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ARTICLE

Feeding of *Sciaena deliciosa* (Perciformes: Sciaenidae): A seasonal analysis in north-central Peru

Alimentación de *Sciaena deliciosa* (Perciformes: Sciaenidae): Un análisis estacional en el norte-centro de Perú

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Resumen.- La región La Libertad, en el norte-centro de Perú, es la principal región de desembarques de peces costeros. Dentro de este grupo de peces costeros, *Sciaena deliciosa* (lorna) es una de las principales especies desembarcadas. Estudios sobre los principales aspectos tróficos en esta especie son escasos pero necesarios para mejorar el conocimiento poblacional de esta especie. Por lo mencionado, el objetivo del presente estudio fue analizar la variación estacional de los principales parámetros tróficos, según sexo y talla, de *S. deliciosa* en el norte-centro de Perú, del 2016 al 2019. Se utilizó el índice de importancia relativa (%IIR) para determinar la relevancia de cada presa. Se determinó la amplitud del nicho trófico de la especie, se cuantificó el nivel trófico y se evaluaron posibles diferencias estadísticas en la dieta según sexo, talla y estacionalidad, a través de un análisis de varianza multivariado permutacional (PERMANOVA). Asimismo, para interpretar la estrategia alimentaria, se generó un diagrama de dispersión basado en el método gráfico de Costello. La dieta de *S. deliciosa* estuvo conformada por 31 presas, de las cuales, el crustáceo *Emerita analoga* y el pez *Engraulis ringens* fueron las más importantes. Las características de alimentación entre los factores tallas y estación del año fueron significativas. Además, *S. deliciosa* presentó una estrecha amplitud trófica y una dieta selectiva, con un nivel trófico estimado de 4.2. Por lo tanto, en el norte-centro de Perú, *S. deliciosa* se constituye como un depredador especialista bentopelágico carnívoro, con una dieta basada principalmente en el consumo del crustáceo *E. analoga* y el pez *E. ringens*, con características adaptativas orientadas al oportunismo trófico que permiten sostener su abundancia.

Palabras clave: *Sciaena deliciosa*, análisis de contenido estomacal, ecología trófica, pesca artesanal

Abstract.- La Libertad Region, in north-central Peru, is the main landing region for coastal fishes. Within this group of coastal fish, *Sciaena deliciosa* (lorna drum) is one of the main species landed. Studies on the main trophic aspects of this species are scarce but necessary to improve the population knowledge of this species. Therefore, the objective of the present study was to analyze the seasonal variation of the main trophic parameters, according to sex and size, of *S. deliciosa* in north-central Peru, from 2016 to 2019. The index of relative importance (%IRI) was used to determine the relevance of each prey item. The breadth of the trophic niche of the species was determined, the trophic level was quantified and possible statistical differences in diet according to sex, size and seasonality were evaluated using permutational multivariate analysis of variance (PERMANOVA). Also, to interpret the feeding strategy, a scatter plot was generated based on Costello's graphical method. The diet of *S. deliciosa* consisted of 31 prey items, of which the crustacean *Emerita analoga* and the fish *Engraulis ringens* were the most important. The feeding characteristics between the factors size and season of the year were significant. In addition, *S. deliciosa* presented a narrow trophic breadth and a selective diet, with an estimated trophic level of 4.2. Therefore, in north-central Peru, *S. deliciosa* is a carnivorous benthopelagic specialist predator, with a diet based mainly on the consumption of the crustacean *E. ringens* and the fish *E. analoga*, with adaptive characteristics oriented to trophic opportunism that allow it to sustain its abundance.

Key words: *Sciaena deliciosa,* stomach content analysis, trophic ecology, artisanal fishing

INTRODUCTION

Stomach content analysis is one of the most practical and effective methods for determining the diet of a fish. Understanding the diet of fish species is fundamental in the evaluation of fishery resources (Hilborn & Walters 1992, Pauly *et al.* 1998, Micheli 1999, Mackinson *et al.* 2009). In addition, this information is crucial because it allows it to be applied in sustainable fishing and management models (Amezaga-Herrán 1988, Lozano-Montes *et al.* 2011, Braga *et al.* 2012, Stewart 2015), in understanding the functioning of marine ecosystem (Paine 1980, Sala & Ballesteros 1997, Cox *et al.* 2002, Frank *et al.* 2005, Sánchez-Hernández *et al.* 2011), even in estimating the health of marine ecosystems (Bezerra *et al.* 2021).

The lorna drum *Sciaena deliciosa* (Tschudi, 1846) is a fish of the Sciaenidae family, distributed from Ecuador, Puerto Pizarro (Peru) to Corral, Chile (39°52'S) and inhabits the benthopelagic zone of the continental shelf, on shallow sandy

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and sandy-rocky bottoms, common in the area of the Peruvian Coastal Current (Chirichigno & Cornejo 2001). It supports significant artisanal fisheries throughout its distribution range, particularly in Peru where it is the main landed species of the demersal-benthic group of artisanal fisheries in Peru (Guevara-Carrasco & Bertrand 2017) and the second most landed coastal fish in La Libertad Region (Atoche 2024)[1].

Studies on the main trophic aspects of *S. deliciosa* are not common. Previous studies in Chile, categorize lorna drum as carcinophagous, exhibiting a preference for consuming crustaceans and polychaetes (Vargas *et al.* 1999). In Peru, one of the oldest antecedents is the one reported by Mejía *et al.* (1970), who registered polychaetes as the most important group in the diet. Also, undergraduate thesis by Jaime (1999), Paredes (2003) and Gutiérrez (2017), describe that *S. deliciosa* feeds mainly on crustaceans, ophiuroids and polychaetes. Nevertheless, these studies often lack temporal resolution, limiting understanding of seasonal variability.

Continuous monitoring of the trophic ecology of *Sciaena deliciosa* is conducted across the Peruvian regions of La Libertad, Ancash, Lima, Arequipa, and Moquegua. La Libertad, recognized as the most important region for coastal resource landings (IMARPE 2020), harbors *S. deliciosa* as one of its key species. Although their general diet is known, potential variations in feeding patterns related to sex and size, observed in other coastal teleosts, remain uninvestigated (Valle-Lopez *et al.* 2021). Therefore, the objective of this study was to analyze the feeding ecology of *S. deliciosa* in northern central Peru through monthly samplings over a 4-year period (2016-2019). By examining the seasonal variation in key trophic parameters across sexes and size, this research provides a comprehensive understanding of the species' feeding strategies and contributes to sustainable fisheries management in the region.

Materials and methods

Study area

The study area is located in the coastal zone of the La Libertad Region, which extends from Punta Cherrepe (07º10'27''S; 79º41'18''W) to the Santa River (08º57'45''S; 78º58'06''W). This area is highly productive due to the influence of the Humboldt Current System and the occurrence of El Niño events (Bakun & Weeks 2008, Chavez *et al.* 2008). Due to its location, this zone is governed by the austral seasonality, which for practical purposes of this study has been determined from the beginning of the year, uniformizing between early and late seasonality, corresponding to summer from January to March, autumn from April to June, winter from July to September, and spring from October to December (Echevin *et al.* 2008). In addition, there is an important artisanal fishing activity in this region, of which the *S. deliciosa* fishery is one of the most important resources in terms of landings (Atoche *et al.* 2020). Forty-five samples were taken from 23 lorna drum fishing grounds (Fig. 1), caught within 2 nautical miles offshore. The lorna drum catches were made by artisanal wooden boats and "caballitos de totora", using curtain nets with a mesh size of 63.5 mm to 114.3 mm.

Sampling

From 2016 to 2019, monthly biometric and biological samplings of *S. deliciosa* were conducted from commercial catches. Data collected in 2016 was partially obtained from Gutiérrez (2017). Specimens were sexed (female or male) and categorized into two size ranges based on the minimum capture size of *S. deliciosa* (PRODUCE 2001)[2]: juveniles (15-23 cm) and adults (≥ 24 cm), This categorization was employed due to the lack of dedicated maturity size studies for this species. Stomachs analysis involved recording the weights (g) of full stomach, empty stomach and stomach contents using a calibrated scale with a capacity of 5 kg capacity and 0.01 g sensitivity. A total of 2,359 specimens were sampled, ranging in total length from 18 to 50 cm. Of these, 766 stomachs contained identifiable food items and were analyzed. Stomachs with digested or empty contents were excluded. The entire sampling procedure followed the protocols established by Laboratorio de Ecología Trófica, IMARPE (Peru).

For prey recognition, stomach contents were poured into Petri dishes, discarding digested stomach contents. To determine the lowest possible taxon, when prey could not be recognized to the plain eye, a LEICA® S6D stereoscope was used. Then the taxonomic determination was validated with the works of Fauchald (1977) for polychaetes, Alamo & Valdivieso (1997) for mollusks, Chirichigno & Cornejo (2001) for fishes, Salgado & Hendrickx (2010) for stomatopods, Moscoso (2013) for decapod crustaceans, and Uribe *et al.* (2013) for benthic invertebrates.

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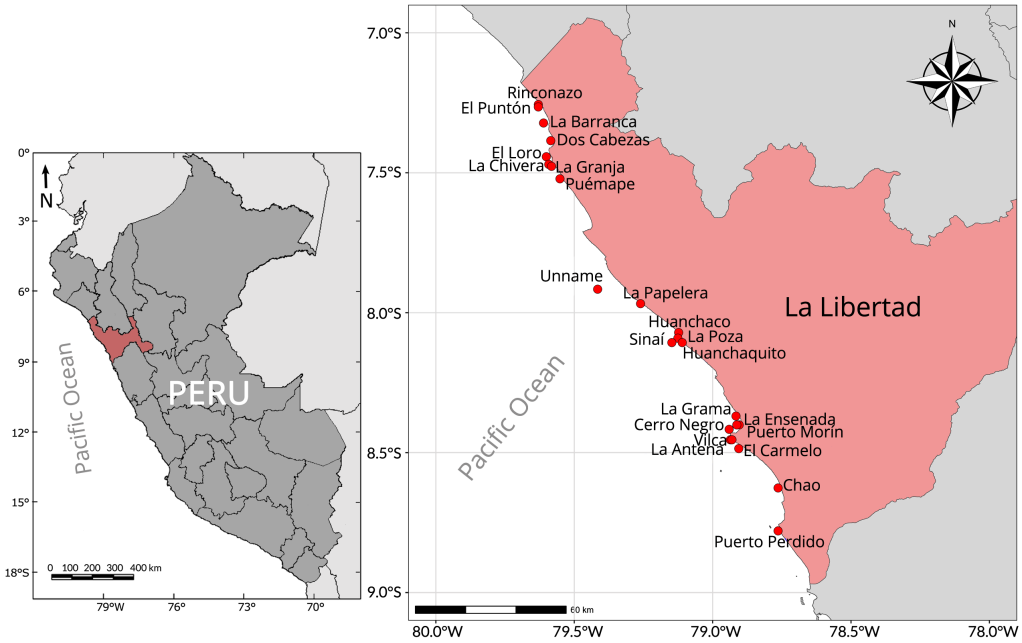

Figure 1. Geographic map of La Libertad Region, northern Peru, highlighting the fishing zone sampling sites (red dots) / Mapa geográfico de la región de La Libertad, norte de Perú, destacando los lugares de muestreo de las zonas de pesca (puntos rojos)

Feeding habits

To determine the intensity of feeding, the vacuity index was used:

$$\%VI = (A \times 100)/B$$

where A is the number of empty stomachs and B is the total number of analyzed stomachs (Hyslop 1980). The frequency of occurrence (%FO), numerical (%N) and gravimetric (%W) methods were used to analyze the trophic composition of the diet (Hyslop 1980). To determine the feeding preference of *S. deliciosa*, the above indices were integrated using the Index of Relative Importance (IRI) (Hacunda 1981). The IRI values was determined by prey as a function of sex, size and seasonality.

$$IRI = (\%N + \%W) \times \%FO$$

In each taxonomic category, the percentage value of the relative importance index (%IRI) proposed by Cortés (1997) was calculated to allow comparisons between species, as well as between items according to their relative importance (IRI), and is expressed as follows:

$$\%IRI = \frac{IRI_i}{\sum_{i=1}^{n} IRI_i} \times 100$$

where IRI_i is the value of IRI for prey *i*, and *n* is the total number of trophic categories considered.

The diet breadth (B_i) of *S. deliciosa* was calculated using Levin's standardized index (Krebs 1989). Niche breadth was evaluated based on Labropoulou & Eleftheriou (1997), where values close to zero indicate that the species has a specialized feeding strategy, while values close to one indicate that the species has a generalist strategy:

$$B_i = \frac{1}{n-1}\left(\frac{1}{\sum_j P_{ij}^2} - 1\right)$$

where *Bi:* niche breadth, $\sum_j P_{ij}^2$: proportion of the j^{th} item in the diet of the i^{th} predator, and n: total number of prey items.

To interpret the feeding strategy of *S. deliciosa* in the study area, we created a dispersion diagram based on the graphical method proposed by Costello (1990) and modified by Amundsen *et al.* (1996). The concepts refer to a two-dimensional representation of the strategy used by predators, plotting the values of the frequency of occurrence and abundance of prey.

For the quantification of the trophic level (TL), preys were grouped into taxonomic groups with their respective reference trophic level obtained from Pauly & Christensen (1995), Pauly *et al.* (1998, 2000). The trophic level (TL) was calculated for juveniles and adults, taking as reference the minimum catch size of 24 cm of *S. deliciosa*. This was estimated according to Cortés (1999), using the following equation:

$$TL = 1 + \sum_{j=1}^{n} P_j \times TL_j$$

where, *TL*: trophic level of *S. deliciosa*, TL_j: trophic level of each prey category consumed, P_j: proportion of each prey category in the diet of the predator, and *n*: number of prey items.

Data analysis

A permutational multivariate analysis of variance (PERMANOVA) (Anderson *et al*. 2008) with 10,000 permutations was performed to assess possible statistical differences in *S. deliciosa* diet according to sex (female and male), size (juvenile and adult) and seasonality (summer, autumn, winter and spring), and possible interactions between factors, using biomass (W) obtained from the stomach contents of each prey species. Biomass data were transformed to the fourth root to reduce the influence of common prey taxa. The analysis was performed using PRIMER 6 software (v.6.0; PRIMER).

Results

Environmental variables

During the 2016-2019 study period, the coastal marine environment was characterized by cold (Niña event), neutral and warm (Niño event) periods. With cold events between spring of 2017 to June 2018 and a neutral period between July and September 2019. Regarding the Niño event, it occurred from January to March of 2016; between February and April 2017 and, the last one, in January 2019. The other values corresponded to neutral periods (Fig. 2A). The mean sea surface temperature (SST) in La Libertad Region ranged from 15.9 °C to 24.6 °C (Fig. 2B).

General dietary characteristics

A total of 2,359 stomachs were studied for stomach content analysis (SCA). A total of 1,593 specimens had an empty stomach (VI= 67.5%), the VI of females was higher than that of males (VI= 36.8% and 26.5% respectively) and adults had higher VI than juveniles (VI= 32.0% and 35.5% respectively). The diet was composed of 31 prey belonging to the Phylum: Annelida, Arthropoda, Chordata, Cnidaria, Echinodermata, Mollusca, Nemertea and Rhodophyta, of which the Phylum Arthropoda provided the highest number of species of the class Malacostraca (9 prey species). The most frequent prey items were Pacific sand crab *Emerita analoga* (33.6%, n= 856), peruvian anchoveta *Engraulis ringens* (21.4%, n= 261), worm *Pherusa* spp. (12.9%, n= 968) and brittle star *Ophiactis* spp. (10.5%, n= 1348). In terms of biomass contribution, the Teleostei (59.0%, 3450.7 g) and Malacostrata (31.1%, 1815.5 g) classes were the most relevant. However, according to the IRI, the most important prey species were *E. analoga* (42.2%), *E. ringens* (36.0%), *Pherusa* spp. (10.7%) and *Ophiactis* spp. (9.9%), varying according to seasonality (Table 1).

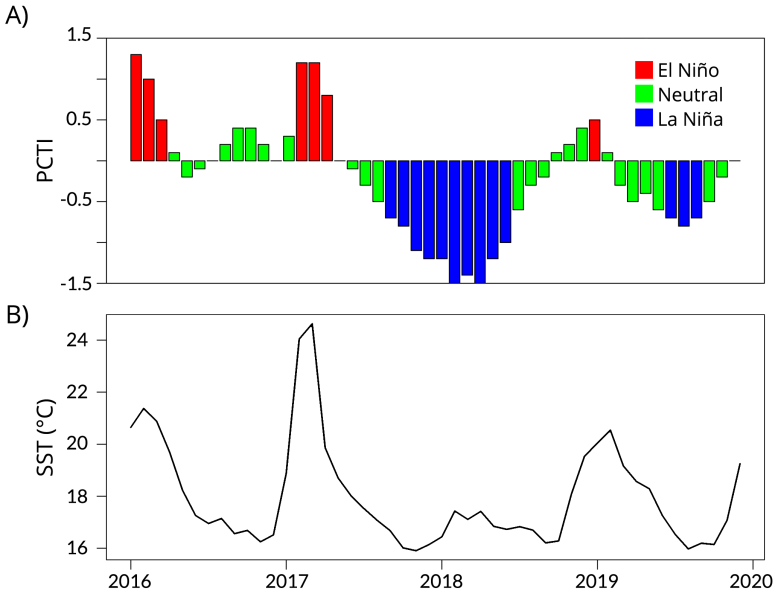

Figure 2. Variation of thermal parameters. A) Peruvian Coastal Thermal Index (PCTI), which indicates the environmental categories: El Niño, Neutral and La Niña. B) Sea Surface Temperature (SST) in La Libertad Region, Peru / Variación de parámetros térmicos. A) Índice térmico costero peruano (PCTI), que indica las categorías ambientales: El Niño, Neutro y La Niña. B) Temperatura superficial del mar (SST) en la región La Libertad, Perú

Tx	Prey	N	Summer					Autumn					Winter					Spring				
			%N	%W	%FO	IRI	%IRI	%N	%W	%FO	IRI	%IRI	%N	%W	%FO	IRI	%IRI	%N	%W	%FO	IRI	%IRI
Po	*Arenicola marina*	12																0.99	0.45	1.41		
	Capitellidae	18											1.43	0.66	1.08	2.26	0.04	0.25	0.11	0.47	0.17	
	Chaetopterus spp.	21	2.71	0.34	1.59	4.85	0.07	0.86	0.2	3.23	3.42	0.09	0.1	0.18	0.54	0.15						
	Glycera spp.	22						1.45	0.36	1.38	2.5	0.06	0	0	0	0						
	Lumbrineris spp.	178	3.1	0.5	1.59	5.72	0.09	3.7	1.2	2.3	11.27	0.29	10.89	2.55	9.73	130.8	2.40	0	0	0	0	
	Oweniidae	3						0.2	0.04	0.46	0.11											
	Pherusa spp.	968						5.08	1.71	7.83	53.17	1.37	18.05	8.33	7.57	199.7	3.66	58.16	8.64	26.76	1788	26.26
Ma	*Allopetrolisthes spinifrons*	2																0.17	0.21	0.94	0.36	0.01
	Callichirus islagrande	31	5.04	16.38	19.05	408.1	6.16	0.33	2.67	2.3	6.90	0.18	1.24	5.21	3.24	20.9	0.38					
	Emerita analoga	856	46.9	48.66	58.73	5612	84.71	21.45	40.03	35.94	2209.59	57.09	34	62.56	49.19	4750	87.08	4.47	5.65	10.33	104.5	1.54
	Pilumnoides perlatus	2																0.17	0.04	0.94	0.2	
	Pinnixa transversalis	44	0.39	0.07	1.59	0.73	0.01	1.39	0.17	3.23	5.04	0.13	2.1	0.16	7.03	15.89	0.29	0	0	0	0	0.00
	Platyxanthus orbignyi	6																0.5	0.15	1.41	0.92	0.01
	Pleuroncodes monodon	57						3.56	3.85	0.92	6.82	0.18						0.25	0.1	0.47	0.16	
	Pseudosquillopsis lessonii	7						0.07	0.68	0.46	0.35	0.01	0.29	2	1.62	3.71	0.07	0.25	0.54	1.41	1.11	0.02
	Romaleon setosum	14																1.16	2.03	1.88	6	0.09
Te	*Anchoa nasus*	9						0.53	4.93	2.76	15.07	0.39						0.08	0.45	0.47	0.25	
	Engraulis ringens	261	4.26	32.69	11.11	410.5	6.20	1.85	30.12	10.14	324.18	8.38	1.24	14.56	5.95	94.01	1.72	17.32	80.93	49.3	4844	71.14
	Mugil cephalus	11						0.73	8.54	3.69	34.21	0.88										
	Odontesthes regia	4											0.38	0.62	0.54	0.54	0.01					
Ac	*Anthothoe chilensis*	1																0.08	0.04	0.47	0.06	
	Phymactis clematis	1						0.07	0.08	0.46	0.07											
	Phymanthea pluvia	11						0.73	0.27	1.38	1.38	0.04										
Oph	*Ophiactis* spp.	1348	36.82	1.3	4.76	181.5	2.74	56.63	3.63	19.82	1194.35	30.86	19.1	1.43	9.19	188.7	3.46	16.16	0.67	3.76	63.28	0.93
Mo	*Alia* spp.	2						0.13		0.92	0.12											
	Mulinia coloradoensis	14						0.92	0.47	0.46	0.64	0.02										
	Nassarius dentifer	1						0.07		0.46	0.03											
	Semimytilus algosus	3	0.78	0.06	1.59	1.34	0.02	0.07		0.46	0.03											
	Sinum cymba	2						0.13	0.54	0.92	0.62	0.02										
Ne	Nemertine	2						0.07	0.5	0.46	0.26	0.01	0.1	0.1	0.54	0.11						
Flo	Red algae	116											11.08	1.63	3.78	48.04	0.88					

Tx: taxon; Po: Polychaeta; Ma: Malacostraca; Te: Teleostei; Ac: Actiniaria; Oph: Ophiactidae; Mo: Mollusca; Ne: Nemertina; Flo: Florideophyceae
N: number of individuals per prey; %N: percentage by number; %W: percentage by weight; %FO: percentage by frequency of occurrence; IRI: index of relative importance and its respective percentage (%IRI)

Table 1. Diet composition of *S. deliciosa* in north-central Peru (2016-2019) / Composición de la dieta de *S. deliciosa* en el norte-centro de Perú (2016-2019)

PERMANOVA analysis revealed that the feeding characteristics between females and males were not significant (Pseudo-F= 1.049; $P > 0.05$), while the factors size and season of the year were significant (Pseudo-F= 3.506; $P < 0.05$ and Pseudo-F= 2.5; $P < 0.05$, respectively). Although, there were no significant differences in the interaction between sex and size (F= 0.852; $P = 0.546$), between sex and season (F= 0.709; $P = 0.826$), between size and season (F= 1.42; $P = 0.108$), and between sex, size and season (F= 0.524; $P = 0.958$) (Table 2).

Table 2. Results of the PERMANOVA (Permutational multivariate analysis of variance) analysis of *S. deliciosa* diet between sexes (male and female), sizes (juvenile and adult) and seasons (summer, autumn, winter and spring) in north-central Peru (2016-2019) / Resultados del análisis PERMANOVA (Análisis multivariado permutacional de varianza) de la dieta de *S. deliciosa* entre sexos (macho y hembra), tallas (juvenil y adulto) y estaciones (verano, otoño, invierno y primavera) en el centro norte del Perú (2016-2019)

Factor	df	MS	F	P(>F)	Significance
Sex	1	3067.3	1.049	0.39	NS
Size	1	10252	3.506	0.003	$P < 0.05$
Season	3	21934	2.5	0.002	$P < 0.05$
Sex:Size	1	2490.9	0.852	0.546	NS
Sex:Season	3	6218.3	0.709	0.826	NS
Size:Season	3	12452	1.42	0.108	NS
Sex:Size:Season	3	4594.3	0.524	0.958	NS

df: degrees of freedom; MS: mean squares; F: Fischer's F; P: significance level; NS= no significance ($P \geq 0.05$)

Seasonal variation in diet

Diet variation by sex

Diet composition by sex was similar, with 28 prey items in the stomachs of males and 24 prey items in females. In both sexes, the most important prey according to %IRI was Pacific sand crab *E. analoga* (35.7% in females and 35.9% in males) (Fig. 3). In summer, the most important prey for females was *E. analoga* (87.9%) and for males it was Peruvian anchoveta *E. ringens* (83.6%). In autumn and winter, the most important prey for both sexes was *Emerita analoga*. In spring the most important prey for both sexes was *E. ringens* (Fig. 3).

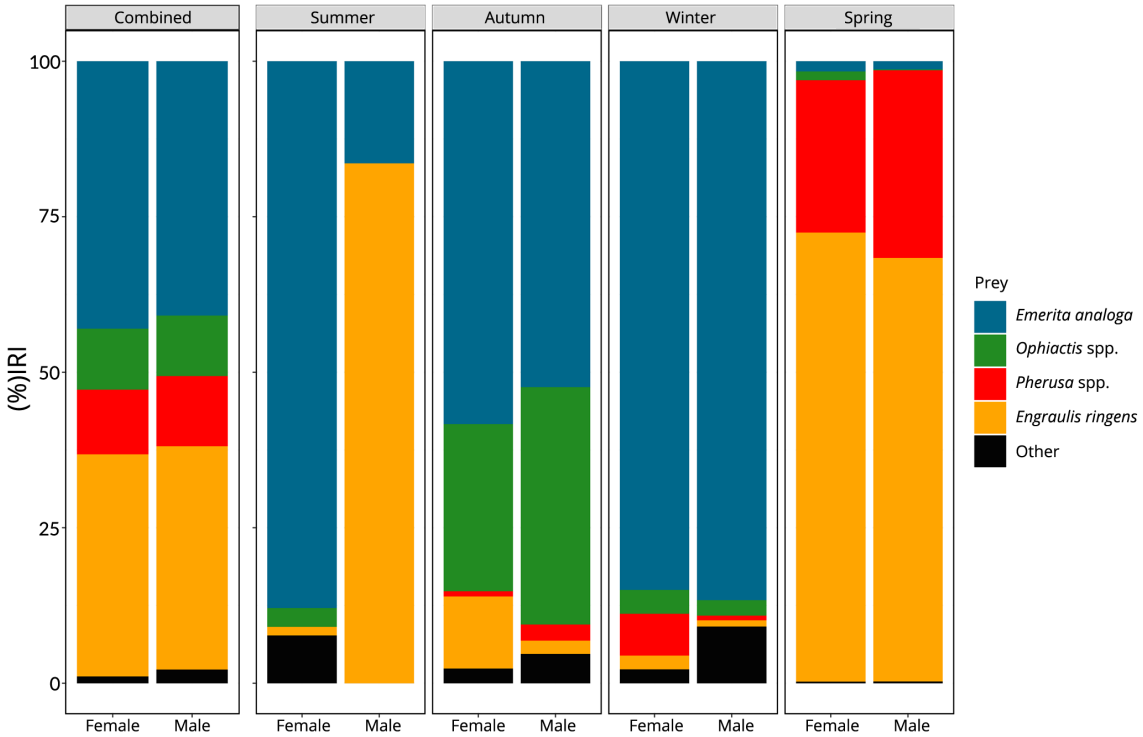

Figure 3. Intersexual variation (male and female) of *S. deliciosa* diet in north-central Peru, using the Relative Importance Index (%IRI) / Variación intersexual (macho y hembra) de la dieta de *S. deliciosa* en el norte-centro del Perú, usando el índice de importancia relativa (%IIR)

Diet variation by size

Diet composition between juveniles and adults was different. The number of prey items present in the stomachs of juveniles was 13, and 31 in adults. In juveniles, the most important prey according to %IRI was *E. analoga* (57.9%) and in adults it was *E. ringens* (44.1%) (Fig. 4). The highest number of preys was observed during autumn and the lowest in summer. In summer, autumn and winter, the most important prey, for both sizes, was *E. analoga*. On the other hand, in spring, the most important prey in juveniles was *Pherusa* spp. (97.3%) and in adults was *E. ringens* (83.3%) (Fig. 4).

Trophic niche breadth and feeding strategy

Niche breadth (B_i) had low and similar values for the entire sampled population (B_i=0.066) indicating a selective diet and narrow niche breadth. In females, the niche breadth was 0.074 and in males it was 0.093. Similar variation was observed between juveniles and adults (0.064 and 0.085 respectively). The Costello's modified graphs showed a higher prey concentration with a low frequency of occurrence, with the exception of 5 preys, and varied prey-specific abundances (Fig. 5). In males (Fig. 5B) and adults (Fig. 5D), higher prey concentrations with high prey-specific abundance and intermediate frequency of occurrence were observed. In terms of seasonality, the prey with the highest frequency of occurrence and the highest specific abundance was *E. analoga* (Fig. 5E-G), except in the spring, when *E. ringens* and *Pherusa* spp. were the most abundant. (Fig. 5H).

Trophic level

The trophic level calculated for *S. deliciosa* was 4.2. The trophic levels for juveniles and adults were 3.7 and 3.9, respectively. The minimum trophic level value in juveniles occurred in spring (3.3) and the maximum in autumn (4.0). In adults, the maximum values were observed in summer and spring (4.0) and the minimum value was in autumn (3.8) (Fig. 6). Nevertheless, the trophic levels between juveniles and adults were statistically similar ($P > 0.05$).

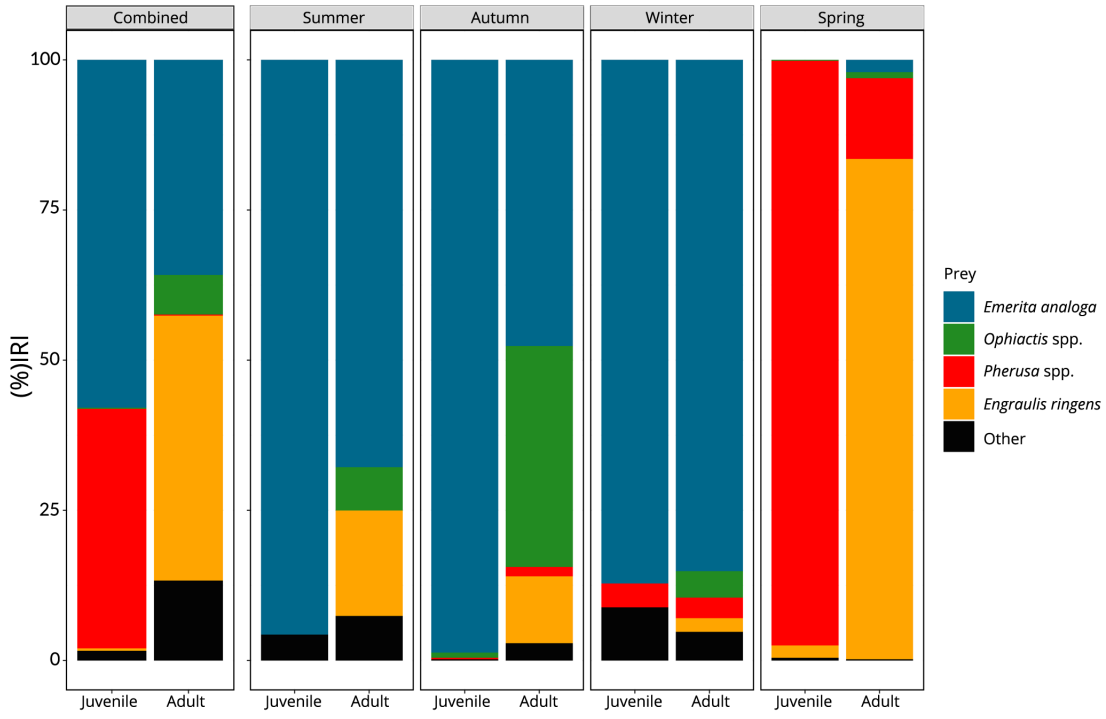

Figure 4. Size variation (juvenile and adults) of *S. deliciosa* diet in north-central Peru, measured with the Index of Relative Importance (%IRI) / Variación de tamaño (juveniles y adultos) de la dieta de *S. deliciosa* en el norte centro del Perú, medida con el índice de importancia relativa (%IIR)

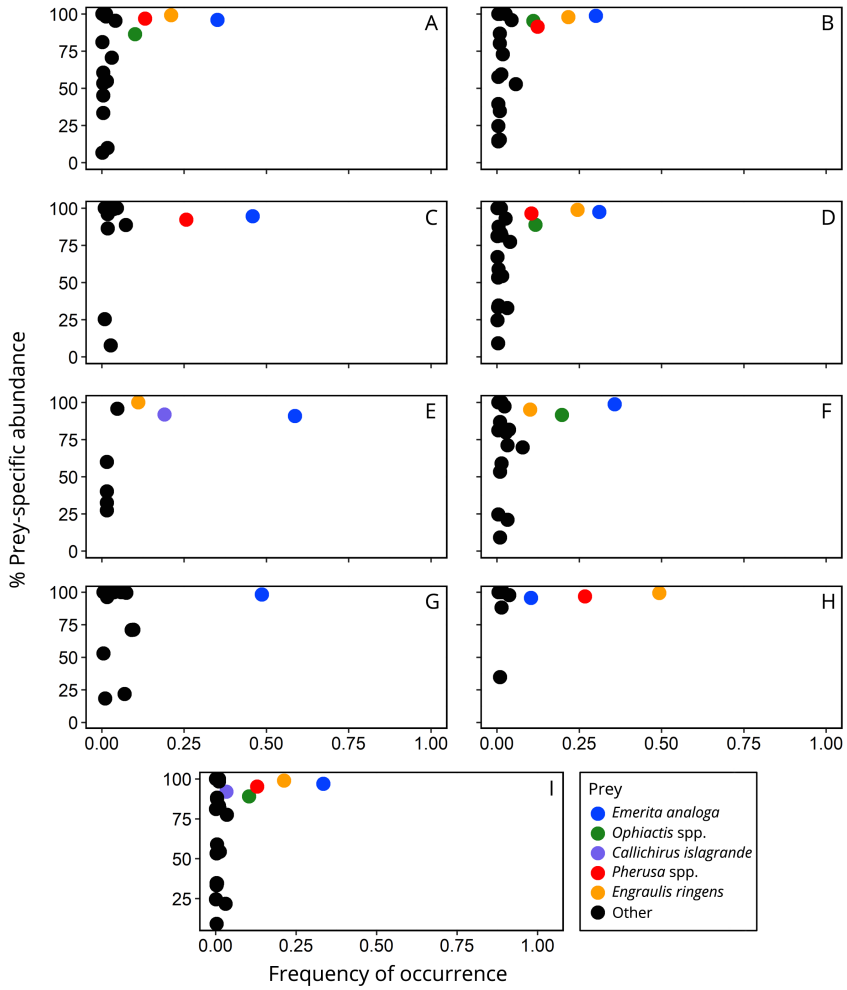

Figure 5. Relationship between the relative prey-specific abundance (%) and the frequency of occurrence of prey items in the diet of *S. deliciosa* in north-central Peru. A) female, B) male, C) juvenile. D) adult, E) summer, F) autumn, G) winter, H) spring, I) general / Relación entre la abundancia relativa de presas específicas (%) y la frecuencia de ocurrencia de presas en la dieta de *S. deliciosa* en el norte-centro del Perú. A) hembra, B) macho, C) juvenil, D) adulto, E) verano, F) otoño, G) invierno, H) primavera, I) general

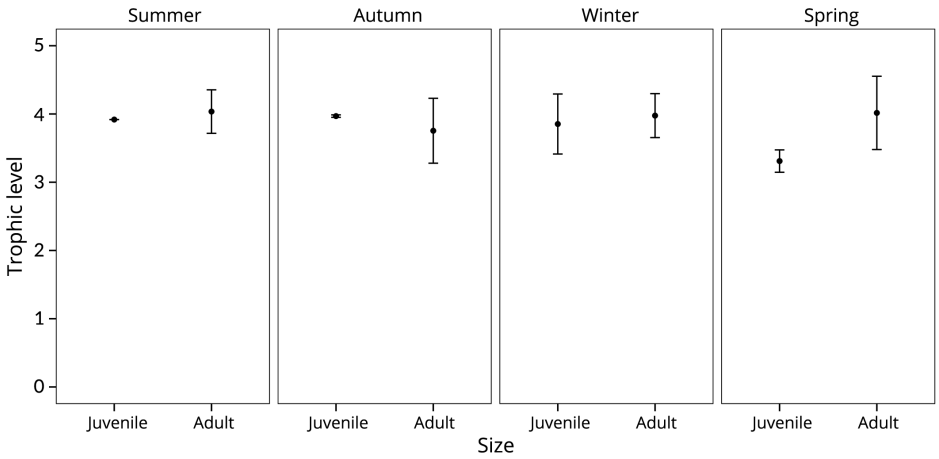

Figure 6. Seasonal trophic level of juvenile and adult *S. deliciosa* / Nivel trófico estacional de juveniles y adultos de *S. deliciosa*

Discussion

In this study, we analyzed for the first time the seasonality variation in the diet of *S. deliciosa* according to sex and size, over a four-year period in the north-central Peru, through the analysis of stomach contents. The findings offer valuable insights that serve as a foundation for further research in ecologically relevant areas, driven by the species' high abundance, evident in its significant landings (Guevara-Carrasco & Bertrand 2017, IMARPE 2020), and the remarkable trophic diversity revealed by this study.

The percentage of empty *S. deliciosa* stomachs throughout the study was higher than 50%, however, this was not a limiting factor for the analysis of the diet of this species, because there was continuous monthly monitoring, which ensured an adequate representation of the sample. In this study area, similar values have been reported in *Paralonchurus peruanus* (Sciaenidae) which presents low feeding dynamics, with values exceeding 60% of empty stomachs (Bringas *et al.* 2014, Pérez *et al.* 2020). A different scenario is observed in the coastal waters of the South Atlantic, where, samples were obtained using active gear nets, obtaining percentages below 30% in Scieanidae of the genera *Micropogonias* (Sardiña & Lopez-Carzola 2005a), *Cynoscion* (Sardiña & Lopez-Carzola 2005b) and *Paralonchurus* (Sedrez *et al.* 2021). Explaining the causes of high empty stomach percentages is important to accurately describe the diet of the species (*e.g.*, as reported in the batoid fish *Rhinoptera steindachneri*, which presented vacuity index values higher than 97%) (Ehemann *et al.* 2019). Starting from the three hypotheses proposed by Ehemann *et al.* (2019) the one most related to the scenario observed in *S. deliciosa*, would be that of their feeding habits and possibly feeding schedules did not coincide with the time of capture.

In addition, it has been observed that some of the fishing areas do not coincide with the feeding areas of *S. deliciosa*, which are mostly located very close to the coast, where, as a precautionary measure, boats do not usually enter (pers. obs.).

Previous studies have provided valuable information on the feeding of *S. deliciosa* in the northern Humboldt ecosystem. This species was considered carcinophagous (Vargas *et al.* 1999), having as important prey polychaetes (Mejía *et al.* 1970), crustaceans, ophiuroids, polychaetes (Jaime 1999, Paredes 2003) and fish such as *E. ringens* (Gutiérrez 2017). The present study indicated that *S. deliciosa* has a trophic plasticity reflected in the number of species reported, having crustaceans *E. analoga*, *Ophiactis* spp., polychaete *Pherusa* spp. and fish *E. ringens* as the most important prey. In addition, it is important to mention that the feeding characteristics of *S. deliciosa* were not significantly different between sexes, but were significantly different between sizes and seasonality. Other similar studies in coastal fishes reveal differences between sexes and seasonality (Valle-Lopez *et al.* 2021). Although these results indicate a possible change in feeding between different sizes, it is advisable to analyze at a larger spatial scale, as it could be related to the characteristics of the substrate in each area.

The diet of *S. deliciosa* presented an important contribution of *E. ringens* and *E. analoga*, except in the spring of the last year of this study, where the predominant prey was *Pherusa* spp. In addition, the diet of *S. deliciosa* presented similar proportions of prey among females and males, in contrast to the different proportion between juveniles and adults. Seasonally, a similar pattern of variation in the most important prey items was observed between females and males, with the exception of summer, where males preferentially consumed *E. ringens*.

A similar pattern of variation was observed between juveniles and adults, however in spring it was observed that in juveniles the most important prey was *Pherusa* spp. and in adults, the most important prey was *E. ringens*. These differences are possibly related to intrinsic fish characteristics (Lukoschek & McCormick 2001, Sardiña & Lopez-Carzola 2005b, Hayden *et al.* 2019), prey availability (Sardiña & Lopez-Carzola 2005b) and environmental factors (Hayden *et al.* 2019). In addition, due to the fact that the sampling was carried out with curtain nets, it is possible that it influenced the composition between sizes, where it was observed that in *S. deliciosa*, the means of the catch sizes were higher than the allowed size of 24 cm (Atoche *et al.* 2020).

A key aspect in the knowledge of feeding is the determination of trophic niche breadth, because it allows us to know if a predator is a specialist or a generalist (Krebs 1989, Labropoulou & Eleftheriou 1997). In the present study, *S. deliciosa* consumed 31 prey species, belonging to eight different taxa. Nevertheless, according to Levin's index (Bi= 0.07) this species had a narrow trophic niche due to the limited availability of key prey species, so it could be considered a benthopelagic specialist predator due to the abundant and frequent consumption of *E. analoga*, *Ophiactis* spp., *Pherusa* spp. and *E. ringens*.

The specialist behavior of *S. deliciosa* is similar to that reported in other coastal sciaenids (Sardiña & Lopez-Carzola 2005b, Blasina *et al.* 2010, Arizmendi-Rodríguez *et al.* 2014, Valle-Lopez *et al.* 2021), where similarities between sexes and sizes may be present (Valle-Lopez *et al.* 2021). Another relevant and complementary aspect to the breadth of the trophic niche would be the feeding strategies. The results obtained indicated that, although *S. deliciosa* presents a feeding strategy with different levels of specialization and generalization on different types of prey, based on the analysis of the modified graphical method of Costello's (Amundsen *et al.* 1996), in general it shows a strong specialization among individual predators and a high contribution among phenotypes to the breadth of the niche. In this sense, no significant differences were observed between females and males, in contrast to the variation by size ranges, where it was observed that adults consumed more frequently *E. ringens* and *Ophiactis* spp. Other factor to consider would be seasonality, observing that *S. deliciosa* changed its feeding strategy between warm and cold periods, showing a higher frequency of occurrence and abundance of *Pherusa* spp. and

E. ringens in spring. Future studies at a larger spatial and temporal scale, should deepen about a possible alternation between the main prey in the diet of *S. deliciosa*, as well as an evaluation of the diet of other coastal fishes present in the Humboldt ecosystem, considering the occurrence of climatic events such as El Niño (Roque-Ventura 2017).

The trophic level of *S. deliciosa* indicates that it was a predatory species, reflecting carnivorous feeding habits, with a feeding preference for prey of intermediate trophic levels. Thus, the trophic level of *S. deliciosa* was higher than that obtained for the genus *Lutjanus*, a coastal fish of the same family, considered a tertiary consumer (Tarnecki & Patterson 2015, Valle-Lopez *et al.* 2021). That is, the trophic level of *S. deliciosa*, given mainly by the biomass contributed by *E. ringens* and *E. analoga*, is comparable to the trophic level of coral fishes of the genus *Plectropomus* (Frisch *et al.* 2014) and even with sharks that present trophic levels higher than 4 (Cortes 1999). Therefore, the results obtained are relevant because the trophic level of *S. deliciosa* may be indicative that it is a superpredator species, which means that it fulfills a functional role in the food web.

Understanding the diet of *S. deliciosa* in north-central Peru serves as a critical foundation for future trophic studies within the Humboldt Current Ecosystem. Integrating complementary methods like stable isotope analysis would further enhance our comprehension of key trophic parameters, such as feeding shifts (Varela *et al.* 2017, Cornelissen *et al.* 2018) and trophic level variations (Amezcua *et al.* 2015, Varela *et al.* 2019). Ultimately, the findings of this research suggest that *S. deliciosa* is a carnivorous benthopelagic specialist predator with a diet heavily reliant on *E. ringens* and *E. analoga*. This species exhibits adaptive characteristics that facilitate trophic opportunism, contributing to its sustained abundance.

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