RDA

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1. Primer paso: cargar las librerias que necesitas.

```
library(ggplot2)
library(dplyr)
library(vegan)
```

2. Segundo paso: cargar los datos.

```
species=read.csv("data/RDA_species.csv", header=T, row.names=NULL, sep=",")
env=read.csv("data/RDA_environmetal.csv", header=T, row.names=NULL, sep=",")
```

3. Before we can use this explanatory matrix we need to check that its rows are in the same order as our response matrix all.equal(rownames(species), rownames(env))

```
all.equal(rownames(species), rownames(env))
```

```
## [1] TRUE
```

4. Remover la columna de sitos.

```
species_1 <- select(species, -site)
env_1 <- select(env, -site)
```

5. Transformar datos. Hellinger es una transformacion recomendada por Legendre & Callagher (2001) en datos de abundancia y con una respuesta lineal

```
species_2 <- decostand(species_1, method = "hellinger")
```

6.

vegan requires that we write out each term if we are not going to

convert the factor to a dummy matrix

```
rda_tree_all = rda(species_2 ~ temperature + pH +
                oxygen + conductivity + plants, data= env_1, scale=T)
rda_tree_all
```

```
## Call: rda(formula = species_2 ~ temperature + pH + oxygen +
## conductivity + plants, data = env_1, scale = T)
##
##               Inertia Proportion Rank
## Total          47.0000    1.0000
## Constrained     8.9073    0.1895    5
## Unconstrained  38.0927    0.8105   47
## Inertia is correlations
##
## Eigenvalues for constrained axes:
##  RDA1  RDA2  RDA3  RDA4  RDA5
## 4.067 2.255 1.376 0.792 0.417
##
## Eigenvalues for unconstrained axes:
##   PC1   PC2   PC3   PC4   PC5   PC6   PC7   PC8
## 5.045 4.820 3.785 2.839 2.079 1.798 1.619 1.404
## (Showing 8 of 47 unconstrained eigenvalues)
```

7. Summary http://dmcglinn.github.io/quant_methods/lessons/multivariate_models.html

Inertia is another name for variation or variance in this case. "Total" refers to total variance "Constrained" refers to the amount of variance explained by the explanatory variables, "Unconstrained" refers to the residual variance. Constrained + Unconstrained = Total.

An R2 statistic can be derived simply as Constrained / Total.

```
summary(rda_tree_all)
```

```
##
## Call:
## rda(formula = species_2 ~ temperature + pH + oxygen + conductivity +      plants, data = env_1, scale
##
## Partitioning of correlations:
##               Inertia Proportion
## Total           47.000    1.0000
## Constrained      8.907    0.1895
## Unconstrained   38.093    0.8105
##
## Eigenvalues, and their contribution to the correlations
##
## Importance of components:
##                           RDA1    RDA2    RDA3    RDA4     RDA5     PC1     PC2
## Eigenvalue             4.06679 2.25482 1.37627 0.79194 0.417482  5.0453  4.8203
## Proportion Explained   0.08653 0.04797 0.02928 0.01685 0.008883  0.1073  0.1026
## Cumulative Proportion  0.08653 0.13450 0.16378 0.18063 0.189517  0.2969  0.3994
##                           PC3     PC4     PC5     PC6     PC7     PC8     PC9
## Eigenvalue             3.78471 2.83946 2.07941 1.79779 1.61889 1.40426 1.28896
## Proportion Explained   0.08053 0.06041 0.04424 0.03825 0.03444 0.02988 0.02742
```

```
## Cumulative Proportion 0.47995 0.54036 0.58461 0.62286 0.65730 0.68718 0.71460
##                           PC10    PC11    PC12    PC13    PC14    PC15    PC16
## Eigenvalue              1.19207 1.09439 1.08068 0.97083 0.91273 0.85041 0.78867
## Proportion Explained    0.02536 0.02328 0.02299 0.02066 0.01942 0.01809 0.01678
## Cumulative Proportion   0.73997 0.76325 0.78624 0.80690 0.82632 0.84441 0.86119
##                           PC17    PC18    PC19    PC20    PC21    PC22     PC23
## Eigenvalue              0.69918 0.61775 0.58582 0.57070 0.48347 0.46437 0.410574
## Proportion Explained    0.01488 0.01314 0.01246 0.01214 0.01029 0.00988 0.008736
## Cumulative Proportion   0.87607 0.88921 0.90168 0.91382 0.92411 0.93399 0.942723
##                            PC24     PC25     PC26     PC27     PC28     PC29
## Eigenvalue              0.384870 0.33090 0.309928 0.293196 0.235722 0.204967
## Proportion Explained    0.008189 0.00704 0.006594 0.006238 0.005015 0.004361
## Cumulative Proportion   0.950911 0.95795 0.964546 0.970784 0.975800 0.980161
##                            PC30     PC31     PC32     PC33     PC34     PC35
## Eigenvalue              0.191153 0.169063 0.125743 0.076653 0.072208 0.064563
## Proportion Explained    0.004067 0.003597 0.002675 0.001631 0.001536 0.001374
## Cumulative Proportion   0.984228 0.987825 0.990500 0.992131 0.993667 0.995041
##                            PC36      PC37      PC38      PC39      PC40
## Eigenvalue              0.049611 0.0419889 0.0381111 0.0342656 0.0228705
## Proportion Explained    0.001056 0.0008934 0.0008109 0.0007291 0.0004866
## Cumulative Proportion   0.996097 0.9969900 0.9978009 0.9985300 0.9990166
##                             PC41     PC42      PC43      PC44      PC45
## Eigenvalue              0.0163275 0.012502 0.0093315 0.0055293 1.296e-03
## Proportion Explained    0.0003474 0.000266 0.0001985 0.0001176 2.758e-05
## Cumulative Proportion   0.9993640 0.999630 0.9998285 0.9999462 1.000e+00
##                             PC46      PC47
## Eigenvalue              7.940e-04 4.408e-04
## Proportion Explained    1.689e-05 9.378e-06
## Cumulative Proportion   1.000e+00 1.000e+00
##
## Accumulated constrained eigenvalues
## Importance of components:
##                            RDA1    RDA2    RDA3    RDA4    RDA5
## Eigenvalue              4.0668  2.2548  1.3763 0.79194 0.41748
## Proportion Explained    0.4566  0.2531  0.1545 0.08891 0.04687
## Cumulative Proportion   0.4566  0.7097  0.8642 0.95313 1.00000
##
## Scaling 2 for species and site scores
## * Species are scaled proportional to eigenvalues
## * Sites are unscaled: weighted dispersion equal on all dimensions
## * General scaling constant of scores:  7.194377
##
##
## Species scores
##
##                      RDA1      RDA2      RDA3      RDA4      RDA5       PC1
## acan_speculum     -0.56635  0.174225  0.012091 -0.059736  0.027177  0.0555015
## acan_trilobatum    0.22379  0.201319 -0.424041  0.085697  0.116983 -0.2831852
## ani_allopterum     0.34237 -0.225464  0.033024  0.034060 -0.054269 -0.4931210
## arg_anceps         0.53063 -0.068151 -0.074167 -0.076600 -0.191017 -0.0769561
## arg_ellongata      0.38020 -0.028739 -0.126081 -0.239406 -0.003290 -0.4432599
## arg_pulla          0.20645  0.199453 -0.416753  0.096749  0.093944 -0.2005521
## arg_translata      0.11795 -0.026002 -0.138746 -0.147740  0.038229 -0.1666081
## bra_furcata       -0.19121  0.357038  0.273934  0.022463  0.037009  0.5482178
```

3

```
## can_vibex          0.16613  0.017311 -0.055460  0.040377  0.072448 -0.2712934
## dyt_nigra          0.06760  0.328213  0.117171  0.232796 -0.208999  0.4861273
## dyt_sterilis       0.42742  0.014951 -0.190910 -0.066271  0.081848 -0.3244196
## ena_civile         0.28133  0.051758 -0.076657 -0.222578 -0.034812  0.4988285
## ena_novaehispaniae 0.10535  0.175792 -0.011138 -0.282879 -0.132417  0.0889268
## erythe_attala     -0.58814  0.058109 -0.085068  0.050608  0.046613  0.1945645
## erythe_peruviana  -0.40640  0.089686 -0.112724 -0.079167  0.065561 -0.0517349
## erythe_plebeja    -0.36344 -0.069846 -0.132813  0.114418  0.061040  0.2363204
## erythe_vesiculosa  0.15599 -0.150890 -0.057331 -0.134456  0.178474  0.1744324
## erythr_fervida    -0.43529  0.123737  0.016983 -0.105057  0.074120  0.3420191
## erythr_funerea     0.14350  0.145748  0.254622 -0.268198  0.099007  0.2192590
## erythr_fusca      -0.57750  0.117559  0.098058 -0.308824 -0.052209 -0.0154398
## erythr_umbrata     0.09625  0.210565 -0.051355  0.214595 -0.160077  0.0542030
## het_cruentata      0.28978 -0.110885  0.013473 -0.128867 -0.149976 -0.3434451
## isc_capreola      -0.44929 -0.474919  0.090810  0.168794 -0.024459  0.2201268
## isc_ramburii      -0.12392 -0.566227  0.261880 -0.008813  0.085193  0.0888216
## les_tenuatus       0.17328 -0.007860  0.005584  0.051217  0.117939 -0.4603314
## lib_herculea      -0.31406 -0.081507 -0.354544 -0.077658 -0.161722  0.2355933
## mac_pseudimitans   0.08469  0.141945 -0.020065 -0.045587 -0.002069 -0.4095923
## mia_marcella       0.03101  0.369162  0.327434 -0.025711  0.079036  0.6348831
## mic_aequalis      -0.25930  0.132426 -0.062756  0.004040 -0.120485  0.0009114
## mic_atra          -0.18845 -0.005004 -0.034717  0.224143 -0.014931 -0.0803580
## mic_mengeri        0.06803  0.356810  0.133127  0.169256 -0.086707  0.5379574
## mic_ocellata      -0.55827  0.046166 -0.066868 -0.157877 -0.059001  0.0391176
## mic_schumanni      0.08663  0.095410  0.070262 -0.135939 -0.086617 -0.4900225
## neo_cultellatum   -0.33112  0.258514  0.045463 -0.139860  0.078101  0.3507857
## oli_umbricola      0.00000  0.000000  0.000000  0.000000  0.000000  0.0000000
## ort_discolor       0.18884  0.271442 -0.320455  0.074843 -0.008280 -0.5106693
## ort_ferruginea     0.19892  0.335125  0.310869  0.076157  0.003996  0.6103688
## pal_lineatipes     0.16079 -0.079136 -0.023440  0.077224 -0.096927 -0.0946139
## pan_flavecens      0.18745  0.355312  0.278650  0.057720 -0.009532  0.6022441
## pan_hymenaea       0.14232  0.206311  0.190710  0.018467  0.184033  0.6116925
## per_mooma         -0.01314  0.559071 -0.103248  0.034689  0.066810  0.3170722
## rem_luteipennis    0.03717 -0.379952  0.187306  0.227218  0.120282 -0.4528407
## rhi_jalapensis     0.17012 -0.091011  0.098058  0.049158 -0.157195 -0.1159048
## tau_argo           0.00000  0.000000  0.000000  0.000000  0.000000  0.0000000
## tau_australis      0.01700  0.306013  0.029876  0.142745  0.039210  0.4338115
## tel_digiticolis   -0.57986  0.034523 -0.128704  0.109802 -0.004543  0.2215035
## tel_filiola       -0.58657  0.044191 -0.201962  0.020802 -0.076858  0.2069809
## tel_salva         -0.26606  0.160484  0.062011 -0.020506 -0.076262 -0.0282824
## Gomphidae          0.18263  0.138073 -0.302768  0.054845  0.133397 -0.1991074
##
##
##
## Site scores (weighted sums of species scores)
##
##           RDA1      RDA2     RDA3     RDA4      RDA5      PC1
## row1  -2.34062  0.367106 -0.86489  0.35331  1.398270  0.80689
## row2  -0.06932 -1.720847  0.96051  1.12267  0.647840  0.06049
## row3   1.20432  0.523913 -3.02251  0.22035  1.848212 -0.61954
## row4   0.76929 -0.265067 -0.63310 -0.19901  0.729802 -0.05932
## row5   0.13512 -1.136051  0.70430  0.18790  0.416868  0.08071
## row6   1.62816 -1.131078  0.22063 -0.90133 -5.543507 -0.78772
## row7  -3.06222  0.409328 -2.28831 -0.80906 -1.719443  1.05261
## row8  -0.06623 -1.669057  0.92494  1.02285  0.575982 -0.06461
```

```
## row9   0.75463  0.596024 -1.86921  0.97715  2.122455 -0.56325
## row10  0.47967 -1.177751  0.28321 -0.61564 -1.129926  1.79942
## row11  0.63178 -0.373815  0.04090 -0.81800 -0.709860  0.07991
## row12  0.67378 -1.354297 -0.09839 -1.34885 -2.442458 -0.38932
## row13 -3.04431  0.254577 -2.21428 -0.70320 -2.306937  1.20211
## row14 -0.30342 -1.584942  0.84487  0.98682 -0.002383 -0.75783
## row15  0.86311  0.835042 -2.97650  1.28609  2.804836 -0.36456
## row16  0.60442 -0.964110 -0.26359 -1.49993  3.174251  1.18549
## row17  0.46498  0.618156  0.58847  0.15026  0.162726 -0.10825
## row18  0.81394 -1.119690 -0.07207 -0.26968 -2.788060 -0.77797
## row19 -2.77075  1.005968 -0.47312  0.02145  1.091618  0.48056
## row20 -0.45553 -1.662763  0.66237  3.05968  0.096906 -0.54614
## row21  1.02234  1.867314 -2.71759  2.80580 -0.549668 -0.51699
## row22  0.34608  0.156511 -0.33556 -0.67849 -1.615253  0.35243
## row23  0.28405  0.783592  0.95821  0.39643 -0.804511  0.42092
## row24  1.33565 -1.061082 -0.64079 -0.12060 -5.316509 -0.64302
## row25 -0.55971 -0.006254  0.46939 -1.96208 -0.964995 -1.07580
## row26  0.01830 -1.513783  0.71931  0.77932  0.265327 -0.23655
## row27  0.40808  1.282277 -1.64128  0.03989  1.334484 -0.83463
## row28  0.37897  0.354380 -0.32374  0.21877  0.432733 -0.26413
## row29  0.92409  4.680181  4.16703  4.48033 -0.351811  2.94831
## row30  1.05812 -0.896667 -0.02988 -1.09425 -1.022010 -2.52276
## row31 -1.42812  0.689193 -0.12277 -0.24389  0.384007  0.01594
## row32 -0.14991 -1.693987  0.89385  0.95120  0.191491 -0.05879
## row33  0.80533  1.022034 -2.71260  1.11141  2.690842 -0.53659
## row34  0.19001  0.251339 -0.12070 -1.20899 -1.876603  0.46121
## row35  0.49174  2.861819  3.02607  3.59647 -4.164108  1.76896
## row36  1.23195 -0.689798 -0.22319  0.35051  0.128912 -2.14819
## row37 -2.71587  1.057302 -1.15422 -0.61626  0.231418  0.03008
## row38 -0.32729 -1.485983  0.86009  0.30837  0.307584 -0.44787
## row39  0.28076  0.476911 -0.20191 -1.08242 -0.802799 -0.07814
## row40  0.34499  1.715944  2.39958  0.65230 -0.340980  1.16210
## row41  0.97919 -0.925196 -0.20365  1.16152  0.081045 -1.26536
## row42 -2.17756  1.338554  0.09762 -1.24805  0.764429  0.05379
## row43 -0.27012 -1.712056  0.97535  0.77526  0.443011 -0.05352
## row44  1.09828  0.954697 -3.77708 -1.13249  2.684427 -0.77128
## row45  0.20924 -0.210026  1.34341 -3.22416  0.631511  0.04522
## row46  0.28275  1.441965  3.19228 -0.19459  2.430683  1.56899
## row47  0.92245 -0.901607 -0.55128 -0.77293  0.874007 -0.65333
## row48 -1.42792  0.908313 -0.48685  0.44698  0.384335  0.34872
## row49 -0.02002 -1.832898  0.92859  1.30624  0.352968 -0.05425
## row50  1.01503  0.898435 -3.23009 -0.82234  1.957650 -0.88713
## row51  0.33127  0.030597  0.31750 -1.72708  0.455291 -0.13242
## row52  0.40198  1.552848  3.46976 -1.21232  2.894735  2.36774
## row53  0.83082 -1.684325  0.53337  1.46966  0.794600 -0.37659
## row54 -3.40935  1.879938 -0.22944 -1.65410 -0.799397 -0.19222
## row55 -0.05115 -1.600289  0.89217  0.65607  0.238956 -0.37738
## row56 -0.44988  0.447030  0.01173 -3.19969 -1.110610  0.26519
## row57 -0.24346  0.780408  2.63104 -1.52506  2.015678  0.81961
## row58  1.12807 -1.668277  0.36204 -0.01055 -1.678064 -0.21195
## 
## 
## Site constraints (linear combinations of constraining variables)
## 
```

```
##            RDA1     RDA2     RDA3     RDA4     RDA5      PC1
## row1  -0.65000 -0.75055  0.15653  0.6292  1.33209  0.80689
## row2  -0.54753 -2.76358  2.09802 -1.0563 -1.57350  0.06049
## row3   0.66503  0.14970 -1.56316  0.4513  0.42498 -0.61954
## row4   1.22005 -0.76667  0.49217  0.3315 -0.81750 -0.05932
## row5   1.01834 -0.77070  1.48895 -0.9261 -0.31878  0.08071
## row6   1.15621 -0.61854  0.66643  0.3341 -1.06834 -0.78772
## row7  -1.69726 -0.20349 -2.15655 -0.2491 -1.51435  1.05261
## row8  -1.37717 -0.87285 -0.89998 -0.3247  1.16402 -0.06461
## row9   0.15802  1.03950 -1.61860  0.1697  0.15007 -0.56325
## row10  0.63955 -1.79198 -3.45850 -1.2176 -1.78612  1.79942
## row11  0.64080  0.39286  1.03709 -0.1746 -0.22942  0.07991
## row12  0.30816 -0.49323 -0.62302 -2.1018 -0.66262 -0.38932
## row13 -1.39786 -0.52769 -1.41072 -0.4644 -0.27426  1.20211
## row14 -1.36713  0.47936  0.24234  2.1373 -1.07550 -0.75783
## row15  0.72744  0.21193 -1.25614  0.7576  0.04036 -0.36456
## row16  1.06015 -1.02549 -0.38964 -0.9138  1.21296  1.18549
## row17  0.14044  1.78294  0.47397  0.6649 -0.47310 -0.10825
## row18  0.18867  0.68257 -0.16099 -0.5445 -1.45764 -0.77797
## row19 -1.12879  0.39137  0.28438  1.1261  0.01184  0.48056
## row20 -1.28076 -0.03401 -0.23595  1.5233 -0.10148 -0.54614
## row21  0.46829  1.01831 -0.85022  0.9863 -0.11149 -0.51699
## row22  0.74606 -0.06915 -0.26568  0.1874 -1.01673  0.35243
## row23  0.37931  1.21070 -0.16373  0.5002  0.82385  0.42092
## row24  1.09275 -0.53783 -0.15931  0.5248 -0.65874 -0.64302
## row25 -2.08785  0.61959  0.89390 -2.1726 -0.68515 -1.07580
## row26 -1.00180 -1.40620  0.37423 -0.5590  1.42044 -0.23655
## row27  0.42139  0.93312 -0.61545  0.4353  0.22463 -0.83463
## row28  0.59675  0.73795  0.40260  0.3312 -0.06071 -0.26413
## row29  0.11551  2.07975  0.20305  0.9701  0.26648  2.94831
## row30  0.13014  0.58374  0.32038 -1.6786  0.06746 -2.52276
## row31 -0.95014 -0.33334  1.03067  0.5295 -1.03234  0.01594
## row32 -0.54577 -1.48883  0.53941  1.4651 -0.22507 -0.05879
## row33  0.50123  0.86814 -0.95071  0.4540  1.27682 -0.53659
## row34  0.41459 -0.10646 -0.86407 -0.4445 -2.13238  0.46121
## row35  0.50477  1.11596  0.87242  1.2353 -2.10859  1.76896
## row36  0.81845  0.28973  0.36544  0.7633 -1.09268 -2.14819
## row37 -1.43302  0.56577  0.29116  0.2485  0.09561  0.03008
## row38 -1.07949 -0.78158 -0.13619  0.4217  1.55971 -0.44787
## row39  0.10510  1.17547 -0.24151 -0.8351  1.14091 -0.07814
## row40  0.52242  0.48167  1.24928 -0.6944  0.12505  1.16210
## row41  0.73457  0.25494  0.70733 -0.2331  0.27141 -1.26536
## row42 -2.00027  0.83527 -0.23406 -1.5646  1.35328  0.05379
## row43 -0.40769 -1.87423  0.81736  1.0080  0.32826 -0.05352
## row44  0.71952 -0.39567 -0.55517 -0.7756  0.39529 -0.77128
## row45  0.25292  0.65604  0.59784 -1.2433  0.07913  0.04522
## row46  0.69085  0.05078  1.31213 -1.0921  0.94963  1.56899
## row47  0.78271 -0.07583 -0.75293 -0.2442  1.45722 -0.65333
## row48 -0.93692 -0.09313  0.02035  0.8663  0.92379  0.34872
## row49 -0.65649 -1.42747 -0.07534  1.0186  1.15738 -0.05425
## row50  0.34891  0.30446 -0.87894 -0.6393 -0.14767 -0.88713
## row51  0.62508  0.15070  0.28948 -0.6872  0.52651 -0.13242
## row52  0.97592 -0.10272  1.00056 -0.1681  1.09398  2.36774
## row53  1.43720 -0.71917 -0.32373  1.0824  0.90989 -0.37659
```

```
## row54 -1.80820   1.09070   0.42144 -0.1394 -0.51830 -0.19222
## row55 -0.97992 -0.83162   0.60896   1.0147 -0.54566 -0.37738
## row56  0.07891   0.88485   0.30888 -1.4075   0.22265   0.26519
## row57  0.22334   1.05859   1.19542 -0.6582 -0.35368   0.81961
## row58  1.72452 -1.23446   0.07813   1.0416   1.03610 -0.21195
##
##
## Biplot scores for constraining variables
##
##                    RDA1    RDA2    RDA3    RDA4    RDA5 PC1
## temperature   -0.43020   0.8404 -0.3197 -0.0630 -0.05065   0
## pH             0.09972   0.1058   0.3653   0.3928 -0.83137   0
## oxygen         0.22572   0.3153   0.3833 -0.7680 -0.33595   0
## conductivity   0.39715 -0.1615 -0.8061 -0.2094 -0.35005   0
## plants        -0.87704 -0.3946   0.1208   0.2338   0.07652   0
```

```
head (summary (rda_tree_all))
```

```
##
## Call:
## rda(formula = species_2 ~ temperature + pH + oxygen + conductivity +        plants, data = env_1, scal
##
## Partitioning of correlations:
##             Inertia Proportion
## Total        47.000     1.0000
## Constrained   8.907     0.1895
## Unconstrained 38.093    0.8105
##
## Eigenvalues, and their contribution to the correlations
##
## Importance of components:
##                       RDA1    RDA2    RDA3    RDA4     RDA5     PC1     PC2
## Eigenvalue          4.06679 2.25482 1.37627 0.79194 0.417482 5.0453 4.8203
## Proportion Explained 0.08653 0.04797 0.02928 0.01685 0.008883 0.1073 0.1026
## Cumulative Proportion 0.08653 0.13450 0.16378 0.18063 0.189517 0.2969 0.3994
##                        PC3     PC4     PC5     PC6     PC7     PC8     PC9
## Eigenvalue          3.78471 2.83946 2.07941 1.79779 1.61889 1.40426 1.28896
## Proportion Explained 0.08053 0.06041 0.04424 0.03825 0.03444 0.02988 0.02742
## Cumulative Proportion 0.47995 0.54036 0.58461 0.62286 0.65730 0.68718 0.71460
##                       PC10    PC11    PC12    PC13    PC14    PC15    PC16
## Eigenvalue          1.19207 1.09439 1.08068 0.97083 0.91273 0.85041 0.78867
## Proportion Explained 0.02536 0.02328 0.02299 0.02066 0.01942 0.01809 0.01678
## Cumulative Proportion 0.73997 0.76325 0.78624 0.80690 0.82632 0.84441 0.86119
##                       PC17    PC18    PC19    PC20    PC21    PC22     PC23
## Eigenvalue          0.69918 0.61775 0.58582 0.57070 0.48347 0.46437 0.410574
## Proportion Explained 0.01488 0.01314 0.01246 0.01214 0.01029 0.00988 0.008736
## Cumulative Proportion 0.87607 0.88921 0.90168 0.91382 0.92411 0.93399 0.942723
##                        PC24    PC25     PC26     PC27     PC28     PC29
## Eigenvalue          0.384870 0.33090 0.309928 0.293196 0.235722 0.204967
## Proportion Explained 0.008189 0.00704 0.006594 0.006238 0.005015 0.004361
## Cumulative Proportion 0.950911 0.95795 0.964546 0.970784 0.975800 0.980161
##                        PC30     PC31     PC32     PC33     PC34     PC35
## Eigenvalue          0.191153 0.169063 0.125743 0.076653 0.072208 0.064563
## Proportion Explained 0.004067 0.003597 0.002675 0.001631 0.001536 0.001374
```

```
## Cumulative Proportion 0.984228 0.987825 0.990500 0.992131 0.993667 0.995041
##                                 PC36      PC37      PC38      PC39      PC40
## Eigenvalue             0.049611 0.0419889 0.0381111 0.0342656 0.0228705
## Proportion Explained   0.001056 0.0008934 0.0008109 0.0007291 0.0004866
## Cumulative Proportion  0.996097 0.9969900 0.9978009 0.9985300 0.9990166
##                                 PC41      PC42      PC43      PC44      PC45
## Eigenvalue             0.0163275 0.012502 0.0093315 0.0055293 1.296e-03
## Proportion Explained   0.0003474 0.000266 0.0001985 0.0001176 2.758e-05
## Cumulative Proportion  0.9993640 0.999630 0.9998285 0.9999462 1.000e+00
##                                 PC46      PC47
## Eigenvalue             7.940e-04 4.408e-04
## Proportion Explained   1.689e-05 9.378e-06
## Cumulative Proportion  1.000e+00 1.000e+00
##
## Accumulated constrained eigenvalues
## Importance of components:
##                            RDA1    RDA2    RDA3    RDA4    RDA5
## Eigenvalue              4.0668  2.2548  1.3763 0.79194 0.41748
## Proportion Explained    0.4566  0.2531  0.1545 0.08891 0.04687
## Cumulative Proportion   0.4566  0.7097  0.8642 0.95313 1.00000
##
## Scaling 2 for species and site scores
## * Species are scaled proportional to eigenvalues
## * Sites are unscaled: weighted dispersion equal on all dimensions
## * General scaling constant of scores:  7.194377
##
##
## Species scores
##
##                    RDA1     RDA2     RDA3     RDA4     RDA5      PC1
## acan_speculum   -0.5664  0.17423  0.01209 -0.05974  0.02718  0.05550
## acan_trilobatum  0.2238  0.20132 -0.42404  0.08570  0.11698 -0.28319
## ani_allopterum   0.3424 -0.22546  0.03302  0.03406 -0.05427 -0.49312
## arg_anceps       0.5306 -0.06815 -0.07417 -0.07660 -0.19102 -0.07696
## arg_ellongata    0.3802 -0.02874 -0.12608 -0.23941 -0.00329 -0.44326
## arg_pulla        0.2065  0.19945 -0.41675  0.09675  0.09394 -0.20055
## ....
##
##
## Site scores (weighted sums of species scores)
##
##           RDA1    RDA2    RDA3    RDA4    RDA5      PC1
## row1 -2.34062  0.3671 -0.8649  0.3533  1.3983  0.80689
## row2 -0.06932 -1.7208  0.9605  1.1227  0.6478  0.06049
## row3  1.20432  0.5239 -3.0225  0.2203  1.8482 -0.61954
## row4  0.76929 -0.2651 -0.6331 -0.1990  0.7298 -0.05932
## row5  0.13512 -1.1361  0.7043  0.1879  0.4169  0.08071
## row6  1.62816 -1.1311  0.2206 -0.9013 -5.5435 -0.78772
## ....
##
##
## Site constraints (linear combinations of constraining variables)
##
##           RDA1    RDA2    RDA3    RDA4    RDA5      PC1
```

8

```
## row1 -0.6500 -0.7506  0.1565  0.6292  1.3321  0.80689
## row2 -0.5475 -2.7636  2.0980 -1.0563 -1.5735  0.06049
## row3  0.6650  0.1497 -1.5632  0.4513  0.4250 -0.61954
## row4  1.2200 -0.7667  0.4922  0.3315 -0.8175 -0.05932
## row5  1.0183 -0.7707  1.4889 -0.9261 -0.3188  0.08071
## row6  1.1562 -0.6185  0.6664  0.3341 -1.0683 -0.78772
## ....
##
##
## Biplot scores for constraining variables
##
##                  RDA1     RDA2     RDA3     RDA4     RDA5 PC1
## temperature  -0.43020  0.8404 -0.3197 -0.0630 -0.05065   0
## pH            0.09972  0.1058  0.3653  0.3928 -0.83137   0
## oxygen        0.22572  0.3153  0.3833 -0.7680 -0.33595   0
## conductivity  0.39715 -0.1615 -0.8061 -0.2094 -0.35005   0
## plants       -0.87704 -0.3946  0.1208  0.2338  0.07652   0
```

8. Test for colinearity

Then, we can calculate Variance Inflation Factors (VIF) for each of the constraints (variables) from the "env" matrix (environmental matrix). If we find an environmental variable with VIF>10, we'll know that this variable presents colinearity with another or other variables. In that case, we would have to delete the variable from our initial dataset and redo all the analysis. In our example, no variable is redundant with each other (all of them have VIF<10).

Linear dependencies can be explored by computing the variables' variance inflation factors (VIF), which measure the proportion by which the variance of a regression coefficient is inflated in the presence of other explanatory variables. VIFs above 20 indicate strong collinearity. Ideally, VIFs above 10 should be at least examined, and avoided if possible. VIFs can be computed in vegan after RDA or CCA: (Bocard et al. page 175)

```
vif.cca(rda_tree_all)
```

```
## temperature           pH       oxygen conductivity       plants
##    1.020607     1.041448     1.459971     1.370939     1.781782
```
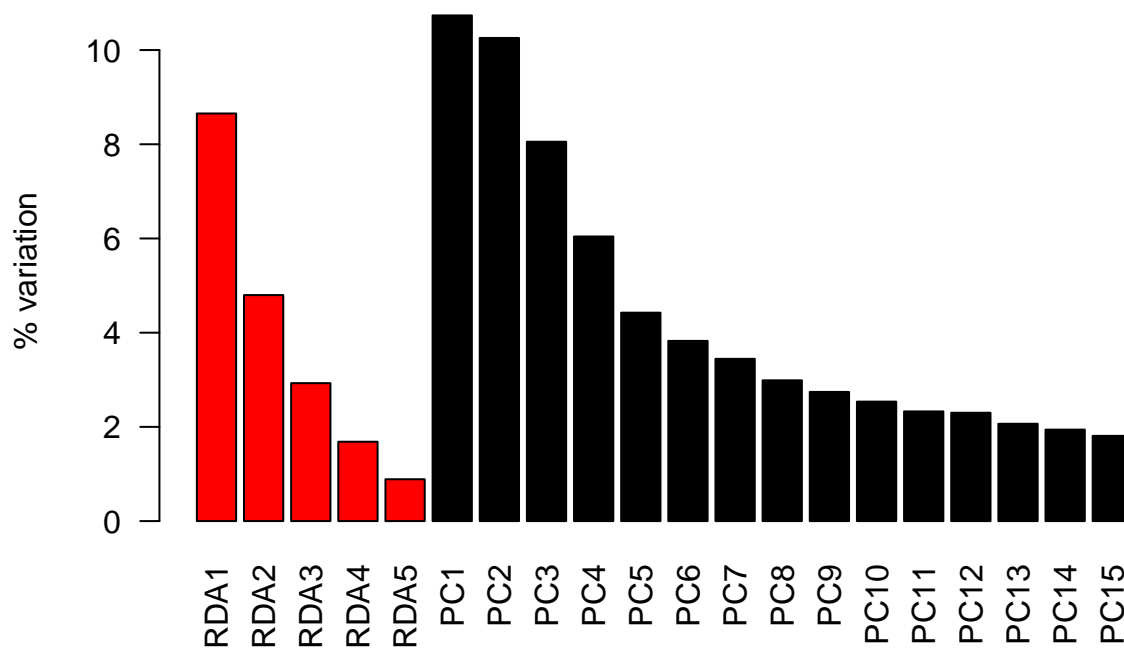
9. Plots

```
screeplot(rda_tree_all)
```
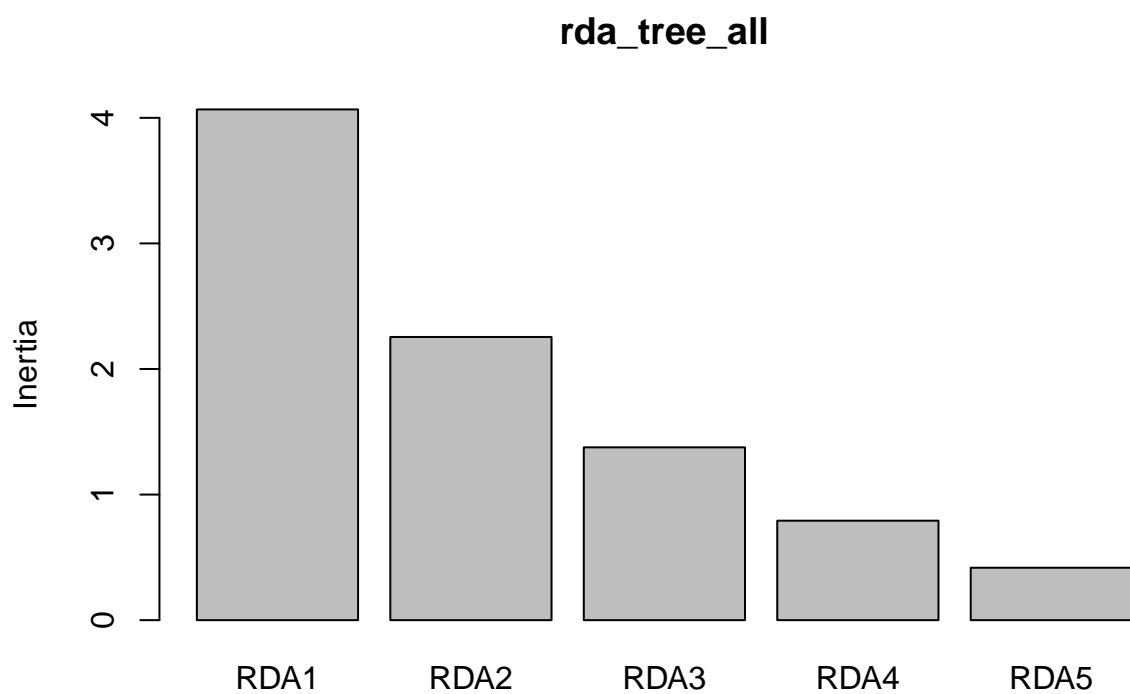
rda_tree_all

10. Percentage explained by constrained and unconstrained variables.

```
constrained_eig <- rda_tree_all$CCA$eig/rda_tree_all$tot.chi*100
unconstrained_eig <- rda_tree_all$CA$eig/rda_tree_all$tot.chi*100
expl_var <- c(constrained_eig, unconstrained_eig)
barplot (expl_var[1:20], col = c(rep ('red', length (constrained_eig)), rep ('black', length (unconstra
        las = 2, ylab = '% variation')
```

11. Ordination plots

Scaling 1 (distance biplot): Se prioriza que la distancia entre objetos en el gráfico respete tanto como sea posible las distancias euclidias de la matriz original. Los ángulos entre vectores (variables) pueden ser distorsionados.

Scaling 2 (correlation biplot): Se prioriza que los ángulos entre vectores respeten la correlación original entre variables. La distancia entre objetos en el gráfico puede estar distorsionada.

En resumen, utilizaremos scaling 1 si nos interesa más ver cómo se diferencian los objetos, y scaling 2 si nos interesa más ver cómo se relacionan las distintas variables.

https://bookdown.org/stephi_gascon/bookdown-demo-master_-_multivariant/_book/ordination.html

#https://fukamilab.github.io/BIO202/06-B-constrained-ordination.html

```
par(mfrow=c(1,2))

plot(rda_tree_all, scaling=1, main="Odonata in Urban ponds,, scaling=1")
spe.sc <- scores(rda_tree_all, choices=1:2, scaling=1, display="sp")
arrows(0,0,spe.sc[,1], spe.sc[,2], length=0, lty=1, col='red')

plot(rda_tree_all, scaling=2, main="Odonata in Urban ponds, scaling=2")
```

```
spe.sc <- scores(rda_tree_all, choices=1:2, scaling=1, display="sp")
arrows(0,0,spe.sc[,1], spe.sc[,2], length=0, lty=1, col='red')
```

Odonata in Urban ponds,, scaling   **Odonata in Urban ponds, scaling**
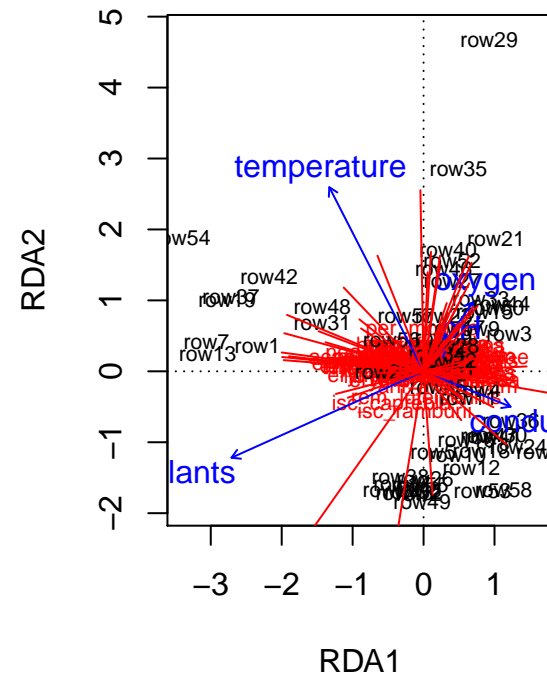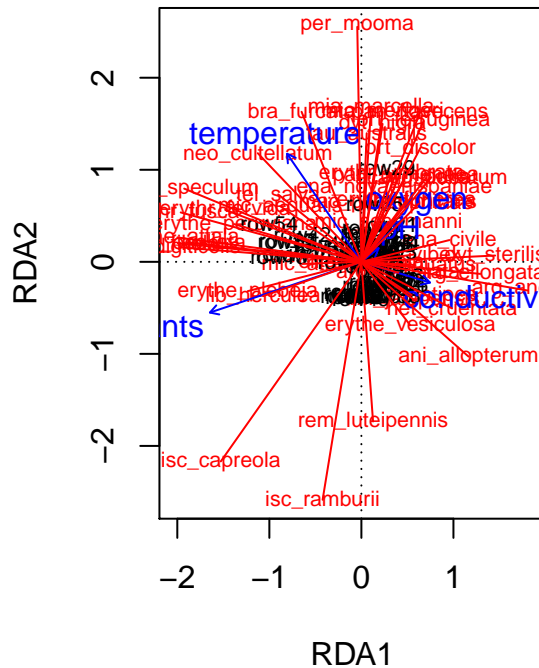
12. Calcular las R

```
(R2 <- RsquareAdj(rda_tree_all)$r.squared)
```

```
## [1] 0.1895171
```

```
(R2adj <- RsquareAdj(rda_tree_all)$adj.r.squared)
```

```
## [1] 0.1115861
```

13a Testing the global significance of RDA

```
set.seed(1)
```

```
anova.cca(rda_tree_all, step=1000)
```

```
## Permutation test for rda under reduced model
## Permutation: free
## Number of permutations: 999
```

```
##
## Model: rda(formula = species_2 ~ temperature + pH + oxygen + conductivity + plants, data = env_1, sca
##          Df Variance      F Pr(>F)
## Model     5   8.907 2.4319  0.001 ***
## Residual 52   38.093
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

13b Testing the significance of CCA axes (at least the first two or three should present a significant p value)
Hint Argument "step" gives the minimal number of permutations requested to assess if the F value of a test
is obviously significant or not

```
set.seed(1)

anova.cca(rda_tree_all, by='axis', step=1000)
```

```
## Permutation test for rda under reduced model
## Forward tests for axes
## Permutation: free
## Number of permutations: 999
##
## Model: rda(formula = species_2 ~ temperature + pH + oxygen + conductivity + plants, data = env_1, sc
##          Df Variance      F Pr(>F)
## RDA1      1   4.067 5.5515  0.001 ***
## RDA2      1   2.255 3.0780  0.005 **
## RDA3      1   1.376 1.8787  0.122
## RDA4      1   0.792 1.0811  0.699
## RDA5      1   0.417 0.5699  0.963
## Residual 52   38.093
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

13c Testing the significance of terms (environmental variables) Hint Argument "step" gives the minimal
number of permutations requested to assess if the F value of a test is obviously significant or not

```
anova.cca(rda_tree_all, by='terms', step=1000)
```

```
## Permutation test for rda under reduced model
## Terms added sequentially (first to last)
## Permutation: free
## Number of permutations: 999
##
## Model: rda(formula = species_2 ~ temperature + pH + oxygen + conductivity + plants, data = env_1, sc
##               Df Variance      F Pr(>F)
## temperature    1   2.490 3.3989  0.001 ***
## pH             1   0.654 0.8933  0.573
## oxygen         1   1.146 1.5642  0.073 .
## conductivity   1   1.631 2.2265  0.010 **
## plants         1   2.986 4.0763  0.001 ***
## Residual      52   38.093
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```