

# Homework 8: Squirrel Sizes

## Comparing a Numerical Variable Across More Than Two Groups

Researchers set out to explore how squirrel size is impacted by latitude. Specifically, focusing on the lengths (in mm) observed in four distinct California locations: Big Bear, Hemet, Susanville, and Loop Hill. As these agile creatures navigate different environments, their lengths become a fascinating avenue for investigation, offering insights into potential ecological variations and adaptation strategies. Understanding the nuances in squirrel lengths across diverse locations not only contributes to our knowledge of local fauna but also has broader implications for ecosystem dynamics and the impact of environmental factors on wildlife morphology.

```
head(squirrels)
```

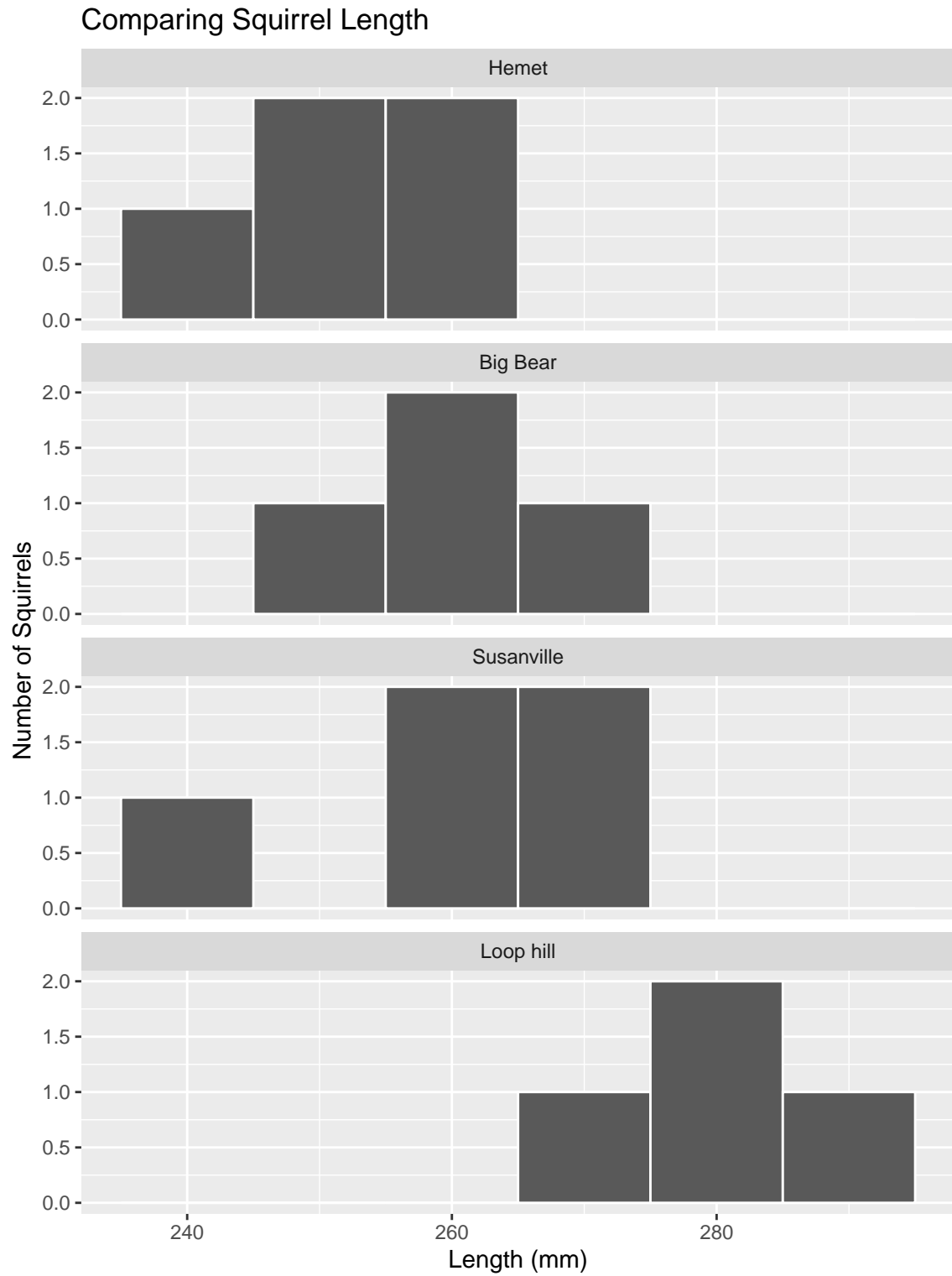
```
# A tibble: 6 x 2
  Location Length
  <fct>      <dbl>
1 Big Bear    249
2 Hemet       248
3 Hemet       242
4 Big Bear    256
5 Hemet       251
6 Loop hill   291
```

**Research question** Does the mean length of all squirrels differ between the four selected California locations?

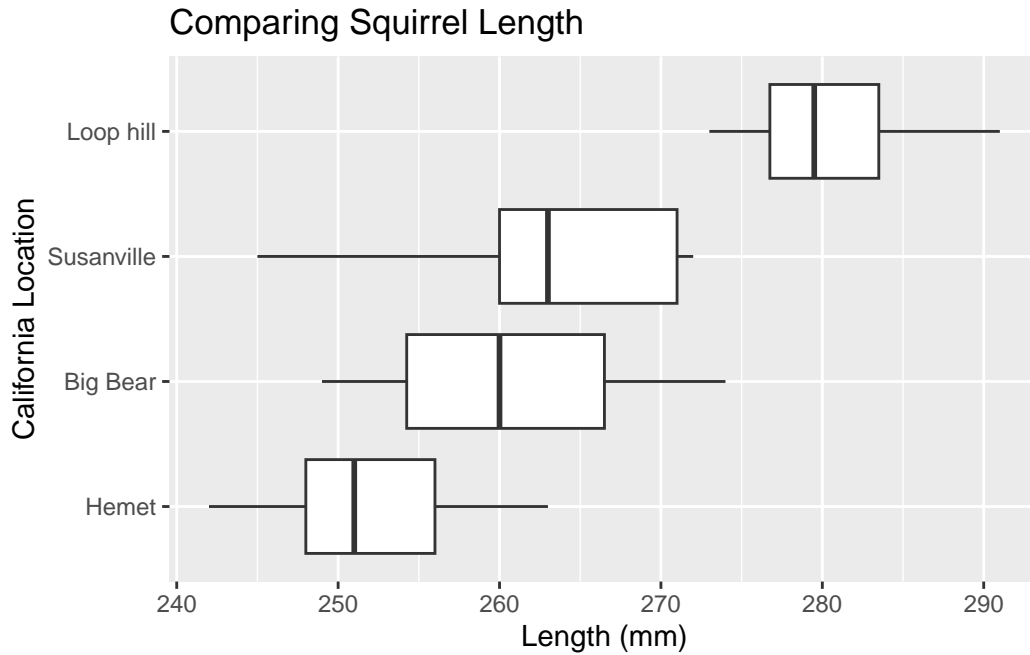
```
favstats(Length ~ Location, data = squirrels)
```

	Location	min	Q1	median	Q3	max	mean	sd	n	missing
1	Hemet	242	248.00	251.0	256.0	263	252.00	7.968689	5	0
2	Big Bear	249	254.25	260.0	266.5	274	260.75	10.750969	4	0
3	Susanville	245	260.00	263.0	271.0	272	262.20	10.894953	5	0
4	Loop hill	273	276.75	279.5	283.5	291	280.75	7.588368	4	0

```
ggplot(data = squirrels,
       mapping = aes(x = Length)) +
  geom_histogram(binwidth = 10, color = "white") +
  facet_wrap(~Location, ncol = 1) +
  labs(title = "Comparing Squirrel Length",
       x = "Length (mm)",
       y = "Number of Squirrels")
```



```
ggplot(data = squirrels,  
       mapping = aes(x = Length,  
                     y = Location))  
  ) +  
  geom_boxplot() +  
  labs(title = "Comparing Squirrel Length",  
       x = "Length (mm)",  
       y = "California Location")
```



1. Identify the variables (levels/units) and data type.
  - Explanatory:
  - Response:
2. Is this an experimental study or observational study? Explain.

3. Discuss the visual comparison of the the four California locations. Which location appears to have a higher average squirrel length? The smallest? Do you think you will find evidence of a discernible difference in length between locations?
4. Identify the observed mean, standard deviation, and sample size of each Location in the study. make sure to assign appropriate symbols.
5. State the parameters in words with symbols (hint: there should be 4 of them).
7. Write the null and alternative hypotheses using the appropriate mathematical symbols.
8. Check the assumptions necessary to conduct an ANOVA F-test.

9. The following R code conducts an ANOVA F-test on the data. I have intentionally removed the degrees of freedom, mean square values, and statistic. Show how to determine / calculate these values using the information provided. Make sure to indicate what each value represents (e.g., df1, MSE, F-statistic, etc.).

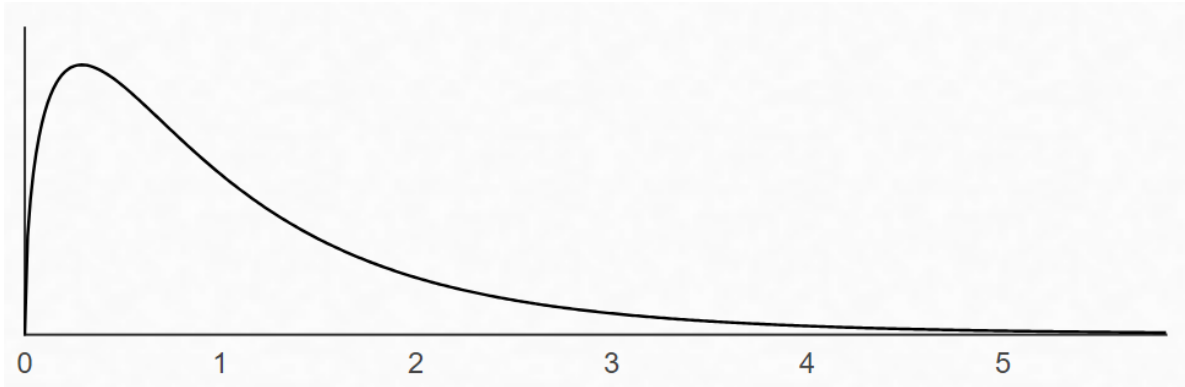
```
squirrel_model <- aov(Length ~ Location,
  data = squirrels
)

squirrel_model |>
  tidy()
```

```
# A tibble: 2 x 6
  term      df    sumsq meansq statistic  p.value
<chr>    <chr> <dbl> <chr>   <chr>    <dbl>
1 Location A      1888. C      E      0.00401
2 Residuals B      1248. D      <NA>    NA
```

- A:
- B:
- C:
- D:
- E

10. Using the F-distribution below, show how you would calculate/estimate the p-value.
11. Using the output above and an  $\alpha = 0.01$  significance level, write a conclusion in the context of the problem.



12. What type of error could have been made? Explain.

Type I

Type II

12. The code below shows the pairwise comparisons with *no multiplicity* adjustment. At an  $\alpha = 0.01$  significance level, which locations indicate a discernible difference in mean squirrel length?

```
emmmeans(squirrel_model,
          specs = ~ Location) |>
pairs(adjust = "none")
```

contrast	estimate	SE	df	t.ratio	p.value
Hemet - Big Bear	-8.75	6.33	14	-1.381	0.1888
Hemet - Susanville	-10.20	5.97	14	-1.708	0.1097
Hemet - Loop hill	-28.75	6.33	14	-4.539	0.0005
Big Bear - Susanville	-1.45	6.33	14	-0.229	0.8222
Big Bear - Loop hill	-20.00	6.68	14	-2.995	0.0096
Susanville - Loop hill	-18.55	6.33	14	-2.928	0.0110

13. The code below shows the pairwise comparisons with a *tukey* multiplicity adjustment. At an  $\alpha = 0.01$  significance level, which locations indicate a discernible difference in mean squirrel length?

```
emmmeans(squirrel_model,
          specs = ~ Location) |>
pairs(adjust = "tukey")
```

contrast	estimate	SE	df	t.ratio	p.value
Hemet - Big Bear	-8.75	6.33	14	-1.381	0.5303
Hemet - Susanville	-10.20	5.97	14	-1.708	0.3560
Hemet - Loop hill	-28.75	6.33	14	-4.539	0.0023
Big Bear - Susanville	-1.45	6.33	14	-0.229	0.9956
Big Bear - Loop hill	-20.00	6.68	14	-2.995	0.0425
Susanville - Loop hill	-18.55	6.33	14	-2.928	0.0480

P value adjustment: tukey method for comparing a family of 4 estimates

14. Compare your decisions/results in the previous two questions. How does including a multiplicity adjustment (e.g., Tukey's) impact the results?

#### Canvas Quiz

Make sure to complete the Homework Quiz on Canvas.