HOBO Data Logger Climate Treatment Summary

Savannah Weaver

2021

Contents

Packages

```
`%nin%` = Negate(`%in%`)
```

```
if (!require("tidyverse")) install.packages("tidyverse")
library("tidyverse")
```

remember to do rehab data separately

Load in Data

This data was collected using Onset HOBO temperature and humidity dataloggers during the course of our experiment. See ___ for full details.

The data is in a separate file for each download for each logger, so I need to compile each of those into one dataset.

To do this, first I compile a list of the filenames I need to read-in.

File Names

```
# make a list of file names of all data to load in
filenames <- list.files(path = "data/HOBOs")
```

Next, I make a function that will read in the data from each csv, name and organize the data correctly.

Function

```
# make a function to read in data from each csv file and add correct identifiers
read_HOBO_files <- function(filename) {

  # edit the filename inputted to funtion
  # to make a unique identifier for each logger
  name <- substr(filename, 1, nchar(filename)-15)
  # read in the csv file for this given filename
  dat <- read.csv(file.path("data/HOBOs", filename),
                  # each csv has headers
                  header = TRUE,
                  # this is what I want to rename the col headers
                  col.names = c("order", "date_time_PST", "temp_C",
                                "relative_humidity", "dew_pt_C",
                                # the 6,7,8th cols are not data
                                # logger use info we don't need
                                "mostly_blank", "mostly_blank", "mostly_blank")
                  ) %>%
    # select only the cols with data we want
    # don't need order- just an arbitrary observation identifier
    # don't need "mostly_blank" cols- unnecessary logger use info
    # but get the rest of the cols with informative data
    dplyr::select(date_time_PST, temp_C, relative_humidity, dew_pt_C) %>%
    # add a column with the name of the HOBO the data is from
    dplyr::mutate(HOBO_ID = name)

  # return the dataframe for that single csv file
  dat
}
```

Apply

Finally, I apply the function I made to all of the filenames I compiled, then put all of those dataframes into one dataframe for my analyses.

This will print warnings saying that header and col.names are different lengths, because the data has extra notes on logger usage that we read-in, but get rid of.

```
# apply function to get data from all csvs
all_HOBO_data <- lapply(filenames, read_HOBO_files) %>%
  # paste all data files together into one df by row
  reduce(rbind) %>%
  mutate(date_time_PST = as.POSIXct(date_time_PST,
                                    format = "%m/%d/%Y %H:%M:%S")) %>%
  # remove missing data
  dplyr::filter(complete.cases(date_time_PST, relative_humidity)) %>%
  mutate(serial = (substr(HOBO_ID, 7, 15)), # select characters
```

```
        serial = str_trim(serial), # remove trailing white space
        serial = str_replace_all(serial, "[^A-z0-9]", "_"), # replace any special characters with unde
        serial = as.factor(serial), # set class as factor
        temp_C = as.numeric(temp_C),
        relative_humidity = as.numeric(relative_humidity),
        dew_pt_C = as.numeric(dew_pt_C)
        )
```

```
## Warning in read.table(file = file, header = header, sep = sep, quote = quote, :
## header and 'col.names' are of different lengths

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```

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## Warning in read.table(file = file, header = header, sep = sep, quote = quote, :
## header and 'col.names' are of different lengths
```

```
summary(all_HOBO_data)
```

```
##  date_time_PST                    temp_C      relative_humidity
##  Min.   :2021-06-16 16:00:00   Min.   :16.72   Min.   :  6.47
##  1st Qu.:2021-07-02 08:30:00   1st Qu.:24.68   1st Qu.: 31.41
##  Median :2021-07-19 03:30:00   Median :25.27   Median : 46.68
##  Mean   :2021-07-22 04:26:33   Mean   :28.25   Mean   : 50.50
##  3rd Qu.:2021-08-12 10:00:00   3rd Qu.:34.70   3rd Qu.: 72.73
##  Max.   :2021-09-02 10:00:00   Max.   :38.34   Max.   :100.00
##     dew_pt_C        HOBO_ID              serial
##  Min.   :-14.98   Length:12893       20785309:2374
##  1st Qu.: 11.94   Class :character   20785311:2887
##  Median : 14.25   Mode  :character   20785317:2887
##  Mean   : 15.04                      20793609:2887
##  3rd Qu.: 21.34                      20932041:1258
##  Max.   : 35.06                      20932042: 600
```

```
head(all_HOBO_data)
```

```
##         date_time_PST temp_C relative_humidity dew_pt_C
## 1 2021-06-16 16:00:00  27.46             28.69     7.71
## 2 2021-06-16 16:30:00  27.61             28.61     7.80
## 3 2021-06-16 17:00:00  27.75             27.71     7.44
## 4 2021-06-16 17:30:00  27.94             27.08     7.27
## 5 2021-06-16 18:00:00  28.14             28.02     7.94
## 6 2021-06-16 18:30:00  29.30             37.74    13.42
##                                  HOBO_ID   serial
## 1 serial 20785309 2021-06-26 16_18_44 PST 20785309
## 2 serial 20785309 2021-06-26 16_18_44 PST 20785309
## 3 serial 20785309 2021-06-26 16_18_44 PST 20785309
## 4 serial 20785309 2021-06-26 16_18_44 PST 20785309
## 5 serial 20785309 2021-06-26 16_18_44 PST 20785309
## 6 serial 20785309 2021-06-26 16_18_44 PST 20785309
```

Data Wrangling

Dates

I need to subset the data based on the date range for actual experiment days.

Trail 1: June 16-24 Trail 2: June 26 - July 4 Trial 3: July 20-28 Trial 4: August 8-16 Trial 5: August 22-30 Trial 5 rehab: August 31-32

Lizards were usually placed in the chambers late on the first day and taken out early on the last day, so I'll only use from 8 pm on the first day up to 6 am the last day.

```
t1_days <- seq(as.POSIXct("2021-06-16 20:00:00"),
               as.POSIXct("2021-06-24 06:00:00"), "1 min")
t2_days <- seq(as.POSIXct("2021-06-26 20:00:00"),
               as.POSIXct("2021-07-04 06:00:00"), "1 min")
t3_days <- seq(as.POSIXct("2021-07-20 20:00:00"),
               as.POSIXct("2021-07-28 06:00:00"), "1 min")
t4_days <- seq(as.POSIXct("2021-08-08 20:00:00"),
               as.POSIXct("2021-08-16 06:00:00"), "1 min")
t5_days <- seq(as.POSIXct("2021-08-22 20:00:00"),
               as.POSIXct("2021-08-30 06:00:00"), "1 min")
exp_dates <- c(t1_days, t2_days, t3_days, t4_days, t5_days)
```

Subset data:

```
subset_HOBO_data <- all_HOBO_data %>%
  dplyr::filter(date_time_PST %in% exp_dates)
```

Trial & Tmt

```
# load HOBO assignment data
HOBO_tmts <- read.csv("./data/HOBO_assignments.csv") %>%
  dplyr::filter(trial != "5 rehab") %>%
  mutate(trial = as.factor(trial),
         serial = as.factor(serial),
         humidity_tmt = as.factor(humidity_tmt),
         temp_tmt = as.factor(temp_tmt),
         tmt = as.factor(paste(temp_tmt, humidity_tmt, sep = "-"))
         ) %>%
  dplyr::select(-notes, -in.google.drive.)
# combine
format_HOBO_data <- subset_HOBO_data %>%
  mutate(trial = as.factor(case_when(date_time_PST %in% t1_days ~ 1,
                                     date_time_PST %in% t2_days ~ 2,
                                     date_time_PST %in% t3_days ~ 3,
                                     date_time_PST %in% t4_days ~ 4,
                                     date_time_PST %in% t5_days ~ 5)),
         date_only = as.Date(date_time_PST)
         ) %>%
  left_join(HOBO_tmts, by = c("trial", "serial"))
summary(format_HOBO_data)
```

```
##  date_time_PST                    temp_C      relative_humidity
##  Min.   :2021-06-16 20:00:00   Min.   :16.72   Min.   :  6.47
##  1st Qu.:2021-06-29 05:15:00   1st Qu.:24.43   1st Qu.: 25.59
```

```
##  Median :2021-07-25 13:30:00   Median :26.30   Median : 43.10
##  Mean   :2021-07-24 05:02:27   Mean   :29.56   Mean   : 52.34
##  3rd Qu.:2021-08-13 21:30:00   3rd Qu.:35.22   3rd Qu.: 83.81
##  Max.   :2021-08-30 06:00:00   Max.   :38.34   Max.   :100.00
##
##     dew_pt_C        HOBO_ID               serial     trial
##  Min.   :-14.98   Length:8431        20785309:1428   1:1648
##  1st Qu.:  6.20   Class :character   20785311:1785   2:1428
##  Median : 17.98   Mode  :character   20785317:1785   3:1785
##  Mean   : 15.91                      20793609:1785   4:2142
##  3rd Qu.: 24.09                      20932041:1071   5:1428
##  Max.   : 35.06                      20932042: 577
##                                      20785308:   0
##    date_only          humidity_tmt temp_tmt            tmt
##  Min.   :2021-06-17   dry  :4284   cool:4284   cool-dry  :2142
##  1st Qu.:2021-06-29   humid:4147   hot :4147   cool-humid:2142
##  Median :2021-07-25                           hot-dry   :2142
##  Mean   :2021-07-24                           hot-humid :2005
##  3rd Qu.:2021-08-14
##  Max.   :2021-08-30
##
```

Check Data

Dates

```
format_HOBO_data %>%
  group_by(trial) %>%
  summarise(min_date = (min(date_time_PST)),
            max_date = (max(date_time_PST)))
```

```
## `summarise()` ungrouping output (override with `.groups` argument)
```

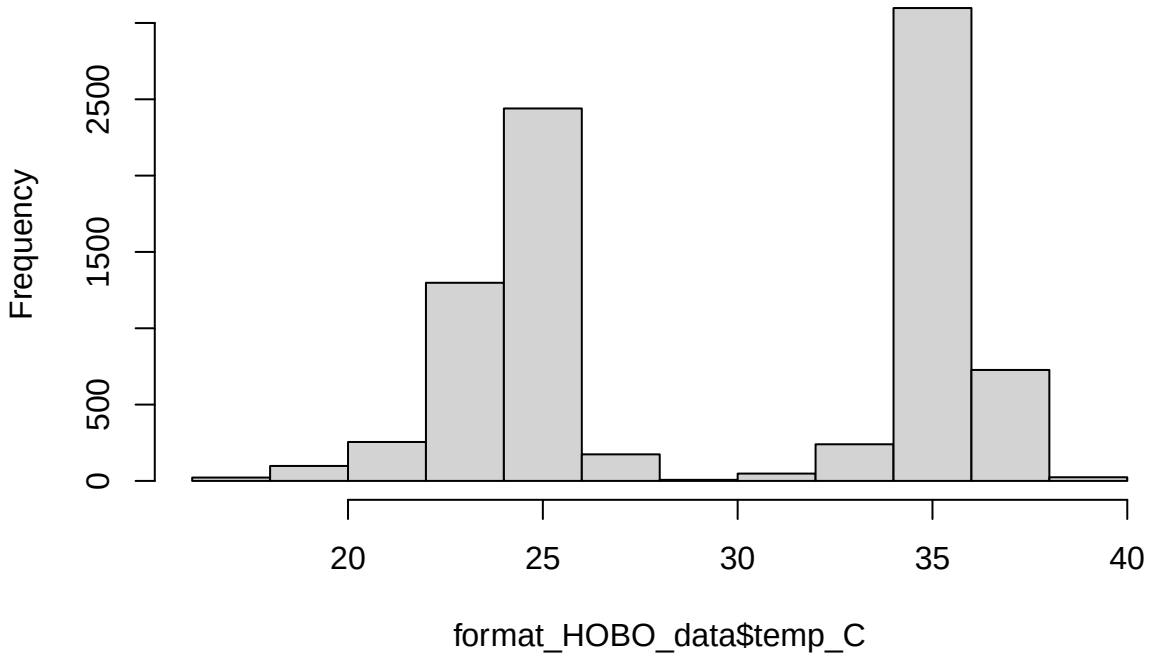
```
## # A tibble: 5 x 3
##   trial min_date            max_date
##   <fct> <dttm>              <dttm>
## 1 1     2021-06-16 20:00:00 2021-06-24 06:00:00
## 2 2     2021-06-26 20:00:00 2021-07-04 06:00:00
## 3 3     2021-07-20 20:00:00 2021-07-28 06:00:00
## 4 4     2021-08-08 20:00:00 2021-08-16 06:00:00
## 5 5     2021-08-22 20:00:00 2021-08-30 06:00:00
```

```
as.Date("2021-06-16 20:00:00")
```

```
## [1] "2021-06-16"
```

Temperature

```
hist(format_HOBO_data$temp_C)
```




```
format_HOBO_data %>%
  group_by(trial, serial, tmt) %>%
  summarise(max(temp_C),
            mean(temp_C),
            min(temp_C)
            ) %>%
  arrange(tmt)
```

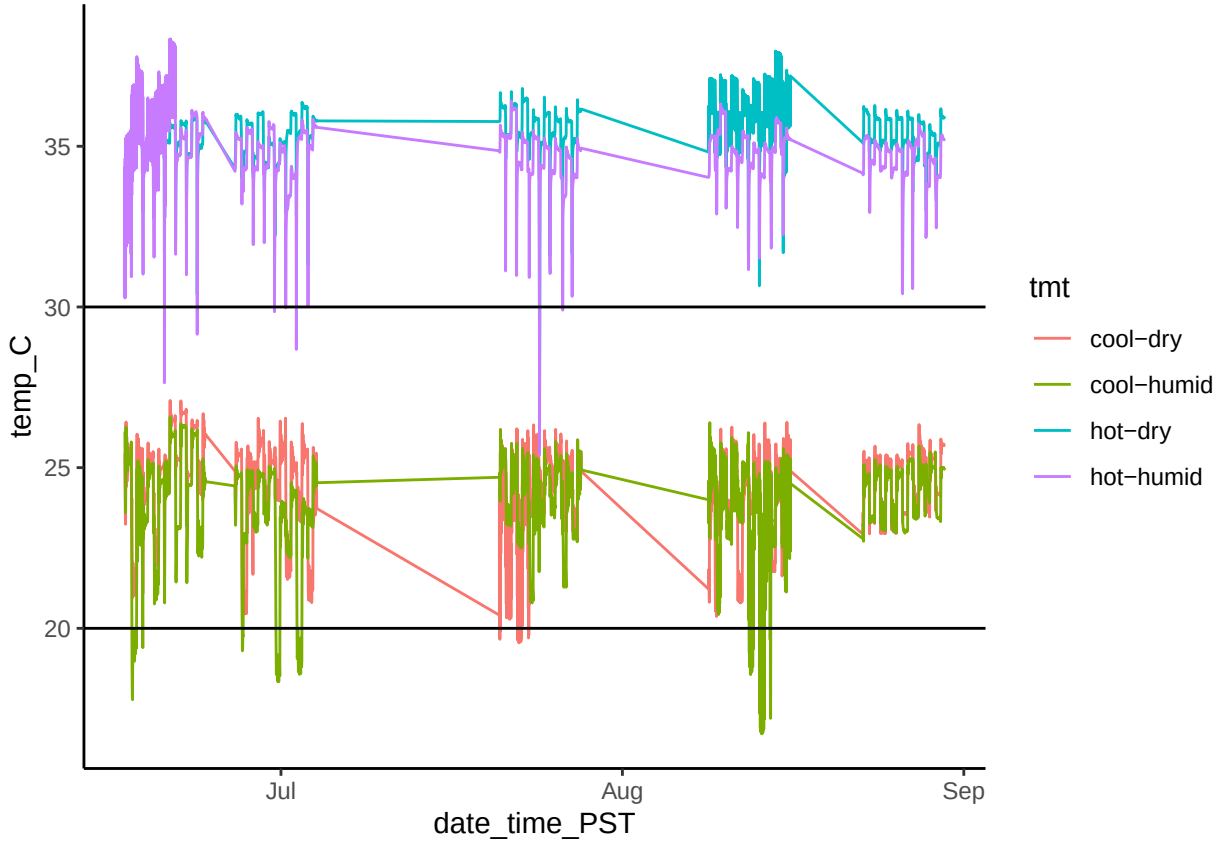
```
## `summarise()` regrouping output by 'trial', 'serial' (override with `.groups` argument)
```

```
## # A tibble: 24 x 6
## # Groups:   trial, serial [24]
##    trial serial   tmt        `max(temp_C)` `mean(temp_C)` `min(temp_C)`
##    <fct> <fct>    <fct>              <dbl>          <dbl>         <dbl>
##  1 1     20785317 cool-dry            27.1           24.9          21.0
##  2 2     20785309 cool-dry            26.5           24.3          20.1
##  3 3     20785311 cool-dry            26.2           24.3          19.7
##  4 3     20793609 cool-dry            26.3           24.2          19.6
##  5 4     20793609 cool-dry            26.4           24.1          20.4
##  6 5     20932041 cool-dry            26.3           24.5          22.9
##  7 1     20793609 cool-humid          26.6           24.0          17.8
##  8 2     20785311 cool-humid          25.4           23.3          18.3
##  9 3     20785317 cool-humid          26.2           24.0          20.8
## 10 4     20785309 cool-humid          26.4           23.8          18.6
## # ... with 14 more rows
```

I noted that the treatment assignment for logger 20785311 during trial 1 might have been mistakenly recorded as hot dry instead of cool dry, but the values definitely match hot treatment.

```
format_HOBO_data %>%
  ggplot() +
```

```
  geom_line(aes(x = date_time_PST,
                y = temp_C,
                color = tmt)) +
  theme_classic() +
  geom_hline(yintercept = 30) +
  geom_hline(yintercept = 20)
```



There's a chance the values <30 for the hot tmt and <20 for the cool tmt are erroneous values.

```
format_HOBO_data %>%
  dplyr::filter(temp_tmt == "hot" & temp_C < 30) %>%
  arrange(temp_C)
```

```
##          date_time_PST temp_C relative_humidity dew_pt_C
## 1  2021-07-24 11:30:00  25.40             89.78    23.63
## 2  2021-07-24 11:30:00  26.48             34.44     9.55
## 3  2021-06-20 10:00:00  27.64             60.87    19.42
## 4  2021-07-02 09:30:00  28.68             83.00    25.53
## 5  2021-06-23 09:30:00  29.15             92.44    27.83
## 6  2021-07-24 12:00:00  29.32             39.31    14.07
## 7  2021-06-20 10:30:00  29.48             98.96    29.34
## 8  2021-06-30 10:00:00  29.85             97.15    29.38
## 9  2021-07-26 14:00:00  29.90             82.90    26.71
## 10 2021-07-01 10:30:00  29.97             94.45    29.02
##                                    HOBO_ID   serial trial  date_only
## 1  serial 20932041 2021-07-28 11_25_35 PST 20932041     3 2021-07-24
## 2  serial 20785309 2021-07-28 11_19_50 PST 20785309     3 2021-07-24
## 3  serial 20932042 2021-06-21 09_54_42 PST 20932042     1 2021-06-20
```

```
## 4  serial 20785317 2021-07-28 11_26_40 PST 20785317     2 2021-07-02
## 5  serial 20785309 2021-06-26 16_18_44 PST 20785309     1 2021-06-23
## 6  serial 20785309 2021-07-28 11_19_50 PST 20785309     3 2021-07-24
## 7  serial 20785309 2021-06-26 16_18_44 PST 20785309     1 2021-06-20
## 8  serial 20785317 2021-07-28 11_26_40 PST 20785317     2 2021-06-30
## 9  serial 20932041 2021-07-28 11_25_35 PST 20932041     3 2021-07-26
## 10 serial 20785317 2021-07-28 11_26_40 PST 20785317     2 2021-07-01
##    humidity_tmt temp_tmt       tmt
## 1         humid      hot hot-humid
## 2           dry      hot   hot-dry
## 3         humid      hot hot-humid
## 4         humid      hot hot-humid
## 5         humid      hot hot-humid
## 6           dry      hot   hot-dry
## 7         humid      hot hot-humid
## 8         humid      hot hot-humid
## 9         humid      hot hot-humid
## 10        humid      hot hot-humid
```

```
format_HOBO_data %>%
  dplyr::filter(temp_tmt == "cool" & temp_C < 20) %>%
  arrange(temp_C)
```

```
##           date_time_PST temp_C relative_humidity dew_pt_C
## 1   2021-08-13 15:30:00  16.72             94.40    15.83
## 2   2021-08-13 16:00:00  16.72             94.75    15.89
## 3   2021-08-13 18:00:00  16.76             94.99    15.97
## 4   2021-08-13 13:00:00  16.78             93.68    15.78
## 5   2021-08-13 17:30:00  16.78             94.73    15.95
## 6   2021-08-13 15:00:00  16.84             94.31    15.94
## 7   2021-08-13 20:00:00  16.86             95.08    16.08
## 8   2021-08-13 19:30:00  16.87             94.89    16.06
## 9   2021-08-13 12:30:00  16.91             91.46    15.53
## 10  2021-08-13 17:00:00  16.91             94.87    16.10
## 11  2021-08-13 16:30:00  16.93             94.93    16.14
## 12  2021-08-13 18:30:00  16.96             95.11    16.20
## 13  2021-08-13 19:00:00  17.03             94.96    16.24
## 14  2021-08-13 14:30:00  17.04             94.28    16.13
## 15  2021-08-13 13:30:00  17.11             94.43    16.23
## 16  2021-08-13 20:30:00  17.16             95.34    16.43
## 17  2021-08-14 11:00:00  17.20             79.19    13.58
## 18  2021-08-13 14:00:00  17.28             94.47    16.40
## 19  2021-08-13 12:00:00  17.34             86.51    15.09
## 20  2021-08-13 21:00:00  17.37             95.22    16.62
## 21  2021-06-17 12:30:00  17.78             98.86    17.62
## 22  2021-06-17 12:00:00  17.94             99.37    17.86
## 23  2021-08-13 11:30:00  18.09             78.53    14.32
## 24  2021-08-14 10:30:00  18.12             66.26    11.75
## 25  2021-08-13 21:30:00  18.25             96.48    17.70
## 26  2021-06-30 19:00:00  18.34             98.13    18.06
## 27  2021-06-30 19:30:00  18.34             98.59    18.14
## 28  2021-06-30 17:00:00  18.35             98.39    18.11
## 29  2021-06-30 16:30:00  18.37             98.03    18.08
## 30  2021-06-30 21:30:00  18.52             98.68    18.33
## 31  2021-08-12 15:30:00  18.56             97.07    18.11
```

```
## 32  2021-06-30 14:00:00  18.56            97.94    18.25
## 33  2021-07-02 16:30:00  18.57            98.94    18.43
## 34  2021-06-30 14:30:00  18.59            98.39    18.36
## 35  2021-07-02 19:00:00  18.59            98.97    18.45
## 36  2021-07-02 14:00:00  18.64            98.97    18.50
## 37  2021-08-12 18:00:00  18.65            97.35    18.24
## 38  2021-08-12 17:30:00  18.67            97.09    18.22
## 39  2021-08-12 16:00:00  18.70            97.46    18.32
## 40  2021-08-12 13:00:00  18.80            96.98    18.33
## 41  2021-08-12 20:00:00  18.80            97.36    18.39
## 42  2021-07-02 21:00:00  18.80            98.67    18.61
## 43  2021-06-17 11:30:00  18.80            99.70    18.78
## 44  2021-06-30 16:00:00  18.81            98.01    18.51
## 45  2021-06-30 17:30:00  18.83            98.45    18.61
## 46  2021-06-17 13:00:00  18.83            98.02    18.53
## 47  2021-06-30 18:30:00  18.84            98.09    18.56
## 48  2021-07-02 18:30:00  18.85            98.71    18.67
## 49  2021-08-12 15:00:00  18.86            96.98    18.40
## 50  2021-08-12 19:30:00  18.86            97.12    18.42
## 51  2021-06-30 20:00:00  18.86            98.74    18.68
## 52  2021-06-30 21:00:00  18.86            98.30    18.61
## 53  2021-07-02 14:30:00  18.87            99.26    18.78
## 54  2021-07-02 17:00:00  18.87            99.20    18.77
## 55  2021-08-12 16:30:00  18.93            97.50    18.55
## 56  2021-08-12 17:00:00  18.94            97.24    18.52
## 57  2021-08-12 18:30:00  18.97            97.59    18.60
## 58  2021-07-02 21:30:00  18.98            99.42    18.91
## 59  2021-06-17 17:00:00  18.98            48.01     7.74
## 60  2021-07-02 16:00:00  19.05            98.70    18.86
## 61  2021-07-02 11:30:00  19.06           100.00    19.08
## 62  2021-08-12 13:30:00  19.08            97.63    18.72
## 63  2021-08-12 19:00:00  19.08            97.39    18.68
## 64  2021-06-30 15:00:00  19.08            98.42    18.85
## 65  2021-06-30 18:00:00  19.14            98.41    18.91
## 66  2021-07-02 19:30:00  19.15            98.99    19.02
## 67  2021-06-17 15:00:00  19.16            47.08     7.63
## 68  2021-06-30 20:30:00  19.17            98.61    18.97
## 69  2021-06-30 15:30:00  19.18            98.28    18.93
## 70  2021-06-17 14:30:00  19.18            50.45     8.66
## 71  2021-06-17 19:00:00  19.21            44.94     6.98
## 72  2021-08-12 14:30:00  19.22            97.23    18.79
## 73  2021-07-02 13:30:00  19.23            98.83    19.06
## 74  2021-08-12 12:30:00  19.24            96.44    18.68
## 75  2021-06-27 12:00:00  19.30            88.84    17.44
## 76  2021-06-30 13:30:00  19.30            97.59    18.94
## 77  2021-07-02 12:00:00  19.33           100.00    19.36
## 78  2021-08-13 11:00:00  19.33            74.81    14.77
## 79  2021-07-02 17:30:00  19.35            99.11    19.23
## 80  2021-08-12 21:30:00  19.36            97.86    19.03
## 81  2021-06-27 12:30:00  19.36            90.41    17.77
## 82  2021-07-02 18:00:00  19.37            98.86    19.21
## 83  2021-08-12 14:00:00  19.38            97.62    19.02
## 84  2021-06-17 17:30:00  19.38            46.36     7.59
## 85  2021-06-17 19:30:00  19.38            45.61     7.36
```

```
## 86  2021-06-17 21:00:00  19.38            43.73     6.74
## 87  2021-06-18 11:00:00  19.40            39.84     5.41
## 88  2021-06-17 16:30:00  19.42            47.25     7.91
## 89  2021-06-17 13:30:00  19.44            95.44    18.72
## 90  2021-07-02 15:00:00  19.46            99.16    19.35
## 91  2021-07-02 20:30:00  19.48            98.64    19.29
## 92  2021-07-22 14:30:00  19.55            14.41    -8.28
## 93  2021-07-02 15:30:00  19.57            98.88    19.41
## 94  2021-07-22 17:00:00  19.57            13.73    -8.88
## 95  2021-08-12 21:00:00  19.60            97.11    19.16
## 96  2021-07-22 19:00:00  19.60            12.99    -9.56
## 97  2021-07-22 12:00:00  19.63            15.34    -7.40
## 98  2021-08-14 10:00:00  19.65            60.54    11.82
## 99  2021-07-20 21:00:00  19.66            38.79     5.26
## 100 2021-07-22 16:30:00  19.69            13.80    -8.72
## 101 2021-06-17 18:30:00  19.70            44.03     7.13
## 102 2021-07-23 11:30:00  19.70            12.41   -10.06
## 103 2021-07-22 19:30:00  19.71            13.08    -9.38
## 104 2021-07-02 20:00:00  19.72            98.77    19.55
## 105 2021-06-27 13:30:00  19.75            88.98    17.91
## 106 2021-06-17 14:00:00  19.75            49.42     8.88
## 107 2021-06-17 15:30:00  19.76            47.75     8.38
## 108 2021-07-23 12:00:00  19.79            13.07    -9.34
## 109 2021-08-12 20:30:00  19.80            97.76    19.46
## 110 2021-06-27 13:00:00  19.80            90.35    18.19
## 111 2021-07-22 14:00:00  19.80            14.44    -8.06
## 112 2021-06-17 18:00:00  19.84            44.32     7.35
## 113 2021-06-17 20:00:00  19.86            43.96     7.25
## 114 2021-07-20 21:30:00  19.91            45.25     7.73
## 115 2021-06-17 16:00:00  19.94            48.37     8.73
## 116 2021-06-17 20:30:00  19.94            43.53     7.18
## 117 2021-07-02 13:00:00  19.96            99.37    19.88
## 118 2021-07-22 15:00:00  19.96            14.48    -7.89
## 119 2021-07-22 11:30:00  19.98            15.34    -7.13
##                                      HOBO_ID   serial trial  date_only
## 1   serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-13
## 2   serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-13
## 3   serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-14
## 4   serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-13
## 5   serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-14
## 6   serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-13
## 7   serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-14
## 8   serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-14
## 9   serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-13
## 10  serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-14
## 11  serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-13
## 12  serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-14
## 13  serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-14
## 14  serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-13
## 15  serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-13
## 16  serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-14
## 17  serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-14
## 18  serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-13
## 19  serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-13
```

```
## 20  serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-14
## 21  serial 20793609 2021-06-26 16_19_03 PST 20793609     1 2021-06-17
## 22  serial 20793609 2021-06-26 16_19_03 PST 20793609     1 2021-06-17
## 23  serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-13
## 24  serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-14
## 25  serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-14
## 26  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-01
## 27  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-01
## 28  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-01
## 29  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-06-30
## 30  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-01
## 31  serial 20785309 2021-08-16 11_38_34 PST 20785309     4 2021-08-12
## 32  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-06-30
## 33  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-02
## 34  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-06-30
## 35  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-03
## 36  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-02
## 37  serial 20785309 2021-08-16 11_38_34 PST 20785309     4 2021-08-13
## 38  serial 20785309 2021-08-16 11_38_34 PST 20785309     4 2021-08-13
## 39  serial 20785309 2021-08-16 11_38_34 PST 20785309     4 2021-08-12
## 40  serial 20785309 2021-08-16 11_38_34 PST 20785309     4 2021-08-12
## 41  serial 20785309 2021-08-16 11_38_34 PST 20785309     4 2021-08-13
## 42  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-03
## 43  serial 20793609 2021-06-26 16_19_03 PST 20793609     1 2021-06-17
## 44  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-06-30
## 45  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-01
## 46  serial 20793609 2021-06-26 16_19_03 PST 20793609     1 2021-06-17
## 47  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-01
## 48  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-03
## 49  serial 20785309 2021-08-16 11_38_34 PST 20785309     4 2021-08-12
## 50  serial 20785309 2021-08-16 11_38_34 PST 20785309     4 2021-08-13
## 51  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-01
## 52  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-01
## 53  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-02
## 54  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-03
## 55  serial 20785309 2021-08-16 11_38_34 PST 20785309     4 2021-08-12
## 56  serial 20785309 2021-08-16 11_38_34 PST 20785309     4 2021-08-13
## 57  serial 20785309 2021-08-16 11_38_34 PST 20785309     4 2021-08-13
## 58  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-03
## 59  serial 20793609 2021-06-26 16_19_03 PST 20793609     1 2021-06-18
## 60  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-02
## 61  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-02
## 62  serial 20785309 2021-08-16 11_38_34 PST 20785309     4 2021-08-12
## 63  serial 20785309 2021-08-16 11_38_34 PST 20785309     4 2021-08-13
## 64  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-06-30
## 65  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-01
## 66  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-03
## 67  serial 20793609 2021-06-26 16_19_03 PST 20793609     1 2021-06-17
## 68  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-01
## 69  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-06-30
## 70  serial 20793609 2021-06-26 16_19_03 PST 20793609     1 2021-06-17
## 71  serial 20793609 2021-06-26 16_19_03 PST 20793609     1 2021-06-18
## 72  serial 20785309 2021-08-16 11_38_34 PST 20785309     4 2021-08-12
## 73  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-02
```

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## 74  serial 20785309 2021-08-16 11_38_34 PST 20785309     4 2021-08-12
## 75  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-06-27
## 76  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-06-30
## 77  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-02
## 78  serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-13
## 79  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-03
## 80  serial 20785309 2021-08-16 11_38_34 PST 20785309     4 2021-08-13
## 81  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-06-27
## 82  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-03
## 83  serial 20785309 2021-08-16 11_38_34 PST 20785309     4 2021-08-12
## 84  serial 20793609 2021-06-26 16_19_03 PST 20793609     1 2021-06-18
## 85  serial 20793609 2021-06-26 16_19_03 PST 20793609     1 2021-06-18
## 86  serial 20793609 2021-06-26 16_19_03 PST 20793609     1 2021-06-18
## 87  serial 20793609 2021-06-26 16_19_03 PST 20793609     1 2021-06-18
## 88  serial 20793609 2021-06-26 16_19_03 PST 20793609     1 2021-06-17
## 89  serial 20793609 2021-06-26 16_19_03 PST 20793609     1 2021-06-17
## 90  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-02
## 91  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-03
## 92  serial 20793609 2021-07-28 11_24_19 PST 20793609     3 2021-07-22
## 93  serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-02
## 94  serial 20793609 2021-07-28 11_24_19 PST 20793609     3 2021-07-23
## 95  serial 20785309 2021-08-16 11_38_34 PST 20785309     4 2021-08-13
## 96  serial 20793609 2021-07-28 11_24_19 PST 20793609     3 2021-07-23
## 97  serial 20793609 2021-07-28 11_24_19 PST 20793609     3 2021-07-22
## 98  serial 20932041 2021-08-16 11_35_50 PST 20932041     4 2021-08-14
## 99  serial 20785311 2021-07-28 11_21_54 PST 20785311     3 2021-07-21
## 100 serial 20793609 2021-07-28 11_24_19 PST 20793609     3 2021-07-22
## 101 serial 20793609 2021-06-26 16_19_03 PST 20793609     1 2021-06-18
## 102 serial 20793609 2021-07-28 11_24_19 PST 20793609     3 2021-07-23
## 103 serial 20793609 2021-07-28 11_24_19 PST 20793609     3 2021-07-23
## 104 serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-03
## 105 serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-06-27
## 106 serial 20793609 2021-06-26 16_19_03 PST 20793609     1 2021-06-17
## 107 serial 20793609 2021-06-26 16_19_03 PST 20793609     1 2021-06-17
## 108 serial 20793609 2021-07-28 11_24_19 PST 20793609     3 2021-07-23
## 109 serial 20785309 2021-08-16 11_38_34 PST 20785309     4 2021-08-13
## 110 serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-06-27
## 111 serial 20793609 2021-07-28 11_24_19 PST 20793609     3 2021-07-22
## 112 serial 20793609 2021-06-26 16_19_03 PST 20793609     1 2021-06-18
## 113 serial 20793609 2021-06-26 16_19_03 PST 20793609     1 2021-06-18
## 114 serial 20785311 2021-07-28 11_21_54 PST 20785311     3 2021-07-21
## 115 serial 20793609 2021-06-26 16_19_03 PST 20793609     1 2021-06-17
## 116 serial 20793609 2021-06-26 16_19_03 PST 20793609     1 2021-06-18
## 117 serial 20785311 2021-07-28 11_21_54 PST 20785311     2 2021-07-02
## 118 serial 20793609 2021-07-28 11_24_19 PST 20793609     3 2021-07-22
## 119 serial 20793609 2021-07-28 11_24_19 PST 20793609     3 2021-07-22
##     humidity_tmt temp_tmt        tmt
## 1          humid     cool cool-humid
## 2          humid     cool cool-humid
## 3          humid     cool cool-humid
## 4          humid     cool cool-humid
## 5          humid     cool cool-humid
## 6          humid     cool cool-humid
## 7          humid     cool cool-humid
```

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## 8          humid     cool cool-humid
## 9          humid     cool cool-humid
## 10         humid     cool cool-humid
## 11         humid     cool cool-humid
## 12         humid     cool cool-humid
## 13         humid     cool cool-humid
## 14         humid     cool cool-humid
## 15         humid     cool cool-humid
## 16         humid     cool cool-humid
## 17         humid     cool cool-humid
## 18         humid     cool cool-humid
## 19         humid     cool cool-humid
## 20         humid     cool cool-humid
## 21         humid     cool cool-humid
## 22         humid     cool cool-humid
## 23         humid     cool cool-humid
## 24         humid     cool cool-humid
## 25         humid     cool cool-humid
## 26         humid     cool cool-humid
## 27         humid     cool cool-humid
## 28         humid     cool cool-humid
## 29         humid     cool cool-humid
## 30         humid     cool cool-humid
## 31         humid     cool cool-humid
## 32         humid     cool cool-humid
## 33         humid     cool cool-humid
## 34         humid     cool cool-humid
## 35         humid     cool cool-humid
## 36         humid     cool cool-humid
## 37         humid     cool cool-humid
## 38         humid     cool cool-humid
## 39         humid     cool cool-humid
## 40         humid     cool cool-humid
## 41         humid     cool cool-humid
## 42         humid     cool cool-humid
## 43         humid     cool cool-humid
## 44         humid     cool cool-humid
## 45         humid     cool cool-humid
## 46         humid     cool cool-humid
## 47         humid     cool cool-humid
## 48         humid     cool cool-humid
## 49         humid     cool cool-humid
## 50         humid     cool cool-humid
## 51         humid     cool cool-humid
## 52         humid     cool cool-humid
## 53         humid     cool cool-humid
## 54         humid     cool cool-humid
## 55         humid     cool cool-humid
## 56         humid     cool cool-humid
## 57         humid     cool cool-humid
## 58         humid     cool cool-humid
## 59         humid     cool cool-humid
## 60         humid     cool cool-humid
## 61         humid     cool cool-humid
```

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## 62         humid     cool cool-humid
## 63         humid     cool cool-humid
## 64         humid     cool cool-humid
## 65         humid     cool cool-humid
## 66         humid     cool cool-humid
## 67         humid     cool cool-humid
## 68         humid     cool cool-humid
## 69         humid     cool cool-humid
## 70         humid     cool cool-humid
## 71         humid     cool cool-humid
## 72         humid     cool cool-humid
## 73         humid     cool cool-humid
## 74         humid     cool cool-humid
## 75         humid     cool cool-humid
## 76         humid     cool cool-humid
## 77         humid     cool cool-humid
## 78         humid     cool cool-humid
## 79         humid     cool cool-humid
## 80         humid     cool cool-humid
## 81         humid     cool cool-humid
## 82         humid     cool cool-humid
## 83         humid     cool cool-humid
## 84         humid     cool cool-humid
## 85         humid     cool cool-humid
## 86         humid     cool cool-humid
## 87         humid     cool cool-humid
## 88         humid     cool cool-humid
## 89         humid     cool cool-humid
## 90         humid     cool cool-humid
## 91         humid     cool cool-humid
## 92           dry     cool   cool-dry
## 93         humid     cool cool-humid
## 94           dry     cool   cool-dry
## 95         humid     cool cool-humid
## 96           dry     cool   cool-dry
## 97           dry     cool   cool-dry
## 98         humid     cool cool-humid
## 99           dry     cool   cool-dry
## 100          dry     cool   cool-dry
## 101        humid     cool cool-humid
## 102          dry     cool   cool-dry
## 103          dry     cool   cool-dry
## 104        humid     cool cool-humid
## 105        humid     cool cool-humid
## 106        humid     cool cool-humid
## 107        humid     cool cool-humid
## 108          dry     cool   cool-dry
## 109        humid     cool cool-humid
## 110        humid     cool cool-humid
## 111          dry     cool   cool-dry
## 112        humid     cool cool-humid
## 113        humid     cool cool-humid
## 114          dry     cool   cool-dry
## 115        humid     cool cool-humid
```

```
## 116        humid     cool cool-humid
## 117        humid     cool cool-humid
## 118          dry     cool   cool-dry
## 119          dry     cool   cool-dry
```

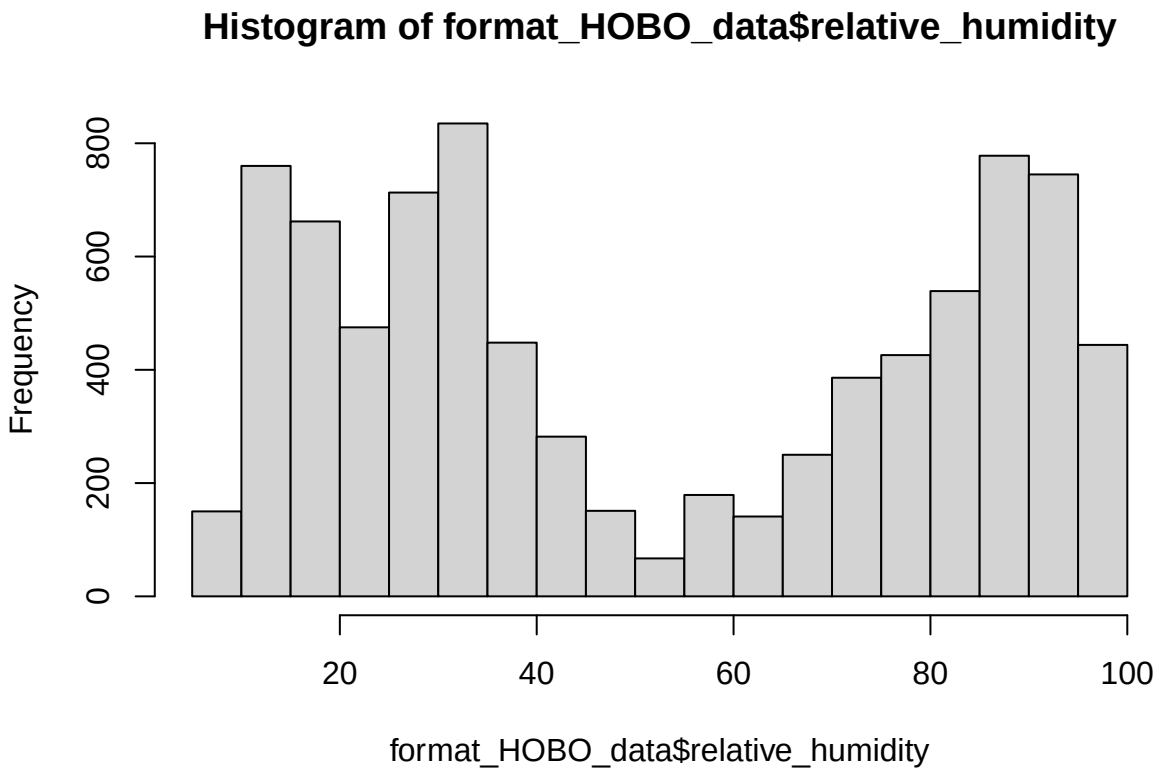
There are only 10 points <30C for the hot treatment, which is very few compared to the total number of measurements. I think these observations are from when the lizards (thus loggers) were out of the incubators for daily checkups. But, this is still technically characteristic of the environment the lizards experienced, and it's very few points, so I'll leave them.

There are many more points <20C for the cool treatment. The lowest is still ~17C, and most of them are very close to 20. The bottom of the cool incubator tended to get extra cold, so I'm not worried about the validity of these points.

All the temperature observations are valid.

Humidity

```
hist(format_HOBO_data$relative_humidity)
```



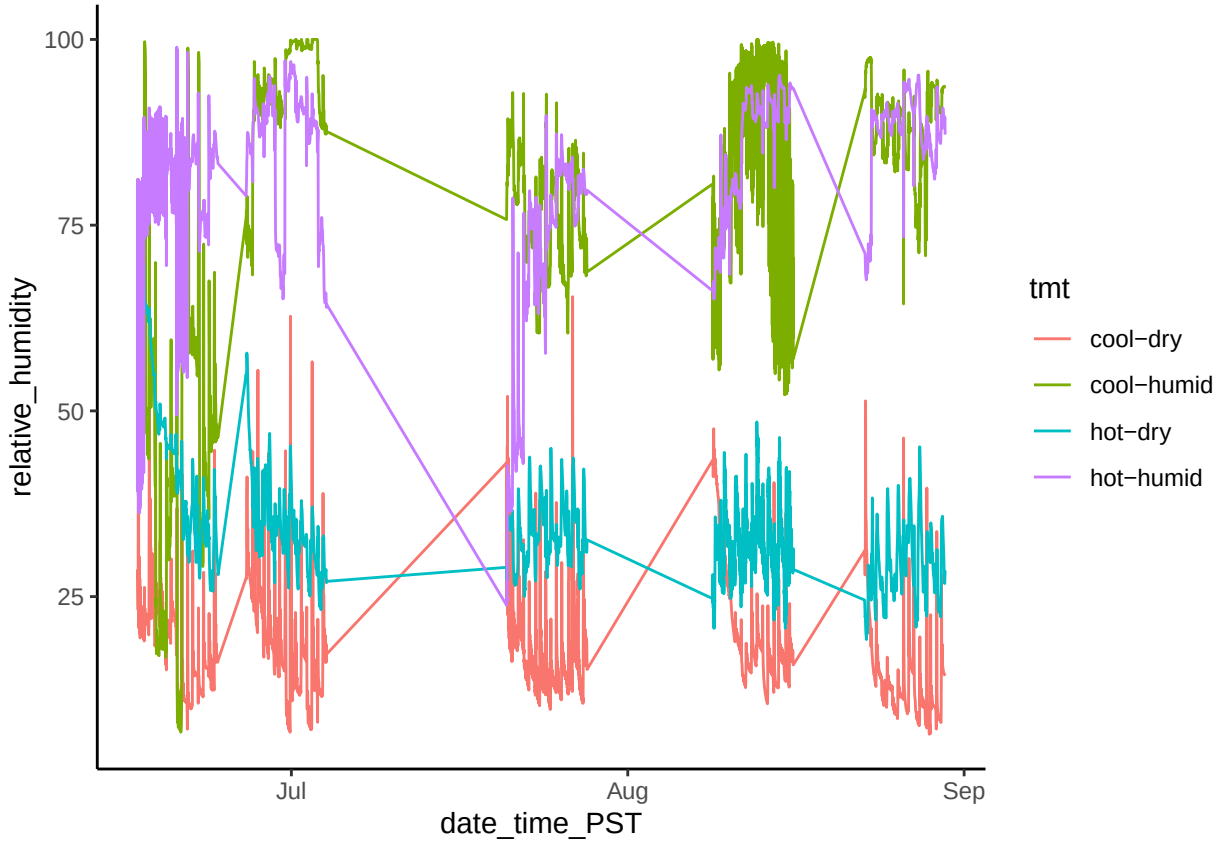

```
format_HOBO_data %>%
  group_by(trial, serial, tmt) %>%
  summarise(max(relative_humidity),
            mean(relative_humidity),
            min(relative_humidity)
            ) %>%
  arrange(tmt)
```

```
## `summarise()` regrouping output by 'trial', 'serial' (override with `.groups` argument)
```

```
## # A tibble: 24 x 6
## # Groups:   trial, serial [24]
```

```
##    trial serial  tmt    `max(relative_hum~ `mean(relative_hu~ `min(relative_hum~
##    <fct> <fct>   <fct>               <dbl>               <dbl>               <dbl>
##  1 1     207853~ cool-~               74.4                19.1                7.16
##  2 2     207853~ cool-~               62.7                18.9                6.74
##  3 3     207853~ cool-~               52.0                17.9               11.3
##  4 3     207936~ cool-~               65.4                17.3                9.8
##  5 4     207936~ cool-~               47.6                20.6               10.6
##  6 5     209320~ cool-~               51.4                13.7                6.47
##  7 1     207936~ cool-~               99.7                46.4                6.75
##  8 2     207853~ cool-~              100                  93.2               68.3
##  9 3     207853~ cool-~               92.8                76.3               60.4
## 10 4     207853~ cool-~              100                  90.3               66.0
## # ... with 14 more rows
```

```
format_HOBO_data %>%
  ggplot() +
  geom_line(aes(x = date_time_PST,
                y = relative_humidity,
                color = tmt)) +
  theme_classic()
```



I'm disappointed in the high variability in humidity treatment, but it is what it is.

Statistics

Treatment Differences

```
tmt_only_means <- format_HOBO_data %>%
  group_by(tmt) %>%
  summarise(temp_mean = mean(temp_C),
            temp_SD = sd(temp_C),
            humidity_mean = mean(relative_humidity),
            humidity_SD = sd(relative_humidity))
```

```
## `summarise()` ungrouping output (override with `.groups` argument)
```

```
tmt_only_means
```

```
## # A tibble: 4 x 5
##   tmt        temp_mean temp_SD humidity_mean humidity_SD
##   <fct>          <dbl>   <dbl>         <dbl>       <dbl>
## 1 cool-dry        24.4   1.35           17.9        7.44
## 2 cool-humid      23.8   1.61           78.3       19.6
## 3 hot-dry         35.5   0.900          34.1        8.40
## 4 hot-humid       34.9   1.14           80.9       12.5
```

Trial Differences

```
tmt_trial_means <- format_HOBO_data %>%
  group_by(tmt, trial) %>%
  summarise(temp_mean = mean(temp_C),
            temp_SD = sd(temp_C),
            humidity_mean = mean(relative_humidity),
            humidity_SD = sd(relative_humidity)) %>%
  arrange(trial)
```

```
## `summarise()` regrouping output by 'tmt' (override with `.groups` argument)
```

```
tmt_trial_means
```

```
## # A tibble: 20 x 6
## # Groups:   tmt [4]
##    tmt        trial temp_mean temp_SD humidity_mean humidity_SD
##    <fct>      <fct>     <dbl>   <dbl>         <dbl>       <dbl>
##  1 cool-dry   1          24.9   1.40           19.1        7.38
##  2 cool-humid 1          24.0   1.84           46.4       19.8
##  3 hot-dry    1          35.0   0.783          44.1       12.4
##  4 hot-humid  1          35.3   1.52           78.3       12.3
##  5 cool-dry   2          24.3   1.52           18.9        8.20
##  6 cool-humid 2          23.3   1.78           93.2        7.25
##  7 hot-dry    2          35.3   0.731          34.6        6.27
##  8 hot-humid  2          34.7   0.947          85.6        9.07
##  9 cool-dry   3          24.3   1.38           17.6        6.25
## 10 cool-humid 3          24.0   1.16           76.3        7.22
## 11 hot-dry    3          35.6   0.896          33.5        4.37
## 12 hot-humid  3          34.6   1.05           69.4       14.9
## 13 cool-dry   4          24.1   1.31           20.6        8.18
## 14 cool-humid 4          23.6   1.78           82.8       14.0
## 15 hot-dry    4          36.0   0.943          31.6        4.97
```

```
## 16 hot-humid  4          34.9   0.751          85.5        8.34
## 17 cool-dry   5          24.5   0.862          13.7        6.23
## 18 cool-humid 5          24.3   0.752          88.1        5.79
## 19 hot-dry    5          35.4   0.597          29.2        5.10
## 20 hot-humid  5          34.6   0.696          87.3        5.97
```

```
write.csv(tmt_trial_means, "./results_statistics/HOBO_mean_diffs.csv")
```

Models

Run linear models with pairwise post-hoc tests to determine when and how much climate varied among treatments.

```
# temperature
temp_mod <- lm(data = format_HOBO_data,
               temp_C ~ tmt * trial)
a_temp_mod <- aov(temp_mod)
ph_temp_mod <- TukeyHSD(a_temp_mod)
summary(temp_mod)
```

```
##
## Call:
## lm(formula = temp_C ~ tmt * trial, data = format_HOBO_data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -9.2267 -0.5199  0.1815  0.7600  2.9955
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)           24.87529    0.06560 379.223  < 2e-16 ***
## tmtcool-humid         -0.83773    0.09277  -9.031  < 2e-16 ***
## tmthot-dry            10.17272    0.09277 109.660  < 2e-16 ***
## tmthot-humid          10.46923    0.08346 125.446  < 2e-16 ***
## trial2                -0.60280    0.09277  -6.498 8.60e-11 ***
## trial3                -0.60679    0.08034  -7.553 4.70e-14 ***
## trial4                -0.82151    0.09277  -8.856  < 2e-16 ***
## trial5                -0.34527    0.09277  -3.722 0.000199 ***
## tmtcool-humid:trial2  -0.13162    0.13119  -1.003 0.315741
## tmthot-dry:trial2      0.81426    0.13119   6.207 5.67e-10 ***
## tmthot-humid:trial2   -0.07046    0.12478  -0.565 0.572306
## tmtcool-humid:trial3   0.59937    0.12272   4.884 1.06e-06 ***
## tmthot-dry:trial3      1.13220    0.12272   9.226  < 2e-16 ***
## tmthot-humid:trial3   -0.11101    0.11584  -0.958 0.337948
## tmtcool-humid:trial4   0.37371    0.12272   3.045 0.002332 **
## tmthot-dry:trial4      1.77665    0.12272  14.478  < 2e-16 ***
## tmthot-humid:trial4    0.32892    0.12478   2.636 0.008405 **
## tmtcool-humid:trial5   0.56888    0.13119   4.336 1.47e-05 ***
## tmthot-dry:trial5      0.65812    0.13119   5.017 5.37e-07 ***
## tmthot-humid:trial5   -0.39265    0.12478  -3.147 0.001657 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.239 on 8411 degrees of freedom
## Multiple R-squared:  0.9531, Adjusted R-squared:  0.953
```

```
## F-statistic:  9002 on 19 and 8411 DF,  p-value: < 2.2e-16
```

```
temp_mod_df <- data.frame(broom::tidy(ph_temp_mod)) %>%
  arrange(desc(term, adj.p.value))
write.csv(temp_mod_df, "./results_statistics/HOBO_temp_pairwise_diffs.csv")

# humidity
humidity_mod <- lm(data = format_HOBO_data,
                   relative_humidity ~ tmt * trial)
a_humid_mod <- aov(humidity_mod)
ph_humid_mod <- TukeyHSD(a_humid_mod)
summary(humidity_mod)
```

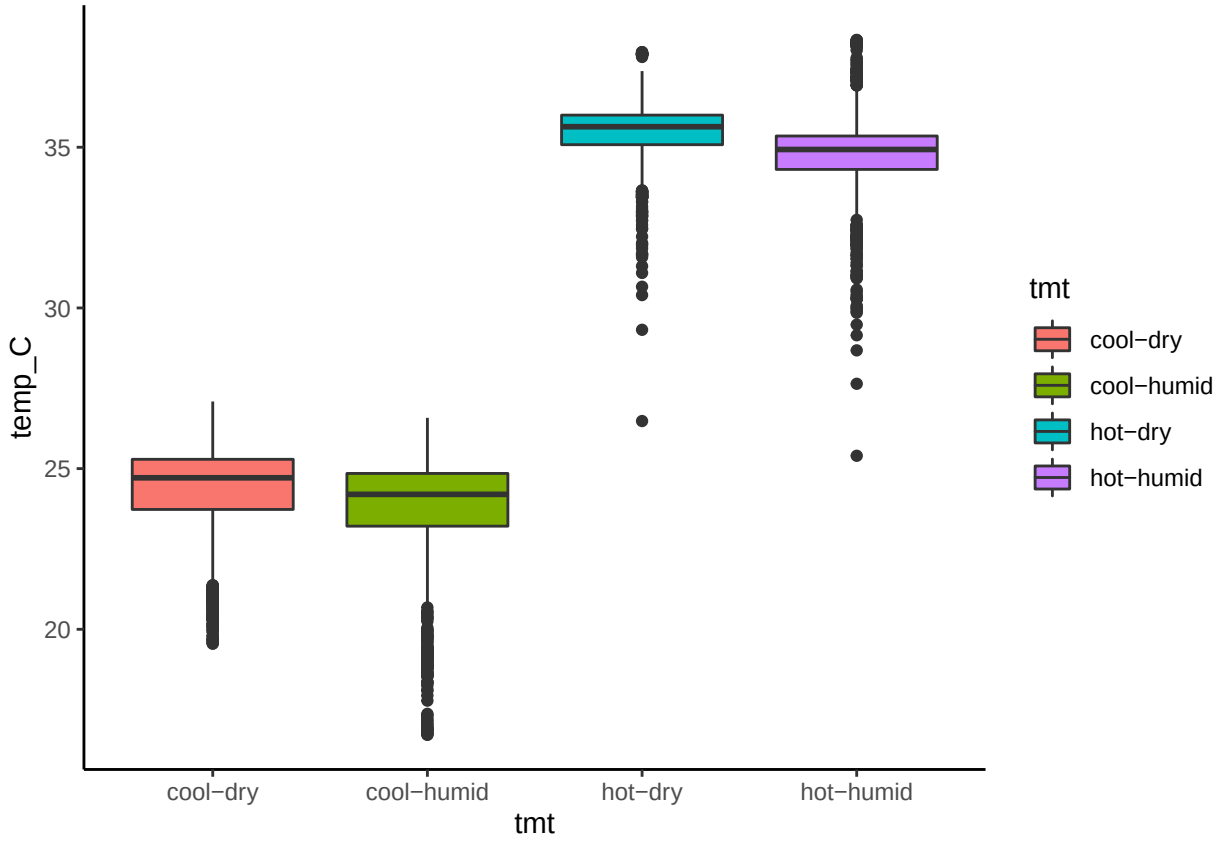
```
##
## Call:
## lm(formula = relative_humidity ~ tmt * trial, data = format_HOBO_data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -45.531  -4.378   0.038   5.433  55.347
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)            19.0529     0.5073  37.557  < 2e-16 ***
## tmtcool-humid          27.3272     0.7174  38.090  < 2e-16 ***
## tmthot-dry             25.0501     0.7174  34.916  < 2e-16 ***
## tmthot-humid           59.2387     0.6454  91.781  < 2e-16 ***
## trial2                 -0.1427     0.7174  -0.199   0.8424
## trial3                 -1.4748     0.6213  -2.374   0.0176 *
## trial4                  1.5711     0.7174   2.190   0.0286 *
## trial5                 -5.3075     0.7174  -7.398 1.52e-13 ***
## tmtcool-humid:trial2   46.9146     1.0146  46.239  < 2e-16 ***
## tmthot-dry:trial2      -9.3720     1.0146  -9.237  < 2e-16 ***
## tmthot-humid:trial2     7.5008     0.9650   7.773 8.60e-15 ***
## tmtcool-humid:trial3   31.4109     0.9491  33.096  < 2e-16 ***
## tmthot-dry:trial3      -9.1325     0.9491  -9.622  < 2e-16 ***
## tmthot-humid:trial3    -7.4453     0.8959  -8.310  < 2e-16 ***
## tmtcool-humid:trial4   34.8869     0.9491  36.759  < 2e-16 ***
## tmthot-dry:trial4     -14.0446     0.9491 -14.798  < 2e-16 ***
## tmthot-humid:trial4     5.6174     0.9650   5.821 6.07e-09 ***
## tmtcool-humid:trial5   47.0594     1.0146  46.382  < 2e-16 ***
## tmthot-dry:trial5      -9.5900     1.0146  -9.452  < 2e-16 ***
## tmthot-humid:trial5    14.3259     0.9650  14.845  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 9.585 on 8411 degrees of freedom
## Multiple R-squared:  0.9001, Adjusted R-squared:  0.8998
## F-statistic:  3987 on 19 and 8411 DF,  p-value: < 2.2e-16
```

```
humid_mod_df <- data.frame(broom::tidy(ph_humid_mod)) %>%
  arrange(desc(term, adj.p.value))
write.csv(humid_mod_df,
          "./results_statistics/HOBO_humidity_pairwise_diffs.csv")
```

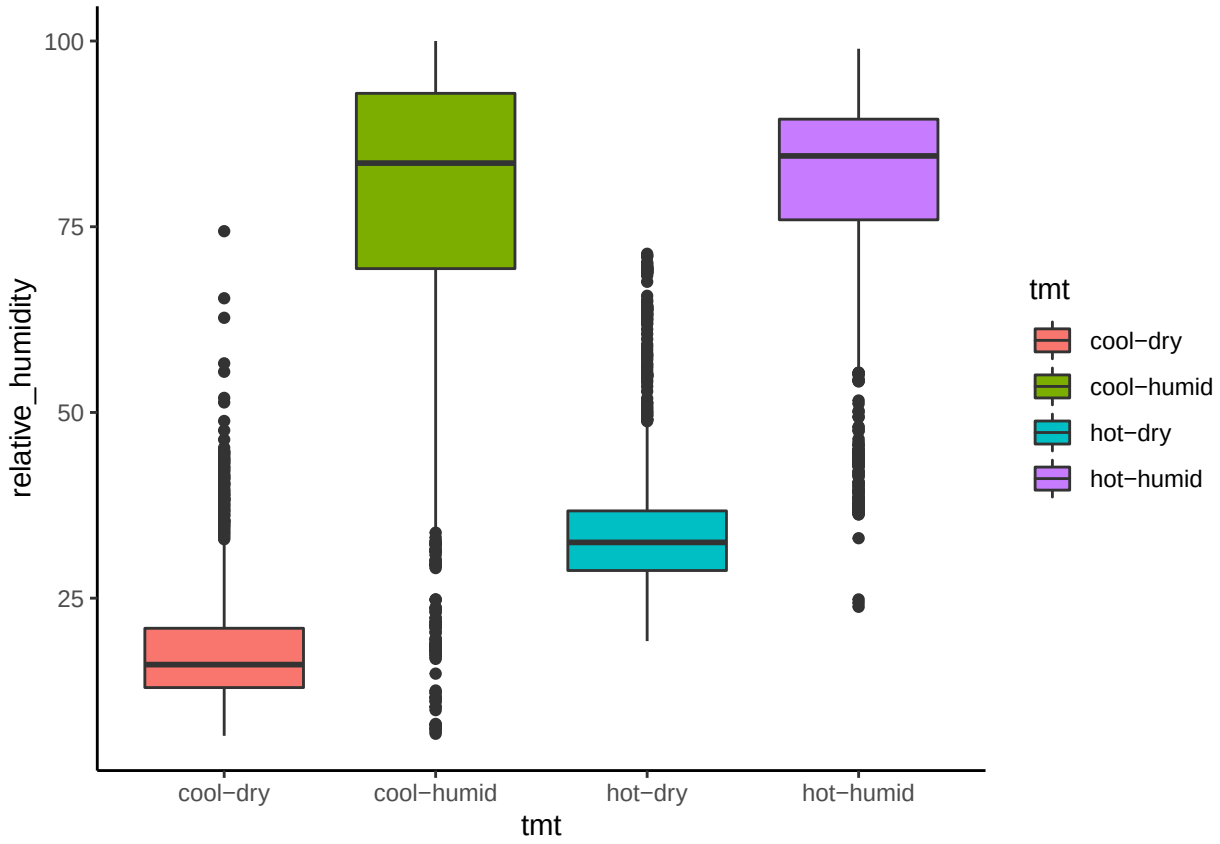
Boxplots

Simple plots looking at the distribution of temperature and humidity for each treatment group:

```
format_HOBO_data %>%
  ggplot() +
  geom_boxplot(aes(x = tmt,
                   y = temp_C,
                   fill = tmt)) +
  theme_classic()
```




```
format_HOBO_data %>%
  ggplot() +
  geom_boxplot(aes(x = tmt,
                   y = relative_humidity,
                   fill = tmt)) +
  theme_classic()
```

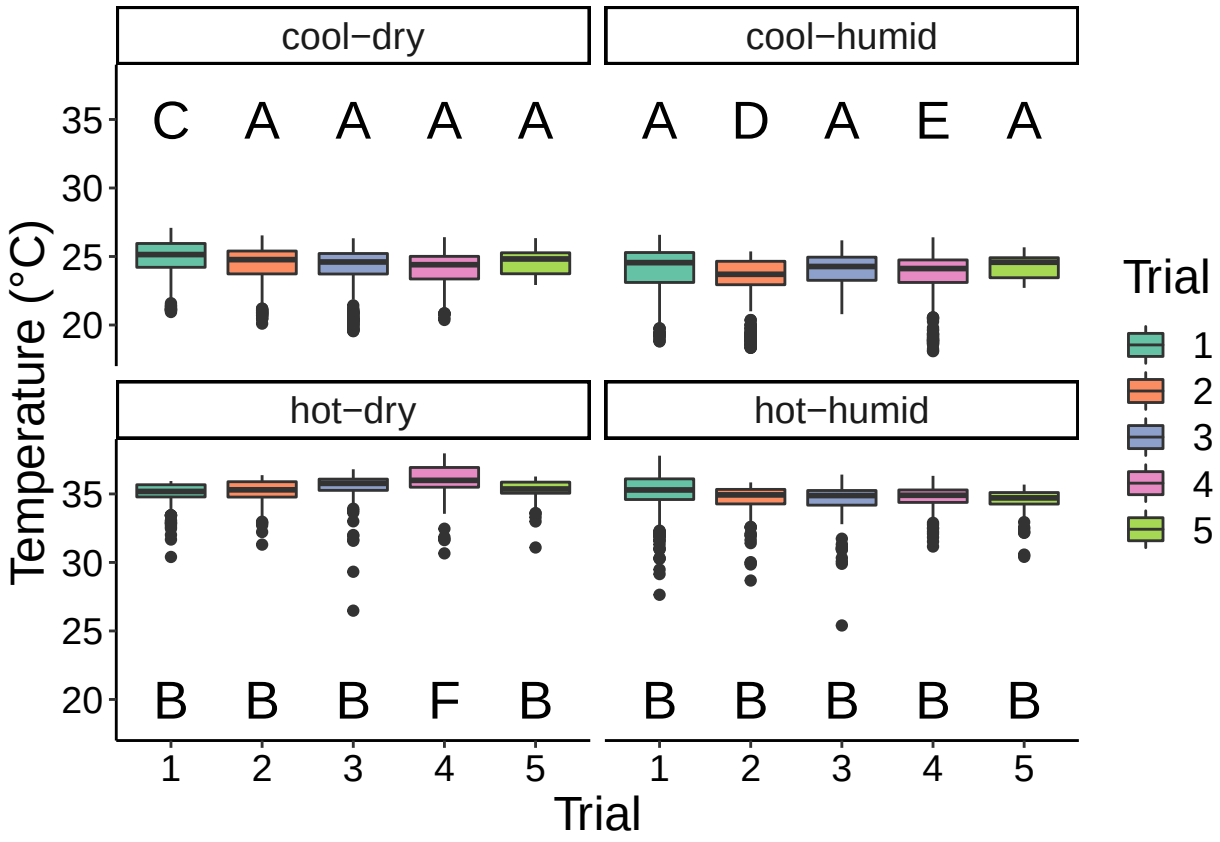


FANCY boxplot for **temperature**, with ANOVA groups overlaid:

```
# create ANOVA labels
anova_labels_temp <- data.frame(tmt = c("cool-dry",
                                        "cool-humid",
                                        "hot-dry",
                                        "hot-humid"
                                       ),
                                     # c-d, c-h, h-d, h-h
                                t1 = c("C", "A", "B", "B"),
                                t2 = c("A", "D", "B", "B"),
                                t3 = c("A", "A", "B", "B"),
                                t4 = c("A", "E", "F", "B"),
                                t5 = c("A", "A", "B", "B"))
# plot!
format_HOBO_data %>%
  ggplot() +
  geom_boxplot(aes(x = trial,
                   y = temp_C,
                   fill = trial)) +
  theme_classic() +
  facet_wrap(~tmt) +
  xlab("Trial") +
  ylab("Temperature (°C)") +
  ylim(18,38) +
  scale_fill_brewer(palette = "Set2",
                    name = "Trial") +
  theme(text = element_text(color = "black",
```

```
                            family = "sans",
                            size = 18),
        axis.text = element_text(color = "black",
                                 family = "sans",
                                 size = 14),
        legend.text.align = 0,
        legend.position = "right") +
  # trial 1 labels
  geom_text(data = anova_labels_temp,
            size = 7,
            mapping = aes(x = 1, y = c(35,35,20,20), label = t1)) +
  # trial 2 labels
  geom_text(data = anova_labels_temp,
            size = 7,
            mapping = aes(x = 2, y = c(35,35,20,20), label = t2)) +
  # trial 3 labels
  geom_text(data = anova_labels_temp,
            size = 7,
            mapping = aes(x = 3, y = c(35,35,20,20), label = t3)) +
  # trial 4 labels
  geom_text(data = anova_labels_temp,
            size = 7,
            mapping = aes(x = 4, y = c(35,35,20,20), label = t4)) +
  # trial 5 labels
  geom_text(data = anova_labels_temp,
            size = 7,
            mapping = aes(x = 5, y = c(35,35,20,20), label = t5)
            ) -> ANOVA_temp_boxplot
ANOVA_temp_boxplot
```

```
## Warning: Removed 46 rows containing non-finite values (stat_boxplot).
```



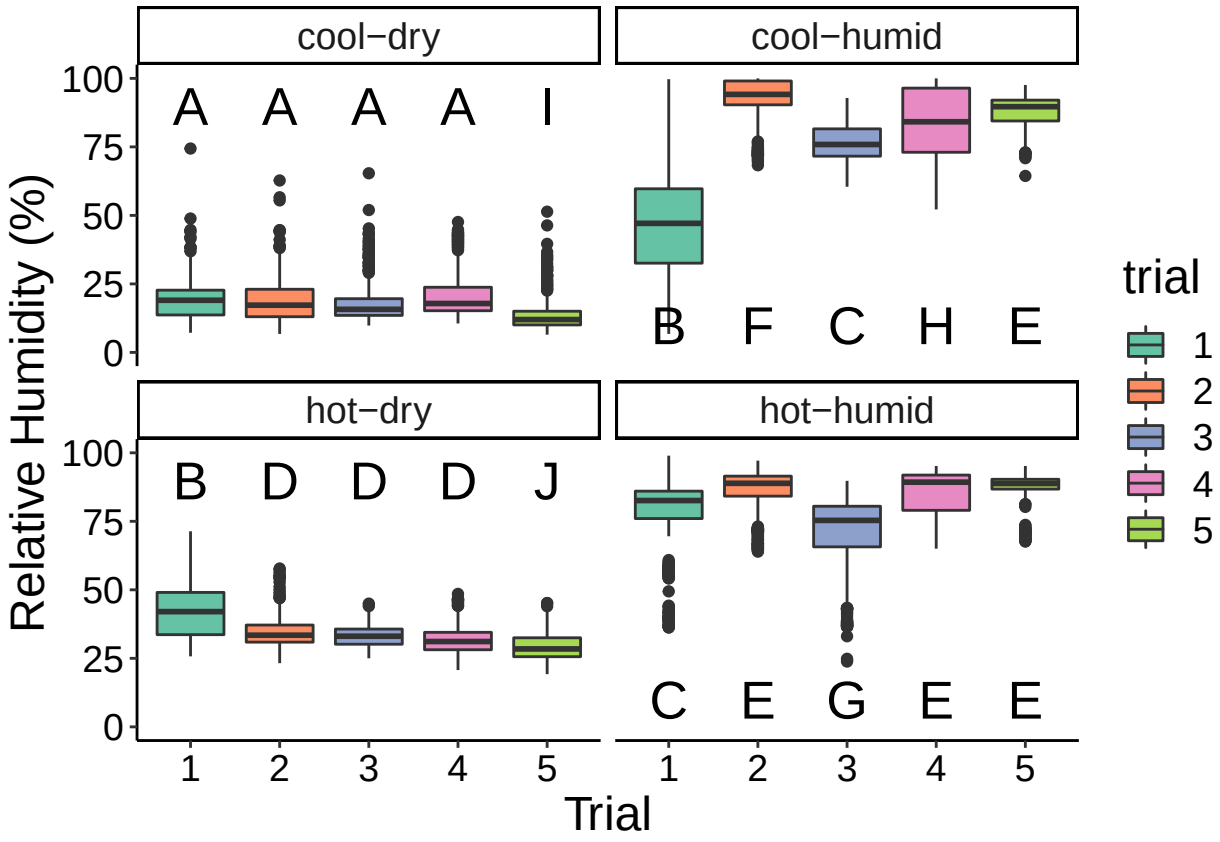

```
# save
ggsave(filename = "ANOVA_temp_boxplot.jpeg",
       plot = ANOVA_temp_boxplot,
       path = "./results_figures",
       device = "jpeg",
       dpi = 1200,
       width = 6, height = 4)
```

```
## Warning: Removed 46 rows containing non-finite values (stat_boxplot).
```

FANCY boxplot for **humidity**, with ANOVA groups overlaid:

```
# create ANOVA labels
anova_labels_humidity <- data.frame(tmt = c("cool-dry",
                                            "cool-humid",
                                            "hot-dry",
                                            "hot-humid"
                                           ),
                                    # c-d, c-h, h-d, h-h
                                    t1 = c("A", "B", "B", "C"),
                                    t2 = c("A", "F", "D", "E"),
                                    t3 = c("A", "C", "D", "G"),
                                    t4 = c("A", "H", "D", "E"),
                                    t5 = c("I", "E", "J", "E"))
# plot!
format_HOBO_data %>%
  ggplot() +
  geom_boxplot(aes(x = trial,
                   y = relative_humidity,
```

```
                  fill = trial)) +
  theme_classic() +
  facet_wrap(~tmt) +
  xlab("Trial") +
  ylab("Relative Humidity (%)") +
  ylim(0,100) +
  scale_fill_brewer(palette = "Set2") +
  theme(text = element_text(color = "black",
                            family = "sans",
                            size = 18),
        axis.text = element_text(color = "black",
                                 family = "sans",
                                 size = 14),
        legend.text.align = 0,
        legend.position = "right") +
  # trial 1 labels
  geom_text(data = anova_labels_humidity,
            size = 7,
            mapping = aes(x = 1, y = c(90,10,90,10), label = t1)) +
  # trial 2 labels
  geom_text(data = anova_labels_humidity,
            size = 7,
            mapping = aes(x = 2, y = c(90,10,90,10), label = t2)) +
  # trial 3 labels
  geom_text(data = anova_labels_humidity,
            size = 7,
            mapping = aes(x = 3, y = c(90,10,90,10), label = t3)) +
  # trial 4 labels
  geom_text(data = anova_labels_humidity,
            size = 7,
            mapping = aes(x = 4, y = c(90,10,90,10), label = t4)) +
  # trial 5 labels
  geom_text(data = anova_labels_humidity,
            size = 7,
            mapping = aes(x = 5, y = c(90,10,90,10), label = t5)
            ) -> ANOVA_humidity_boxplot
ANOVA_humidity_boxplot
```




```
# save
ggsave(filename = "ANOVA_humidity_boxplot.jpeg",
       plot = ANOVA_humidity_boxplot,
       path = "./results_figures",
       device = "jpeg",
       dpi = 1200,
       width = 6, height = 4)
```