Statistical Ecology
Stat 555

Canonical Correspondence Analysis

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********** Canonical Correspondence Analysis **********
PC-ORD, 5.10

DATA MATRICES
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     Main matrix:
            114 Plots    (rows)
              8 Species  (columns)

     Second matrix:
            114 Plots    (rows)
              6 Species  (columns)

     Finished reading data.
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OPTIONS SELECTED
     Axis scores centered and standardized to unit variance
     Axes scaled to compromise representation of Species  and Plots
     Scores for graphing Plots    are derived from Species
     No Monte Carlo tests


RAW CORRELATIONS AMONG VARIABLES IN SECOND MATRIX
           Depth    Rugosity Finger c Turf-Bar Cauliflo Lobe cor
Depth       1.000   -0.006    0.207   -0.330    0.164   -0.143
Rugosity   -0.006    1.000   -0.023   -0.056   -0.020   -0.008
Finger c    0.207   -0.023    1.000   -0.527    0.928   -0.012
Turf-Bar   -0.330   -0.056   -0.527    1.000   -0.500   -0.437
Cauliflo    0.164   -0.020    0.928   -0.500    1.000    0.027
Lobe cor   -0.143   -0.008   -0.012   -0.437    0.027    1.000


WEIGHTED CORRELATIONS AMONG VARIABLES IN SECOND MATRIX
(weighted by row totals in main matrix)
         Depth    Rugosity Finger c Turf-Bar Cauliflo Lobe cor
Depth       1.000   -0.022    0.300   -0.415    0.255   -0.113
Rugosity   -0.022    1.000   -0.075   -0.036   -0.049    0.021
Finger c    0.300   -0.075    1.000   -0.546    0.910   -0.049
Turf-Bar   -0.415   -0.036   -0.546    1.000   -0.511   -0.418
Cauliflo    0.255   -0.049    0.910   -0.511    1.000   -0.003
Lobe cor   -0.113    0.021   -0.049   -0.418   -0.003    1.000


ITERATION REPORT
-----------------------------------------------------------------
Calculating axis 1
Residual =   0.52E+04 at iteration   1
```

Different options available

mostly independent perceptions

→ repeated for each axis

AXIS SUMMARY STATISTICS
Number of canonical axes: 3
Total variance ("inertia") in the species data: 1.0225

	Axis 1	Axis 2	Axis 3
Eigenvalue	0.170	0.054	0.023
Variance in species data			
% of variance explained	16.6	5.3	2.2
Cumulative % explained	16.6	21.9	24.1
Pearson Correlation, Spp-Envt*	0.729	0.572	0.395
Kendall (Rank) Corr., Spp-Envt	0.499	0.423	0.259

low %, multiple gradients likely

small, not worth interpreting

r w/ environ

* Correlation between sample scores for an axis derived from the species data and the sample scores that are linear combinations of the environmental variables. Set to 0.000 if axis is not canonical.

MULTIPLE REGRESSION RESULTS:
Regression of Plots in Species space on Species → contribution of variables to constraining ordination

	Canonical Coefficients						
	Standardized			Original Units			
Variable	Axis 1	Axis 2	Axis 3	Axis 1	Axis 2	Axis 3	S.Dev
1 Depth	-0.257	-0.227	0.363	-0.055	-0.049	0.078	0.467E+01
2 Rugosity	0.004	0.078	0.111	0.027	0.581	0.828	0.133E+00
3 Finger c	-0.310	0.329	0.156	-3.363	3.573	1.689	0.921E-01
4 Turf-Bar	0.180	0.380	0.471	0.838	1.764	2.186	0.215E+00
5 Cauliflo	-0.069	0.202	-0.017	-0.791	2.319	-0.198	0.871E-01
6 Lobe cor	-0.048	0.167	0.115	-0.340	1.176	0.808	0.142E+00

Scores that are derived from the scores of Species (WA Scores)
FINAL SCORES and raw data totals (weights) for 114 Plots

	Axis 1	Axis 2	Axis 3	Raw Data Totals
1 DC	-0.384063	-2.316667	2.171119	55.0000
2 DC	-0.004460	-0.408443	-0.179636	52.0000
. . .				
114 ST	0.161697	-3.238615	2.452734	25.0000

Scores that are linear combinations of Species (LC Scores)
FINAL SCORES and raw data totals (weights) for 114 Plots

Best scores for sample graphing space

spp. fit to environ vars.

	Axis 1	Axis 2	Axis 3	Raw Data Totals
1 DC	-0.161502	-0.560465	0.412596	55.0000
2 DC	-0.074829	-0.542517	0.110228	52.0000
. . .				
114 ST	0.007032	-0.720935	0.419663	25.0000

Species Scores

FINAL SCORES and raw data totals (weights) for 8 Species

	Axis 1	Axis 2	Axis 3	Raw Data Totals
1 CTDCT	-0.777915	-0.091668	-0.546921	811.0000
2 ACNF	0.662158	-0.327063	-0.221397	1045.0000
3 CHMU	-0.557054	-1.232230	0.767157	170.0000
4 CTHA	-0.486102	-1.218366	-0.471222	18.0000
5 CHAG	-2.011567	0.190641	1.013397	139.0000
6 THDU	0.702289	0.411467	0.389316	562.0000
7 PAAR	0.124253	-1.226709	0.513080	192.0000
8 ZEFL	-0.061892	0.400845	0.060775	1560.0000

CORRELATIONS AND BIPLOT SCORES for 6 Species

	Correlations*			Biplot Scores		
Variable	Axis 1	Axis 2	Axis 3	Axis 1	Axis 2	Axis 3
1 Depth	-0.680 ✓	-0.530 ✓	0.499	-0.437	-0.255	0.194
2 Rugosity	0.044	0.079	0.198	0.029	0.038	0.077
3 Finger c	-0.850 ✓	0.464 ✓	-0.057	-0.546	0.224	-0.022
4 Turf-Bar	0.796 ✓	0.246 ✓	0.492	0.511	0.118	0.192
5 Cauliflo	-0.792 ✓	0.509	-0.075	-0.509	0.245	-0.029
6 Lobe cor	-0.123	0.039	-0.330	-0.079	0.019	-0.129

* Correlations are "intraset correlations" of ter Braak (1986)

→ correlations in constrained CA = CCA

INTER-SET CORRELATIONS for 6 Species

	Correlations		
Variable	Axis 1	Axis 2	Axis 3
1 Depth	-0.496	-0.303	0.197
2 Rugosity	0.032	0.045	0.078
3 Finger c	-0.620	0.265	-0.022
4 Turf-Bar	0.580	0.140	0.195
5 Cauliflo	-0.577	0.291	-0.030
6 Lobe cor	-0.090	0.022	-0.130

Independent correlations of env. variables with CA

Note: Obtain joint plots or biplots by selecting GRAPH, then requesting "Joint plots" from the GRAPH menu.

Randomization tests

MONTE CARLO TEST RESULTS -- EIGENVALUES

Axis	Real data Eigenvalue	Randomized data Monte Carlo test, 998 runs Mean	Minimum	Maximum	p
1	0.170	0.033	0.012	0.092	0.0010 ✓
2	0.054	0.016	0.004	0.037	
3	0.023	0.008	0.002	0.019	

sig. community structure

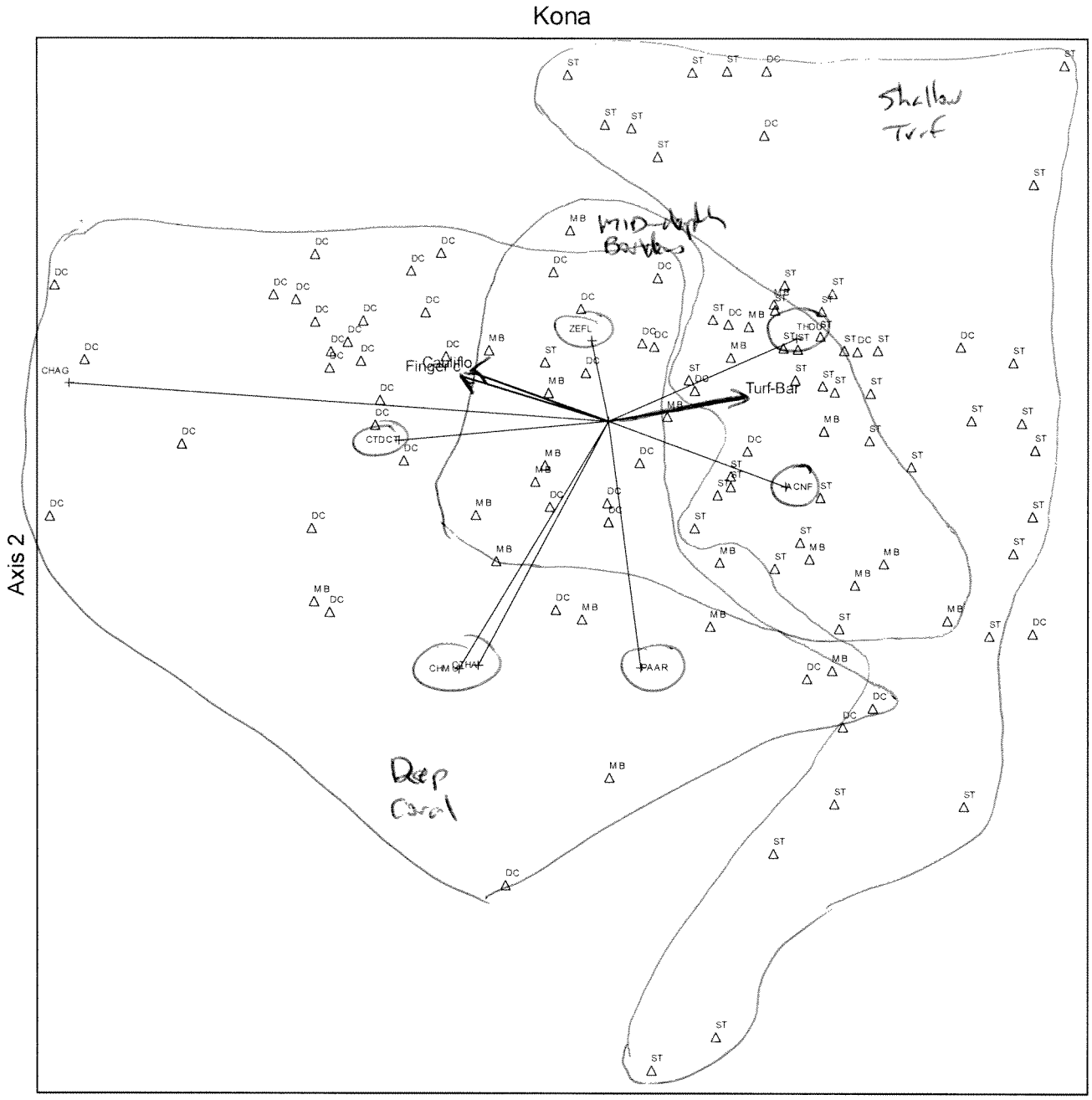
p = proportion of randomized runs with eigenvalue greater than or equal to the observed eigenvalue; i.e.,
p = (1 + no. permutations >= observed)/(1 + no. permutations)
p is not reported for axes 2 and 3 because using a simple randomization test for these axes may bias the p values.

MONTE CARLO TEST RESULTS -- SPECIES-ENVIRONMENT CORRELATIONS

Axis	Spp-Envt Corr.	Randomized data Monte Carlo test, 998 runs Mean	Minimum	Maximum	p
1	0.729	0.370	0.225	0.670	0.0010 ✓
2	0.572	0.294	0.163	0.463	
3	0.395	0.225	0.113	0.378	

sig. species-env. correlation

p = proportion of randomized runs with species-environment correlation greater than or equal to the observed species-environment correlation; i.e.,
p = (1 + no. permutations >= observed)/(1 + no. permutations)
p is not reported for axes 2 and 3 because using a simple randomization test for these axes may bias the p values.


Kona
Axis 2
Axis 1
Deep
Shallow
Shallow Turf
Mid-depth Barrens
Deep Coral
Depth
Fingerlo
Turf-Bar
CHAG
ZEFL
THDU
CTDC
ACNF
CHMS
OTHA
PAAR
ST
DC
MB

Correspondence Analyses

Method	RA/CA *Reciprocal Averaging* or *Correspondence analysis*	DCA *Detrended Correspondence analysis*	CCA *Canonical Correspondence analysis*
Uses	Community structure along gradients	Community structure along gradients	Community structure along gradients constrained by environmental correlations
Input data	Species data from samples (abundance, presence/absences, % cover, ordinal and nominal)	Species data from samples (abundance, presence/absences, % cover, ordinal and nominal)	Species data from samples (abundance, presence/absences, % cover, ordinal and nominal) plus correlated environmental data
Strengths	Robust to many data types, non-linear relationships, and some rare species; can ordinate strong 1-dimensional gradients well	Robust to many data types, non-linear relationships, and some rare species; may ordinate multidimensional gradients	Robust to many data types, non-linear relationships, and some rare species; constrains analyses to community structure correlated with environmental gradients
Weaknesses	Chi-square distances can emphasize rare species; 2^{nd} and subsequent axes may be quadratic distortions of the first axis	Chi-square distances can emphasize rare species; detrending is arbitrary and results on 2^{nd} and subsequent axes may vary depending on no. segments	Weakness associated with multiple regression; chi-square distances can emphasize rare species; not different from CA if no. environmental variables = no. samples
Key outputs	Ordination; number of axes and % variation explained	Ordination; number of axes and % variation explained; no. of segments used and rescaling threshold	Ordination; number of axes and % variation explained; scaling options; correlations of variables with axes