

STATISTICAL ECOLOGY
Stat 555

Analysis of variance models

Example: Model I vs. II ANOVA

PURPOSE: To determine if mean density of rock boring urchins (*Echinometra mathaei*) differed among asampling teams in the same area.
DATA: n=15 0.25m² quadrats were sampled at Onekahaha, Hawaii in 1995 and the total number of urchins was recorded by each team.

- ASSUMPTIONS:**
1. Random sampling
 2. Data normally distributed
 3. Equal group variances
 4. $\alpha = 0.05$

MTB > Oneway 'Density' 'Team'.

ANALYSIS OF VARIANCE ON Density

SOURCE	DF	SS	MS	F	p
Team	5	4450	890	5.07	0.000
ERROR	84	14752	176		
TOTAL	89	19202			

INDIVIDUAL 95 PCT CI'S FOR MEAN
BASED ON POOLED STDEV

LEVEL	N	MEAN	STDEV	CI Lower	CI Upper
1	15	31.20	16.78	14.42	47.98
2	15	20.87	17.90	2.97	38.77
3	15	10.93	8.50	2.43	19.43
4	15	16.60	11.41	5.18	28.02
5	15	11.47	7.91	3.56	19.38
6	15	13.33	13.66	-0.33	27.00

POOLED STDEV = 13.25

$H_0: A_1 = A_2 = A_3 = A_4 = A_5 = A_6$
 $H_A: \text{at least one } A_i \text{ different}$
CONCLUSION: $P < 0.05$ so reject null hypothesis
BIOLOGICAL INTERPRETATION: urchin density varies significantly among different sampling teams

MTB > anova density=team;
 SUBC> random team;
 SUBC> ems.

Factor	Type	Levels	Values
Team	random	6	1 2 3 4 5 6

Analysis of Variance for Density

Source	DF	SS	MS	F	P
Team	5	4449.9	890.0	5.07	0.000
Error	84	14751.7	175.6		
Total	89	19201.6			

Source	Variance component	Error term	Expected (using unrestricted model)	Mean Square
1 Team	47.62	2	(2) +	15.0000(1)
2 Error	175.62		(2)	

$H_0: \sigma_A = 0$

$H_A: \sigma_A \neq 0$

CONCLUSION: $P < 0.05$ so reject null hypothesis; σ_A is non-zero

Estimate σ_A : $47.62 + 175.62 = 223.24$; $47.62/223.24 \times 100 = 21.3\%$

BIOLOGICAL INTERPRETATION: sampling bias from different teams accounts for 21.3% of the variation in urchin density

PURPOSE: To determine the extent of different spatial levels of variation in salinity in shallow, nearshore pond in Hawaii relative to team bias
DATA: Two water samples were taken along three transects in 25 quadrats by two teams at Onekahaha, Hawaii in 1995. The salinity of each sample was determined by two readings with an optical refractometer.

ASSUMPTIONS:

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

```
MTB > ANOVA 'Salinity' = Transect Team Quadrat Sample Reading;
SUBC> Random 'Transect' 'Team' 'Quadrat' 'Sample' 'Reading';
SUBC> EMS.
```

ANOVA: Salinity versus Transect, Team, Quadrat, Sample, Reading

Factor	Type	Levels
Transect	random	3
Team	random	2
Quadrat	random	25
Sample	random	2
Reading	random	2

Factor	Values
Transect	1, 2, 3
Team	1, 2
Quadrat	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25
Sample	1, 2
Reading	1, 2

Analysis of Variance for Salinity

Source	DF	SS	MS	F	P
Transect	2	974.603	487.302	177.34	0.000
Team	1	4.002	4.002	1.46	0.228
Quadrat	24	476.160	19.840	7.22	0.000
Sample	1	21.282	21.282	7.74	0.006
Reading	1	19.802	19.802	7.21	0.007
Error	570	1566.270	2.748		
Total	599	3062.118			

S = 1.65766 R-Sq = 48.85% R-Sq(adj) = 46.25%

	Variance component	Error term	Expected Mean Square for Each Term (using unrestricted model)
1	Transect	2.42277	6 (6) + 200 (1)
2	Team	0.00418	6 (6) + 300 (2)
3	Quadrat	0.71217	6 (6) + 24 (3)
4	Sample	0.06178	6 (6) + 300 (4)
5	Reading	0.05685	6 (6) + 300 (5)
6	Error	2.74784	(6)

$$H_{01}: \sigma_A \text{ transect} = 0$$

$$H_{02}: \sigma_A \text{ team} = 0$$

$$H_{03}: \sigma_A \text{ quadrat} = 0$$

$$H_{04}: \sigma_A \text{ sample} = 0$$

$$H_{05}: \sigma_A \text{ reading} = 0$$

$$H_{A1}: \sigma_A \text{ transect} \neq 0$$

$$H_{A2}: \sigma_A \text{ team} \neq 0$$

$$H_{A3}: \sigma_A \text{ quadrat} \neq 0$$

$$H_{A4}: \sigma_A \text{ sample} \neq 0$$

$$H_{A5}: \sigma_A \text{ reading} \neq 0$$

CONCLUSION: Reject null hypothesis for transect, quadrat, sample, reading; retain null hypothesis for team

Estimate $\sigma_{A's}$: $\Sigma \sigma_{A's} = 6.006$

$$\sigma_A \text{ transect} = 2.42 / 6.006 \times 100 = \mathbf{40.3\%}$$

$$\sigma_A \text{ quadrat} = 0.712 / 6.006 \times 100 = \mathbf{11.8\%}$$

$$\sigma_A \text{ sample} = 0.062 / 6.006 \times 100 = \mathbf{1.0\%}$$

$$\sigma_A \text{ reading} = 0.057 / 6.006 \times 100 = \mathbf{0.9\%}$$

BIOLOGICAL INTERPRETATION: sampling bias is not significant for salinity measurements; most variation is among transects and quadrats, very little among samples and readings