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H Applied Statistics
8 February 2024

Are Snakes Left-Handed?

1) 1-Sample Mean T-test

μ = mean of lateral index values

H_o: μ = 0.5
H_o: μ ≠ 0.5
α = 0.05

Checks:
- Random: assume random selection
- Normal: CLT n>30, sample size is large enough

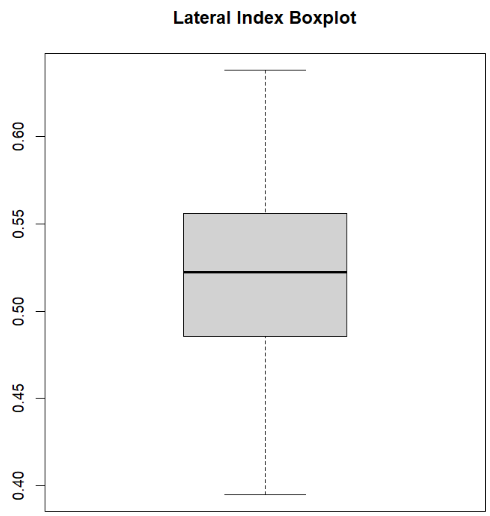
Calculations:

$$t = \frac{\bar{x} - \mu}{\frac{s}{\sqrt{n}}} = \frac{0.5183611 - 0.5}{\frac{0.05658983}{\sqrt{36}}} = 1.9468$$

p-value = p($t >$ 1.9468)x2 = 0.05962

Since the p-value(0.05962) > α(0.05), we fail to reject the null hypothesis. Therefore, there is not convincing evidence that snakes **do not** exhibit asymmetric coiling behavior (based on lateral index values).

Plot:



2) Categories and combinations of categories.

Model	Equation	R^2	R^2(adjusted)	S_e	F-statistic
Length	y = 0.50139 + 0.01471x	0.008874	-0.02028	0.05716	0.3044
Gender	y = 0.53644 - 0.03617x	0.105	0.07871	0.05432	3.99
Age	y = 0.54572 - 0.05472	0.2405	0.2181	0.05004	10.76
Age+Length	y = 0.65768 - 0.09503x1 - 0.07956x2	0.3696	0.3314	0.04627	9.673
Gender+Length	y = 0.47529 - 0.06233x1 + 0.06434x2	0.2198	0.1725	0.05148	4.649
Gender+Age	y = 0.56381 - 0.03617x -	0.3455	0.3058	0.04715	8.709

	0.05472x2				

The chosen model has the highest R^2 and R^2(adjusted) value, the lowest standard error, and the second highest F-statistic, which are all good things to have in a model.

3) Do adults differ from juveniles? Males from females?

2 2-Sample Difference in Means T-tests

First Test:

μ_1= lat index mean for juveniles

μ_2= lat index mean for adults

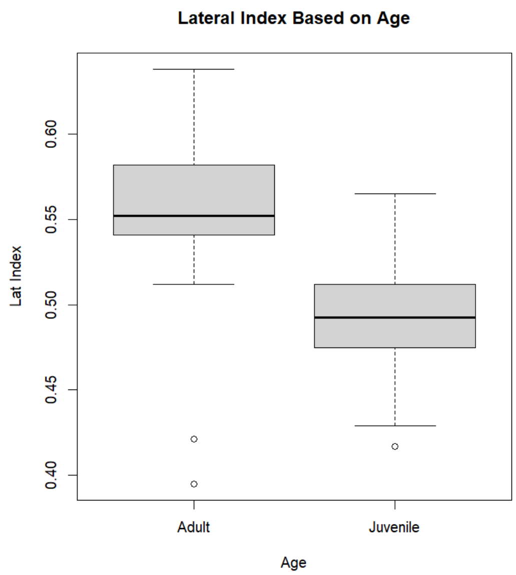
H_o: $\mu_1 = \mu_2$

H_o: $\mu_1 \neq \mu_2$

$\alpha = 0.05$

Checks:

- Normal: Box Plots do not appear normal. Two extreme outliers for adults, and one slight outlier for juveniles. Proceed with caution.



- Assume random selection.

Calculations:

$$t = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} = \frac{(0.491 - 0.5457222) - 0}{\sqrt{\frac{0.03917232^2}{18} + \frac{0.05893546^2}{18}}} = -3.2808 \qquad \text{w/df} = 29.568$$

p-value = p(t > -3.2808) = 0.002657

Since the p-value(0.002657) < α(0.05), we reject the null hypothesis. Therefore, there is convincing evidence to suggest that the difference between the means of the lateral indexes for juveniles and adults are **not** equal to zero.

Second Test:

μ_1= lat index mean for males

μ_2= lat index mean for females

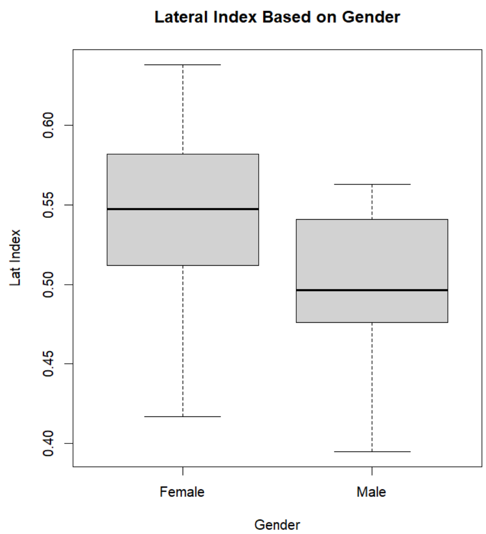
H_o: $\mu_1 = \mu_2$

H_o: $\mu_1 \neq \mu_2$

$\alpha = 0.05$

Checks:

- Normal: The female box plot appears relatively normal, but the male box plot appears skewed left. Proceed with caution.



- Assume random selection.

Calculations:

$$t = \frac{(\overline{x}_1 - \overline{x}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} = \frac{(0.5002778 - 0.5364444) - 0}{\sqrt{\frac{0.04560677^2}{18} + \frac{0.06181207^2}{18}}} = -1.9975 \qquad \text{w/df} = 31.278$$

p-value = p(t > -1.9975) = 0.05453

Since the p-value(0.05453) < α(0.05), we fail to reject the null hypothesis. Therefore, there is not convincing evidence to suggest that the difference between the means of the lateral indexes for males and females is **not** equal to zero.

4) Is there a difference in mean coiling laterality index per each categorical pairing of snake?

μ_1= lat index mean for adults/females (AF)

μ_2= lat index mean for juveniles/females (JF)

μ_3= lat index mean for adults/males (AM)

μ_4= lat index mean for juveniles/males (JM)

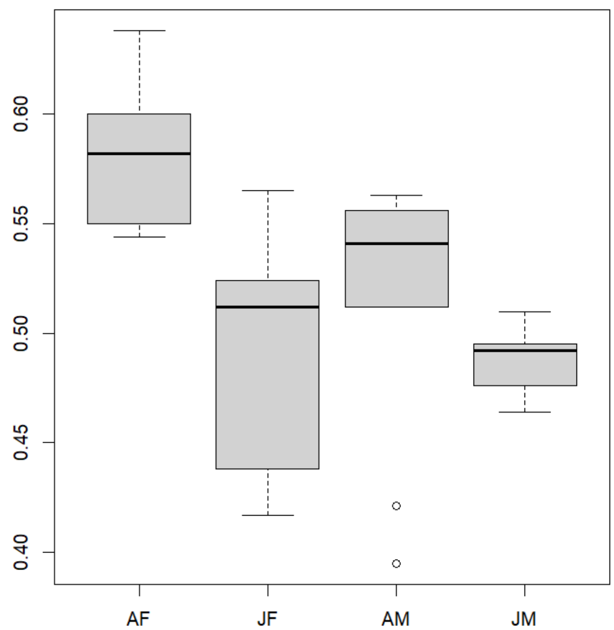
H_o: $\mu_1 = \mu_2 = \mu_3 = \mu_4$

H_o: At least 2 means are different

$\alpha = 0.05$

Checks:

- Normality: Boxplots do not appear normal. AM has extreme outliers, and JM looks the closest to approximately normal. Proceed with caution.



- Equal Variance: the largest standard deviation (S_3) is more than two times the smallest standard deviation (S_4). Proceed with caution.

$S_3 = 0.06218007$

$S_4 = 0.01399107$

- Independence: assume independence.
- Random: assume random selection.

Calculations:

	$\bar{x}$	S	n
μ_1(AF)	0.5785556	0.03300042	9
μ_2(JF)	0.4943333	0.0551362	9
μ_3(AM)	0.5128889	0.06218007	9
μ_4(JM)	0.4876667	0.01399107	9

N = 9(4) = 36
T = 9(0.5785556) + 9(0.4943333) + 9(0.5128889) + 9(0.4876667) = 18.661

$\bar{\bar{x}} = \frac{18.661}{36} = 0.5184$

SSTr = $9(0.5785556 - 0.5184)^2 + 9(0.4943333 - 0.5184)^2 + 9(0.5128889 - 0.5184)^2 + 9(0.4876667 - 0.5184)^2 = 0.046555$

SSE = $8(0.03300042)^2 + 8(0.0551362)^2 + 8(0.06218007)^2 + 8(0.01399107)^2 = 0.065529$

MSTr = $\frac{0.046555}{3} = 0.015518$
MSE = $\frac{0.065529}{32} = 0.00205$

F-stat. = $\frac{0.015518}{0.00205} = 7.5698$

p-value = p(F>7.5698) = 0.00058075

Check means:

```
       AF        AM        JF        JM
0.5785556 0.5128889 0.4943333 0.4876667
```

Check standard deviations:

```
        AF         AM         JF         JM
0.03300042 0.06218007 0.05513620 0.01399107
```

ANOVA Test:

```
Df  Sum Sq  Mean Sq F value   Pr(>F)
Treatment    3 0.04656 0.015518   7.578 0.000577 ***
Residuals   32 0.06553 0.002048
```

Since the p-value(0.00058075) < α(0.05), we reject the null hypothesis. Therefore, there is convincing evidence to suggest that at least two of the mean coiling laterality indexes per each categorical pairing of snakes are **not** equal.