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Habitat choice and predator avoidance by Antarctic amphipods: the roles of algal chemistry and morphology

Jill P. Zamzow[1,*], Charles D. Amsler[1], James B. McClintock[1], Bill J. Baker[2]

[1]Department of Biology, University of Alabama at Birmingham, Birmingham, Alabama 35294, USA
[2]Chemistry Department, University of South Florida, Tampa, Florida 33620, USA

*Email: jzamzow@gmail.com

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Statistical method for choice trials

(Statistical advice provided by Dr. Charles R. Katholi, Professor *emeritus*, Department of Biostatistics, University of Alabama Birmingham, USA)

We used the likelihood ratio test approach based on 8 (generally, but in a few cases, 4 or 12) trinomial sets of data for each experimental pairing of algae. Recall that in the experiment, 14 amphipods are put in the tank with the 2 types of algae, with the third possibility being 'no choice'. The results for each tank can be viewed as the outcomes of 14 trials with 3 possible mutually exclusive outcomes: alga 1, alga 2, and neither. Each trial yields a vector of length 3 such that all elements are either 0 or 1 and such that their sum is 1. Thus each vector has a 1 in a single position and is 0 elsewhere. The sum of the individual vector trials results has a multinomial random variable with parameters (probabilities) p_1, p_2, and p_3 subject to the condition that $p_1 + p_2 + p_3 = 1$. That is, the results for each tank are a multinomial random variable, and the observation is the vector of observed outcomes $n = (n_1, n_2, n_3)$ where n_1 is the number that chose habitat 1, n_2 is the number that chose habitat 2 and n_3 is the number that chose neither. Clearly, then, we have that $n_1 + n_2 + n_3 = 14$. The data, then, are 8 such vectors of counts, and any tank to tank variation in physical attributes such as water temperature, salinity, size of host alga choices, and so on, are part of the 'noise' in the random process.

The distribution function for each of the samples is the function:

$$f(n_1, n_2, n_3 \mid p_1, p_2, p_3) = [14!/(n_1!)(n_2!)(n_3!)](p_1^{n_1})(p_2^{n_2})(p_3^{n_3})$$

subject to the constraint that $p_1 + p_2 + p_3 = 1$. The likelihood function is the product of this function over the 8 sets of data (8 trials). From these we can calculate the unconditional maximum likelihood estimates and then the restricted estimates associated with the null hypothesis that $p_1 = p_2$.

Using the multinomial model it is easy to construct a likelihood ratio test of :

$$H_0: p_1 = p_2 \text{ versus } H_A : p_1 \quad p_2$$

The estimation in each case is done by minimizing –2 log likelihood function. The test statistic is equal to (–2 log likelihood under the restricted model) – (–2 log likelihood under the unrestricted model). The test is based on asymptotic theory, but it is also possible to estimate the sampling distribution under the null hypothesis by bootstrap methods. The asymptotic test is also a χ^2 test against a χ^2 with a single degree of freedom. The computations can be done most easily in SAS software with PROC NLP.

Table S1. Table of statistics. Unconditional: unconditional maximum likelihood estimate; Restricted: restricted estimate associated with the null hypothesis that 'the number of amphipods choosing Choice 1 is equal to the number of amphipods choosing Choice 2'. The p value results from a χ^2 test (df = 1) on the difference between Restricted and Unconditional. *G. antarctica* = *Gondogeneia antarctica*; *P. gracilis* = *Prostebbingia gracilis*; *D. menziesii* = *Desmarestia menziesii*; *P. decipiens* = *Palmaria decipiens*; gel D. = gel *Desmarestia*; gel P. = Gel *Palmaria*; Y = Yes; N = No

Trial	Amphipod species	Fish odor?	Choice 1	Choice 2	Unconditional	Restricted	p
1	*G. antarctica*	N	*D. menziesii*	*P. decipiens*	193.378	230.917	8.96E-10
2	*G. antarctica*	N	*D. menziesii*	D. analogue	203.75	230.92	1.86E-07
3	*G. antarctica*	N	*D. menziesii*	P. analogue	229.06	229.06	1
4	*G. antarctica*	N	*P. decipiens*	P. analogue	218.89	246.02	1.9E-07
5	*G. antarctica*	N	*P. decipiens*	D. analogue	85.28	114.53	6.36E-08
6	*G. antarctica*	N	P. analogue	D. analogue	245.86	245.97	0.740144
7	*G. antarctica*	Y	*D. menziesii*	*P. decipiens*	222.01	243.18	4.2E-06
8	*G. antarctica*	Y	*P. decipiens*	D. analogue	224.11	230.92	0.009065
9	*G. antarctica*	Y	*D. menziesii*	P. analogue	232.82	238.38	0.018375
10	*G. antarctica*	Y	P. analogue	D. analogue	224.9	238.38	0.000241
11	*G. antarctica*	N	*D. menziesii*	gel D.	82.89	122.46	3.17E-10
12	*G. antarctica*	N	*P. decipiens*	gel P.	235.74	235.74	1
13	*G. antarctica*	N	gel P.	gel D.	80.86	193.74	2.29E-26
14	*G. antarctica*	N	gel P.	gel P.	244.81	245.87	0.303215
15	*G. antarctica*	Y	gel P.	gel D.	85.28	114.53	6.36E-08
16	*P. gracilis*	N	*D. menziesii*	*P. decipiens*	152.32	234.25	1.41E-19
17	*P. gracilis*	N	*D. menziesii*	D. analogue	118.41	197.93	4.77E-19
18	*P. gracilis*	N	*D. menziesii*	D. analogue	20.03	86.28	3.97E-16
19	*P. gracilis*	N	*P. decipiens*	P. analogue	351.94	368.71	4.22E-05
20	*P. gracilis*	N	*P. decipiens*	D. analogue	290.6	290.61	0.920344
21	*P. gracilis*	N	P. analogue	D. analogue	158.09	229.06	3.63E-17
22	*P. gracilis*	N	*D. menziesii*	gel D.	17.26	92.12	5.05E-18
23	*P. gracilis*	N	*P. decipiens*	gel P.	215.78	242.41	2.46E-07
24	*P. gracilis*	N	gel P.	gel D.	135.8	245.32	1.25E-25
25	*P. gracilis*	N	gel P.	gel P.	245.43	246.08	0.420113
26	*P. gracilis*	Y	*D. menziesii*	*P. decipiens*	118.57	224.95	6.09E-25