

Statistical Ecology

Stat 555

Assumptions of Analysis of Variance

**PURPOSE:** To determine if shell length of snakehead cowries (*Cypraea caputserpentis*) differ between three populations; a unique Hawaiian subspecies has been proposed that is smaller in size than other Indo-Pacific populations.

**DATA:** n=35 cowries were sampled on Wallaby Is., Fiji, and Oahu and the maximum length of the shell was measured in mm.

MTB > print c1-c5

Data both  
stacked w/ codes  
and unstacked

Row	Wallaby	Fiji	Oahu	All Data Length	codes Pop
1	33.3	31.3	29.3	33.3	1
2	32.2	31.6	29.4	32.2	1
3	24.7	30.4	29.8	24.7	1
4	35.8	30.0	27.9	35.8	1
5	30.0	30.1	29.3	30.0	1

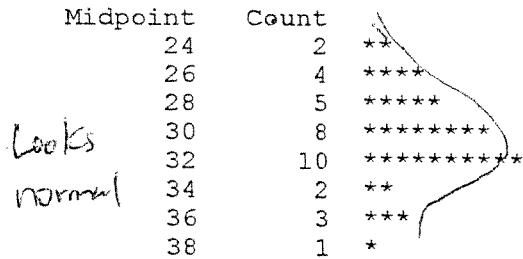
**ASSUMPTIONS:**

1. Random sampling
2. Data normally distributed
3. Sample variances equal
4.  $\alpha = 0.05$

MTB > gstd

MTB > hist c1 c2 c3

Histogram of Wallaby N = 35



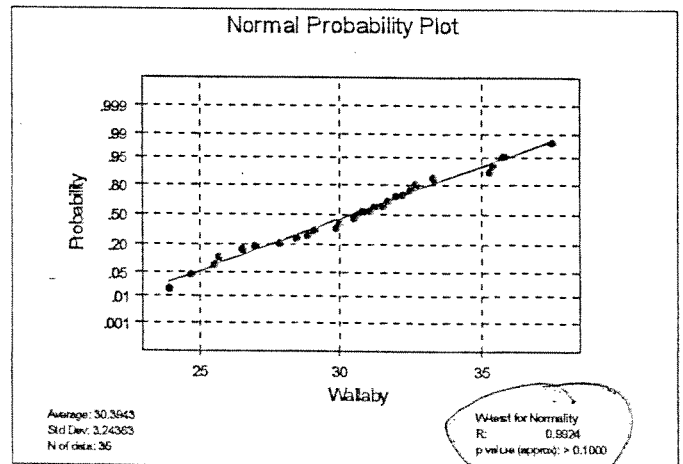
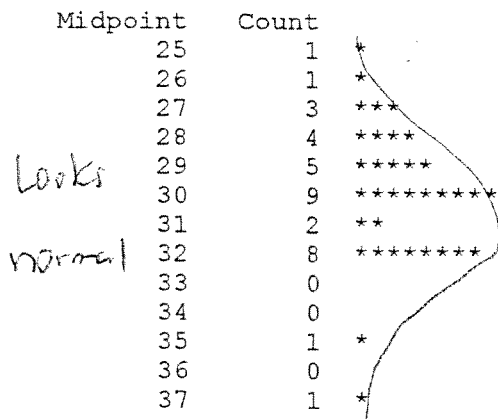
**PURPOSE:** To determine the underlying frequency distribution of shell lengths among snakehead cowries collected at three populations.

**HYPOTHESES:**

$H_0$ : Sample not different from a normally distributed population

$H_A$ : Sample different from a normally distributed population

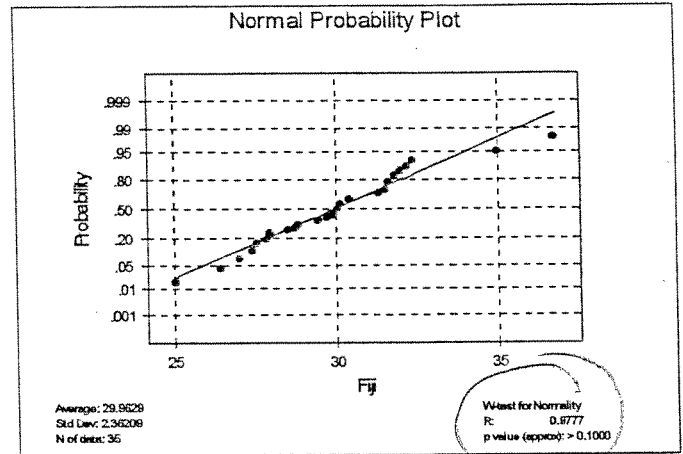
Histogram of Fiji N = 35



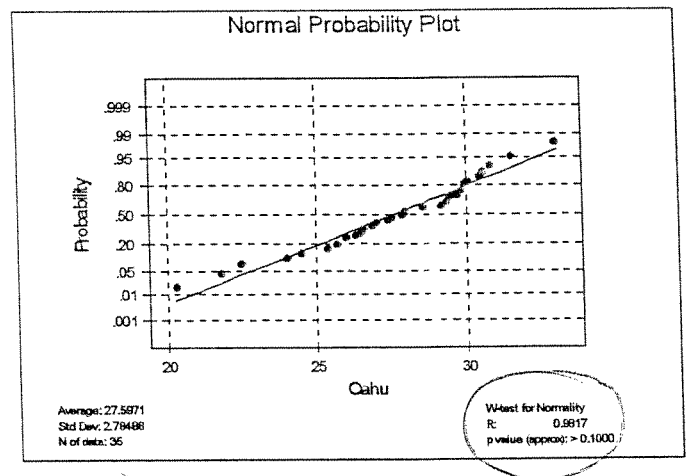
Histogram of Oahu N = 35

Midpoint	Count	
20	1	*
21	0	
22	1	*
23	1	*
24	1	*
25	2	**
26	4	****
27	6	*****
28	4	****
29	5	*****
30	6	*****
31	2	**
32	1	*
33	1	*

Looks  
OK  
Positive  
skew



```
MTB > %NormPlot 'Wallaby';
SUBC> SWTest.
Executing from file:
C:\MTBWIN\MACROS\NormPlot.MAC
Macro is running ... please wait
MTB > %NormPlot 'Fiji';
SUBC> SWTest.
Executing from file:
C:\MTBWIN\MACROS\NormPlot.MAC
Macro is running ... please wait
MTB > %NormPlot 'Oahu';
SUBC> SWTest.
Executing from file:
C:\MTBWIN\MACROS\NormPlot.MAC
Macro is running ... please wait
```



**CONCLUSION:**  $P > 0.05$  for all samples so cannot reject null hypotheses.  
**BIOLOGICAL INTERPRETATION:** all data came from normally distributed populations.

```
MTB > %Vartest Data Codes 'Length' 'Pop';
SUBC> Confidence 95.0.
Executing from file: C:\MTBWIN\MACROS\Vartest.MAC
```

Macro is running ... please wait

Homogeneity of Variance

Response Length  
 Factors Pop  
 ConfLvl 95.0000

↓  
 $\alpha = 5\%$  for  
 each test

Test assumption of equal sample variances  
 (Bartlett's and Levene's Test)

$H_0: \sigma_1 = \sigma_2 = \sigma_3$   
 $H_A: \text{at least one } \sigma \text{ not equal}$

CONCLUSION: both  $P > 0.05$  so cannot reject  $H_0$   
 BIOLOGICAL INTERPRETATION: sample variances not significantly different among populations; assumption of equal variances not violated. Proceed with analysis.

Bonferroni confidence intervals for standard deviations

95% CIs  
for  
Sample  
Variances

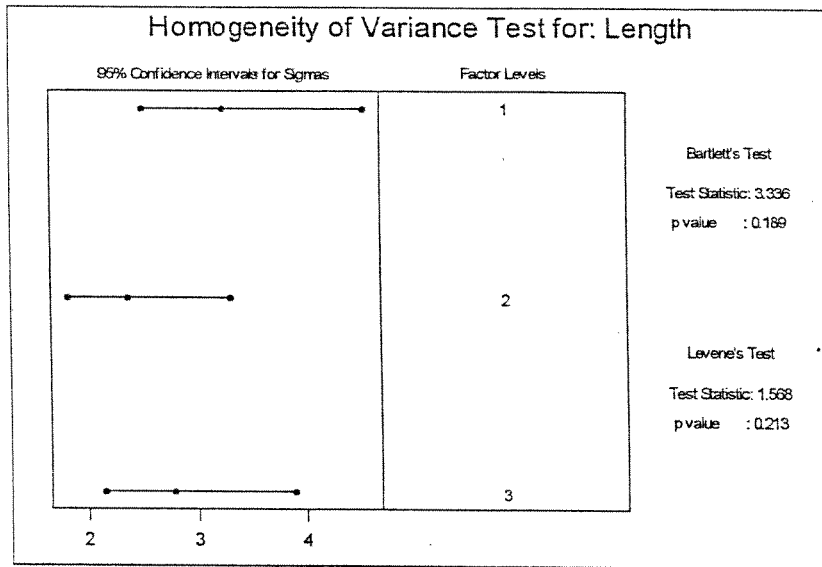
Lower	Sigma	Upper	n	Factor Levels
2.50871	3.24363	4.52983	35	1 Wallaby
1.82690	2.36209	3.29873	35	2 Fiji
2.15390	2.78488	3.88917	35	3 Oahu

Bartlett's Test (normal distribution) → use if normally distributed

Test Statistic: 3.336  
p value : 0.189  $P > 0.05$   $\sigma$ 's not diff.

Levene's Test (any continuous distribution) → use if not normally distributed

Test Statistic: 1.568  
p value : 0.213  $P > 0.05$   $\sigma$ 's not diff.



MTB > Oneway 'Length' 'Pop';  
SUBC> Tukey 5.

One-Way Analysis of Variance

Analysis of Variance on Length

Source	DF	SS	MS
Pop	2	158.75	79.37
Error	102	811.11	7.95
Total	104	969.86	

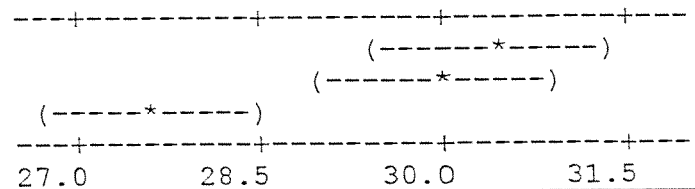
$H_0: \mu_{\text{Wallaby}} = \mu_{\text{Fiji}} = \mu_{\text{Oahu}}$   
 $H_A: \text{at least one } \mu \text{ not equal}$   
 CONCLUSION:  $P < 0.05$  so reject  $H_0$ ;  
 at least one  $\mu$  different

F 9.98      p 0.000

Level	N	Mean	StDev
Wallaby	1	30.394	3.244
Fiji	2	29.963	2.362
Oahu	3	27.597	2.785

Pooled StDev = 2.820

Individual 95% CIs For Mean  
Based on Pooled StDev



Tukey's pairwise comparisons

Family error rate = 0.0500  
Individual error rate = 0.0192

Critical value = 3.36

Intervals for (column level mean)  
- (row level mean)

	Wallaby 1	Fiji 2	
Fiji	2	-1.170 2.033	
Oahu	3	1.196* 4.399	0.764* 3.967

$H_0: \mu_{\text{Wallaby}} = \mu_{\text{Fiji}}$   
 $H_A: \mu_{\text{Wallaby}} \neq \mu_{\text{Fiji}}$   
 CONCLUSION: 95% CI does include 0, cannot reject  $H_0$ ; sample means not different.

$H_0: \mu_{\text{Wallaby}} = \mu_{\text{Oahu}}$   
 $H_A: \mu_{\text{Wallaby}} \neq \mu_{\text{Oahu}}$   
 CONCLUSION: 95% CI does not include 0, reject  $H_0$ ; sample means different.

$H_0: \mu_{\text{Fiji}} = \mu_{\text{Oahu}}$   
 $H_A: \mu_{\text{Fiji}} \neq \mu_{\text{Oahu}}$   
 CONCLUSION: 95% CI does not include 0, reject  $H_0$ ; sample means different.

\* Sig. diff. at  $\alpha = 5\%$

STATISTICAL CONCLUSION:	Sample	Mean Length	Sig. Range
	Wallaby	30.29	I
	Fiji	29.96	I
	Oahu	27.60	I

Shells from Oahu are significantly smaller than those from Wallaby Is. or Fiji

**BIOLOGICAL INTERPRETATION:** Smaller shell size is consistent with the idea of a unique subspecies of snakehead cowry in the Hawaiian Islands. Smaller size could be due to cooler seawater temperatures, a different diet, or a variety of other ecological factors. An additional study is needed to establish that snakehead cowries from other Hawaiian Islands are small in size and differences in the ecological conditions among the three populations needs to be examined in order to reach further conclusions.