

# HOBO Data Logger Climate Treatment Summary

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## 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 function
  # 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 under
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.

```
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> <dtm>          <dtm>
## 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

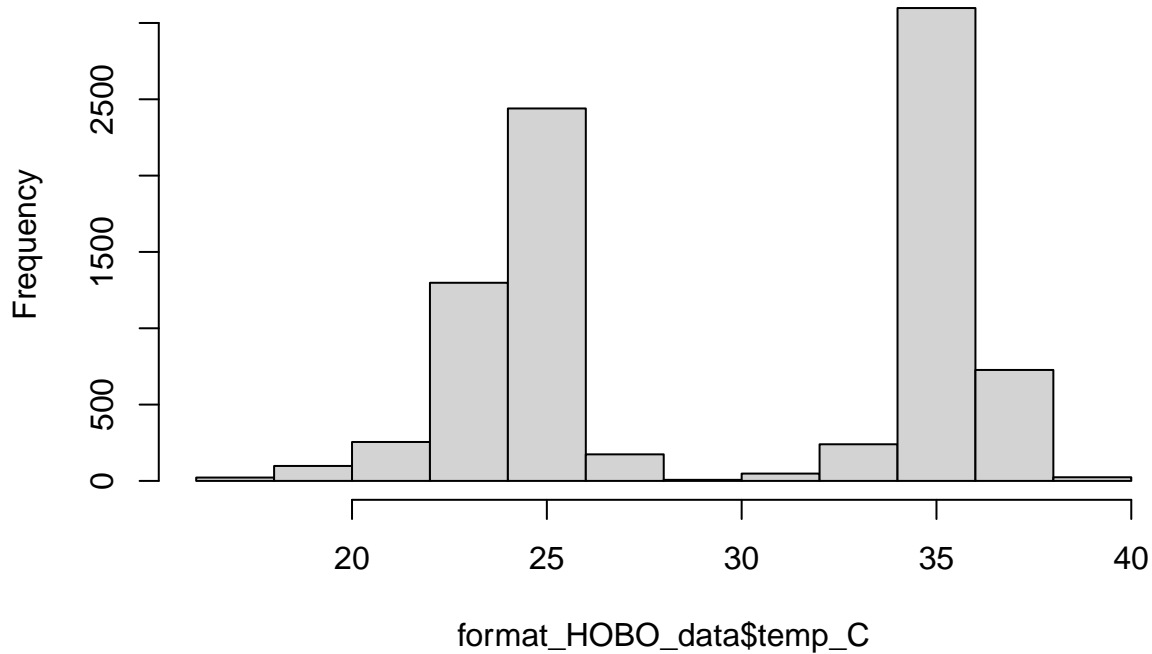
as.Date("2021-06-16 20:00:00")

## [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)
```

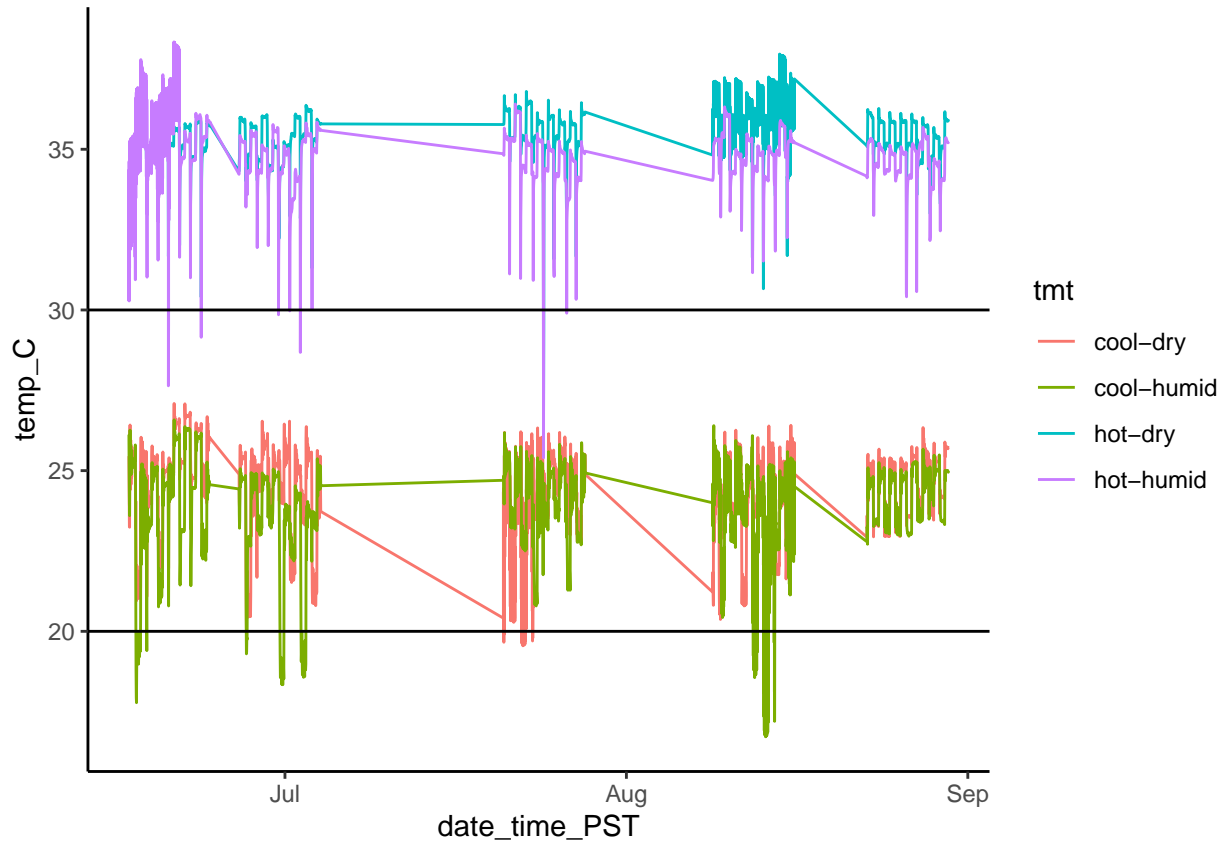
## `summarise()` regrouping output by 'trial', 'serial' (override with `.groups` argument)

```
## # 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
```

```
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	20					

```

## 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
```

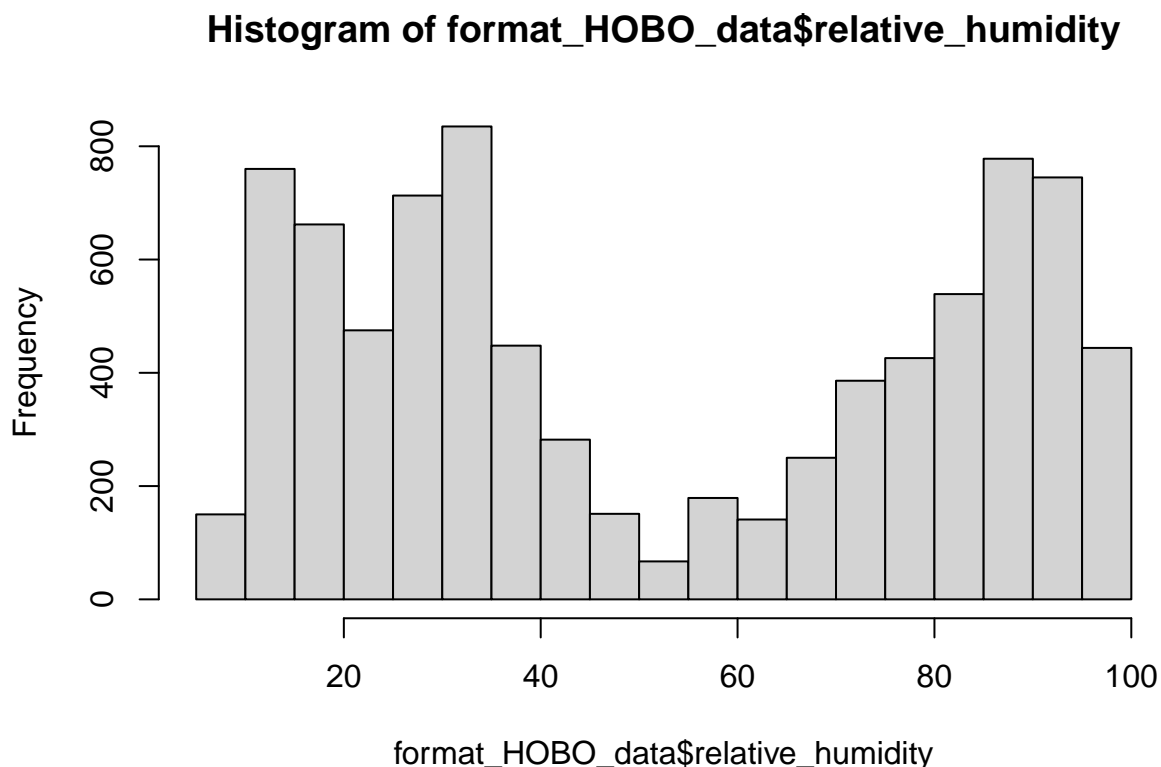
There are only 10 points <30C for the hot treatment, which is very few compared to the total number of measurements. I think these observations are from when the lizards (thus loggers) were out of the incubators for daily checkups. But, this is still technically characteristic of the environment the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

```
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)
```

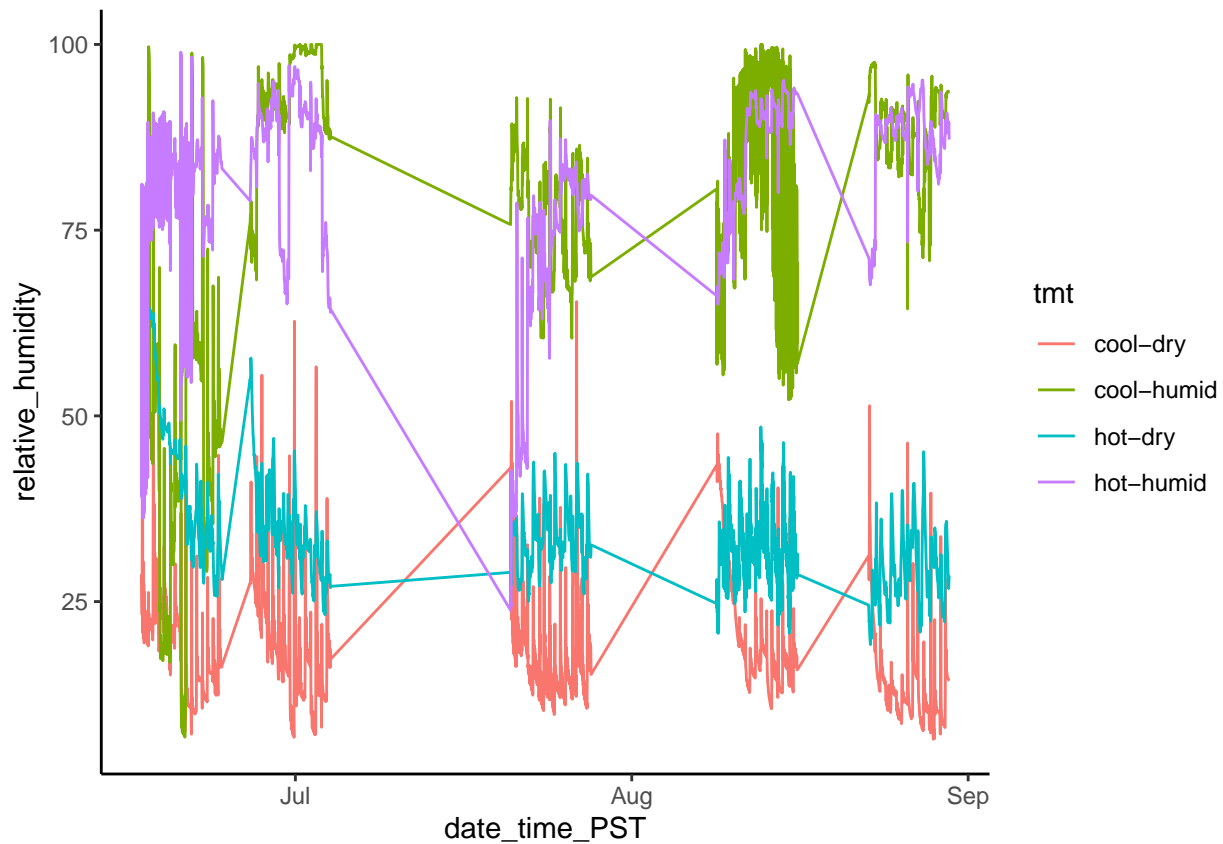
```
## # A tibble: 24 x 6
```

```
## # 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")

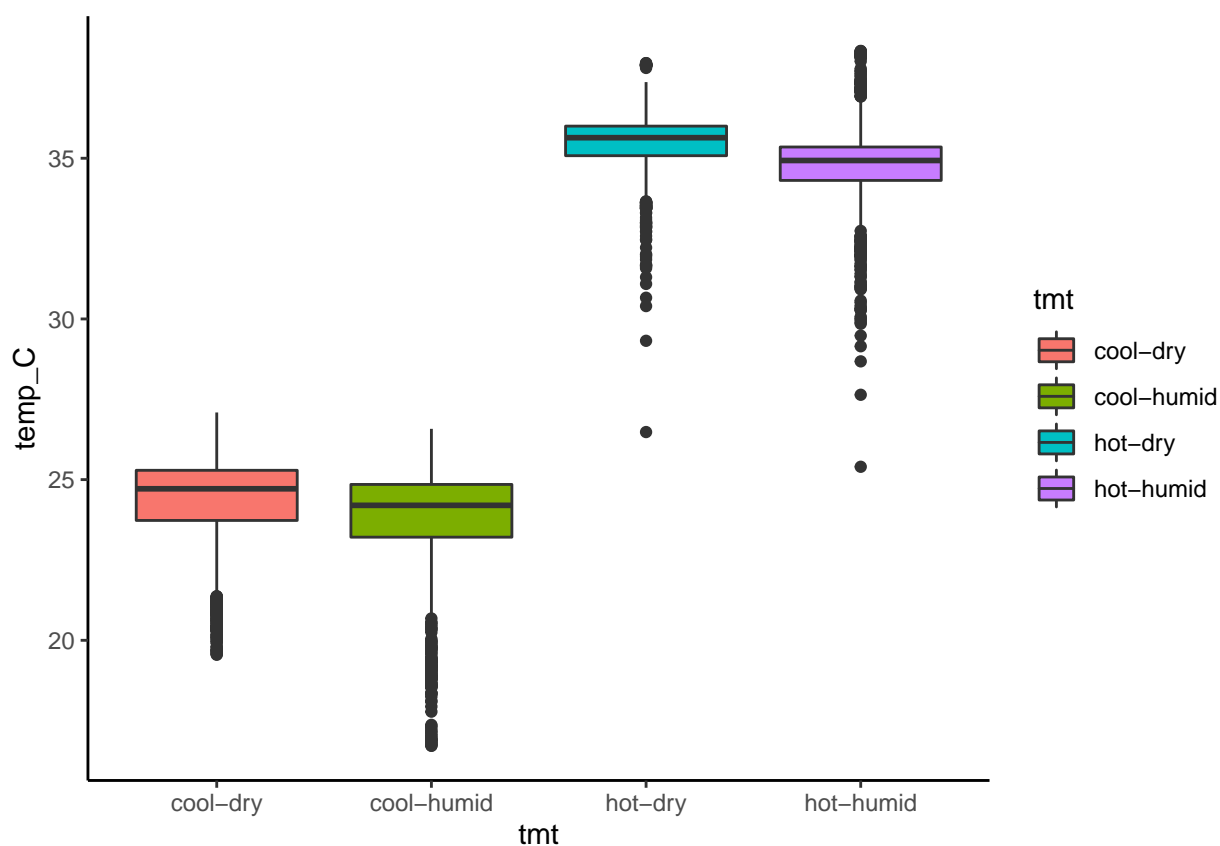
# humidity
humidity_mod <- lm(data = format_HOBO_data,
  relative_humidity ~ tmt * trial)
a_humid_mod <- aov(humidity_mod)
ph_humid_mod <- TukeyHSD(a_humid_mod)
summary(humidity_mod)

##
## 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")
```

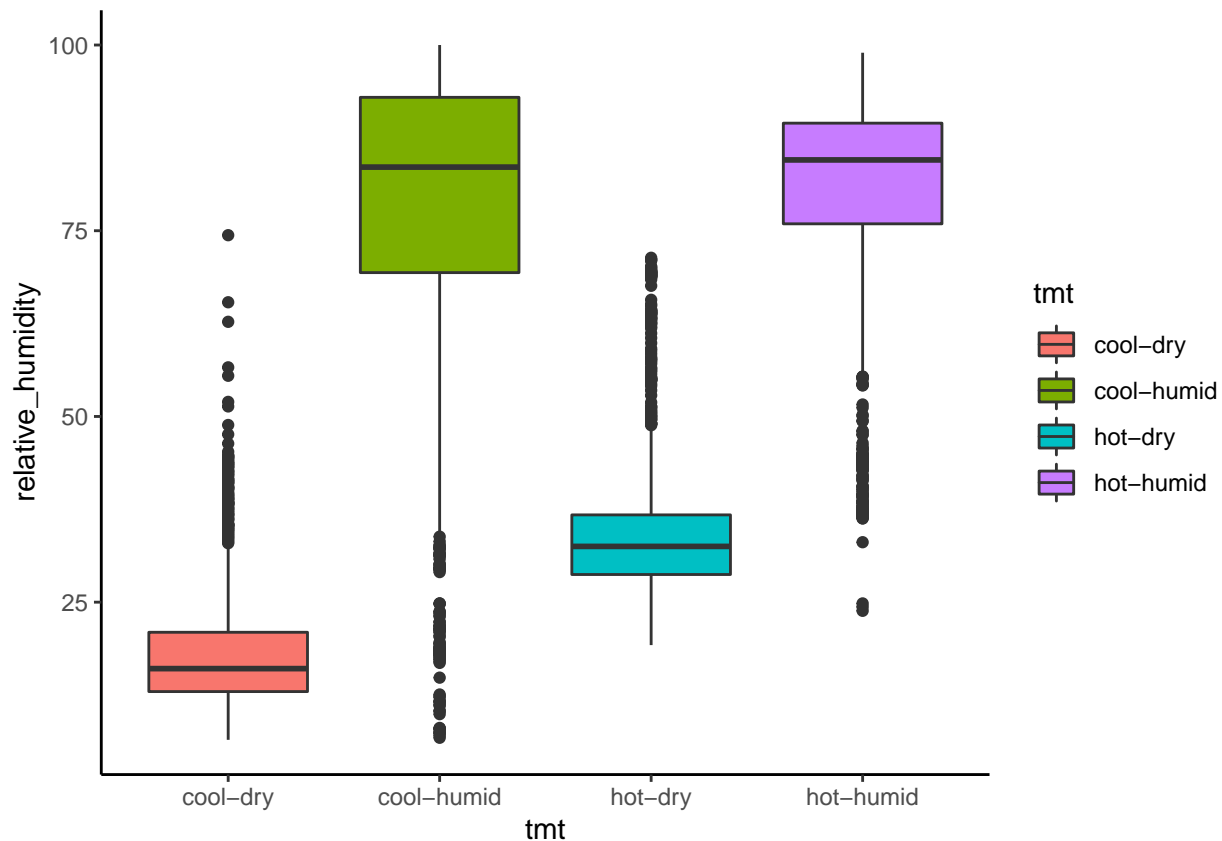
## Boxplots

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",
```

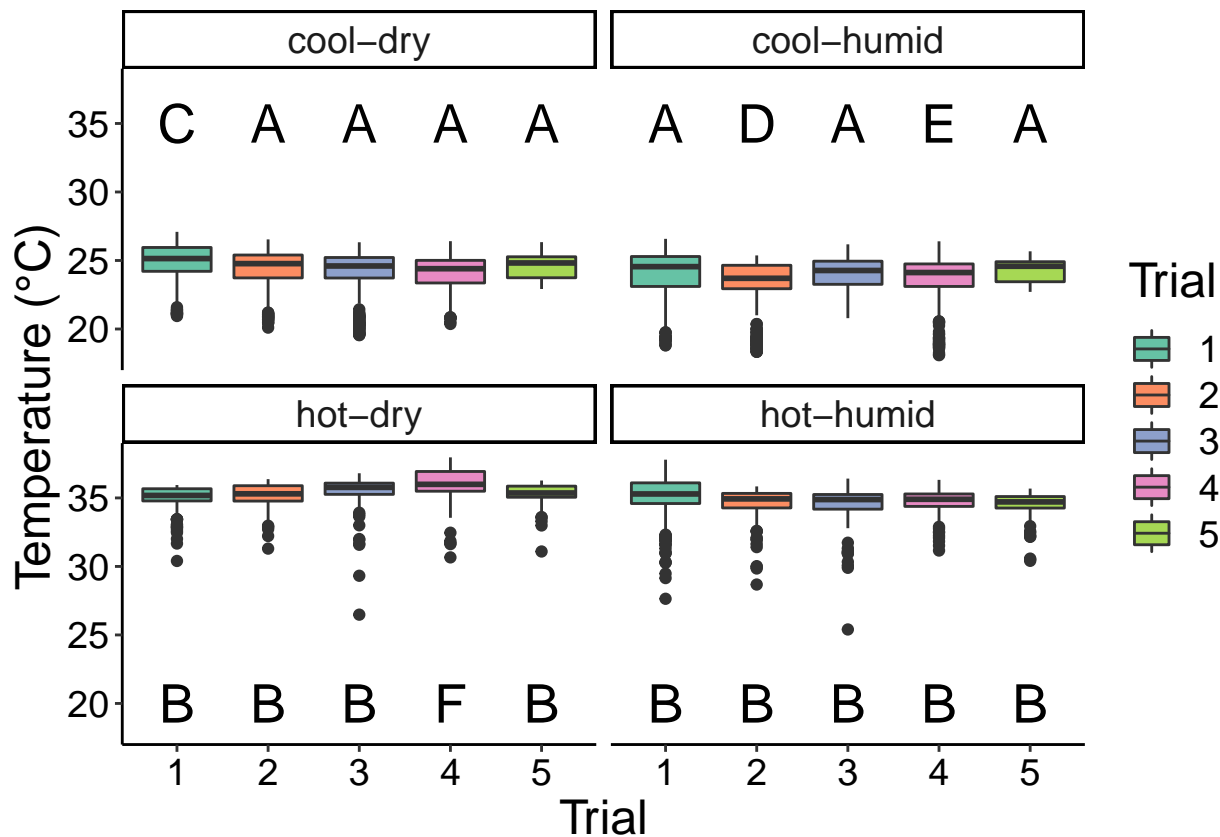
```

        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"))

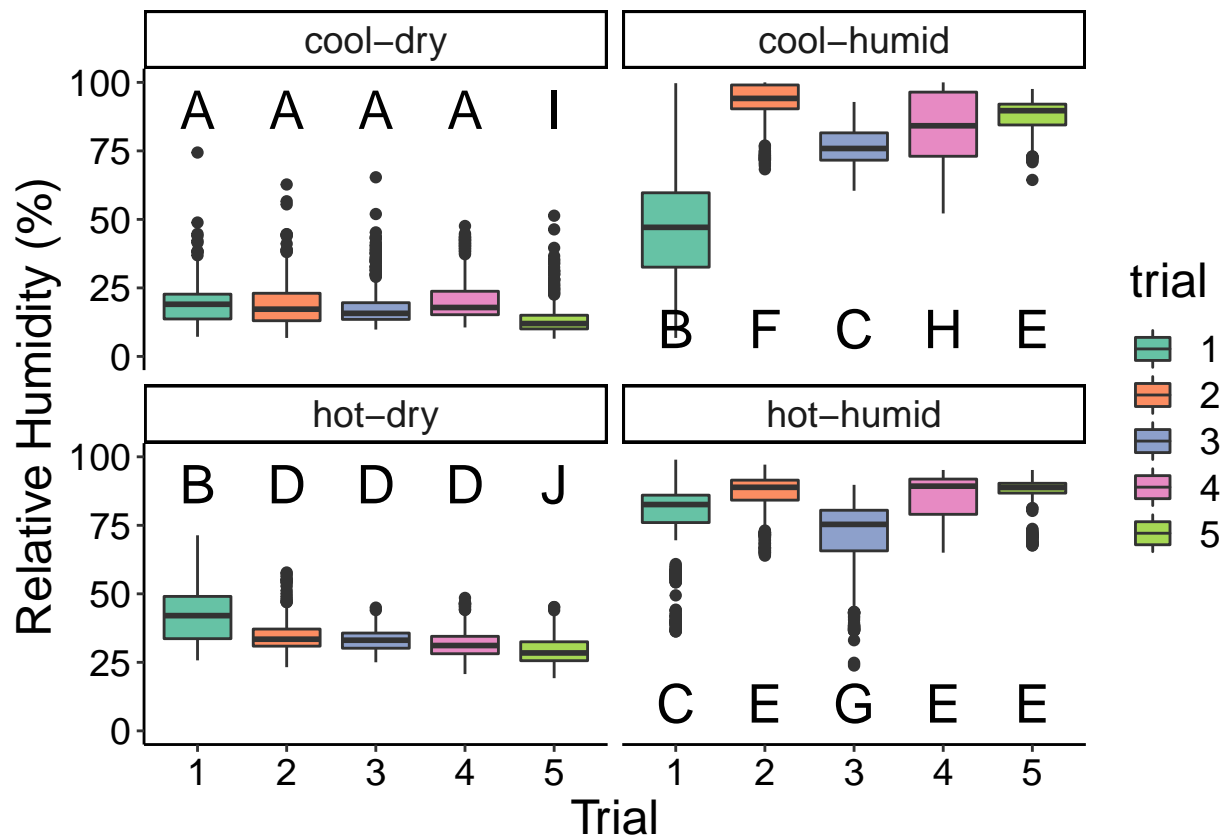
# plot!
format_HOBO_data %>%
  ggplot() +
  geom_boxplot(aes(x = trial,
    y = relative_humidity,
```



```

        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)
```