Electronic Journal of Ichthyology
December, 2005 **2**: 54-60

TROPHIC INTERACTIONS BETWEEN *XYRICHTYS NOVACULA* (LABRIDAE) AND JUVENILE *PAGRUS PAGRUS* (SPARIDAE) IN THE CENTRAL MEDITERRANEAN SEA

Luca Castriota[1], Maria Grazia Finoia[2], Franco Andaloro[1]

1. ICRAM (Central Institute for Applied Marine Research), via Emerico Amari 124, 90139 Palermo, Italy. E-mail: castriotaluca@hotmail.com, andalorofranco@virgilio.it
2. ICRAM, via di Casalotti 300, 00166 Roma, Italy. E-mail mafinoia@tin.it

Abstract: The trophic relationships between the pearly razorfish *Xyrichtys novacula* and the juvenile red porgy *Pagrus pagrus* living in the same area of the Tyrrhenian Sea were investigated. Stomach content analyses revealed that both fishes fed mainly on benthic crustaceans and molluscs. Pagurids, brachyurans and gastropods were preferred prey of red porgy while amphipods, copepods and bivalves were more important in the diet of pearly razorfish. Highly significant differences between predators were found in prey abundance as well as in prey weight. Non significant values of Pianka's index of niche overlap were obtained for prey abundance, weight and IRI. Co-inertia analysis showed prey separated in one or the other predator; they were not particularly segregated in predator size classes of 15 mm TL, which differed significantly in mean prey weight exploited. This study showed that the two predators living in the same habitat occupy a different trophic role, showing prey partitioning and low diet overlap.

Key words: diet overlap, *Pagrus pagrus*, resource partitioning, Tyrrhenian Sea, *Xyrichtys novacula*

Introduction

The pearly razorfish *Xyrichtys novacula* (Linnaeus, 1758) and the juvenile red porgy *Pagrus pagrus* (Linnaeus, 1758) share the same habitat in the southern Tyrrhenian Sea. Both fishes live on shallow sandy bottoms, colonised by the seagrass *Cymodocea nodosa*. This habitat supports a rich benthic fauna that is a potential food resource for both adult and juvenile coastal fishes. Even though red porgy is less strictly linked to the bottom than pearly razorfish, both species rely on benthic organisms for their feeding activity. They also share the ability of crushing their prey, mainly shelled molluscs and armoured crustaceans (Manooch 1977; Cardinale et al. 1997; Labropoulou et al. 1999; Castriota et al. 2005), thanks to their strong denture. Studies on the feeding habits of *X. novacula* in southern Tyrrhenian sea revealed that its diet is mainly composed of crustaceans and molluscs (Castriota et al. 2003; Castriota et al. 2005) which are also preferred prey of juvenile *P. pagrus* in the same area (Castriota et al. unpublished data). Despite the broad range of prey types found in their diets, both predators tend to be specialized in their food preferences showing narrow diet breadth. These observations were the stimuli to investigate potential diet overlap between these two species. Therefore, in this paper we aim at: 1) investigating the differences in prey weight and prey abundance between juvenile red porgy and razorfish; 2) analysing the importance of those prey which are shared by the two fishes; 3) analysing mean prey weight as a factor of selection by predator size classes.

Material and methods

The study area was located on a sandy bottom of Capo d'Orlando, in the northern Sicilian coast (Figure 1).

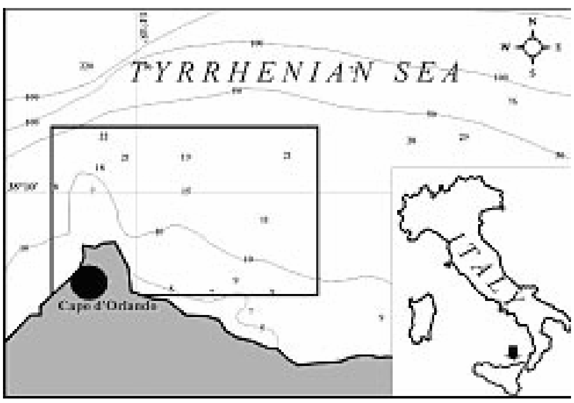

Figure 1. Map of the study area.

This bottom is characterised by fine well-sorted sands, delimited by gravel and very coarse sands near the coast and fine silt between 35 and 50 m in depth; the seagrass *Cymodocea nodosa* (Ucria) Aschers and its associated fauna colonise the bottom from 10 to 20 m (Andaloro 1994). Fishes were sampled during the daytime at depths between 5 and 25 m, from 1994 to 2001. They were caught by hand-line and seine net. Each specimen was measured to the nearest 1 mm TL, weighed to the nearest 0.1 g and its stomach preserved in a 5% neutral solution of formaldehyde and sea water. Prey items were identified, counted and weighed to the nearest 0.1 mg, after removing excess water with blotting paper. Prey importance was evaluated by calculating the frequency of occurrence (%F = number of stomachs containing prey *i* / total number of stomachs containing prey * 100), abundance (%N = number of prey *i* / total number of prey * 100) and weight (%W = weight of prey *i* / total weight of all prey * 100). We used these values to calculate the index of relative importance (IRI) for each prey category using mass instead of volume: IRI = (%N + %W) x (%F) (Hyslop 1980; Hacunda 1981). Prey abundance and prey biomass were analysed by means of a non-parametric multivariate analysis of variance (NPMANOVA) (Anderson 2000, 2001; McArdle & Anderson 2001) to detect differences between species. We performed this analysis on 62 prey categories, belonging to 94 specimens for each species. Data were transformed to ln(x+1); the analysis is based on Gower distances, with 999 permutations used.

Diet overlap was estimated using Pianka’s measure of niche overlap (Pianka 1973) applied to both abundance data and IRI values; this index is symmetric and varies from 0 (no overlap) to 1 (complete overlap).

The prey distribution in the two predators, subdivided in size classes of 15 mm TL, was studied applying co-inertia analysis, a statistical technique that allows the simultaneous ordination of two sets of data sharing the same sets of lines (Dolédec & Chessel 1994, Dolédec et al. 1996). This analysis was performed on the relative prey abundance and relative prey biomass separately, after non significant results of Mantel's permutation test for similarity of two matrices (Mantel, 1967) using 1000 permutations. The overall analysis is the result of a correspondence analysis (CA) performed on prey proportions and a multiple correspondence analysis (MCA) computed on prey proportions in different predator size classes.

Unbalanced two way (species and predator size classes as factors) analysis of variance was computed to test differences in mean prey weight. Student’s *t* test was applied for testing differences between predators size class pairs, after Levene’s test for the homogeneity of variances.

Results

The stomach contents of 177 pearly razorfish and 94 juvenile red porgy were examined. Of 62 food categories identified, 46 were common to both species; they accounted for 93.2% and 64.9% of the total prey abundance and for 80.5% and 85.3% of the total prey biomass, in the red porgy and the pearly razorfish respectively. Crustaceans are the most frequent prey in both predators; of these, pagurids and brachyurans characterise the diet of juvenile red porgy while amphipods and copepods are more important in that of pearly razorfish, according to all numeric indicators (Figure 2). Molluscs are also important in the diet of both predators: juvenile red porgy mostly eat gastropods while pearly razorfish rely also on bivalves as food resource. Teleosts are well represented in juvenile red porgy, less in pearly razorfish. Table 1 shows the percent index of relative importance (% IRI) calculated for each shared prey item.

Results of NPMANOVA showed highly significant differences between predators, for both prey abundance ($F_{1,186}$=18.47; p<0.001) and prey biomass ($F_{1,186}$=2.68; p<0.001).

The Pianka’s measure of niche overlap was 0.20 for prey abundance, 0.46 for prey biomass, 0.14 for IRI values.

Mantel's permutation test for similarity of relative prey abundance and relative prey biomass matrices resulted non significant,

Table 1. Percent index of relative importance (%IRI) for prey items shared by *P. pagrus* and *X. novacula* in the southern Tyrrhenian Sea

% IRI		*P. pagrus*	*X. novacula*
Mollusca	Cardiidae	0.1	3.3
	Musculus costulatus	0.1	0.5
	Solenidae	< 0.1	0.1
	other bivalves	0.1	13.9
	Caecum spp	3.6	4.2
	Smaragdia viridis	0.1	< 0.1
	Limacina inflata	< 0.1	0.2
	Ringicula sp	0.1	< 0.1
	Bullomorpha	7.6	< 0.1
	Nassariidae	0.5	< 0.1
	Naticidae	0.2	< 0.1
	Pyramidellidae	0.1	< 0.1
	Rissoidae	0.1	< 0.1
	Trochidae	< 0.1	< 0.1
	other gastropods	0.5	6.0
Crustacea	*Ilia nucleus*	0.4	< 0.1
	Majidae	0.7	< 0.1
	Portunidae	2.1	0.1
	Brachiura	< 0.1	0.4
	Paguridea	16.6	0.1
	Reptantia	0.1	0.1
	Natantia	0.3	< 0.1
	Decapoda	0.2	0.7
	Leucothoe sp.	0.1	< 0.01
	other gammarideans	0.7	19.1
	Caprellidea	0.5	0.1
	Copepoda	< 0.1	20.9
	Isopoda	1.0	0.1
	Tanaidacea	< 0.1	< 0.1
	crustacean larvae	< 0.1	0.1
	other crustaceans	0.7	< 0.1
Echinodermata	Echinoidea	< 0.1	0.3
	Irregularia	0.4	0.1
	Asteroidea	1.1	< 0.1
	Ophiuroidea	0.3	< 0.1
Polychaeta	Aphroditoidea	0.9	< 0.1
	Onuphidae	0.1	< 0.1
	Maldanidae	0.6	< 0.1
	Nephtyidae	0.1	< 0.1
	other polychaetes	1.4	0.4
Teleostei	Teleostei	31.8	6.2
	fish scales	20.7	< 0.1
other groups	Foraminifera	< 0.1	< 0.1
	Pantopoda	0.1	< 0.1
	Sipuncula	0.3	< 0.1
	Vegetalia	0.4	< 0.1

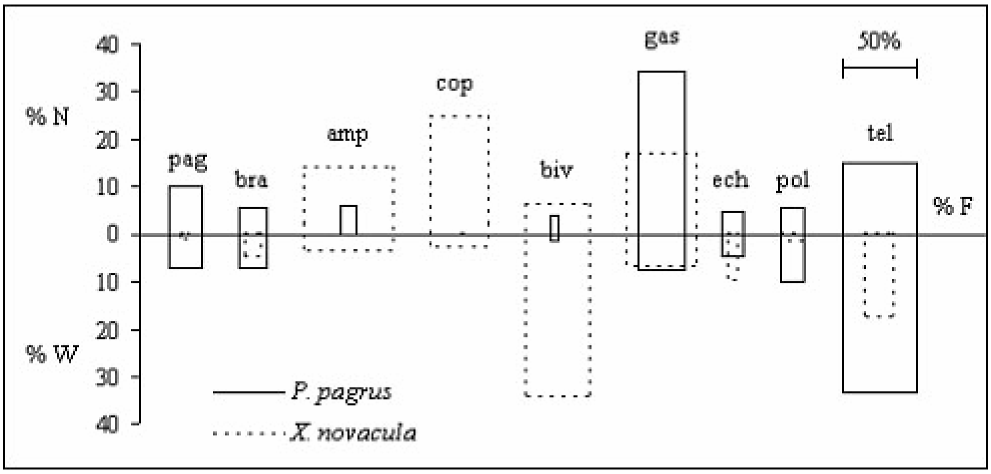

Figure 2. Frequency of occurrence (%F), abundance (%N) and biomass (%W) of main prey categories (pagurids, brachyurans, amphipods, copepods, bivalves, gastropods, echinoderms, polychaetes, teleosts) in the diet of *Pagrus pagrus* and *Xyrichtys novacula* from the southern Tyrrhenian sea.

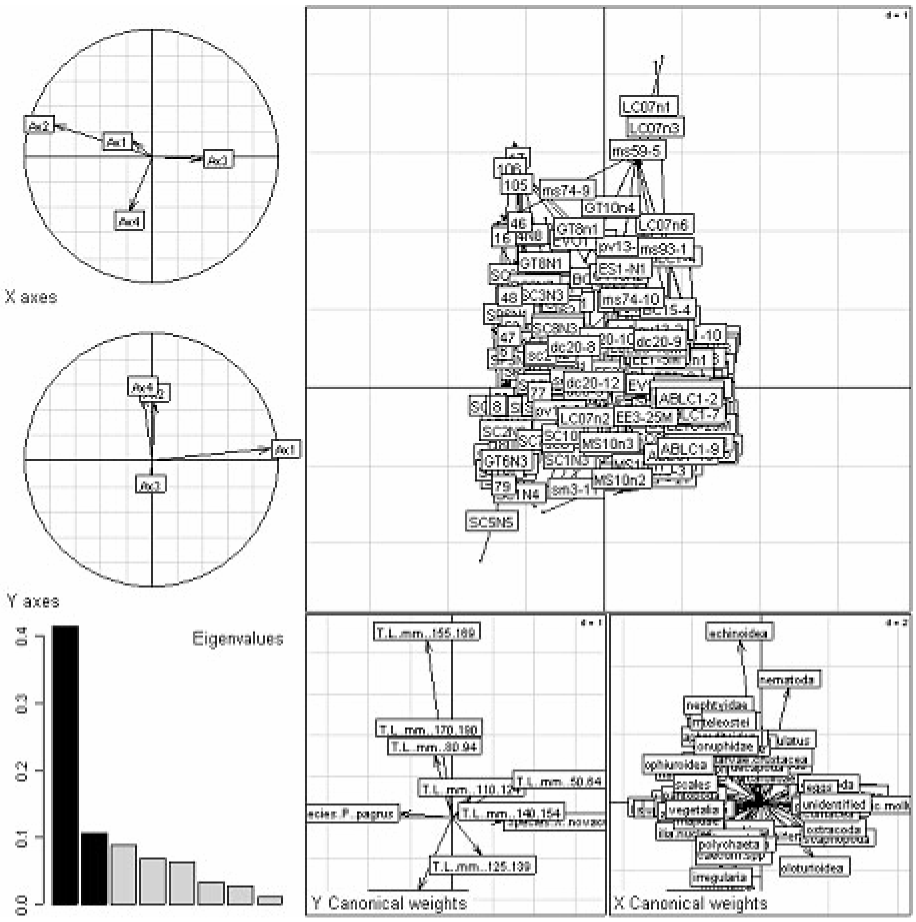

Figure 3. Co-inertia analysis performed on relative prey abundance. Circles in the upper left corner of the graph show the relation between separate analyses and co-inertia analysis (upper circle represents the components of the correspondence analysis on relative prey abundance projected on to the co-inertia axes; lower circle represents the components of the multiple correspondence analysis on relative prey abundance and predator size classes projected on to the co-inertia axes).

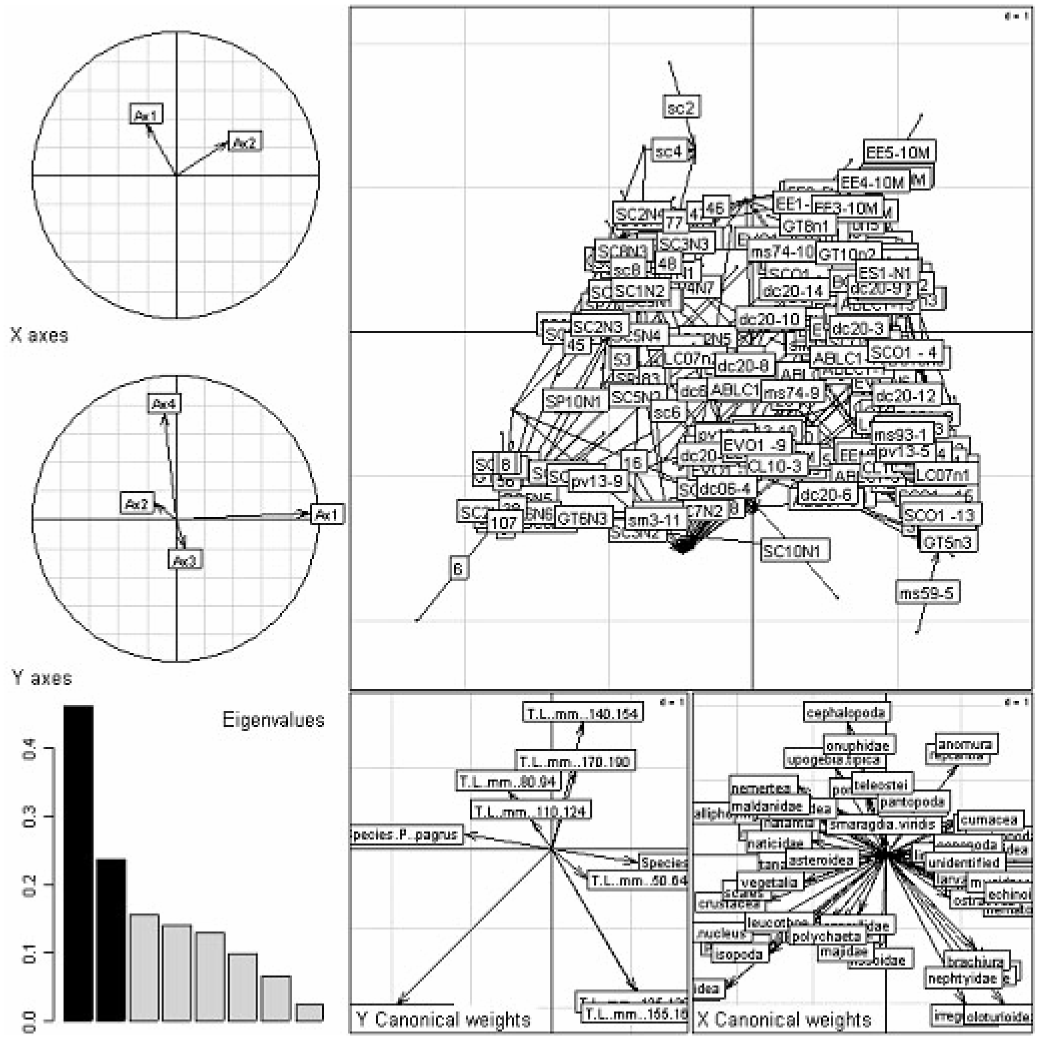

Figure 4. Co-inertia analysis performed on relative prey biomass. Circles in the upper left corner of the graph show the relation between separate analyses and co-inertia analysis (upper circle represents the components of the correspondence analysis on relative prey biomass projected on to the co-inertia axes; lower circle represents the components of the multiple correspondence analysis on relative prey biomass and predator size classes projected on to the co-inertia axes).

indicating that the two distance matrices were not correlated and therefore they have been analysed separately.

For co-inertia analysis computed on prey abundance (Fig. 3), the first two dimensions explained 63.8% of the variance. Most prey items are concentrated towards one or the other predator and are not particularly segregated in size classes.

Similar results were obtained with co-inertia analysis computed on prey biomass (Fig. 4), the first two dimensions explaining 53.2% of the variance.

Two-way ANOVA performed on mean prey weight resulted highly significant ($F_{(15, 248)}$=11.5 p< 0.001). Moreover it showed highly significant differences between predators ($F_{(1, 248)}$=52.31 p< 0.001) and among size classes ($F_{(7, 248)}$=6.39 p< 0.001) but there is also significant predator-size classes interaction ($F_{(6, 248)}$= 6.39 p< 0.001). Student's *t* test showed non significant results (p<0.05) between the size classes <95 mm TL and >140 mm TL; the size class 95-109 mm TL showed significant differences (p<0.05); the size classes 110-124 ($t_{(59)}$=6.29) and 125-139 mm TL ($t_{(39)}$=5.37) showed highly significant differences (p<0.001).

Discussion

Food partitioning allows coexisting fish to exploit the food supply to its fullest extent and it is considered an important feature regulating the structure of fish communities (Gerking 1994). Pearly razorfish and juvenile red porgy are both benthivore secondary consumers and both show specialist feeding in the southern Tyrrhenian sea (Castriota et al. 2005; Castriota et al. unpublished data). Their diets are mainly composed of crustaceans and molluscs which are crushed before ingestion by the action of their strong teeth, although teleosts are also well represented in the diet of juvenile red porgy and less in that of pearly razorfish. The high number of prey items (74%) shared by these two predators living in the same habitat, and their high abundance and biomass, suggest a certain degree of diet overlap. Although the similar prey composition of their diets, the results of NPMANOVA, performed on prey abundance and prey biomass, showed highly significant differences between predators, indicating that they use resources in different ways. In terms of percent relative importance of shared prey, only 13 prey items accounted for more than 1% of total IRI in at least one predator; important prey categories in the diet of one fish resulted irrelevant in the food array of the other species and vice versa. Within crustaceans, juvenile red porgy prefer pagurids and brachyurans to amphipods and copepods which are otherwise preferred prey of pearly razorfish; among molluscs, bivalves are more important food for pearly razorfish than for juvenile red porgy who prefer gastropods to them. These results were also supported by the low Pianka’s index values obtained for all numeric indicators and were well represented by co-inertia analysis, where predators resulted separated with most prey items segregated in one or the other predator. Most prey exploited in similar proportions by the two fishes were represented by very low values of relative importance in their diets. An exception is the gastropod *Caecum* spp. which showed similar %IRI values, resulting from high %N and low %F in the red porgy and the opposite in the pearly razorfish. When analysing the distribution of prey in predator size classes, weak segregation occurs except for few prey categories, such as echinoids, which appear to be consumed in equal relative abundances by certain fish size classes.

At last, red porgy and pearly razorfish exploit different prey sizes, as resulting from two-way ANOVA performed on mean prey weight. Particularly, size classes from 95 to 140 mm TL showed differences in mean prey weight while all the other classes resulted to exploit similar prey sizes and then are potentially overlapping. Therefore, if overlap exists in terms of abundance and biomass of prey, it is further diminished through segregation of prey sizes between predators.

References

Andaloro, F. (1994). Indagini sulle condizioni della fascia costiera della Sicilia settentrionale per la tutela, il ripopolamento e lo sfruttamento ottimale delle risorse biologiche. ICRAM Report.

Anderson, M.J. (2000). NPMANOVA: a FORTRAN computer program for non-parametric multivariate analysis of variance (for any two-factor ANOVA design) using permutation tests. Department of Statistics, University of Auckland.

Anderson, M.J. (2001). A new method for non-parametric multivariate analysis of variance. Austral Ecol. **26**: 32-46.

Cardinale, M., Colloca, F. & Ardizzone, G.D. (1997). Feeding ecology of Mediterranean razorfish *Xyrichthys novacula* in the Tyrrhenian Sea (Central Mediterranean Sea). J. Appl. Ichthyol. **13**: 105-111.

Castriota, L., Sinopoli, M., Falautano, M., Diliberto, S. & Andaloro, F. (2003). Feeding ecology of *Xyrichthys novacula* (Osteichthyes: Labridae) in Sicily Island (Southern Tyrrhenian Sea). In: Island Ecosystems Conservation and Molecular Approach I Symposium, Madeira Island, Portugal 05-09 March 2001. Pinheiro de Carvalho M.Â.A., Pereira Costa G., Abreu Jesus J., Rodrigues D.M.M. Eds., CCBG: 95-100.

Castriota, L., Scarabello, M.P., Finoia, M.G., Sinopoli, M. & Andaloro F. (2005). Food and feeding habits of pearly razorfish, *Xyrichtys novacula* (Linnaeus, 1758), in the southern Tyrrhenian Sea: variation by sex and size. Environ. Biol. Fish. **72** : 123-133.

Chakroun-Marzouk, N. & Kartas, F. (1987). Denture et régime alimentaire des espèces du genre *Pagrus* (Pisces, Sparidae) des côtes tunisiennes. Cybium **11**(1): 3-19.

Dolédec, S. & Chessel, D. (1994). Co-inertia analysis : an alternative method for studying species-environment relationships. Freshwater Biol. **31**:277-294.

Dolédec, S., Chessel, D., Ter Braak, C.J.F. & Champely, S. (1996). Matching species traits to environmental variables: a new three-table ordination method. Environ. Ecol. Stat. **3**: 143-166.

Gerking, S.D. (1994). Feeding ecology of fish. Academic Press. USA. 416pp.

Hacunda, J.S. (1981). Trophic relationships among demersal fishes in a coastal area of the Gulf of Maine. Fish. Bull. **79**: 775-788.

Hyslop, E.J. (1980). Stomach content analysis – a review of methods and their application. J. Fish Biol. **17**: 411-429.

Labropoulou, M., Machias, A. & Tsimenides, N. (1999). Habitat selection and diet of juvenile red porgy, *Pagrus pagrus* (Linnaeus, 1758). Fish. Bull. **97**:495-507.

Manooch, C.S. III (1977). Foods of the red porgy, *Pagrus pagrus* Linnaeus (Pisces: Sparidae), from north Carolina and south Carolina. Bull. Mar. Sci. **27**(4):776-787.

Mantel, N. (1967). The detection of disease clustering and a generalized regression approach. Cancer Res. **27**: 209-220.

McArdle, B.H. & Anderson, M.J. (2001). Fitting multivariate models to community data: a comment on distance-based redundancy analysis. Ecology **82**(1): 290-297.

Pianka, E.R. (1973). The structure of lizard communities. Annu. Rev. Ecol. Syst. **4**: 53-74.