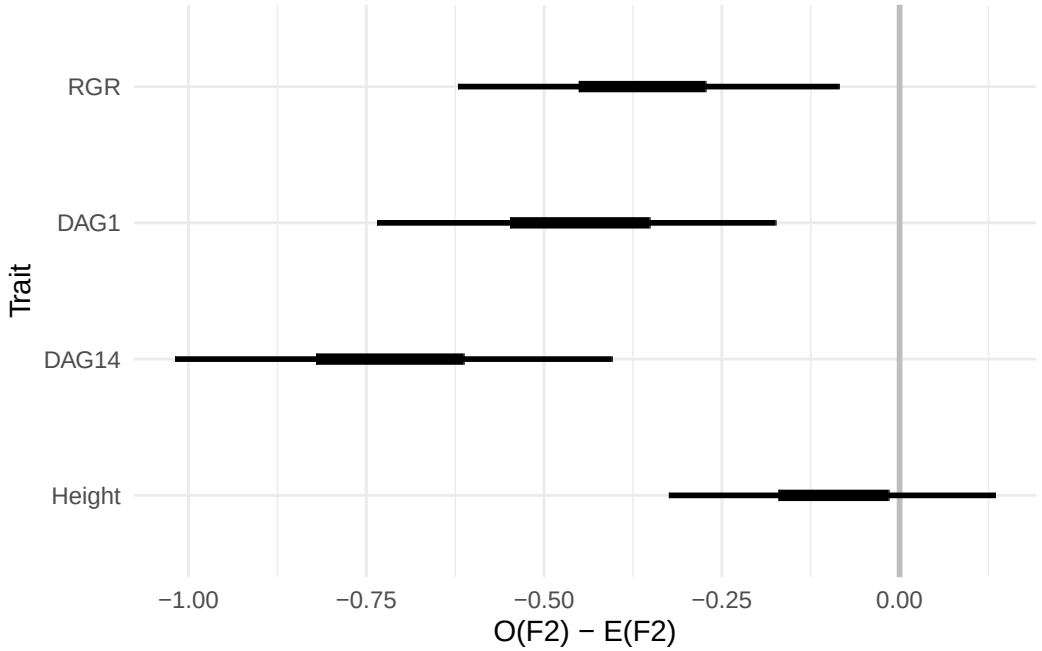



```
# post_pred_check(df, "height_122", "gamma")
# post_pred_check(df, "height_122", "log-normal")
```

Posterior Predictive Distributions of Delta

```
dag1 <- post_pred(df, "day_4", "normal")$delta_pp
dag14 <- post_pred(df, "day_17", "normal")$delta_pp
rgr <- post_pred(df, "rgr", "normal")$delta_pp
height <- post_pred(df, "height_122", "normal")$delta_pp

data.frame(DAG1 = dag1, DAG14= dag14,
           RGR = rgr, Height = height) %>%
  pivot_longer(1:4, names_to = "trait", values_to = "delta") %>%
  mutate(trait = factor(trait, levels = c("Height", "DAG14","DAG1", "RGR"))) %>%
  group_by(trait) %>%
  summarise(upr = quantile(delta, .975),
            lwr = quantile(delta, .025),
            upr.5 = quantile(delta, .75),
            lwr.5 = quantile(delta, .25)) %>%
  ggplot() +
  geom_vline(xintercept = 0, color = "grey", linewidth = 1) +
```

```
  geom_errorbarh(aes(y = trait, xmin = lwr, xmax = upr), height = 0,
                 linewidth = 1) +
  geom_errorbarh(aes(y = trait, xmin = lwr.5, xmax = upr.5), height = 0,
                 linewidth = 2) +
  theme_minimal() +
  labs(y = "Trait",
       x = "O(F2) - E(F2)")
```




```
dag1 <- post_pred(df, "day_4", "normal")$boots
dag1 <- dag1 %>%
  pivot_longer(1:5, names_to = "line", values_to = "trait") %>%
  group_by(line) %>%
  summarise(mu = round(mean(trait),2),
            upr = round(quantile(trait, .975),2),
            lwr = round(quantile(trait, .025),2),
            upr.5 = round(quantile(trait, .75),2),
            lwr.5 = round(quantile(trait, .25),2)) %>%
  mutate(trait = "1DAG")
```

```r
dag14 <- post_pred(df, "day_17", "normal")$boots
dag14 <- dag14 %>%
  pivot_longer(1:5, names_to = "line", values_to = "trait") %>%
  group_by(line) %>%
  summarise(mu = round(mean(trait),2),
            upr = round(quantile(trait, .975),2),
            lwr = round(quantile(trait, .025),2),
            upr.5 = round(quantile(trait, .75),2),
            lwr.5 = round(quantile(trait, .25),2)) %>%
  mutate(trait = "14DAG")

rgr <- post_pred(df, "rgr", "normal")$boots
rgr <- rgr %>%
  pivot_longer(1:5, names_to = "line", values_to = "trait") %>%
  group_by(line) %>%
  summarise(mu = round(mean(trait),2),
            upr = round(quantile(trait, .975),2),
            lwr = round(quantile(trait, .025),2),
            upr.5 = round(quantile(trait, .75),2),
            lwr.5 = round(quantile(trait, .25),2)) %>%
  mutate(trait = "RGR")

height <- post_pred(df, "height_122", "normal")$boots
height <- height %>%
  pivot_longer(1:5, names_to = "line", values_to = "trait") %>%
  group_by(line) %>%
  summarise(mu = round(mean(trait),2),
            upr = round(quantile(trait, .975),2),
            lwr = round(quantile(trait, .025),2),
            upr.5 = round(quantile(trait, .75),2),
            lwr.5 = round(quantile(trait, .25),2)) %>%
  mutate(trait = "Height")

library(knitr)
library(kableExtra)
```

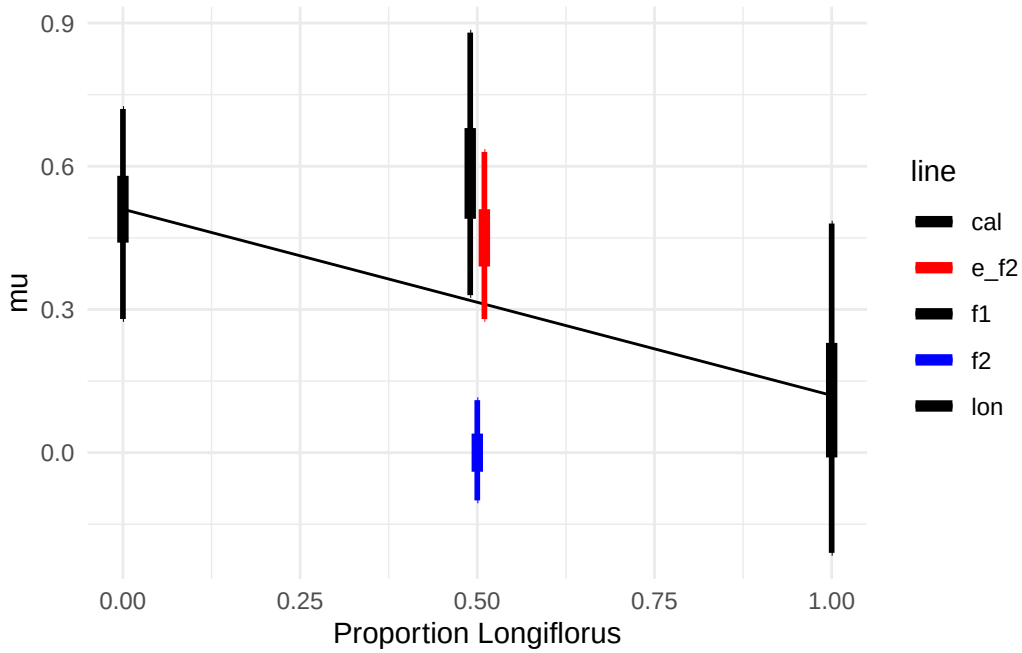
```
Attaching package: 'kableExtra'

The following object is masked from 'package:dplyr':
```

group_rows

```
tab_dat <- bind_rows(dag1, dag14, rgr, height)

tab_dat %>%
  select(Line = line, Mean = mu, "2.5%" = lwr, "25%" = lwr.5,
         "75%" = upr.5, "97.5%" = upr) %>%
  mutate(Line = case_when(Line == "cal" ~ "Calycinus",
                          Line == "f1" ~ "F1",
                          Line == "f2" ~ "F2",
                          Line == "lon" ~ "Longiflorus",
                          Line == "e_f2" ~ "Expected F2")) %>%
  kbl() %>%
  kable_classic_2() %>%
  add_header_above(c(" " = 1, "Posterior Distribution of Line Mean" = 5)) %>%
  pack_rows("1DAG",1,5) %>%
  pack_rows("14DAG",6,10) %>%
  pack_rows("RGR", 11,15) %>%
  pack_rows("Height",16,20)
```

```
(p1 <- dag1 %>%
  mutate(plon = c(0, .51, .49, .5, 1),
         group = c("a", letters[2:4], "a")) %>%
  ggplot(aes(x = plon, y = mu, group = group, color = line)) +
  geom_line() +
  geom_errorbar(aes(x = plon, ymax = upr, ymin = lwr), width = 0,
                linewidth = 1) +
  geom_errorbar(aes(x = plon, ymax = upr.5, ymin = lwr.5), width = 0,
                linewidth = 2) +
  scale_color_manual(values = c("black", "red", "black", "blue", "black")) +
  theme_minimal() +
  labs(x = "Proportion Longiflorus"))
```

	Posterior Distribution of Line Mean				
Line	Mean	2.5%	25%	75%	97.5%
1DAG					
Calycinus	0.51	0.28	0.44	0.58	0.72
Expected F2	0.45	0.28	0.39	0.51	0.63
F1	0.59	0.33	0.49	0.68	0.88
F2	0.00	-0.10	-0.04	0.04	0.11
Longiflorus	0.12	-0.21	-0.01	0.23	0.48
14DAG					
Calycinus	0.77	0.47	0.65	0.88	1.13
Expected F2	0.72	0.53	0.65	0.78	0.91
F1	0.84	0.53	0.74	0.95	1.13
F2	0.00	-0.10	-0.03	0.03	0.10
Longiflorus	0.42	0.11	0.31	0.52	0.75
RGR					
Calycinus	0.41	0.19	0.32	0.49	0.70
Expected F2	0.36	0.20	0.31	0.42	0.51
F1	0.33	0.04	0.26	0.42	0.55
F2	0.00	-0.11	-0.04	0.04	0.11
Longiflorus	0.38	0.16	0.30	0.46	0.62
Height					
Calycinus	0.11	-0.11	0.04	0.19	0.32
Expected F2	0.09	-0.03	0.05	0.13	0.22
F1	0.03	-0.11	-0.02	0.08	0.17
F2	0.00	-0.10	-0.04	0.03	0.11
Longiflorus	0.19	-0.13	0.07	0.31	0.57

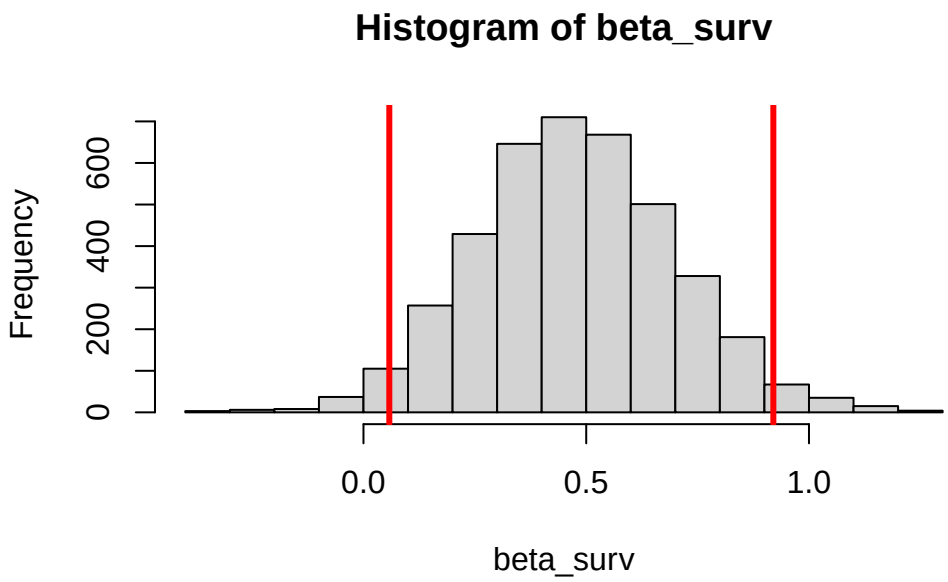


$$
\begin{aligned}
log(size) &\sim Gamma(\alpha, \beta) \\
\alpha &= \frac{\mu^2}{\sigma^2} \\
\beta &= \frac{\mu}{\sigma^2} \\
\mu &= \alpha_{rgr} + rgr \times age \\
\sigma^2 &\sim Normal^{+}(0, .5)
\end{aligned}
$$

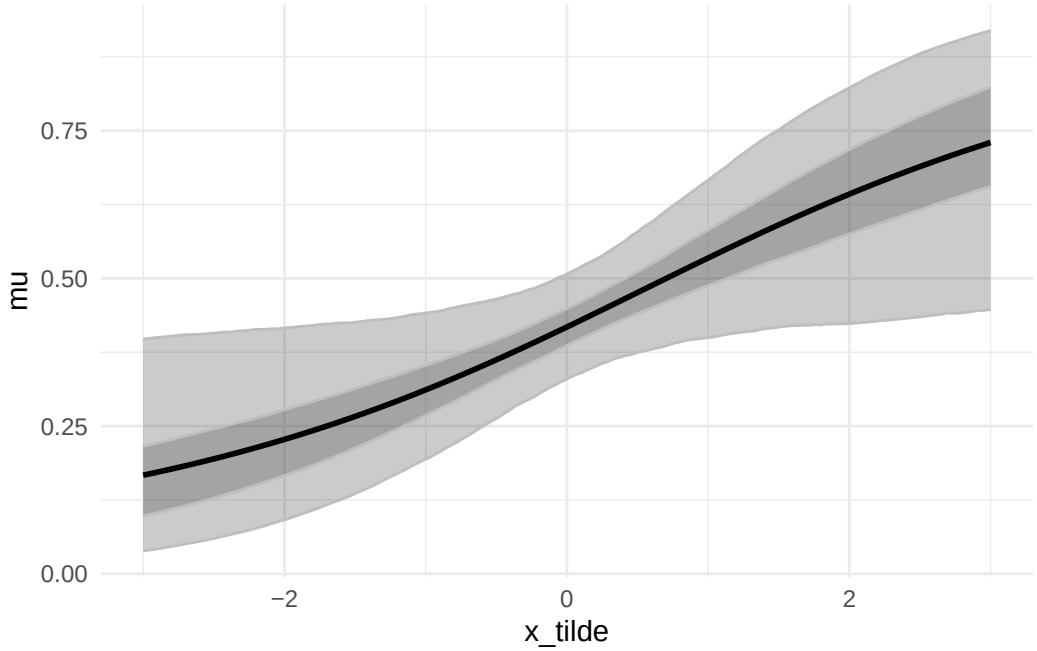
```
d <- read.csv("data/seed_growth_vs_seed_size.csv")


rgr_dat <- d %>%
  drop_na(germ_day, death_day) %>%
  mutate(ind = 1:105) %>%
  pivot_longer(4:10, names_to = "day", values_to = "size") %>%
  drop_na(size) %>%
  mutate(l_size = log(size)) %>%
  separate(day, into = (c("a", "day"))) %>%
  mutate(day = as.numeric(day),
         age = day - germ_day) %>%
```

```
  filter(age > 0) %>%
  select(ind, age, l_size)

full <- d %>% drop_na(germ_day, death_day) %>%
  mutate(ind = 1:105) %>%
  pivot_longer(4:10, names_to = "day", values_to = "size") %>%
  drop_na(size) %>%
  drop_na(size) %>%
  separate(day, c("fubar", "day")) %>%
  mutate(day = as.numeric(day)) %>%
  select(ind, seed_size, germ_day, death_day, day, size) %>%
  mutate(age = day - germ_day) %>%
  filter(age == 1 | day == 17) %>%
  mutate(tp = ifelse(age == 1, "start","finish")) %>%
  pivot_wider(id_cols = c(ind, seed_size, germ_day, death_day),
              names_from = tp, values_from = size)

mu <- mean(full$start[!(is.na(full$start))])

sd <- sd(full$start[!(is.na(full$start))])

full$start <- ifelse(is.na(full$start), -100, (full$start - mu)/sd)
full$finish <- stn(full$finish)
full$seed_size <- stn(full$seed_size)
full$survive <- full$death_day - 3



stan_dat <- list(
  N = nrow(full),
  N_tilde = 200,
  N_obs = sum(full$start != -100),
  N_miss = sum(full$start == -100),
  ind = full$ind,
  ii_obs = full$ind[full$start != -100],
  ii_miss = full$ind[full$start == -100],
  start_obs = full$start[full$start!=-100],
  size_end = full$finish,
  seed_size = full$seed_size,
  germ_day = full$germ_day,
  N_rgr = nrow(rgr_dat),
  l_size = rgr_dat$l_size,
```

```
  age = rgr_dat$age,
  ind_rgr = rgr_dat$ind,
  survive = full$survive,
  x_tilde = seq(-3,3, l = 200)
)




mod <- cmdstan_model("scripts/size.stan")


fit <- mod$sample(
  data = stan_dat,
  chains = 4,
  parallel_chains = 4,
  show_messages = F
)


beta_surv <- fit$draws("beta_surv", format = "df")$beta_surv
hist(beta_surv)
abline(v = quantile(beta_surv, c(.025, .975)), col = "red", lwd = 3)
```




```
p <- fit$draws("p_tilde", format = "df")[,1:200]


mu <- apply(p, 2, mean)
upr <- apply(p, 2, quantile, .975)
lwr <- apply(p, 2, quantile, .025)
upr.5 <- apply(p,2,quantile, .75)
lwr.5 <- apply(p,2,quantile, .25)

data.frame(mu, upr, lwr, upr.5, lwr.5, x_tilde = stan_dat$x_tilde) %>%
  ggplot(aes(x = x_tilde, y = mu)) +
  geom_ribbon(aes(x = x_tilde, ymax = upr, ymin = lwr), color = "grey",
              alpha = .25) +
  geom_ribbon(aes(x = x_tilde, ymax = upr.5, ymin = lwr.5), color = "grey",
              alpha = .25) +
  theme_minimal() +
  geom_line(linewidth = 1)
```


0.75
0.50
0.25
0.00
mu
−2
0
2
x_tilde