ARTICLE

Food resources of *Eucinostomus* (Perciformes: Gerreidae) in a hyperhaline lagoon: Yucatan Peninsula, Mexico

Recursos alimenticios de *Eucinostomus* (Perciformes: Gerreidae) en una laguna hiperhalina: Península de Yucatán, México

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Resumen.- La alta salinidad de las lagunas hiperhalinas las convierte en hábitats extremos para los organismos acuáticos, poniendo presión sobre sus adaptaciones fisiológicas especiales. Gerreidae es una familia de peces de amplia distribución y abundancia en las lagunas costeras, muy importantes para la función del ecosistema y las pesquerías. El objetivo de este estudio fue evaluar y comparar la ecología trófica de 2 especies de mojarra en la laguna hiperhalina (> 50) de Ría Lagartos, Yucatán, para proporcionar evidencia sobre la importancia de este hábitat sobre su crecimiento y requerimientos tróficos. Las muestras fueron colectadas bimensualmente durante un ciclo anual (2004-2005). Un total de 920 ejemplares de *Eucinostomus argenteus* (493) y *E. gula* (427) fueron colectados. Los componentes tróficos fueron analizados usando el Índice de Importancia Relativa (IIR) y análisis multivariados. Las mojarras fueron definidas como consumidores de segundo orden, alimentándose de anélidos, microcrustáceos (anfípodos, copépodos, tanaidáceos, ostrácodos) y cantidades significativas de detritus con variaciones en proporción y frecuencia de acuerdo a la disponibilidad del alimento. Ambas especies compartieron los mismos recursos alimenticios, sin embargo se observaron diferencias ontogenéticas con variaciones espaciales y temporales, que con ello se evita la competencia interespecífica. Los resultados proporcionan evidencia sobre la importancia de estos hábitats costeros durante las etapas del ciclo de vida y los requerimientos tróficos de estos peces juveniles marinos-eurihalinos.

Palabras clave: Sistemas lagunares hiperhalinos, mojarras, preferencias alimenticias, cambios ontogenéticos, presas bénticas

Abstract.- The high salinity of hyperhaline lagoons makes them extreme habitats for aquatic organisms, putting demands on their special physiological adaptations. The Gerreidae are a family of widely distributed and abundant fish in coastal lagoons, which are very important for ecosistem functions and fisheries. The aim of this study was to evaluate and compare the trophic ecology of 2 species of mojarra in the hyperhaline lagoon (>50) of Ria Lagartos, Yucatan, in order to provide evidence of the importance of this habitat for growth and trophic requirements. Samples were collected bimonthly during an annual cycle (2004-2005). A total of 920 fish specimens of *Eucinostomus argenteus* (493) and *E. gula* (427) were collected. Trophic components were analysed using the Relative Importance Index (RII) and multivariate analyses. The mojarras were defined as second-order consumers, feeding on annelids, microcrustaceans (amphipods, copepods, tanaidaceans, ostracods), and significant amounts of detritus with variations in proportion and frequency according to food availability. Both species shared the same food resources, however ontogenetic differences were observed with spatial and temporal variations, thus avoiding interspecific competition. Results provide evidence of the importance of these coastal habitats in the life-history stages for species and food resource requirements of juvenile marine euryhaline fish.

Key words: Hyperhaline lagunar systems, mojarras, feeding preferences, ontogenetic shifts, benthic preys

INTRODUCTION

Hyperhaline coastal lagoons are aquatic systems where freshwater discharges are extremely limited and salinity forms a gradient that increases inwards (Labonne *et al.* 2009). This is the case of Ria Lagartos, Yucatan, where the salinity exceeds 100 in certain areas (Valdés & Real 2004), making it a determining factor for species distribution (Chaves & Robert 2001, Denadai *et al.* 2012). Therefore, these organisms have developed osmoregulatory adaptations in order to take advantage of the hyperhaline conditions (Legendre & Ecoutin 1989, Duponchelle & Panfili 1998).

Fishes of the Gerreidae family are abundant and widespread in tropical coastal lagoons (Gning *et al.* 2010, Denadai *et al.* 2012, Pontes-Franco *et al.* 2012); as a result of this, they are considered a good study model for analysis of spatial and temporal dynamics in estuarine systems (Aguirre-León & Yáñez-Arancibia 1986, Chaves & Robert 2001, Pontes-Franco *et al.* 2012). The adaptations of Gerreidae fish to the saline variability of coastal environments, allows them to take advantage of available resources, reducing interspecific competition (Pontes-Franco *et al.* 2012). The commercial

importance of gerrids lies in their use as bait to support both local and artisanal fisheries (Carpenter 2002, Denadai *et al.* 2012), in addition to their ecological importance for the structure and function of coastal ecosystems in tropical and subtropical regions (Hofling *et al.* 1998, Pessanha & Araújo 2014). Despite its ecological and economic value, information on trophic dynamics of mojarras is very limited for hyperhaline lagoons.

Ontogenetic stages of this fish species, mainly juveniles, take advantage of the oligohaline conditions and high turbidity that characterise several habitats in these environments in search of protection from predators and to find adequate food supplies for growth (Cyrus & Blaber 1984, Gning *et al.* 2008).

In general, all gerrid species present similar features with a highly protusible jaw, which allows them to feed on a wide variety of benthic prey (Cyrus & Blaber 1982, Cervigón 1993, Nelson 2006). However feeding habits and diet compositions can change within the same species due to food availability, seasonality, age and/or sex (Blaber 1997, Gning *et al.* 2008, Denadai *et al.* 2012, Pontes-Franco *et al.* 2012). The aim of the present study was to evaluate the spatial, temporal and ontogenetic trophic preferences of 2 species of mojarra in the hyperhaline lagoon of Ria Lagartos, Yucatan. We used stomach content analyses as a fundamental tool to provide insights into the ecological role of the species in ecosystems (Aguirre-León & Yáñez-Arancibia 1986).

We hypothesized that the diet of *Eucinostomus argenteus* Baird & Girard, 1855 and *E. gula* Quoy & Gaimard, 1824 may vary depending on the sampling site, season and body size or life-history stages. This information contributes to the functional knowledge of an extreme ecosystem such as hyperhaline lagoons.

MATERIALS AND METHODS

STUDY AREA

The Ria Lagartos lagoon is located along the western coast of Yucatan state (21°26'-21°38'N, 87°30'-88°15'W), covering an area of approximately 9,371 ha, with a width that varies from 25 m to 3.5 km, a depth between 0.5-3 m and a length of 80 km. The mean annual temperature is 22°C. Regarding its geomorphology, it has 3 basins: Río Lagartos, Las Coloradas and El Cuyo (INE 1999). The system presents many substrates (sand, seagrass, mud, limestone) (Peralta-Mexueiro & Vega-Cendejas 2011), and a marked salinity gradient with values in the inner zone 4-5 times higher than seawater (>100) (Valdés & Real 2004). Considering hydrologic characteristics, 5 regions were defined by Peralta-Mexueiro & Vega-Cendejas (2011), which are: Marine, Channel, Coloradas west, Coloradas east and Cuyo. The climatic regime is represented by 3 seasons: dry (March-June), rainy (July-October), and notherlies (November-February).

FIELD SAMPLING

Six field samplings were performed (October and December 2004; February, April, June and August 2005), taking into account the 3 climatic seasons in the region (dry, rainy and northerlies). Fish were collected using a beach seine (15 m x 1.5 m, 2.5 cm mesh) at 30 sites distributed throughout the lagoon (Fig. 1). The collected individuals were preserved with formaldehyde (10%) and were subsequently placed in labelled plastic bags for transportation.
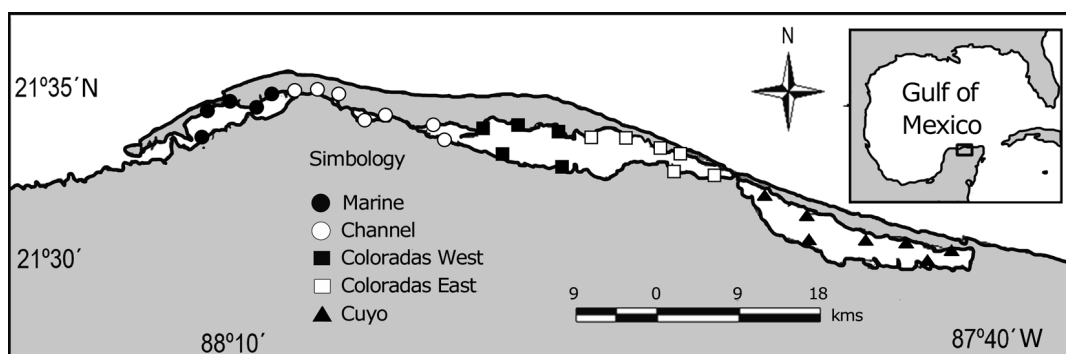

Figure 1. Study area and location of sampling zones / Área de estudio y ubicación de las zonas de muestreo

Laboratory processing and data analysis

In the laboratory the specimens were rinsed with water and finally preserved in 70% ethanol. The fish were identified to species level using specialized keys (Castro-Aguirre *et al.* 1999, Carpenter 2002). Standard length and total weight were measured for all samples. The stomach content was removed and the components of their diets were identified to the lowest possible taxonomic level using specialized literature (Kudo 1976, Amos & Amos 1985, Platt & Warwick 1988, Ruppert & Barnes 1996, Littler & Littler 2000).

The diet composition was analysed using the Relative Importance Index (RII) (Pinkas *et al.* 1971) modified by Hyslop (1980), following the formula RII= (%A+%W)*%FO. %A refers to the estimated percentage of the total digested area occupied by each prey item and was obtained using a millimetric grid (Poot-Salazar *et al.* 2005, Canto-Maza & Vega-Cendejas 2007). The percentage of wet weight (%W) of each diet component was obtained using an analytical balance. The frequency of ocurrence (%FO) was calculated from the number of times (n) that a certain prey item appeared in the stomach content of a group of fish (NE) using the equation FO= (n/NE)*(100) (Tresierra & Culquichicón 1995). The food was classified as preferential (FO > 50%), secondary (50% > FO > 10%) and accidental (FO < 10%) based on the values of FO (Yáñez-Arancibia 1975). For the ontogenetic analysis of the diet, Sturges' rule was used (Sturges 1926), where the fish are divided into size categories based on their standard lengths using the equation: (class interval= maximum size-minimum size)/(N° of classes), where N° of classes= 1+ (3.3 log n) and (n) is the number of individuals.

For each species, 3 canonical correspondence analyses (CCA) (Ter Braak & Smilauer 2002) were performed in order to correlate the prey used with the seasons, zones and size classes. In this analysis specimens from all sizes were used in order to avoid information loss. However, accidental preys items (%FO < 10%) were eliminated from the general analysis, and were included with the standard length and weight of fish as covariates in order to avoid false statistical differences. In both cases, the Monte Carlo test was performed to determine whether the variables recorded were significant (Adjeroud *et al.* 1998, Kupschus & Tremain 2001). For the statistical analysis, the multivariate statistical package CANOCO v. 4.5 (Ter Braak & Smilauer 2002) was used.

RESULTS

Trophic preferences

A total of 493 specimens of *Eucinostomus argenteus* and 427 of *E. gula* were collected in Ria Lagartos during the study period. In general, the food groups consumed preferentially (FO > 50%) by *E. argenteus* were the amphipods, annelids and copepods. The highest RII values were for amphipods (33%), annelids (28%) and detritus (12%). *E. gula* preferentially consumed amphipods, annelids and detritus, and the highest RII values corresponded to the annelids group (45%), amphipods (14%) and detritus (11%) (Appendix 1 and 2).

Spatial and temporal trophic variation

In the inlet of the lagoon (Marine), *E. argenteus* preferentially consumes detritus and some tanaidaceans. In Coloradas west and Coloradas east regions, this species feeds on amphipods and annelids. Finally, in the inner region (Cuyo), its diet changes to insects. The diet of *E. gula* is heterogenous with regards to annelids throughout the lagoon; the intake of amphipods is much greater in Coloradas west and Cuyo (Fig. 2).

During the rainy and northerlies seasons, *E. argenteus* mostly consumed amphipods and annelids; in the dry seasons the proportions of these components in the diet decreased, and an increased consumption of detritus and tanaidacea was observed. In comparison, *E. gula* mainly consumed annelids during the rainy season, accounting for more than half of its diet; while other diets were similarly used with at most 10% each. In the northerlies and dry seasons, *E. gula* consumed annelids, detritus and tanaidaceans in higher proportions, whereas in the northerlies and in the dry season copepods and amphipods were an important component of the diet respectivelty, contributing approximately 20% each (Fig. 3).

Ontogenetic trophic variation

Using Sturges' rule, 9 size classes were identified for *E. argenteus* with intervals of 0.7 cm between sizes, where the number of individuals per class varied between 9 and 102. Using the same rule, 8 different size classes were identified for *E. gula* with intervals of 0.6 cm, with a variation in the number of individuals between 8 and 126 (Table 1).

For *E. argenteus*, the most important components of the diet of the small size classes were amphipods, annelids and copepods, which together comprised more than 90% of the diet. Other prey items such as tanaidaceans, detritus and insects were of minor relevance. The middle and larger sizes classes consumed significant amounts of detritus and tanaidaceans, while the proportion of other prey items decreased, for example amphipods and annelids. In all stages of *E. gula*, annelids and amphipods form part of the diet too, although in small sizes (A and B) an important presence of copepods is observed and in the largest sizes (G and H) tanaidaceans and detritus were observed (Fig. 4).
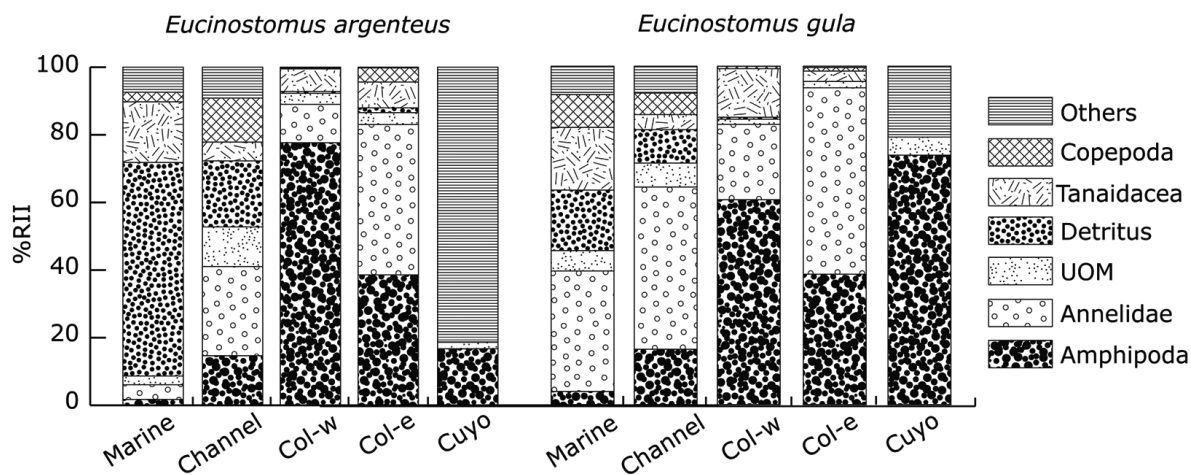
Figure 2. Variation in the trophic spectrum between zones of the Ría Lagartos lagoon system, based on the Percentaje of Relative Importance Index (%RII), where the 'Others' category in Cuyo region corresponds to 90% of insects / Variación en el espectro trófico entre zonas para el sistema lagunar de Ría Lagartos, en base al Porcentaje del Indice de Importancia Relativa (%RII), donde la categoría 'Otros' en la región del Cuyo corresponde a un 90% de insectos
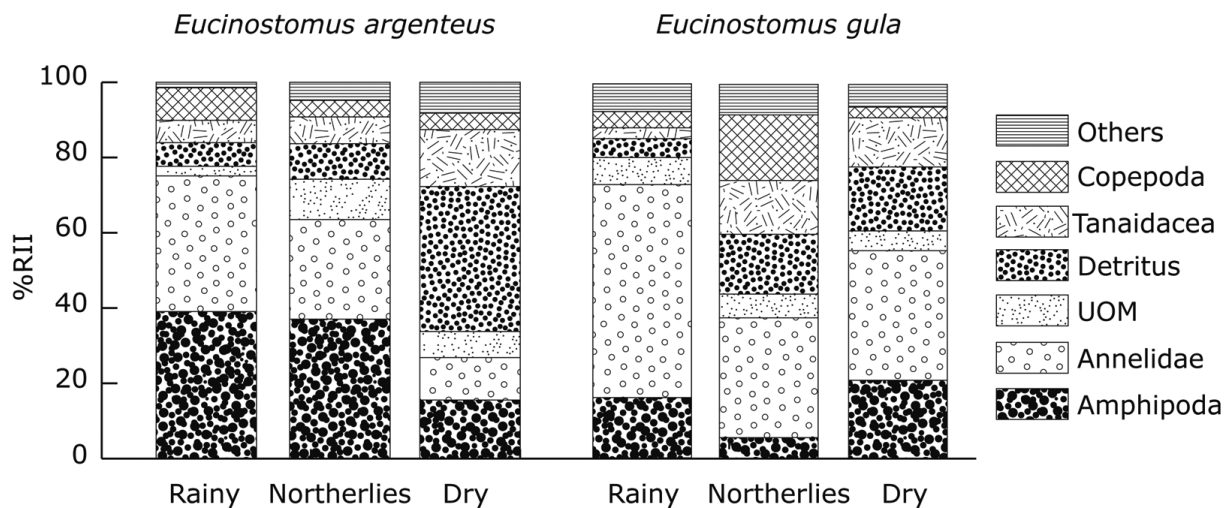

Figure 3. Variation in the trophic spectrum between seasons for the Ría Lagartos lagoon system, based on the Relative Importance Index (RII) / Variación en el espectro trófico entre temporadas para el sistema lagunar de Ría Lagartos, en base al Indice de Importancia Relativa (RII)
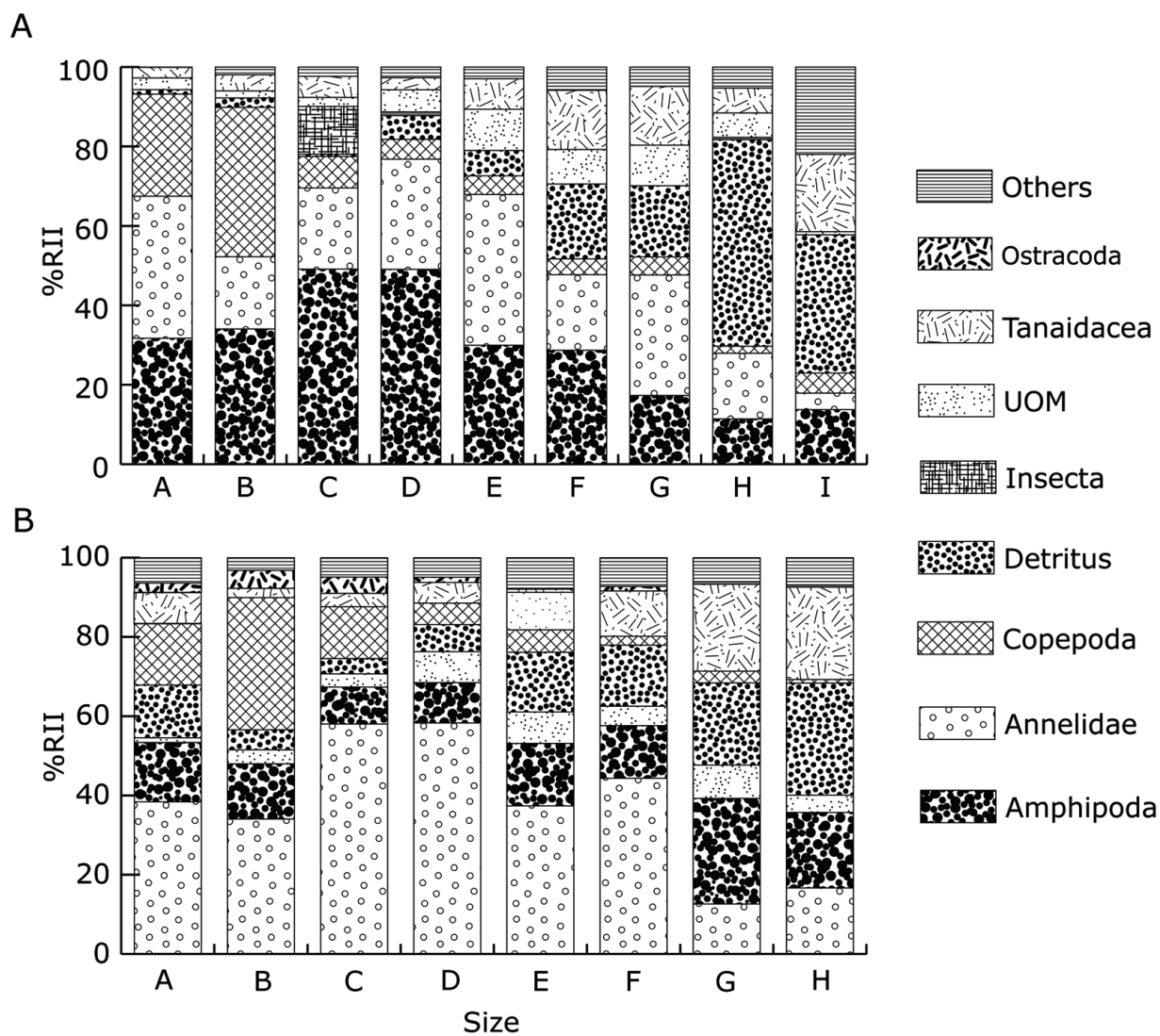
Figure 4. Variation in the trophic spectrum of *E. argenteus* between different size classes (A-I) for the Ría Lagartos lagoon system, based on the Percentage of Relative Importance Index Percentage (%RII). A) corresponds to *E. argenteus* and B) *E. gula* / Variación en el espectro trófico de *E. argenteus* entre los distintos intervalos de clases (A-I) para el sistema lagunar de Ría Lagartos, en base al porcentaje del Indice de Importancia Relativa (%RII). A) corresponde a la especie *E. argenteus* y B) *E. gula*

Table 1. Size intervals in standard length (cm) obtained using Sturges' rule (1926), and number of specimens (N) corresponding to each class in *E. argenteus* (Ea) and *E. gula* (Eg) / Intervalo de talla en longitud estándar (cm) obtenido mediante la regla de Sturges (1926), y número de especímenes (N) correspondientes a cada clase en *E. argenteus* (Ea) y *E. gula* (Eg)

Class	Interval		N	
	Ea	Eg	Ea	Eg
A	1.3 - 2.0	2.5 - 3.1	9	8
B	2.1 - 2.8	3.2 - 3.8	51	42
C	2.9 - 3.6	3.9 - 4.5	102	52
D	3.7 - 4.4	4.6 - 5.2	102	126
E	4.5 - 5.2	5.3 - 5.9	59	124
F	5.3 - 6.0	6.0 - 6.6	85	49
G	6.1 - 6.8	6.7 - 7.3	55	17
H	6.9 - 7.6	7.4 - 8.0	18	9
I	7.7 - 8.4	-	12	-

The results of the canonical correspondence analysis (CCA) indicated that the dietary components of *E. argenteus* presented significant variations at a temporal (gl= 492; F= 24.07; *P*= 0.002), spatial (gl= 492; F= 75.66; *P*= 0.002) and ontogenetic level (gl= 492; F= 30.61; *P*= 0.002). Similarly, *E. gula* presented significant temporal (gl= 426; F= 11.97; *P*= 0.002), spatial (gl= 426; F= 14.16; *P*= 0.002) and ontogenetic differences (gl= 426; F= 5.48; *P*= 0.020) (Fig. 5).

DISCUSSION

Eucinostomus argenteus and *E. gula* in the Ria Lagartos lagoon consume a wide variety of benthic food elements (approximately 78 items), since these are sympatric species, a superimposition of food resources might be expected (Russo *et al.* 2008, Mariani *et al.* 2011). However between the 2 species, there is a resource partitioning in terms of the proportion and frequency of prey items. These changes are probably a consequence of habitat use and morphological changes in the fish (Ward-Campbell *et al.* 2005, Russo *et al.* 2008, Pereira *et al.* 2014), which results in a wide trophic spectrum (generalist) or reduced trophic spectrum (specialist) (Hammerschlag *et al.* 2010). These variations are in accordance with the niche partitioning theory (Bolnick *et al.* 2003, Mariani *et al.* 2011), which states that every time that a species decreases food resources shared by specialization, it reduces interspecific competition, while intraspecific competition increases (Pereira *et al.* 2014).

The diet of *E. argenteus* and *E. gula* mainly consists of microcrustacea, including copepods and amphipods, as well

as polychaetes and has been repeatedly cited in the literature (Cyrus & Blaber 1982, Motta *et al.* 1995, Zahorcsak *et al.* 2000, Gning *et al.* 2010, Denadai *et al.* 2012). However, Kershner & Peterson (1985) mentioned bivalves as preferential prey, which were not reflected in the present study, probably as a result of the low abundance of these in the system (Kuk-Dzul *et al.* 2012). Furthermore, Branco *et al.* (1997) and Hofling *et al.* (1998) highlight those algae were an important component of the diet. Nevertheless, plant fragments have been found in the stomachs of multiple species, although in reality their presence may be accidental due to the voracity with which the organisms consume their main prey (Gning *et al.* 2008, Nanjo *et al.* 2008, Nakane *et al.* 2011), since these species have been considered second order consumers.

In certain estuaries or coastal lagoons where freshwater discharges are limited, salinity increases towards the inner zone, forming a hyperhaline system (Labonne *et al.* 2009). This is the case of the Ria Lagartos coastal lagoon, where salinities exceed 100 (Valdés & Real 2004). Since salinity is the determining factor in the distribution of fish species (Chaves & Robert 2001, Denadai *et al.* 2012), they have developed very clear osmoregulatory adaptations, involving modifications in their growth or reproduction to take advantage of the hyperhaline conditions (Legendre & Ecoutin 1989, Duponchelle & Panfili 1998).

In the present study, *E. argenteus* exhibits behavior associated with euryhaline conditions (sal: 10-100) with a broad feeding spectrum along the lagoon. The presence of detritus recorded in specimens from the inlet of the lagoon (Marine zone) is related to the currents, which result in an accumulation of organic matter on the bottom (Hernández-Guevara *et al.* 2008). In the Channel, Coloradas west and Coloradas east regions, the specimens from this species preferentially consume amphipods and annelids in different proportions, a diet that has been observed by other authors (Branco *et al.* 1997, Denadai *et al.* 2012). However, in the region of Cuyo, there is an increased consumption of insects (Diptera and Hymenoptera), which provides an insight into the degree of connectivity between the mangroves and coastal lagoons (Odum & Heald 1975); and demonstrates the importance of this food resource in the ecosystem's trophic web.

On the other hand, *E. gula* exhibits a diet with high preference for annelids in similar proportions in all regions, and a consumption of amphipods that gradually increases towards the inner region; this diet has also been reported by other authors (Kershner & Peterson 1985, Gning *et al.* 2008). Since the distribution of amphipods is more related to their salinity tolerance (Gning *et al.* 2010), the increasing trophic preference of *E. gula* for amphipod consumption towards the inner region could be more related to the numerical abundance of these
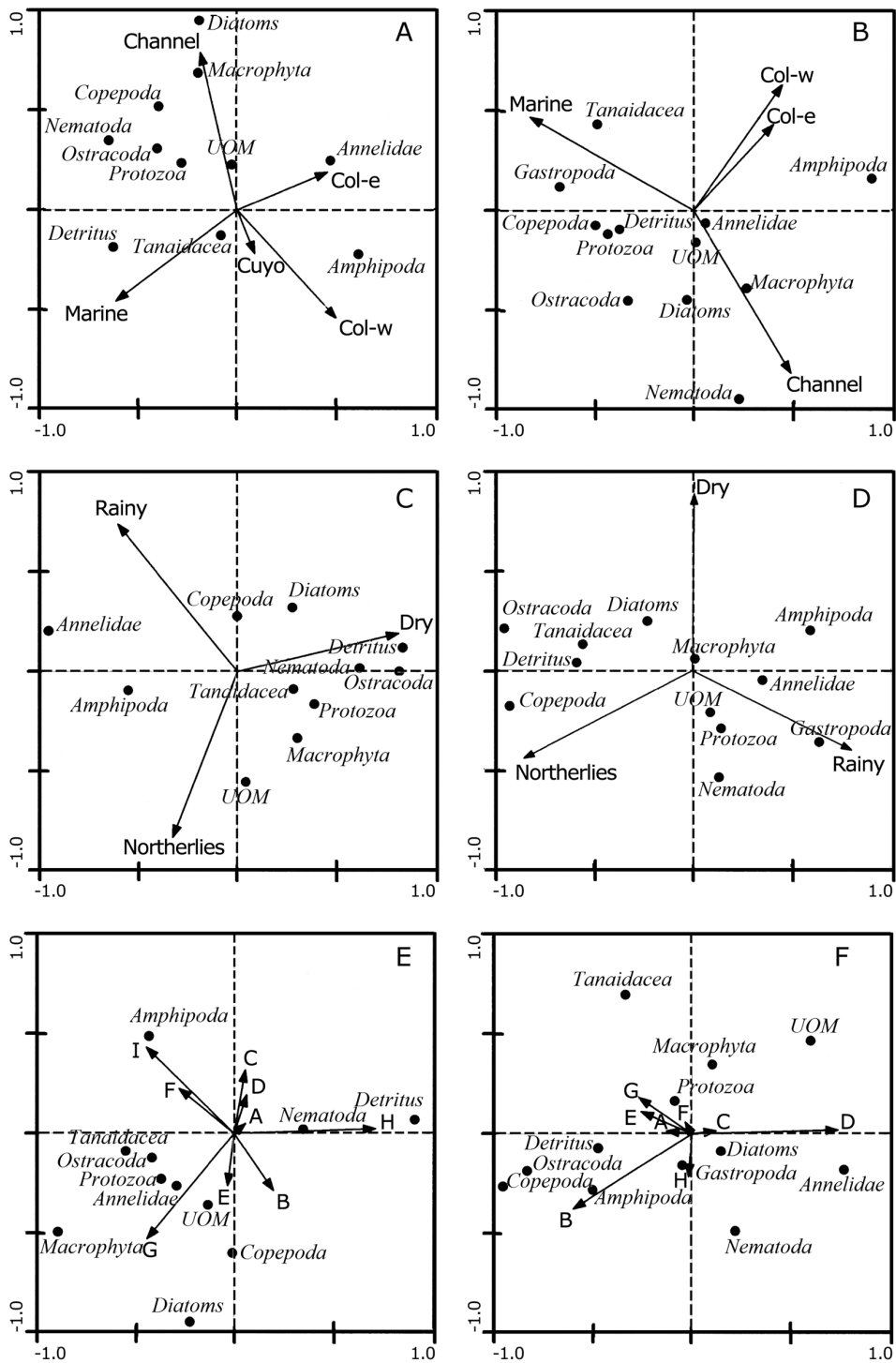
Figure 5. Ordination biplot of CCA of the proportion of food resources (preferential and secondary), using the accidental species, standard length and weight as covariables, where: A) *E. argenteus* **(prey-zone), C)** *E. argenteus* **(prey-season), E)** *E. argenteus* **(prey-size), B)** *E. gula* **(prey-zone), D)** *E. gula* **(prey-season), F)** *E. gula* **(prey-size)** / Biplot de ordenación del CCA de la proporcion de los recursos alimenticios (preferencial y secundario), usando las especies accidentales, longitud estandar y peso como covariables, donde: A) *E. argenteus* (presa-zona), C) *E. argenteus* (presa-temporada), E) *E. argenteus* (presa-talla), B) *E. gula* (presa-zona), D) *E. gula* (presa-temporada), F) *E. gula* (presa-talla)

invertebrates in the mangroves (Kuk-Dzul *et al.* 2012), than to the feeding preference of the species (Cyrus & Blaber 1992, Gning *et al.* 2008).

A factor that undoubtedly has a great influence on the diet of the fish is the availability of the resource in the environment. Pech *et al.* (2007) and Hernández-Guevara *et al.* (2008) mentioned that polychaetes were the most abundant benthic fauna in a lagoon system on the Yucatecan coast, primarily during the rainy season. This population decreases in northerlies and recovers during the dry season. In the rainy season there is an increase in precipitation and organic matter, and a decrease in salinity in the system (Kolm & Andretta 2003), which results in an increase in macrophyte biomass and abundance of the resources available in them (Castro-Aguirre *et al.* 1999). However, there is a reduction in polychaete populations since they are sensitive to the increase in salinity (Pech *et al.* 2007), and tend to consume organic matter or detritus during the dry season.

It is known that the composition and distribution of the species respond seasonally to variations in hydrological factors, for example salinity, transparency, and suspended sediment (Hernández-Guevara *et al.* 2008). Furthermore, the grain size characteristics affect the benthic community (Beukema & Flach 1995). These factors could lead to seasonal diet variation. During the rainy season freshwater discharges reduce salinity, which is conducive to the development of polychaetes. In northerlies wind intensity increases, inducing mixing in the water column, resulting in suspension of organic matter and turbidity (Jayaraj *et al.* 2007) which greatly benefits filter feeding organisms (Pech *et al.* 2007), including copepods and tanaidaceans and a high availability of detritus, as reflected in the diet of *E. gula*. Finally, in the dry season, evaporation increases salinity, favouring the presence of marine benthic larvae, which together with the colonization and opportunistic behaviour of organisms, contributes to increasing the species abundance of populations, just as the entrance of sea water to the lagoon contributes to the recovery of polychaete populations (Hernández-Guevara *et al.* 2008).

Trophic variation during growth is a common characteristic in ichthyofauna (Gning *et al.* 2008). In the present study, *E. argenteus* and *E. gula* had a similar diet, however a food resource partition was observed, where *E. argenteus* fed on amphipods and *E. gula* on annelids. This flexibility of diet, could be influenced by several factors including salinity, dissolved oxygen, temperature (Dantas *et al.* 2013), prey distribution (Pech *et al.* 2007, Kuk-Dzul *et al.* 2012), morphological changes such as increased mouth size (Ward-Campbell et al. 2005, Nakane *et al.* 2011), strengthening of the jaw and teeth, an increase in capturability (Nanjo *et al.* 2008, Pereira *et al.*

2014), or a simple change in metabolic requirements (Wootton 1998, Hammerschlag *et al.* 2010) where juveniles use the energy for growth and survival, while adults utilize it for reproduction and maintenance (Gning *et al.* 2008).

When both species of Gerrids (*E. argenteus* and *E. gula*) are small, they consume large amounts of copepods. This could be due to their vertical distribution, substrate preferences, feeding behavior or species social interaction (Van Rooij *et al.* 1996), where juveniles feed on water column organisms including copepods or amphipods, and adults feed on benthic ones such as annelids and crustaceans (Pereira *et al.* 2014). In the case of adults, their benthic feeding behavior is reflected in an important accidental ingestion of detritus (Motta *et al.* 1995, Gning *et al.* 2008, 2010).

In conclusion, *E. argenteus* and *E. gula* use the same dietary items but they differ in the proportion they consume. These changes where observed at spatial, temporal and ontogenic levels, which suggests a partitioning of resources between both species (Arenas-Granados & Acero 1992). In this study, the mojarras were classified as benthic organism consumers, focusing mainly on annelids and amphipods, both during different life stages and across throughout different habitats and seasons, taking advantage of the availability of the most abundant resources in the lagoons, which are equally affected by the salinity gradient and temporal variations in turbidity (Hernández-Guevara *et al.* 2008).

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Appendix 1. Food spectrum of *E. argenteus* (Ea) and *E. gula* (Eg) in the Ría Lagartos lagoon system, Yucatán. UOM: unidentified organic material and UAM: unidentified animal material / Espectro alimentario de *E. argenteus* (Ea) y *E. gula* (Eg) en el sistema lagunar de Ría Lagartos, Yucatán. UOM: material orgánico no identificado y UAM: material animal no identificado

Taxonomic groups		Ea	Eg	Taxonomic groups		Ea	Eg
Phytoplankton				Polychaeta	39. *Onuphidae* spp.	x	
Cyanophyceae	1. *Oscillatoria* spp.	x	x		40. *Nereidae* spp.	x	x
	2. *Cyanophita* unident.		x		41. *Sabellydae* spp.	x	
Diatoms	3. *Biddulphia* spp.	x	x		42. *Syllidae* spp.	x	x
	4. *Cytatesima* spp.	x			43. *Afroditidae* spp		x
	5. *Amphora* spp.	x	x		44. *Spionidae* spp.		x
	6. *Grammatophora* spp.	x	x		45. *Ampharetidae* spp.		x
	7. *Gyrosigma* spp.	x	x		46. *Orbinidae* spp.		x
	8. *Melosira* spp.	x	x		47. Polychaete unident.	x	x
	9. *Navicula* spp.	x	x	Echiura			
	10. *Nitzchia* spp.	x	x	Echiuroidea	48. Equiurid unident.	x	x
	11. *Cymatosira* spp.		x	Crustacea			
	12. *Fragillaria* spp.		x	Ostracoda	49. Ostracods unident.	x	x
	13. *Pinnularia* spp.		x	Copepoda	50. *Calanoida* spp.	x	x
	14. *Merismopedia* spp		x		51. *Cyclopoida* spp.	x	x
	15. Diatoms unident.	x	x		52. *Harpacticoida* spp.	x	x
Macrophytes				Amphipoda	53. *Aoridae* spp.	x	x
Algae	16. *Hypnea* spp.	x	x		54. *Corophiidae* spp.	x	x
Seagrass	17. *Halodule* spp.	x	x		55. Gammaridae	x	x
Protozoa					56. Amphipods unident.	x	x
Dinoflagellata	18. Dinoflagellata		x	Isopoda	57. *Sphaeroma* spp.	x	x
Ciliophora	19. *Ciliophora* unident.		x		58. *Aega* spp.		x
Foraminifera	20. *Anomalina* spp.	x	x		59. *Cassidinidea* spp.		x
	21. *Bolivina* spp.	x	x		60. *Idotea* spp.		x
	22. *Globigerina* spp.	x	x		61. Isopods unident.	x	x
	23. *Spiroculina* spp.	x	x	Tanaidacea	62. *Leptucheila* spp.	x	x
	24. *Triloculina* spp.	x	x		63. Paratanidae	x	x
Mollusca					64. Tanaidaceans unident.	x	x
Gastropoda	25. *Barleeia* spp.	x		Cumacea	65. Cumaceo unident.	x	x
	26. *Bulla* spp.	x		Mysidacea	66. Mysids unident.	x	x
	27. *Crepidula* spp.	x	x	Insecta			
	27. Hydrobiidae	x		Diptera	67. Diptera unident.	x	x
	28. *Marginella* spp.	x		Hymenoptera	68. Hymenoptera unident.	x	
	29. *Tricolia* spp.	x		Coleoptera	69. Coleoptera unident.	x	
	30. *Alvania* spp.		x	Zoobenthos	70. Eggs	x	x
	31. Haminoidea		x	UOM	71. UOM	x	x
	32. Scaphandridae		x		72. UAM	x	x
	33. Gastropods unident.	x	x	Detritus	73. Organic matter	x	x
Bivalvia	34. *Chione* spp.	x		Others	74. Sponge spicules	x	x
	35. *Parastarte* spp.	x			75. Fish larvae	x	
	36. Bivalve unident.	x	x		76. *Limulus polyphemus*	x	
Nematoda	37. Nematode unident.	x	x		77. Seeds		x
Annelidae					78. Pycnogonids	x	x
Oligochaeta	38. *Arenicola* spp.	x	x				

Appendix 2. Trophic spectrum of *E. argenteus* (Ea) and *E. gula* (Eg) in Ría Lagartos lagoon system, Yucatán, expressed in terms of relative percentage of abundance (A), weight (W), frequency of occurrence (FO) and Relative Importance Index (RII) of the taxonomic groups. UOM: unidentified organic material / Espectro trófico de *E. argenteus* (Ea) y *E. gula* (Eg) en el sistema lagunar de Ría Lagartos, Yucatán, expresado en términos de abundancia relativa (A), peso (W), frecuencia de ocurrencia (FO) e Indice de Importancia Relativa (RII) de los grupos taxonómicos. UOM: material organico no identificado

Taxonomic group	A		W		FO		RII	
	Ea	Eg	Ea	Eg	Ea	Eg	Ea	Eg
Phytoplankton								
Cyanophyceae	0.11	0.93	0.11	0.69	3.04	7.96	0.01	0.13
Diatoms	0.5	0.82	0.54	0.62	12.17	20.37	0.15	0.3
Macrophyta								
Seagrasses	1.24	2.27	1.62	1.88	16.02	37	0.58	1.58
Protozoa								
Foraminifera	1.98	2.15	2.08	2.04	26.77	34.89	1.22	1.5
Nematoda								
Nematodes	0.96	1.19	0.75	1.3	23.53	20.84	0.39	0.53
Annelidae								
Polychaeta	16.04	27.52	23.11	32.82	57	72.6	28.12	45.03
Echiuridae								
Echiurids	0.59	2.79	2.61	2.67	1.42	9.6	0.09	0.54
Mollusca								
Bivalvia	0.55	2.51	0.82	2.4	6.9	15.69	0.13	0.79
Gastropoda	1.06	0.38	1.13	0.29	5.88	6.09	0.16	0.04
Crustacea								
Amphipoda	22.56	16.23	26.76	16.03	58.22	42.86	33.33	14.21
Copepoda	5.15	6.45	5.23	6.11	50.71	54.57	5.7	7.05
Ostracoda	1.69	2.33	1.56	2.54	29.82	31.38	1.02	1.57
Cumacea	0.12	0.08	0.11	0.07	1.22	1.64	0.01	0
Mysidacea	0.3	0.68	0.33	0.43	2.64	3.04	0.02	0.03
Isopoda	0.07	0.78	0.08	1.95	1.62	4.68	0	0.13
Tanaidacea	10.18	12.73	10.28	10.15	42.6	36.3	9.45	8.54
Insecta								
Insects	3.14	0.04	1.89	0.02	7.51	0.23	0.36	0
Detritus								
Detritus	25.62	11.68	13.21	10.37	42.8	50.12	12.46	11.36
UOM								
UOM	7.74	7.76	7.41	7.06	42.19	43.56	6.76	6.63
Zoobenthos								
Zoobenthos	0.1	0.14	0.12	0.1	1.62	1.17	0.01	0
Others								
Others	0.3	0.55	0.26	0.47	4.06	5.15	0.03	0.02