

Raceway Project Specifics

Julie Jacques, January 2018, Biology 7220 Project

Question: To determine the effect of urchin density on aggregation behaviour and gonad index when being fed specialized feed pellets in a stacked raceway design.

My raceway design includes 3 tiers. Initially we were going to use all 3 tiers for the experiment, however now we are hoping to use 2 tiers (if we have enough df) and use the bottom tier to test kelp (a separate experiment). Each tier is divided into 12 compartments which are grouped into sets of 3 by location (first 3 compartments, second 3 compartments, third 3 compartments, and fourth 3 compartments). Each location will have the 3 densities of urchins, one in each compartment of the location. During our last meeting, we also discussed the use of a regression variable as a covariate which would take into account the order of all compartments as a gradient. We are hoping to run 7 trials, and each trial will involve taking ~17 photos of each compartment for aggregation measures (one aggregation measure per photo). At the end of the 7 trials, we will measure the gonad index of 5 urchins per compartment (5 x 24 compartments = 120 measures of gonad index).



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1. Response variables

Response variable 1: Aggregation: Nearest neighbour r-ratio*

Scale: Ratio

Units: no units (fraction)

N = 17

*Nearest neighbour distance (NND: linear distance between the center of each individual and the center of its closest neighbour)

Nearest neighbour R-ratio ($R = r_a/r_e$) (Frey and Gagnon 2016)

- r_e : mean nearest neighbour distance expected under a random distribution at a given density ρ ($r_e = 0.5\rho^{-0.5}$)
- r_a : mean NND for the 72 hour trial

Response variable 2: Gonad index*

Scale: Ratio

Units: Percent

N = 120 (24 compartments x 5 urchins measured per compartment)

$$\text{*Gonad index (GI) (\%)} = \frac{\text{Wet gonad mass (g)}}{\text{Whole urchin wet mass (g)}} \times 100$$

2. Explanatory variables

Name: Density treatment

Scale: Ratio

Units: urchins/m²

Levels: 3

Fixed (we are controlling the levels of this factor)

Name: Tier

Scale: Ordinal

Units: no units

Levels: 2 (had 3 before)

Fixed (we are controlling the levels of this factor)

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Name: Location

Scale: Ordinal

Units: no units

Levels: 4 (maybe 5)

Fixed (we are controlling the levels of this factor)

Name: Trial

Scale: Ordinal

Units: no units

Levels: hopefully 7 (maybe 6)

Random (we just want to control for possible effects by factor)

Name: Gradient covariate

Regression

3. Crosses

Trial x Location: crossed

	Trial 1	Trial 2	Trial 3	...	Trial 7
Loc 1	2	2	2	2	2
Loc 2	2	2	2	2	2
Loc 3	2	2	2	2	2
Loc 4	2	2	2	2	2

Tier x Location: crossed

	Tier 1	Tier 2
Loc 1	1	1
Loc 2	1	1
Loc 3	1	1
Loc 4	1	1

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Trt x Location: crossed

	Low	Med	High
Loc 1	1	1	1
Loc 2	1	1	1
Loc 3	1	1	1
Loc 4	1	1	1

Trt x Tier: crossed

	Low	Med	High
Tier 1	4	4	4
Tier 2	4	4	4

Trial x Tier: crossed

	Trial 1	Trial 2	Trial 3	...	Trial 7
Tier 1	1	1	1	1	1
Tier 2	1	1	1	1	1

Trt x Trial: crossed

	Low	Med	High
Trial 1	8	8	8
Trial 2	8	8	8
Trial 3	8	8	8
...	8	8	8
Trial 7	8	8	8

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Source	df	Crossed/Nested	Fixed/Random
Trt	2		F
Loc	3		F
Tier	1		F
Trial	6		R
Trt*Loc	6	C	F*F
Trt*Tier	2	C	F*F
Trt*Trial	12	C	F*R
Loc*Tier	3	C	F*F
Loc*Trial	18	C	F*R
Tier*Trial	6	C	F*R
Trt*Loc*Tier	6	C	F*F*F
Trt*Loc*Trial	36	C	F*F*R
Loc*Tier*Trial	18	C	F*F*R
Trt*Tier*Trial	12	C	F*F*R
Trt*Loc*Tier*Trial	36	C	F*F*F*R
Covariate	1		
Residuals	2688 (aggregation) 0 (gonad index)		
Total	2856 (aggregation) - 168 120 (gonad index) - 168		

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$$F_{\text{trt}} = \frac{\text{Trt} + \text{Trial} * \text{Trt} + \text{Loc} * \text{Trial} * \text{Trt} + (\text{Tier} * \text{Trial})(\text{Trt}) + (\text{Loc} * \text{Tier} * \text{Trial})(\text{Trt}) + E}{\text{Trial}(\text{Trt}) + (\text{Loc} * \text{Trial})(\text{Trt}) + (\text{Tier} * \text{Trial})(\text{Trt}) + (\text{Loc} * \text{Tier} * \text{Trial})(\text{Trt}) + E}$$
$$= \text{Trt} / \text{Trt} * \text{Trial} \times 12/2$$

$$F_{\text{loc}} = \frac{\text{Loc} + \text{Trial}(\text{Loc}) + (\text{Trt} * \text{Trial})(\text{Loc}) + (\text{Tier} * \text{Trial})(\text{Loc}) + (\text{Trt} * \text{Tier} * \text{Trial})(\text{Loc}) + E}{\text{Trial}(\text{Loc}) + (\text{Trt} * \text{Trial})(\text{Loc}) + (\text{Tier} * \text{Trial})(\text{Loc}) + (\text{Trt} * \text{Tier} * \text{Trial})(\text{Loc}) + E}$$
$$= \text{Loc} / \text{Loc} * \text{Trial} \times 18/3$$

$$F_{\text{tier}} = \frac{\text{Tier} + \text{Trial}(\text{Tier}) + (\text{Loc} * \text{Trial})(\text{Tier}) + (\text{Trt} * \text{Trial})(\text{Tier}) + (\text{Trt} * \text{Loc} * \text{Trial})(\text{Tier}) + E}{\text{Trial}(\text{Tier}) + (\text{Loc} * \text{Trial})(\text{Tier}) + (\text{Trt} * \text{Trial})(\text{Tier}) + (\text{Trt} * \text{Loc} * \text{Trial})(\text{Tier}) + E}$$
$$= \text{Tier} / \text{Tier} * \text{Trial} \times 6/1$$

$$F_{\text{trt} * \text{loc}} = \frac{\text{Trt} * \text{Loc} + \text{Trial}(\text{Trt} * \text{Loc}) + (\text{Tier} * \text{Trial})(\text{Trt} * \text{Loc}) + E}{\text{Trial}(\text{Trt} * \text{Loc}) + (\text{Tier} * \text{Trial})(\text{Trt} * \text{Loc}) + E}$$
$$= \text{Trt} * \text{Loc} / \text{Trt} * \text{Loc} * \text{Trial} \times 36/6$$

$$F_{\text{trt} * \text{tier}} = \frac{\text{Trt} * \text{Tier} + \text{Trial}(\text{Trt} * \text{Tier}) + (\text{Loc} * \text{Trial})(\text{Trt} * \text{Tier}) + E}{\text{Trial}(\text{Trt} * \text{Tier}) + (\text{Loc} * \text{Trial})(\text{Trt} * \text{Tier}) + E}$$
$$= \text{Trt} * \text{Tier} / \text{Trt} * \text{Tier} * \text{Trial} \times 12/2$$

$$F_{\text{loc} * \text{tier}} = \frac{\text{Loc} * \text{Tier} + \text{Trial}(\text{Loc} * \text{Tier}) + (\text{Trt} * \text{Trial})(\text{Loc} * \text{Tier}) + E}{\text{Trial}(\text{Loc} * \text{Tier}) + (\text{Trt} * \text{Trial})(\text{Loc} * \text{Tier}) + E}$$
$$= \text{Loc} * \text{Tier} / \text{Loc} * \text{Tier} * \text{Trial} \times 18/3$$

$$F_{\text{trt} * \text{loc} * \text{tier}} = \frac{\text{Trt} * \text{Loc} * \text{Tier} + \text{Trial}(\text{Trt} * \text{Loc} * \text{Tier}) + E}{\text{Trial}(\text{Trt} * \text{Loc} * \text{Tier}) + E}$$
$$= \text{Trt} * \text{Loc} * \text{Tier} / \text{Trt} * \text{Loc} * \text{Tier} * \text{Trial} \times 36/6$$