HOBO Data Logger Climate Treatment Summary

Savannah Weaver

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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

```r
# 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

```r
# 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.

```r
# 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
```

```r
        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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## header and 'col.names' are of different lengths

## 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.

```r
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:

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

Trial & Tmt

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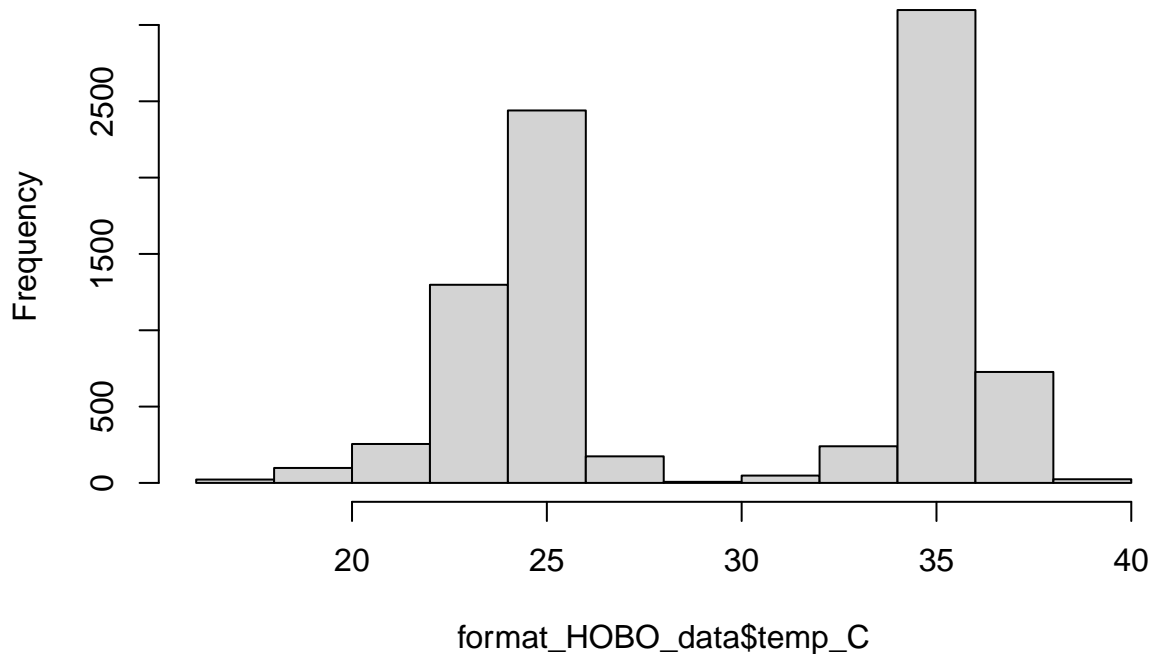
```
as.Date("2021-06-16 20:00:00")
```

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

Temperature

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

Histogram of 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)
```
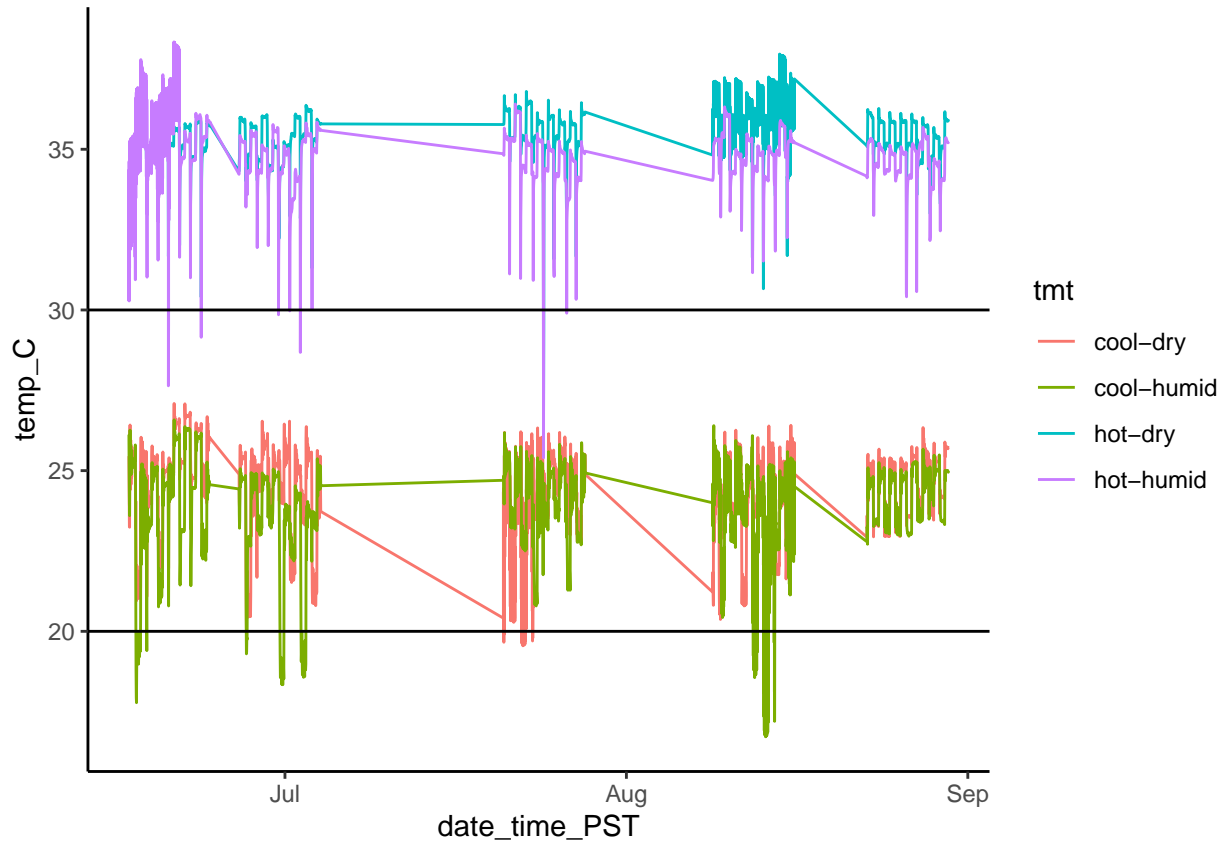

There's a chance the values <30 for the hot tmt and <20 for the cool tmt are erroneous values.

```
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
```

```r
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
```

```
## 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
```

```
## 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
```

```
## 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

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

Histogram of format_HOBO_data$relative_humidity
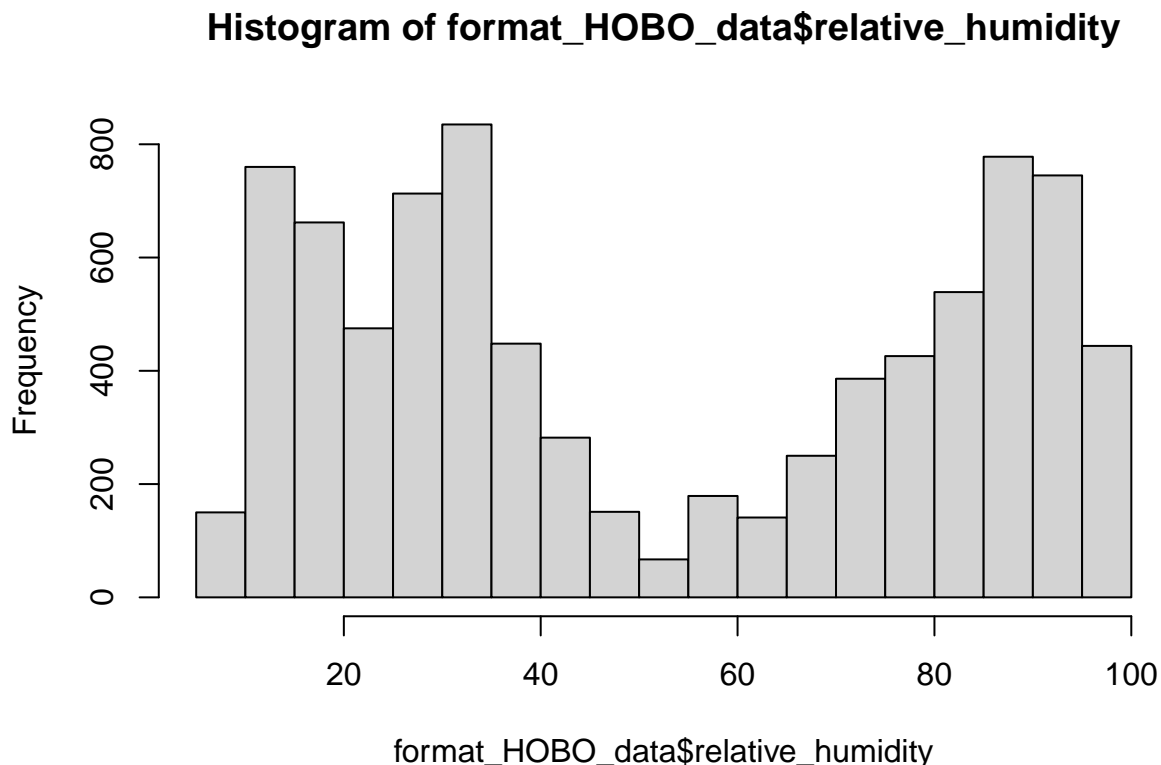

```r
format_HOBO_data %>%
  group_by(trial, serial, tmt) %>%
  summarise(max(relative_humidity),
            mean(relative_humidity),
            min(relative_humidity)
            ) %>%
  arrange(tmt)
```

```
## `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()
```
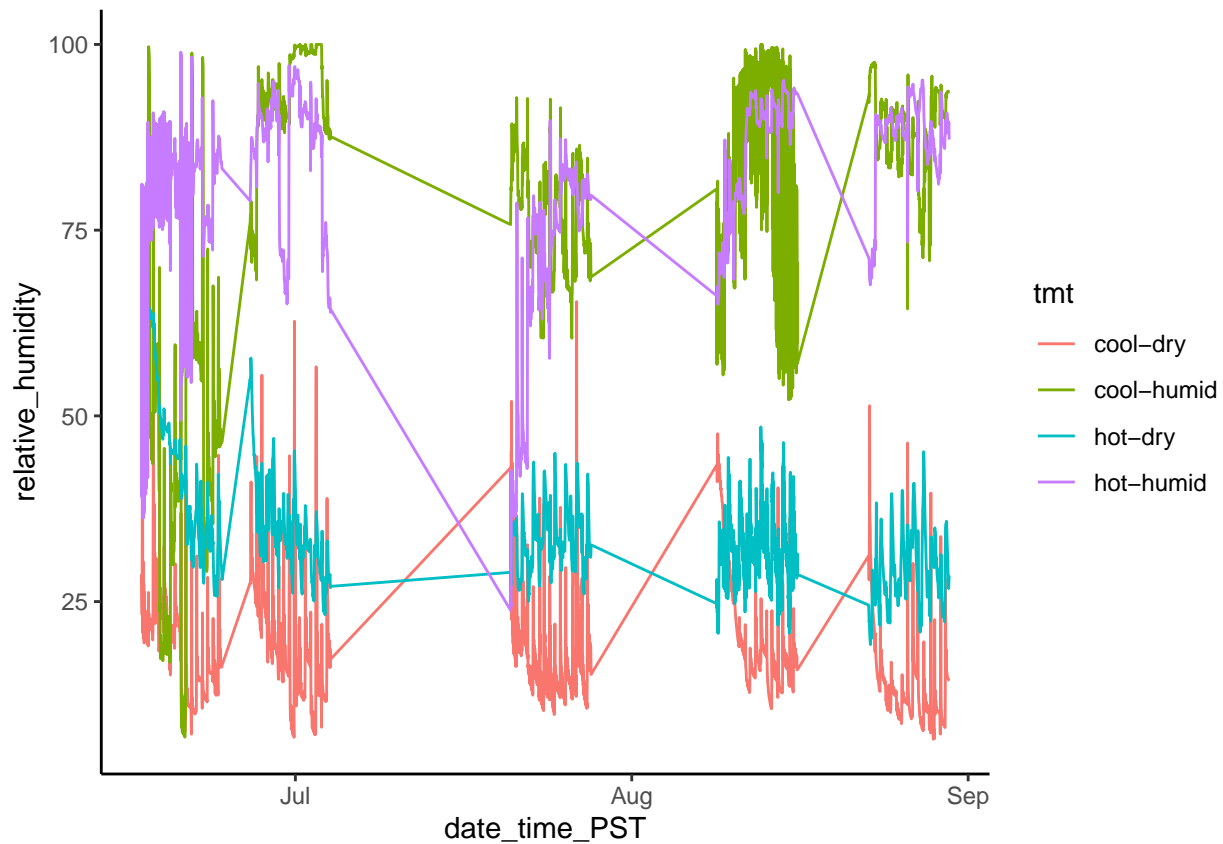

I'm disappointed in the high variability in humidity treatment, but it is what it is.

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
```

```r
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.

```r
# 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")
```
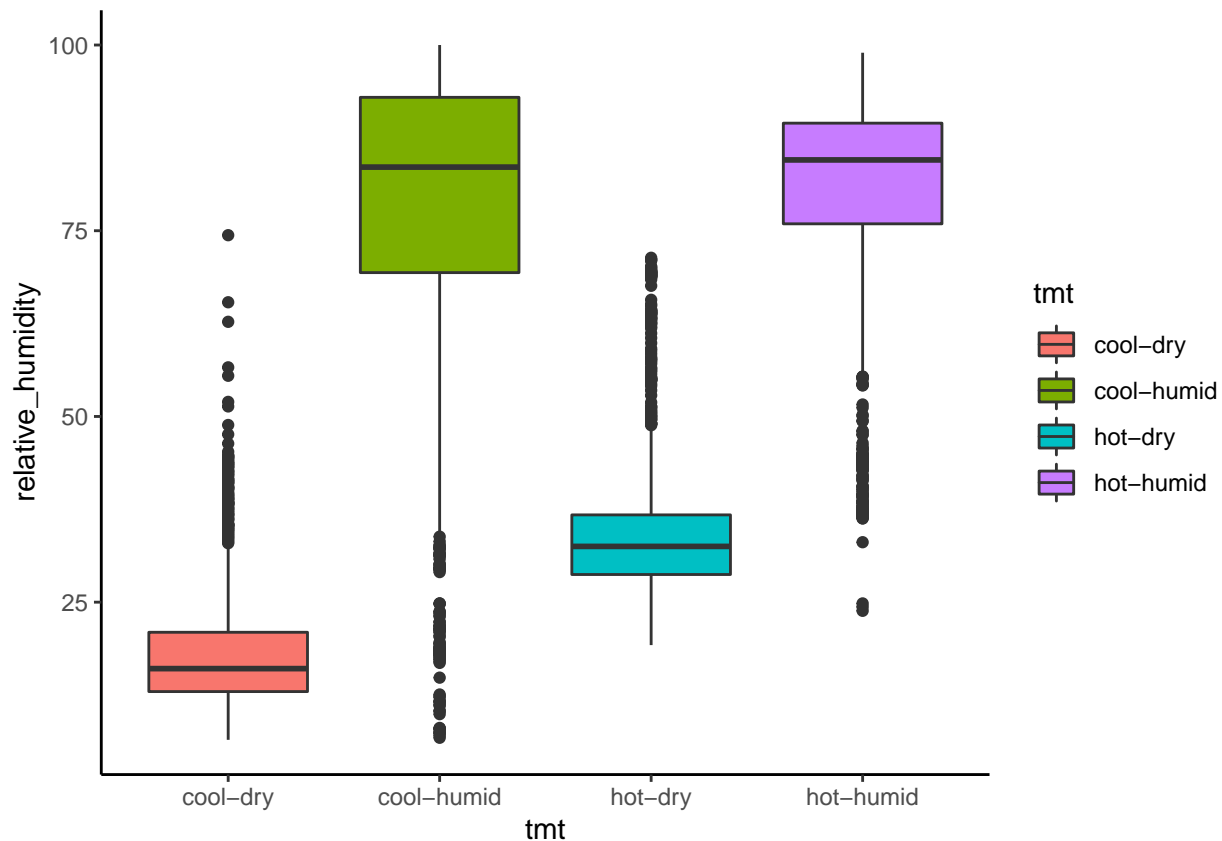
Boxplots

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()
```
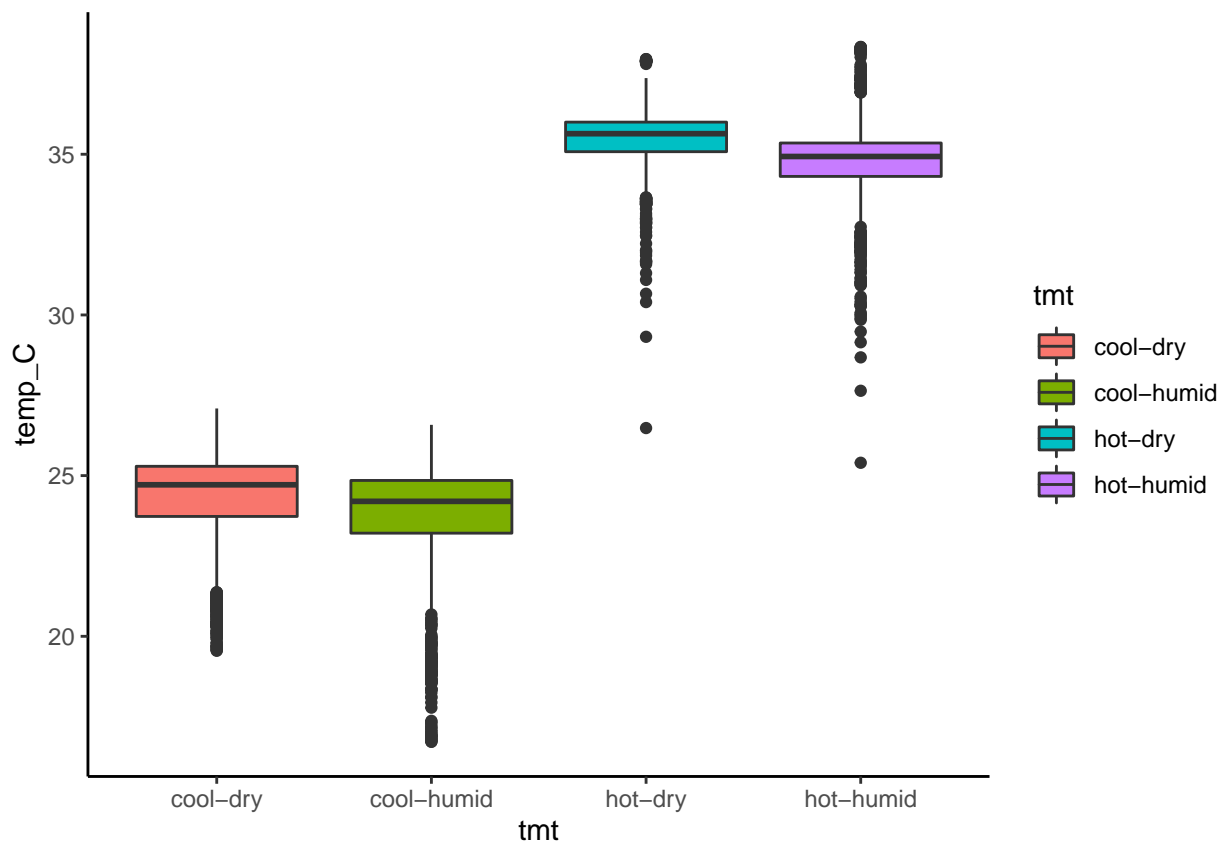


```
format_HOBO_data %>%
  ggplot() +
  geom_boxplot(aes(x = tmt,
                   y = relative_humidity,
                   fill = tmt)) +
  theme_classic()
```

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

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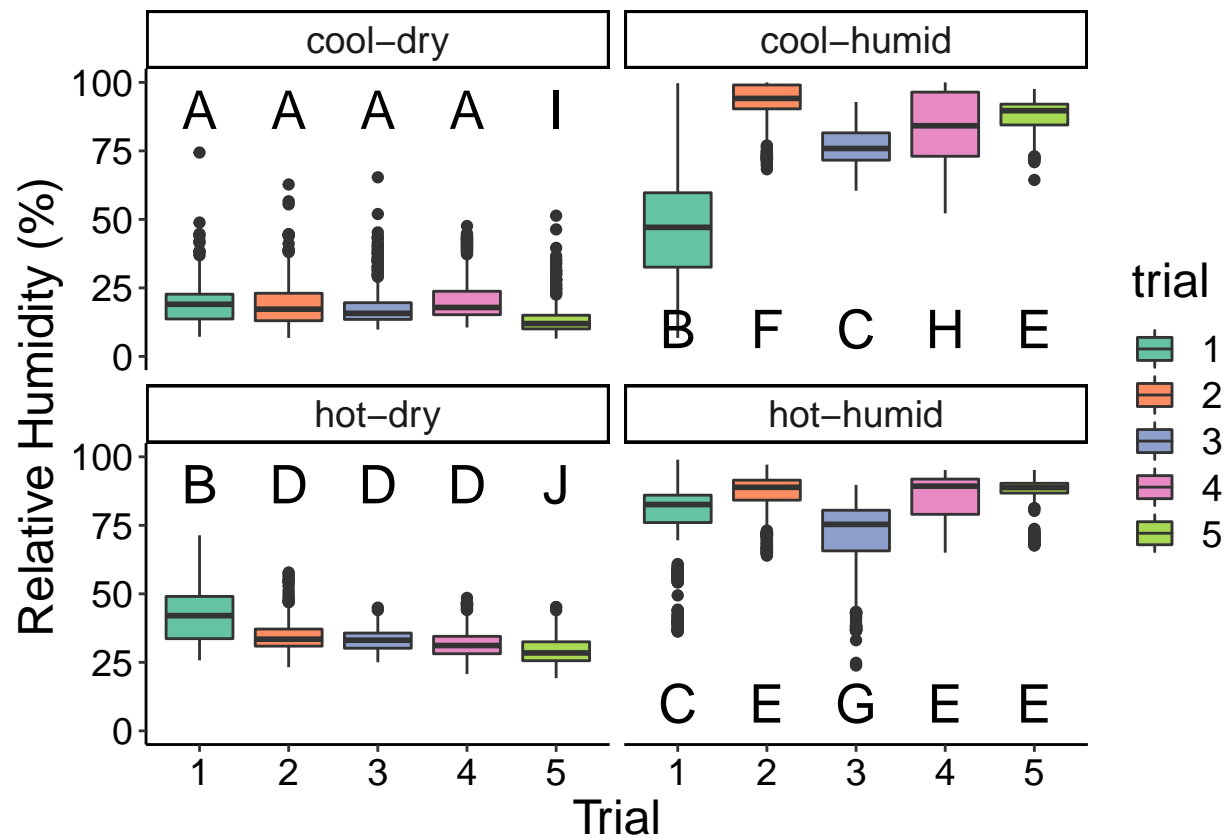
```
# save
ggsave(filename = "ANOVA_humidity_boxplot.jpeg",
       plot = ANOVA_humidity_boxplot,
       path = "./results_figures",
       device = "jpeg",
       dpi = 1200,
       width = 6, height = 4)
```

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