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ECOMORFOLOGIA E PAPEL DO AMBIENTE DE ZONA DE ARREBENTAÇÃO NOS ESTÁGIOS DE VIDA INICIAIS DE ESPÉCIES DE CLUPEIFORMES EM UMA PRAIA ARENOSA TROPICAL BRASILEIRA

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UNIVERSIDADE FEDERAL RURAL DE PERNAMBUCOPRÓ-REITORIA DE ENSINO DE GRADUAÇÃO BACHAREL EM ENGENHARIA DE PESCA

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Dedicatória

"E quando a tempestade tiver passado, mal te lembrarás de ter conseguido atravessá-la, de ter conseguido sobreviver. Nem sequer terás a certeza de a tormenta ter realmente chegado ao fim. Mas uma coisa é certa. Quando saíres da tempestade já não serás a mesma pessoa. Só assim as tempestades fazem sentido."

-Murakami, Haruki

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Resumo

As zonas de arrebentação são ambientes de elevada importância para os estágios de vida iniciais de diversas espécies de peixes por apresentar características como alta produtividade fito planctônica, provendo uma elevada disponibilidade de alimento, e seus fatores físicos como ação das ondas, ocasionando uma grande ciclagem de nutrientes e eleva a turbidez, tornando estes ambientes habitats de berçário ideais para várias espécies, por permitir seu desenvolvimento, dentre as quais se incluem as pertencentes a ordem Clupeiformes. Os peixes da ordem clupeiformes possuem grande importância ecológica e comercial por se tratarem de peixes abundantes em praias tropicais com importância significativa nas pescarias artesanais e industriais ao redor do mundo. Estudos sobre sua ecologia alimentar e utilização de ambiente são relevantes e um dos métodos para a construção deste conhecimento é a aplicação de análises ecomorfológicas, por tornar possível o entendimento das interações ecológicas das espécies e suas adaptações. 10 variáveis ecomorfológicas foram analisadas de indivíduos pertencentes as espécies *Anchoa tricolor*, *Anchoa januaria*, *Anchovia clupeoides*, *Anchovia lepidentostole*, *Lycengraulis grossidens*, *Chirocentrodon bleekerianus*, *Harengula clupeola* and *Opisthonema oglinum* cujos valores foram aplicados numa análise de componentes principais (PCA) com os dois primeiros eixos explicando 60,71% da variância total. Foi observada uma grande sobreposição morfológica entre as espécies de Engraulidae com exceção de *A. clupeoides*, que se diferenciou das demais por apresentar altos valores do índice de compressão e do índice de compressão do pedúnculo caudal. As espécies de Clupeidae diferiram das outras famílias devido aos seus altos valores de altura relativa e comprimento relativo da cabeça, o que também mostrou diferenças entre elas com *Harengula clupeola* apresentando maiores valores destas variáveis. O representante da família Pristigasteridae apresentou sobreposição intermediária com as demais famílias pois apesar de ter apresentado elevados valores dos índices de compressão e de achatamento ventral, ela obteve baixos valores de altura relativa, comprimento relativo do pedúnculo caudal, e aspecto médio da boca. A diferenciação morfológica entre as famílias e até entre espécies de uma mesma família indica diferenciação de nicho, mostrando que apesar da proximidade filogenética das espécies, há diferenciação em suas interações ecológicas com o ambiente, tornando sua coexistência possível.

PALAVRAS CHAVE: Ecologia alimentar, Plasticidade de dieta, Competição interespecífica.

Lista de figuras

Figura 1– Diagrama de ordenação das variáveis ecomorfológicas das espécies de clupeiformes analisadas de acordo com suas relações com os dois primeiros eixos da PCA......................................28
Figura 2- Cluster da sobreposição ecomorfologica das espécies analisadas baseadas em suas relações com os dois primeiros eixos da PCA 29

Lista de tabelas

Tabela 1- Valores medianos, máximos, mínimos e p valores das variáveis ecomorfológicas das espécies analisadas. 30
Tabela 2-Valores resultantes dos dois primeiros eixos da PCA para os atributos ecomorfológicos das espécies de clupeiformes analisadas. 31

SUMÁRIO

Dedicatória iv

Agradecimentos vi

Resumo 7

Lista de figuras 8

Lista de tabelas 9

1 – Introdução 11

REFERENCIAS BIBLIOGRÁFICAS 12

2 - Artigo Científico 14

REFERENCES 22

1 – Introdução

As zonas de arrebentação são ambientes que se caracterizam pela intensa influência das ondas tanto nos bancos de areia quanto nas comunidades que nela habitam (Nnafie *et al*., 2020; McLachlan, 1990), mas que apresenta fatores como ciclagem de nutrientes, alta produtividade primária e elevada disponibilidade de alimentos tornando este ambiente o habitat de berçário para diversas espécies de peixes (Salant & Shanks, 2018; Izumiyama *et al*., 2020, Gutiérrez-Martinez *et al.*, 2021) dentre as quais, comumente se incluem as sardinhas e anchovas, representantes da ordem Clupeiformes.

Clupeiformes é uma ordem de peixes com hábito alimentar geralmente planctônico e que apresenta longos e numerosos arcos branquiais (Nelson *et al.*, 2016), sendo encontrados em várias regiões ao longo da costa Brasileira (Silva & Araújo, 2000; Lopes *et al*., 2018; Favero *et al*., 2019). Esta ordem inclui peixes com importância ecológica, econômica e cultural para diversas comunidades pesqueiras ao redor do mundo (Juliani *et al.*, 2019; Okangny *et al*., 2020; Birge *et al.*, 2021; Wang *et al*., 2021) tornando relevante estudos sobre sua ecologia alimentar e interações ecológicas.

Espécies pertencentes a ordem clupeiformes possuem formato de corpo similar e são comumente reportados coexistindo ao longo da costa brasileira (Santana & Severi, 2009; Pessanha *et al.*, 2015; Cardoso *et al*., 2021) o que nos leva ao teorema de partição de nicho que indica que espécies com preferências alimentares e formato de corpo similares tendem a explorar o ambiente de maneiras diferentes e a possuir diferenciações ecológicas distintas para evitar competição, e permitir sua coexistência (Hardin, 1960). Uma maneira efetiva de avaliar diferenciações ecológicas distintas entre espécies similares em ordem para avaliar possíveis mecanismos de coexistência entre as espécies é a aplicação de análises ecomorfológicas (Adite & Winemiller, 1997).

Deste modo, o presente trabalho tem como objetivo identificar relações ecomorfológicas e inferir sobre as relações ecológicas e mecanismos de coexistência das espécies *Anchoa januaria* (Steindachner, 1879), *Anchoa tricolor* (Spix & Agassiz, 1829), *Anchovia clupeoides* (Swainson, 1839), *Anchovia lepidentostole* (Fowler, 1911), *Lycengraulis grossidens* (Spix & Agassiz, 1829), representantes da família engraulidae, *Harengula clupeola* (Cuvier, 1829), *Opisthonema oglinum* (Lesueur, 1818), representantes da família clupeidae, e *Chirocentrodon bleekerianus* (Poey, 1867), da família pristigasteridae, representantes sintópicos comuns da ordem clupeiformes na Praia de Jaguaribe, (Ilha de Itamaracá, Litoral

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2 - Artigo Científico

Ecomorphology and role of the surf-zone environment in the early life stages of clupeiformes species in a brazilian sandy beach

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Ecomorphology and role of the surf-zone environment in the early life stages of clupeiformes species in a brazilian sandy beach

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ABSTRACT

Surf zones are environments with a huge importance for the early life stages of several fish species for presenting characteristics such as the high phytoplanktonic activity providing an elevated availability of food and their physical factors such as the wave actions that supply a great nutrient cycling and increases the turbidity featuring the surf zones ideal nursery environments for diverse species of fish for allow its development, among which, those of the clupeiforms order are included. The clupeiform fishes have a great ecological and economic importance for being abundant fish in tropical sandy beaches surf zones with significant fisheries importance. Studies about their feeding ecology and environment utilization are relevant and one of the methods for the construction of this knowledge is the application of ecomorphological analyses, which turns possible the understanding of the species ecological interactions and their adaptations. 10 ecomorphological variables were analyzed of individuals belonging to the species *Anchoa tricolor*, *Anchoa januaria*, *Anchovia clupeoides*, *Anchovia lepidentostole*, *Lycengraulis grossidens*, *Chirocentrodon bleekerianus*, *Harengula clupeola* and *Opisthonema oglinum* whose values were employed in a principal component analysis (PCA) with the two first axis explaining 60,71% of the total variance. It was observed a high morphological overlap between the species of Engraulidae with the exception of *A. clupeoides*, which differed from the others for presenting higher values of the compression index and caudal peduncle compression index. The Clupeidae species differed from the other families due to its big values of relative height and relative head length that also showed differences between the species themselves, having *Harengula clupeola* presented the highest values of these variables. The representative of the Pristigasteridae showed intermediate overlap between the other families because it is a compressed specie but with low scores of relative height, caudal peduncle relative length and mouth aspect ratio. The morphological differentiation between the families and even between specimens from a same family indicated niche divergences, showing

that besides their phylogenetically proximity there are differences in their ecological interactions turning possible their coexistence.

KEYWORDS: Feeding ecology; diet plasticity; interspecific competition.

INTRODUCTION

Surf zones are highly energetic environments where much of the wave's energy is dissipated as it breaks on the shore (Peregrine, 1998). Despite presenting intense wave action over the communities that live there (McLachlan, 1990), surf zones serve as nursery environments to several marine species as they present high phytoplankton productivity, elevated turbidity, nutrients cycling and shelter against predators (Salant & Shanks, 2018; Izumiyama *et al*., 2020). In this way, they serve as an adequate habitat to the larval stages of fish species which develop into adult phases in this environment (Godefroid *et al*., 1999), and for others that complete their life cycle in surf zones (Monteiro-Neto *et al*., 2003), such as sardines, anchovies and pilchards, which are common components belonging to the Clupeiformes (Nascimento *et al.*, 2019).

Clupeiformes is an order of fishes with predominant planktonic feeding habit presenting long and often numerous brachial arches, in addition to having high importance for the industrial fisheries around the world (Nelson *et al*., 2016). This order is found in many habitats according to the phase of the life cycle, with juveniles being found more often in estuarine environments and surf zones, while adults are found in deeper portions of coastal bays (Araújo *et al*., 2009; Mai *et al.*, 2014).

Despite individuals belonging to the same order tend to present similar phenotypical characteristics, morphological differences among individuals from a single species have been reported (Cheng *et al.*, 2005). The coexistence of fishes with similar body shape and feeding preferences leads to niche partitioning among species (Hardin, 1960), which makes them have different interactions with the environment, and exploit it in a different way in order to avoid competition. A good approach to understand the interaction of fishes and their environments is the use of ecomorphological analysis (Wikramanayake, 1990; Adite & Winemiller, 1997; Olivier *et al*., 2019).

Ecomorphological studies in teleost fish have been developed as an important tool to understanding how the individual's morphology influences its feeding patterns and use of the environment, assuming that there is correlation between the shape of a species and its life cycle (Winemiller, 1991; Teixeira & Bennemann, 2007). In a short period of time body morphology is expected to influence the fish diet, although in a larger period the diet may influence the morphology due to different factors, such as phenotypic plasticity, according to the environmental conditions in which the species thrive and its ecological interactions (Mittelbach *et al*., 1999; Svanbäck & Eklöv, 2002).

Ecomorphology may be an important indicator of the diet and trophic position of one species (Blasina *et al*., 2016), being able to identify adaptative convergences in phylogenetically distant species and adaptative divergences in phylogenetically close ones (Reilly & Wainwright, 1994; Cassati & Castro, 2006). In this context, the present study seeks to identify the morphological relations and infer the ecological relations of the clupeiform species *Anchoa januaria* (Steindachner, 1879), *Anchoa tricolor* (Spix & Agassiz, 1829), *Anchovia clupeoides* (Swainson, 1839), *Anchovia lepidentostole* (Fowler, 1911), *Lycengraulis grossidens* (Spix & Agassiz, 1829), *Harengula clupeola* (Cuvier, 1829), *Opisthonema oglinum* (Lesueur, 1818) and *Chirocentrodon bleekerianus* (Poey, 1867), common syntopic representatives of the order in a sandy beach surfzone in northeastern Brazil.

MATERIAL AND METHODS

The clupeiform individuals used are part of the Fish Collection of the Ichthyology Laboratory of Universidade Federal Rural de Pernambuco, collected in the Jaguaribe Beach (Itamaracá Island, northern State of Pernambuco) monthly from March 2005 to February 2006 at low tide in the periods of day and night in two moon phases (new and crescent) with depth lower than 1.5 meter (see Santana & Severi (2009) for further data on fish fauna composition). The collected specimens were fixed in 4% formaldehyde, conservated in 70% ethanol and identified according to Figueiredo & Menezes (1978) and Carpenter (2002).

Twenty individuals from each species, except *Anchoa januaria* and *Harengula clupeola* (respectively 14 and 10 individuals), had their standard length (SL), body height (BH), medium body height (MHB), body width (BW), head length (HL), head height (HH), relative eye height (ERH), pectoral fin length (PFL), pectoral fin width (PFW), caudal fin height (CFH), caudal peduncle length (CPL), caudal peduncle height (CPH), caudal peduncle width (CPW), mouth width (WM) and mouth height (HM), measured with the aid of a 0.01mm digital caliper (Keast & Webb, 1966; Gatz, 1979; Watson & Balon, 1984; Beaumord & Petrere Jr, 1994).

Based on the measurements taken from each individuals, the following ecomorphological variables were calculated: Compression Index (IC = BH / BW) (Watson & Balon, 1984): indicate the fish’s position in the water column; high scores indicating laterally compressed fish; Relative Height (HR = BH / SL) (Gatz, 1979): directly related to the ability to make vertical turns; low scores indicating elongated fish; Relative Peduncle Length (RPL = CPL / SL) (Watson & Balon, 1984): elongated peduncles indicate fish with good swimming ability; Caudal Peduncle Compression Index (CPCI = CPH / CPW) (Gatz, 1979): high scores are typical in less active swimmers; Index of ventral flattening (FIV = MHB / BH) (Watson & Balon, 1984): low scores indicate fish inhabitants of waters with high hydrodynamics; Aspect of pectoral fin ratio (APFR = PFL / PFW) (Keast & Webb, 1966): high scores indicate long and narrow fins; Relative Eye Position (REP = ERH / BH) (Gatz, 1979): indicate the vertical habitat preference, benthic fish have eyes localized more dorsally and nektonic fish eyes localized laterally; Relative Head Length (RHL = HL / SL) (Watson & Balon, 1984): relatively longer heads indicate that the fish is able to handle larger prey items; Relative Mouth Width (RMW = WM / SL) (Gatz, 1979): indicate the relative size of the prey items; and Mouth Aspect Ratio (MAR = HM / WM) (Beaumord & Petrere Jr., 1994): the mouth aspect ratio is related to the shape of the feed items; elevated scores indicating narrow but wide-open mouths. With the aid of the software R (ver 4.0.3) (R Core Team, 2009) and its package 'ggstatsplot' (Patil, 2021) the normality of the ecomorphological variables was checked using a Shapiro-Wilk test followed by a Kruskall-Wallis test, to identify significative differences between the calculated values of each species, followed by a Dunn multiple comparison test. After this, the values of the eleven variables were examined through a principal component analysis (PCA), to evaluate the affinity of each species based on the Euclidian distance of the medium values of the two first axis of the PCA.

RESULTS

Based on the species ecomorphological data, higher values of the compression index (IC) were found in *A. clupeoides*, indicating its larger compression in relation to the other species, besides presenting the second smallest scores of relative height (HR), and together with *C. bleekerianus*, *O. oglinum* and *H. clupeola* had the smallest values of the relative peduncle length (RPL) and caudal peduncle compression index (CPCI) (Table 1). There were statistical significative differences of the ecomorphological variables between all species.

The two first axis of the PCA explained together 60.71% of the total variance (Table 2), the first axis representing 36.46% of the total variance and correlating positively in a more intense way with HR, RHL e APFR, what differentiated *H. clupeola* and *O. oglinum* from all other species (Fig. 1). The second axis representing 24.25% of the total variance, evidencing positive relations with IC, CPCI and FIV and a strong negative relation with MAR, differentiating *A. clupeoides* from the other engraulids and positioning *C. bleekerianus* in an intermediate way between the species, besides having high scores of IC, CPCI and FIV, and also intermediate scores of MAR.

It was observed a considerable morphological overlap of some species in the PCA (Fig. 2), and a strong association between the Engraulidae species with the exception of *A. clupeoides*, because of its deeper body and higher caudal peduncle compression in relation to the other engraulids. The Clupeidae species differentiated from the remainders, and the representative of Pristigasteridae occupied an intermediate position between the other families, due to its low scores of RHL and HR when compared with the clupeids, low scores of MAR and elevated values of FIV, IC and CPCI when compared with the engraulids.

DISCUSSION

The first two axes of the PCA showed a clear separation of *H. clupeola* and *O. oglinum* from the other clupeiforms, owing to their high scores of relative height and relative head length. These variables are directly related to the body stretching and to the ability to feed on bigger prey items (Gatz, 1979; Watson & Balon, 1984). This not only significantly differentiated these clupeids, for being species of carnivorous food habit, but also showed differences between them, since *H. clupeola* presents a piscivore habit while *O. oglinum* has a food preference for crustaceans (Vega-Candejas *et al.*, 1997; Chaves & Vendel, 2008; Soares *et al.*, 2018; Bomfim *et al*., 2020).

It was also observed the separation of a group with higher scores of mouth aspect ratio, whose big scores indicate fishes with narrow but wide open mouths (Beaumord & Petrere Jr., 1994), thus contributing to the similarity between engraulids. In contrast, the second axis of the PCA grouped positively species with the highest scores of compression index, index of ventral flattening and caudal peduncle compression index, which are respectively related to body compression, occupation of environments with high hydrodynamics and to swimming intensity (Gatz, 1979; Watson & Balon, 1984). This differentiated *A. clupeoides* from the remaining engraulids for being more compressed, corroborating with the data found by Pessanha *et al*., (2015), who registered the compression index as a differential of *A. clupeoides* from the all the other species analyzed belonging to the ichthyofauna of the surf zone estuary from the Mamanguape River (Paraíba, Brazil). The species that presented the highest scores of the relative peduncle length reinforced the ecomorphological resemblance between *A. januaria*, *A. tricolor*, *A. lepidentostole* e *L. grossidens* although differences in feeding habits are found in literature between the analyzed engraulidae species, with *A. januaria* and *A. clupeoides* having preferences for copepods, *A. lepidentostole* feeding over crustacea items, *L. grossidens* having a more piscivorous habit and *A. tricolor* preferring zooplanktonic items (Duque & Acero, 2003; Bortoluzzi, 2006; Chaves & Vendel, 2008; Medeiros *et al.*, 2017)

Although fish species belonging to the same taxonomic group tend to have similar body shape (Catella & Petrere, 1998), the ecomorphological analyzes can infer differences between them and their way of life, according to differences of their morphological variables (Piet, 1998; Garcia *et al.*, 2020). In the studies of Nunes & Hartz (2006) about two species from the Characidae family inhabiting the Fortaleza Lake (Rio Grande do Sul, Brazil), the authors have observed differences in their morphology and diet besides their morphological similarity. These differences were also found in the present study, since although the species belong to the same order, morphological differences are perceived even in specimens from the same family, such as *A. clupeoides* and the others engraulids, and the separation between the clupeids.

Despite the ecomorphological similarity of engraulids, except for *A. clupeoides*, it can be said that species belonging to this family have distinct ecological niches in the Jaguaribe Beach. Species such as *L. grossidens* and *A. lepidentostole* have a more generalist feeding habit depending on the food source available in the environment (Beneditto, 2020), what can indicate a plasticity in their diet. In addition, exclusion mechanisms can be observed between species, such as species abundance variability throughout the year, as reported by Santana & Severi (2009) in the Jaguaribe Beach surf zone, with a higher occurrence of *A. tricolor* in the rainy season, *A. clupeoides* being more abundant in the drought season, and *L. grossidens* occurring in both seasons.

Morphological differences may be an excellent proxy for variation in the diet of fish belonging to the same family or to species since in distinct environments without genetical exchange (Santos *et al.*, 2018; Delariva & Neves, 2020). Temporal variation of environment conditions can be an explanation to the coexistence of morphologically similar species, because disturbances in the environmental variables such as temperature, pluviosity, luminosity and food supply can significantly alter interspecific interactions in consonance with the distinct species' response to these variations (Meffe, 1984; Godinho *et al.*, 2000; Beyst *et, al*., 2001; Helland *et al.*, 2011).

These variations may result in changes in species abundances which may imply different use of environmental food resources, altering the feeding habit of some species according to the food resources' availability and use based on prey behavior or size, being the choice for different prey items one of the factors that allow the coexistence of species (Meffe, 1984;

Winemiler, 1990; Robertson, 1996; Crawford *et al.*, 1998; Sánchez-Hernández *et al.*, 2011).

This difference in the choice of prey was observed by Medeiros *et al.* (2017) between *A. clupeoides*, *A. tricolor*, *H. clupeola* and *O. oglinum*. These authors observed distinct feeding preferences between species, with *A. clupeoides* being a piscivorous one, *H. clupeola* showing a phytoplanktonic preferences in its diet, and *A. tricolor* together with *O. oglinum* zooplanktonic preferences.

Although species belonging to the same order generally have morphological similarities, niche differentiations are found as observed by Favero *et al.* (2019) in their studies on Maracaípe estuary, southern coast of Pernambuco, which has classified clupeiforms species into distinct trophic guilds, reinforcing a niche differentiation between them.

Previous studies reported clupeiforms as common components of the ichthyofauna in diverse coastal environments along the Brazilian coast (Silva & Araújo, 2000; Lopes *et al.*, 2018; Reis *et al*., 2020), with a significant participation in artisanal fisheries around the world (Sunyé & Servain, 1998; Schwingel & Occhialini, 2003), thus indicating their ecological and economic importance.

The occurrence of this economically important fish order in the Jaguaribe Beach surf zone indicates the relevance of such environments for the life cycle of these species. Their morphological differences and temporal variation in abundance imply in diverse environmental interactions and resource use (Chesson, 1984; Mouchet *et al*., 2013; Silva *et al*., 2017) which might contribute to the coexistence of these clupeiforms in coastal areas.

CONCLUSION

It is concluded that besides their phylogenetic proximity, the clupeiform species of the Jaguaribe Beach have distinct ecomorphological characteristics, indicating adaptative responses to the environment. Despite being phylogenetically close and morphologically similar, the differences in their ecomorphological characteristics allow a coexistence strategy that needs to be further investigated. Moreover, studies of the feeding ecology of clupeiforms are necessary to better assessing the role of surf zones for the survival of the early life stages of species in this environment.

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Figura 1– Diagrama de ordenação das variáveis ecomorfológicas das espécies de clupeiformes analisadas de acordo com suas relações com os dois primeiros eixos da PCA

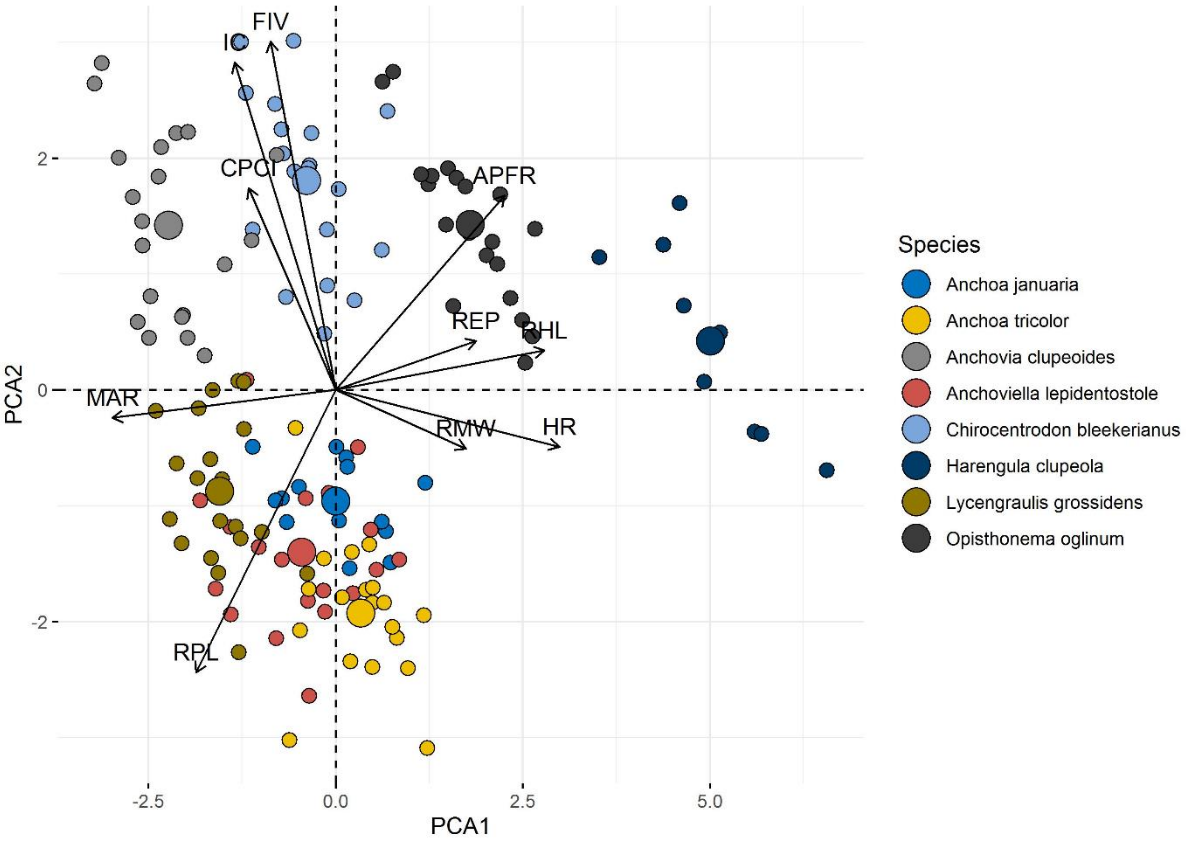

Figura 2- Cluster da sobreposição ecomorfologica das espécies analisadas baseadas em suas relações com os dois primeiros eixos da PCA

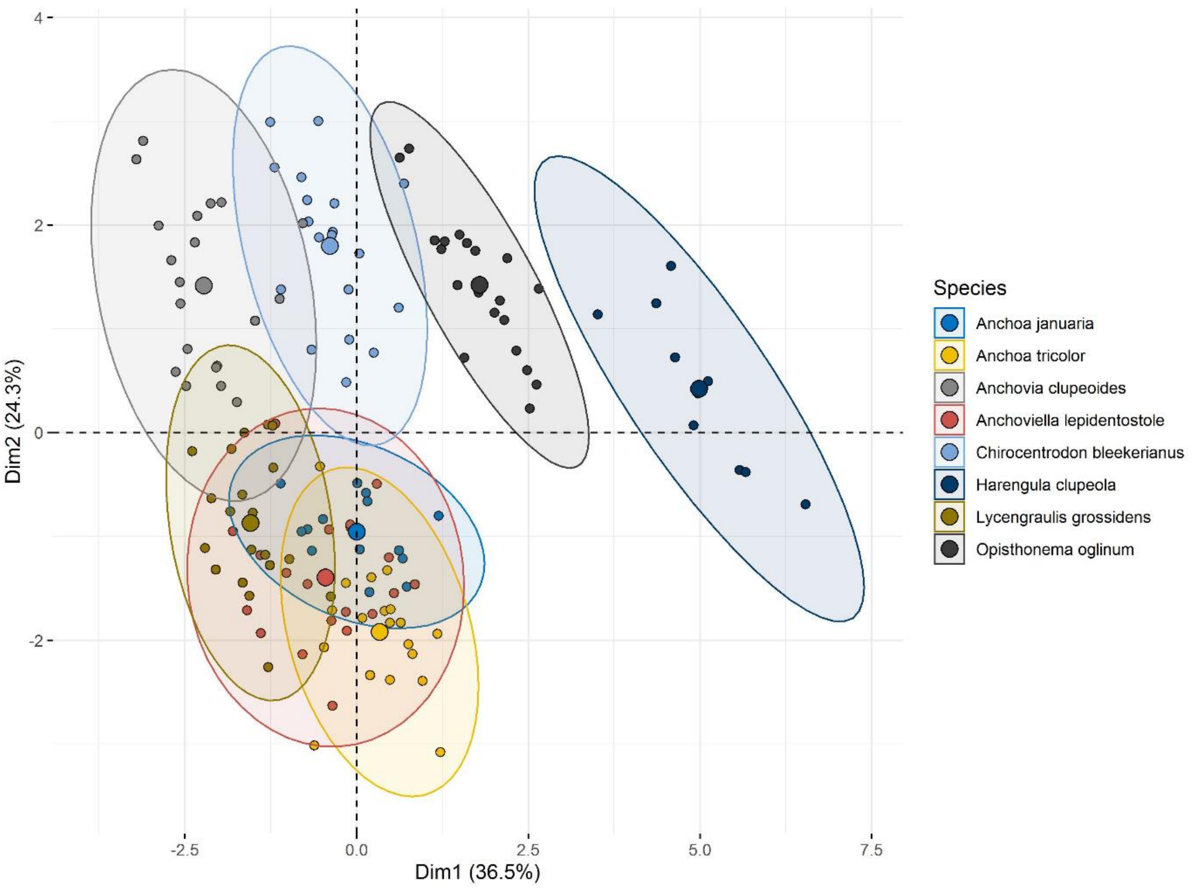

Tabela 1- Valores medianos, máximos, mínimos e p valores das variáveis ecomorfológicas das espécies analisadas.

Species		IC	HR	RPL	CPCI	FIV	APFR	REP	RHL	RMW	MAR
A. clupeoides	Median	3,2335	0,0878	0,1333	3,7355	2,6066	1,3150	0,4061	0,1914	0,0626	4,2888
	Minimum	2,9806	0,0782	0,1100	2,6618	2,1236	1,0280	0,3005	0,1693	0,0537	3,1484
	Maximum	3,5566	0,0993	0,1509	4,7276	2,9234	1,6166	0,5312	0,2264	0,0722	4,9925
A. januaria	Median	2,2960	0,0966	0,1397	3,2023	1,9550	1,8900	0,6094	0,1933	0,0557	3,5317
	Minimum	2,1504	0,0790	0,1085	2,4564	1,8673	1,5699	0,5318	0,1733	0,0516	2,9474
	Maximum	2,4849	0,1046	0,1639	3,8780	2,1558	3,0180	0,7130	0,2282	0,0613	3,9828
A. lepidentostole	Median	2,1991	0,1003	0,1517	3,1694	1,8054	2,6801	0,3795	0,2007	0,0515	3,6176
	Minimum	2,0086	0,0869	0,1162	2,5814	1,5920	1,7599	0,3186	0,1738	0,0446	2,6468
	Maximum	2,5936	0,1089	0,1755	3,9603	2,1823	3,8297	0,4782	0,2210	0,0628	4,1840
A. tricolor	Median	2,1043	0,1022	0,1332	3,3397	1,7443	1,1325	0,5149	0,2095	0,0700	3,6111
	Minimum	1,9239	0,0920	0,1070	2,7805	1,4567	0,9237	0,4283	0,1935	0,0629	3,3441
	Maximum	2,3633	0,1091	0,1718	4,3839	1,9275	1,3701	0,5997	0,2302	0,0830	4,2385
C. bleekerianus	Median	2,7614	0,0866	0,0897	3,8892	2,2829	3,0485	0,5401	0,1937	0,0544	3,5311
	Minimum	2,3454	0,0708	0,0737	3,2394	1,8442	2,3356	0,4873	0,1637	0,0487	3,0137
	Maximum	3,0691	0,1064	0,0978	4,3968	2,6546	4,8244	0,5733	0,2169	0,0623	4,1129
H. clupeola	Median	2,3390	0,1391	0,0851	2,9754	2,1196	4,1045	0,5672	0,2410	0,0848	1,9667
	Minimum	2,2006	0,1166	0,0791	2,7109	1,9286	3,3682	0,4711	0,2335	0,0676	1,3359
	Maximum	2,7412	0,1692	0,0978	3,6013	2,3982	4,6077	0,6153	0,2652	0,0964	2,4178
L. grossidens	Median	2,3927	0,0891	0,1357	3,6095	1,9781	1,1966	0,4135	0,1889	0,0552	3,6394
	Minimum	2,2033	0,0827	0,1199	2,7547	1,7785	1,0642	0,3583	0,1758	0,0473	2,7535
	Maximum	2,5591	0,1045	0,1770	4,3014	2,4092	1,6059	0,4802	0,2102	0,0644	4,6102
O. oglinum	Median	2,5496	0,1143	0,0855	3,5806	2,1624	3,8060	0,5174	0,2239	0,0531	3,0174
	Minimum	2,2500	0,0998	0,0625	3,1818	1,8474	3,3270	0,4444	0,2103	0,0427	2,4482
	Maximum	2,8730	0,1273	0,0917	4,8770	2,4048	4,5668	0,6085	0,2402	0,0597	3,7923
	p	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001

Tabela 2-Valores resultantes dos dois primeiros eixos da PCA para os atributos ecomorfológicos das espécies de clupeiformes analisadas.

Ecomorphological attributes	PC1	PC2
IC	-0,2015760	0,51887867
HR	0,4471527	-0,09024531
RPL	-0,2790665	-0,44773814
CPCI	-0,1739107	0,31985535
FIV	-0,1300004	0,55187479
APFR	0,3379236	0,30782204
RRP	0,2807720	0,07759448
RHL	0,4174447	0,06237517
RMW	0,2605942	-0,09300874
MAR	-0,4463224	-0,04427569
Proporção da variância	36.46%	24.25%
Proporção cumulativa	36.46%	60.71%