

Statistical Ecology Stat 555

Factorial Experiments

Purpose: determine the effects of two growth hormones and sex on calcium levels in dogs

MTB > ANOVA 'Calcium' = Sex Hormone Sex*Hormone.

ANOVA: Calcium versus Sex, Hormone

$H_0: A_1 = A_2$ Sex
 $H_0: B_1 = B_2$ Hormone
 $H_0: \text{no } A \times B \text{ interaction}$

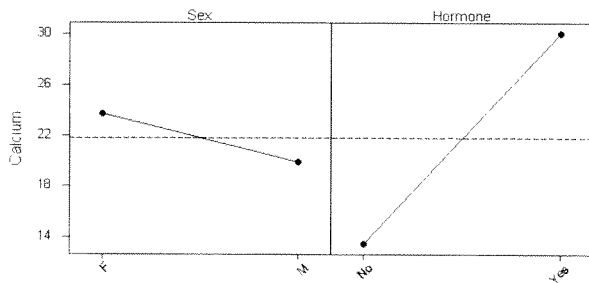
Factor	Type	Levels	Values
Sex	fixed	2	F M
Hormone	fixed	2	No Yes

$$X = \mu + A + B + AB + e$$

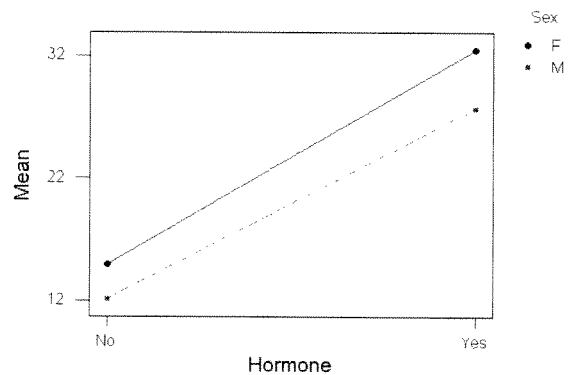
Analysis of Variance for Calcium

Source	DF	SS	MS	F	P
Sex	1	72.20	72.20	3.16	0.094
Hormone	1	1377.80	1377.80	60.31	0.000
Sex*Hormone	1	5.41	5.41	0.24	0.633
Error	16	365.55	22.85		
Total	19	1820.96			

Main Effects Plot - Data Means for Calcium



Interaction Plot - Data Means for Calcium



Purpose: determine the effects of sites, depth and orientation of settling plates on barnacle recruitment in Hilo Bay

MTB > ANOVA 'data' = site|orient|depth.

ANOVA: data versus site, orient, depth

Factor	Type	Levels	Values
site	fixed	2	1 2
orient	fixed	2	1 2
depth	fixed	3	1 2 3

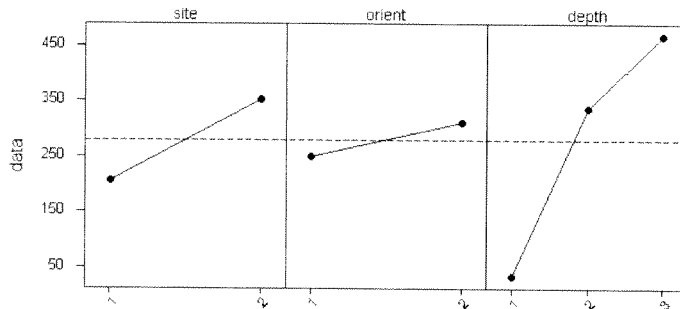
- $H_0: A_1 = A_2$ Sites
- $H_0: B_1 = B_2 = B_3$ Depth
- $H_0: C_1 = C_2$ Orientation
- $H_0: \text{no A x B interaction}$
- $H_0: \text{no A x C interaction}$
- $H_0: \text{no B x C interaction}$
- $H_0: \text{no A x B X C interaction}$

Analysis of Variance for data

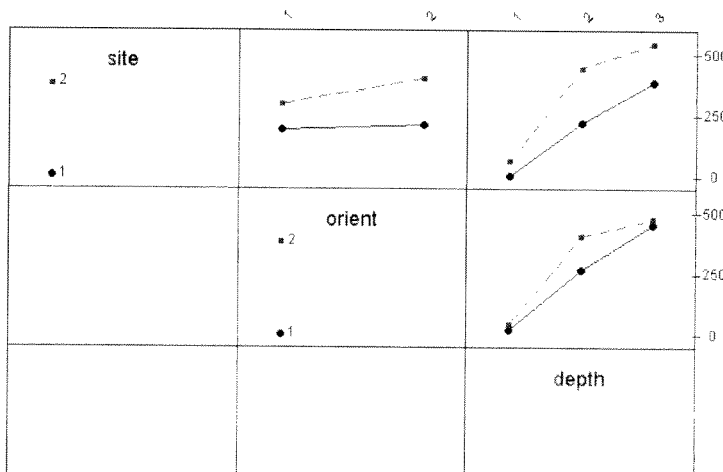
Source	DF	SS	MS	F	P
site	1	129067	129067	27.67	0.000
orient	1	22571	22571	4.84	0.048
depth	2	790677	395339	84.77	0.000
site*orient	1	11354	11354	2.43	0.145
site*depth	2	26916	13458	2.89	0.095
orient*depth	2	17634	8817	1.89	0.193
site*orient*depth	2	4201	2101	0.45	0.648
Error	12	55967	4664		
Total	23	1058387			

$$X = \mu + A + B + C + AB + AC + BC + ABC + e$$

Main Effects Plot - Data Means for data



Interaction Plot - Data Means for data



Purpose: determine the effects of transect, quadrat and depth on salinity in Onekahaha Bay, Hawaii

MTB > ANOVA 'Salinity' = Transect! Quadrat! Depth.

ANOVA: Salinity versus Transect, Quadrat, Depth

Factor	Type	Levels
Transect	fixed	3
Quadrat	fixed	25
Depth	fixed	2

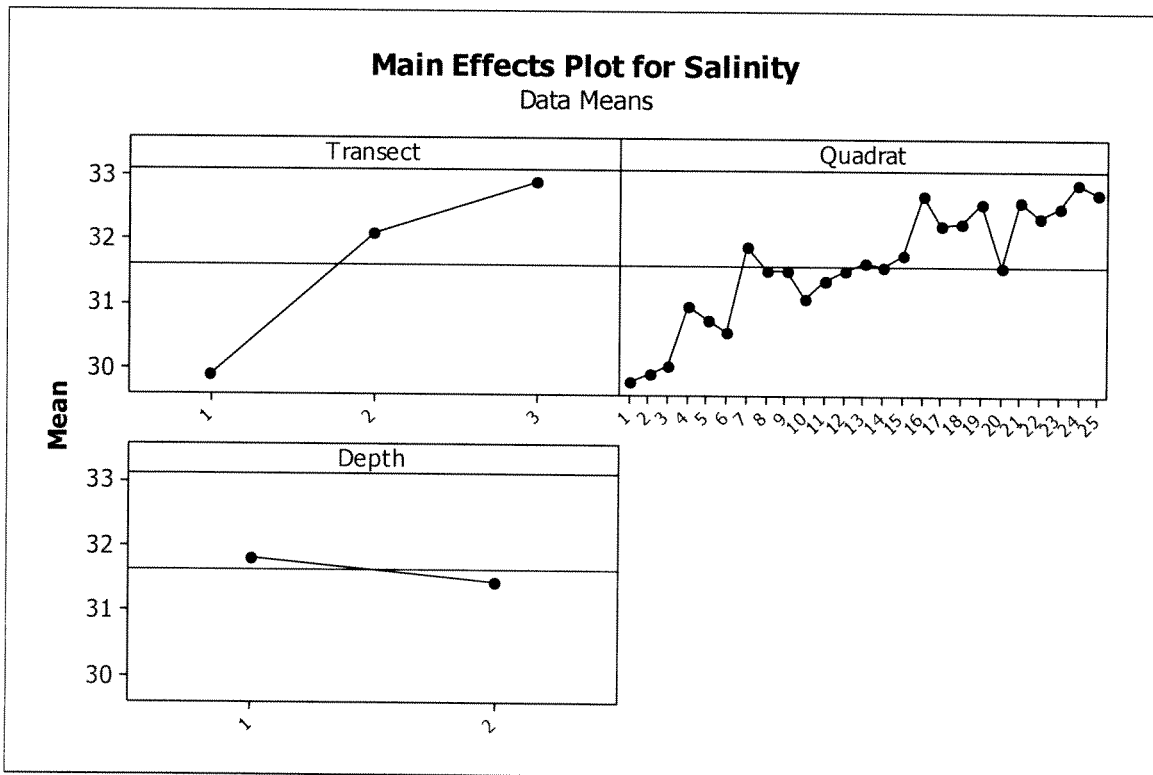
Factor	Values
Transect	1, 2, 3
Quadrat	1, 2, 3, ..., 25
Depth	1, 2

- H₀: A₁ = A₂ = A₃ Transects
- H₀: B₁ = B₂ = ... B₂₅ Quadrats
- H₀: C₁ = C₂ Depth
- H₀: no A x B interaction
- H₀: no A x C interaction
- H₀: no B x C interaction
- H₀: no A x B x C interaction

Analysis of Variance for Salinity

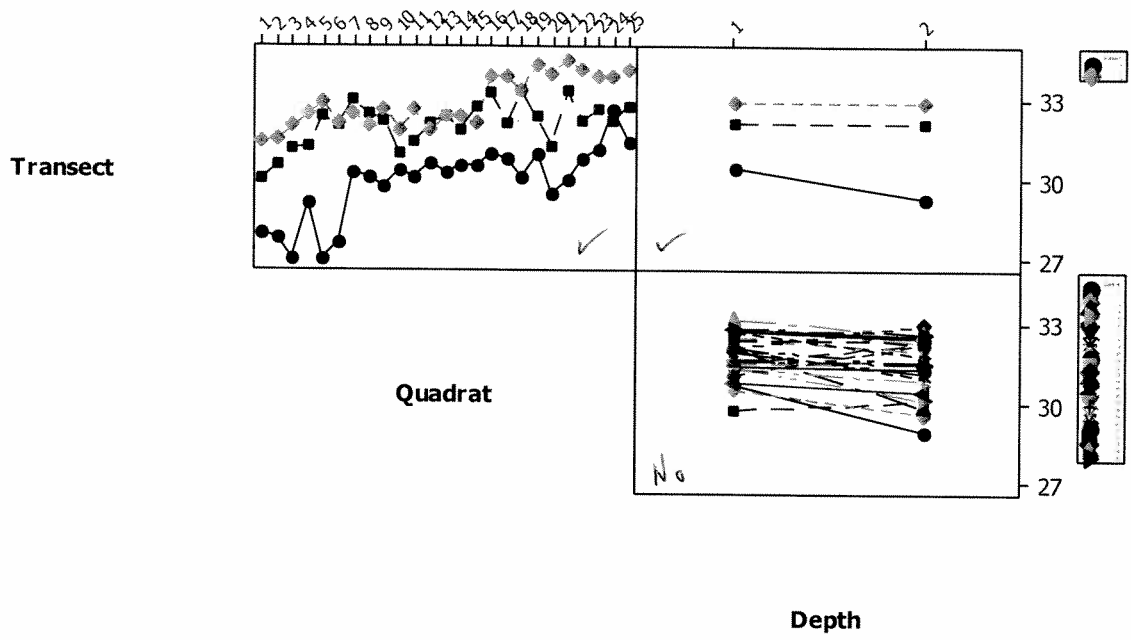
$$X = \mu + A + B + C + AB + AC + BC + ABC + e$$

Source	DF	SS	MS	F	P
Transect	2	974.603	487.302	208.30	0.000
Quadrat	24	476.160	19.840	8.48	0.000
Depth	1	21.282	21.282	9.10	0.003
Transect*Quadrat	48	237.230	4.942	2.11	0.000
Transect*Depth	2	48.423	24.212	10.35	0.000
Quadrat*Depth	24	84.093	3.504	1.50	0.062
Transect*Quadrat*Depth	48	167.577	3.491	1.49	0.022
Error	450	1052.750	2.339		
Total	599	3062.118			



Interaction Plot for Salinity

Data Means



Surface Plot of Salinity vs Transect, Quadrat

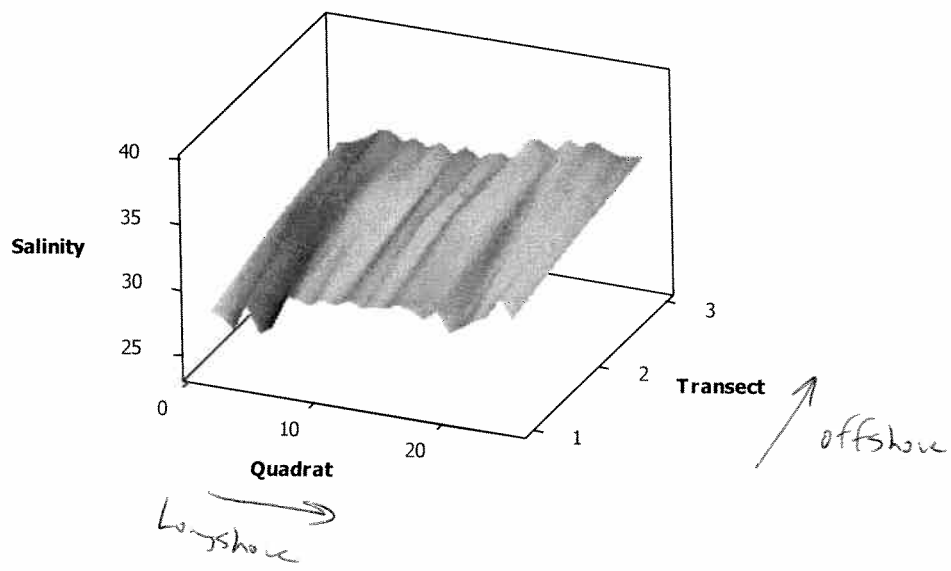


TABLE II
Summary of algal recruitment experiments.

	Wave exposed		Wave sheltered	
	Fogarty Creek Point	Boiler Bay Exposed	Manipulation Bay	North Cove
Dates: Expt. 1 "Winter"	21.7.'86 to 12.14.6.'87 and 10.11.7.'87	24.6.'86 to 14.5.'87 and 11.6.'87	7.7.'86 to 29.4.'87	6.7.'86 to 13.5.'87
Expt. 2 "Summer"	-	-	29.4.'87 to 7.9.'87	13.5.'87 to 10.8.'87
Treatments: Propagule Source	<i>Constantinea simplex</i>		(1) <i>Odonthalia floccosa</i> (2) <i>Neorhodomela larix</i>	
Grazers	(1) Copper barrier (- Grazers, + Copper) (2) Copper strips (+ Grazers, + Copper) (3) Marked plots (+ Grazers, - Copper)		NOT MANIPULATED (Grazers naturally scarce)	
Direction of plots from propagules			Seaward ("upstream") vs. Shoreward ("downstream")	
Early colonists (ephemeral algae)			Present (+ preemptive competition; early colonists not scraped) Absent (- preemptive competition; early colonists scraped except at FCP)	
Distance of plots from propagule source			10, 50, and 100 cm	

plot was 15 × 30 cm, so each row of each block (= three rows of six plots each) was 30 × 200 cm. Wave-exposed blocks consisted of three rows of six 15 × 30 cm plots, while wave-protected blocks consisted of single rows of six 15 × 30 cm plots. As a consequence, the potential influence of edge effects by surfgrass differed between experiments at different exposures. To minimize potential edge effects, surfgrass was cleared from a 10- to 15-cm zone around each block and we trimmed the surfgrass blades so that they could not lie over the recruitment plots. To further minimize edge effects, only the central 10 × 10 cm area was sampled in the top and bottom halves of the 15 × 30 cm plots.

EXPERIMENTAL DESIGN: DEVELOPMENT OF PLANT MOSAIC

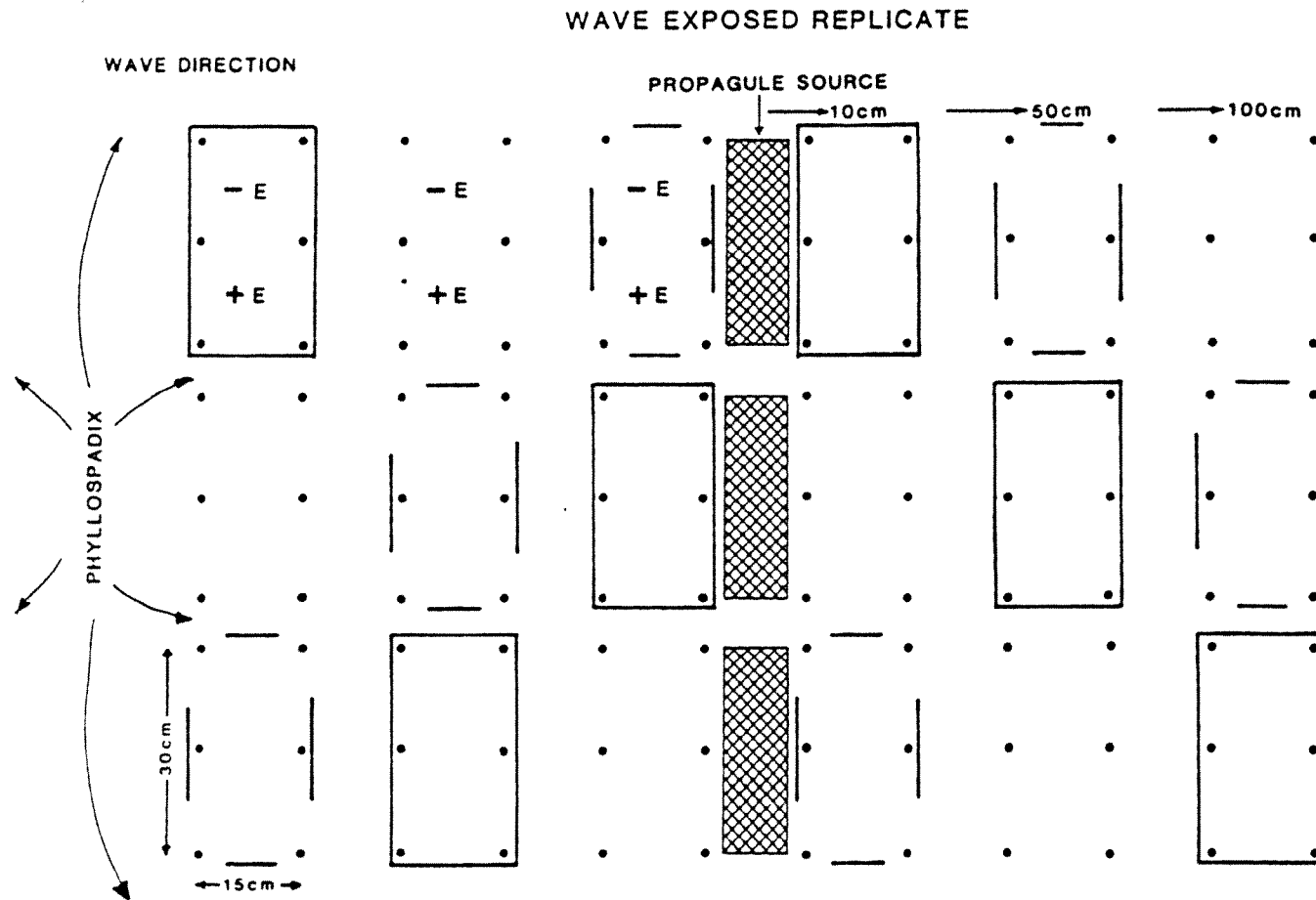


Fig. 1. Design of a wave-exposed replicate of the recruitment experiments. Each was surrounded by *Phyllospadix scouleri* Hook./*P. torreyi* S. Wats. (arrows). Squares or lines around plots represent partial or complete copper metal barriers which excluded limpets and chitons. Propagule source diagrams represent propagule sources (plastic mesh [Vexar] bags containing reproductive thalli of the appropriate species). Rows of plots were arranged parallel to shore and/or perpendicular to wave direction. "Wave direction" indicates the seaward side of the replicate, or the side from which waves first struck the replicate. + E, early colonists present; - E, early colonists removed.

TABLE III

Analysis of variance (Model I, fixed) of the effects of block ($n = 2$), distance of plot from spore source ($n = 3$), grazers ($n = 3$) and direction of plot from spore source ($n = 2$) (X_i) on \ln (number of recruits) per 15×30 cm plot (Y_i) on colonization of *Constantinea simplex* at wave-exposed sites. In all cases, a general linear-model approach was used producing a 3-way ANOVA: $\ln(\text{recruitment}) = B_0$ (constant) + B_1 (block effect) + B_2 (distance effect) + B_3 (direction effect) + B_4 (grazer effect) + B_5 (distance \times direction interaction) + B_6 (distance \times grazer interaction) + B_7 (direction \times grazer interaction) + B_8 (distance \times direction \times grazer interaction). $N = 36$ plots. See Table II for further details.

Site	Source of variation	Sum of squares	df	Mean square	F	p	R^2 (%)
FCP	Block	33.58	1	33.58	39.91	<0.0001	56.3
	Distance	1.17	2	0.58	0.69	0.51	
	Grazers	0.63	2	0.32	0.38	0.69	
	Direction	0.22	1	0.22	0.26	0.62	
	Distance \times grazers	3.66	4	0.92	1.09	0.39	
	Distance \times direction	1.18	2	0.59	0.70	0.51	
	Grazers \times direction	1.17	2	0.58	0.69	0.51	
	Distance \times grazers \times direction	3.76	4	0.94	1.12	0.38	
	Error	14.30	17	0.84			
	Total variance explained						
BBE	Block	4.34	1	4.34	5.57	<0.05	12.9
	Distance	2.54	2	1.27	1.63	0.23	
	Grazers	0.37	2	0.18	0.23	0.79	
	Direction	1.83	1	1.83	2.34	0.14	
	Distance \times grazers	0.96	4	0.24	0.31	0.87	
	Distance \times direction	6.66	2	3.33	4.27	<0.05	
	Grazers \times direction	0.66	2	0.33	0.42	0.66	
	Distance \times grazers \times direction	3.03	4	0.76	0.97	0.45	
	Error	13.26	17	0.78			
	Total variance explained						

Menge et al., 1993