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Family composition and distribution of fish larvae in La Restinga Lagoon, Margarita Island, Northeastern Venezuela

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Abstract

This work is a contribution to the knowledge of the species composition, the abundance and the spatiotemporal distribution of fish larvae in the coastal lagoon La Restinga, Margarita Island, Northeastern Venezuela. Samples were collected from June to September 1996, in four lagoon interior stations, and from January to June 1998, at the lagoon mouth. In the lagoon interior 1223 larvae belonging to 18 families, 30 genera and 24 species, were collected. The most frequent families were: Gobiidae, Engraulidae, Sparidae and Carangidae, which embraced 83.07% of the collected larvae. Two abundance peaks occurred, one in mid-July and the other in mid-August. At the lagoon mouth 5575 larvae representative of 13 families, 12 genera and 12 species, were collected. The most frequent families were: Gobiidae, Engraulidae, Blenniidae and Grammistidae, comprising over 95.00% of the collected larvae. Two abundance peaks occurred, one in early March and the other in late May. Through both sampling periods representatives of 21 families, 36 genera and 33 species were collected, indicating that La Restinga is a spawning and nursery ground for resident fish species while no resident species rely on the area for survival of the early stages.

Key words: coastal lagoon, fish larvae, La Restinga, Venezuela.

Composición de familias y distribución de larvas de peces en la Laguna La Restinga, Isla Margarita, noreste de Venezuela

Resumen

El presente trabajo es una contribución al conocimiento de la composición de especies, la abundancia y la distribución espaciotemporal de larvas de peces en la laguna costera La Restinga, Isla Margarita, noreste de Venezuela. Las muestras fueron recolectadas de junio a septiembre de 1996, en cuatro estaciones interiores, y de enero a junio de 1998, en la boca lagunar. En el interior de la laguna fueron recolectadas 1223 larvas, pertenecientes a 18 familias, 30 géneros y 24 especies. Las familias más frecuentes fueron: Gobiidae, Engraulidae, Sparidae y Carangidae, las cuales aportaron el 83,07% de las larvas recolectadas. Se registraron dos picos de abundancia, uno a mediados de julio y otro a mediados de agosto. En la boca de la laguna fue-

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ron recolectadas 5575 larvas pertenecientes a 13 familias, 12 géneros y 12 especies. Las familias más frecuentes fueron: Gobiidae, Engraulidae, Blenniidae y Grammistidae, las cuales aportaron más del 95,00% de las larvas recolectadas. Se registraron dos picos de abundancia, uno a principios de marzo y otro a finales de mayo. Durante ambos periodos de muestreo fueron recolectados representantes de 21 familias, 36 géneros y 33 especies, lo cual indica que La Restinga es área de desove y vivero para especies residentes de peces mientras que especies no residentes dependen del área para la sobrevivencia de los estadios tempranos.

Palabras clave: laguna costera, larvas de peces, La Restinga, Venezuela.

Introduction

Coastal environments such as bays, estuaries and lagoons, play a vital role in the reproduction, growth and survival of larvae and juveniles of many fish species (1-3). Most commercial important fishes of the tropical and subtropical continental shelves depend on these areas as spawning and nursery grounds, so that, the migration patterns in and out, have received great deal of attention (4-6). Some species spend their entire life cycles within estuaries or lagoons, as others recruit from coastal or offshore spawning grounds to these nursery areas, which are environments of high productivity, protected from sea currents, and with a diminished predation pressure (7-9). The structure of the ichthyoplankton assemblages indicates the spawning areas and seasons, as well as, the larval abundance and potential recruitment, telling about the ecological importance of a given coastal zone for the life history of fish (10-13).

La Restinga Lagoon, located in Eastern Venezuela, is a rich fishing area characterized by an upwelling system, which generates over 50% of the commercial pelagic fish species of the country (14, 15). In spite of this fact, few ichthyoplankton studies have been undertaken in the region, among these: Gómez (16), Esteve (17), Esteve *et al.* (18) and Villalba (19). La Restinga Lagoon is National Park since 1974, and currently stands a heavy turistic-recreational activity, and a subsistence fishery by resident populations (20). Thus, the aim of this research was to evaluate the composition and the spatiotemporal distribution of fish larvae in La Restinga Lagoon, to estimate its value as reproductive and nursery ground for local fish.

Materials and Methods

La Restinga Lagoon is located in Margarita Island, Northeastern Venezuela, 10° 58' and 11° 05' N, and 64° 01' and 64° 17' W. It covers 18,862 hectares conformed by an intricate net of creeks bordered of dense mangrove formations (21). A sand bar or "restinga" delimits the lagoon to the North, while to the South, it communicates with the contiguous sea through a channel of 150 m in its narrowest part (21). The depth of the lagoon ranges from one (1) m in marginal areas to 4 m in the central part, while the channel and the mouth can reach 6 m (21). Rain is markedly seasonal and reduced, bringing 296.8 mm/year; median annual temperature is 27.0°C (22); the tide cycle is diurnal during 21 days and semidiurnal the rest of the month (23), and the daily water volume exchange has been estimated in 15% (24). The described conditions make the lagoon a high hypersaline environment.

Samples were collected in four lagoon interior stations during 10 weeks from June 28 to September 2 of 1996, and during 15 weeks from January 27 to June of 1998 at the lagoon mouth. The stations were established following the lagoon "V" configuration: station 1, at the entrance channel (6 m deep); station 2 (1 m deep), opposite to station 1; stations 3 (4 m deep) and 4 (2-4 m deep), at the central part of the lagoon, and

station 5 at the lagoon mouth (2-6 m deep) (Figure 1). Samples, fixed in buffered seawater 10% formalin and preserved in buffered seawater 4% formalin, were examined in the whole content. Larvae were sorted out, counted, measured and classified to the lowest possible taxon (25, 26).

A boat of 7 m propelled by a 48 HP motor permitted high maneuverability of the net and a towing speed between 1 and 2 knots, to sweep the water column from the surface to the bottom, where allowed by depth, following a circular path. The bongo net was equipped with 333 m mesh in both sizes to obtain replicate hauls. Tows lasted 5 minutes. A digital current meter General Oceanic model 2031 was used to estimate the volume of water filtered through the net. During both sampling periods temperature, salinity and oxygen concentration of the water surface were registered.

Larval abundance was expressed in absolute number, percentage, density (number of larvae per 100 m^3) and frequency of occurrence per family. A three way ANOVA was applied to the data from the lagoon interior samples to compare the number of larvae by sampling date, by sampling station, and for each side of the net. The data from the lagoon mouth was analyzed by a two way ANOVA for the number of larvae by sampling date and for each side of the net. A significant level of 5% was established. All statistical analyses were done following Sokal and Rohlf (27), through the software Statgraphics Plus 1.0.

Results

Family composition and distribution

Through the two sampling periods 21 families were collected, representing 36 genera and 33 species. The families Sciaenidae, Haemulidae, Mugilidae, Ephippidae, Bothidae, Atherinidae, Hemirhamphidae and Centropomidae occurred only inside the lagoon, as the families Eleotridae, Grammistidae and Pomatomidae were caught only at the lagoon mouth station. The families Gobiidae and Engraulidae dominated the spatial and temporal distributions.

In the lagoon interior stations (June-September 1996) 1223 larvae belonging to 18 families were collected, as 30 genera and 24 species could be identified (table 1). The distribution of larvae per family is shown in

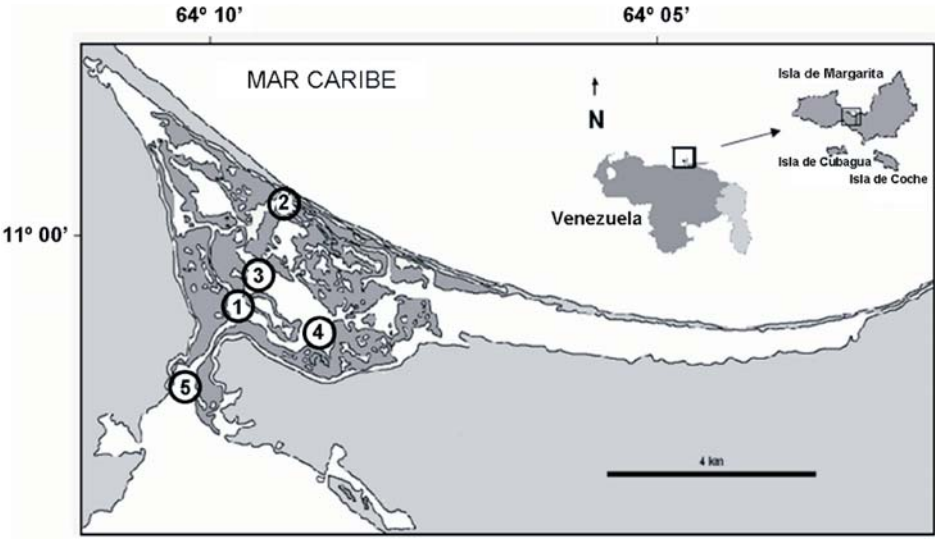

Figure 1. Geographical location of La Restinga Lagoon, Margarita Island, showing the sampling stations.

Table 1
List of the fish taxa collected in the La Restinga Lagoon interior stations during the sampling period June-September 1996

Family	Species
Gobiidae	*Microgobius meeki* Evermann and Marsh 1900
	Gobionellus oceanicus Pallas, 1770
	Gobiosoma sp.
	Gobiidae *sp.*1
	Gobiidae *sp.*2
	Gobiidae *sp.*3
	Gobiidae *sp.*4
	Gobiidae *sp.*5
Engraulidae	*Anchoviella brevirostris* (Gunther, 1868)
	Anchoa hepsetus (Linnaeus, 1758)
	Anchoa trinitatis (Fowler, 1915)
	Anchoa parva (Meek and Hildebrand, 1923)
	Anchoa sp.
Sparidae	*Calamus penna* (Valenciennes, 1830)
	Archosargus rhomboidalis (Linnaeus, 1758)
Carangidae	*Alectis ciliaris* (Bloch, 1788)
	Oligoplites palometa (Cuvier, 1831)
	*Caranx sp.*1
	*Caranx sp.*2
	Trachinotus sp.
Blenniidae	*Lupinoblennius dispar* Herre, 1942
Clupeidae	*Lile piquitinga* (Schreiner and Ribeiro, 1903)
	Harengula sp.
	Jenkinsia lamprotaenia Jordan y Evermann, 1896
	Opisthonema oglinum Le Sueur, 1818
Clinidae	*Paraclinus nigripinnis* (Steindachner, 1876)
	*Clinidae sp.*1
	*Clinidae sp.*2
Sciaenidae	*Micropogonias sp.*
	Bairdiella ronchus (Cuvier, 1830)
	Cynoscion sp.
Haemulidae	*Haemulon sp.*
Mugilidae	*Mugil sp.*
	M. curema Valenciennes, 1836
Ephippidae	*Chaetodipterus faber* (Broussonet, 1782)
Bothidae	*Citharichthys spilopterus* Gunther, 1862
Atherinidae	*Xenomelaniris brasiliensis* (Quoy and Gaimard, 1824)
Soleidae	*Trinectes paulistanus* (Ribeiro, 1915)
Tetraodontidae	*Sphoeroides testudineus* (Linnaeus, 1758)
Hemirhamphide	*Hyporhamphus unifasciatus* (Ranzani, 1842)
Centropomidae	*Centropomus sp.*
Syngnathidae	*Hippocampus erectus* Perry, 1810

table 2. The most abundant families, Gobiidae, Engraulidae, Sparidae, and Carangidae, comprised 83.07% of the collected larvae. The rest 14 families, Blenniidae, Clupeidae, Clinidae, Sciaenidae, Haemulidae, Mugilidae, Ephippidae, Bothidae, Atherinidae, Soleidae, Tetraodontidae, Hemirhamphidae, Centropomidae and Syngnathidae, accounted for 13.17% of the larvae, as a 3.76% remained unidentified. Only gobies occurred in all samples. Table 3 shows the distribution of the larvae among the four stations as table 4 contains the temporal distribution. The larvae displayed two abundance peaks, mid-July (21.91%) and mid-August (17.74%). There were not significant differences ($p>0.05$) of the number of larvae among stations, among sampling dates and for each side of the net (table 5).

At the lagoon mouth station (January-June 1998) 5575 larvae belonging to 13 families were collected, as 12 genera and 12 species could be identified (table 6). The distribution of larvae per family is shown in table 7. The families Gobiidae, Engraulidae, Blenniidae and Grammistidae, comprised 95.12% of the collected larvae. The families Soleidae, Carangidae, Clupeidae, Syngnathidae, Sparidae, Pomatomidae, Clinidae, Eleotridae and Tetraodontidae, comprised a

Table 2
Number of larvae, percentage (%), density (nº larvae/100m3) and frequency of occurrence (%) per family, collected in La Restinga Lagoon interior stations during the period June-September 1996

Taxa	Number of Larvae	(%)	Larval Density (nºlarvae/100m^3)	Frequency (%)
Gobiidae	483	39.49	67.19	100
Engraulidae	299	24.45	41.59	80
Sparidae	152	12.43	21.14	60
Carangidae	82	6.70	11.41	60
Blenniidae	46	3.76	6.40	90
Clupeidae	28	2.29	3.89	50
Clinidae	21	1.72	2.92	50
Sciaenidae	19	1.55	2.64	40
Haemulidae	16	1.31	2.23	10
Mugilidae	10	0.82	1.39	20
Ephippidae	8	0.65	1.11	10
Bothidae	4	0.33	0.57	10
Atherinidae	3	0.25	0.42	20
Soleidae	2	0.16	0.29	10
Tetraodontidae	1	0.08	0.14	10
Hemirhamphidae	1	0.08	0.14	10
Centropomidae	1	0.08	0.14	10
Syngnathidae	1	0.08	0.14	10
Unidentified	46	3.76	-	-

Table 3
Spatial distribution of fish larvae collected in La Restinga Lagoon interior stations during the sampling period June-September 1996, expressed as number of larvae, percentage (%) and larval density (nº larva/100m³)

Station	Number of Larvae	(%)	Larval Density (nºlarvae/100m³)
1	403	32.95	56.05
2	173	14.14	24.06
3	311	25.42	43.26
4	336	27.47	46.73

Table 4
Temporal distribution of fish larvae collected in La Restinga Lagoon during the sampling period June-September 1996, expressed as number of larvae, percentage (%) and larval density (nºlarva/100m³)

Sampling Date	Number of Larvae	(%)	Larval Density (nºlarvae/100m³)
June 21	28	2.28	9.73
June 29	162	13.24	56.34
July 07	76	6.21	23.43
July 15	268	21.91	93.21
July 22	103	8.42	35.82
August 01	100	8.17	34.78
August 09	94	7.68	32.68
August 16	217	17.74	75.47
August 23	113	9.23	39.29
Sept. 02	62	5.06	21.56

Table 5
Three factors ANOVA for the larval abundance by sampling date, by sampling station and for each side of the net, for fish larvae collected in La Restinga Lagoon interior stations during the period June-September 1996

Source	SS	DF	MS	F	P-value
Main effects					
A: larvae.date	5845.95	9	649.55	1.16	0.3586 NS
B: larvae.station	1389.85	3	463.283	0.83	0.4986 NS
C: larvae.side	396.05	1	396.05	0.71	0.4048 NS
Interactions					
AB	10100.1	27	374.08	0.67	0.8499 NS
AC	2418.95	9	268.772	0.48	0.8753 NS
BC	1494.85	3	498.283	0.89	0.4591 NS
Residuals	15126.2	27	560.228		
Total	36772.0	79			

NS: no significant differences.

Table 6
List of the fish taxa collected in La Restinga Lagoon mouth station during the sampling period January-June 1998

Family	Species
Blenniidae	Blenniidae *sp.*1 *Lupinoblennius dispar* Herre, 1942
Carangidae	*Caranx crysos* Mitchill, 1815
Clinidae	Clinidae *sp.*
Clupeidae	*Jenkinsia lamprotaenia* Gasse, 1851 *Etrumeus teres* Blecker, 1853
Engraulidae	*Engraulidae sp.*1 *Anchoa sp.* Jordan y Everman, 1927
Eleotridae	*Guavina guavina* (Cuvier y Valenciennes, 1837)
Gobiidae	Gobiidae *sp.*1 *Gobionellus boleosoma* Jordan y Gilbert, 1882
Grammistidae	*Rypticus saponeaus* Bloch y Schneider, 1801
Pomatomidae	*Pomatomus saltatrix* Linneaus, 1766
Soleidae	*Achirus lineatus* Linneaus, 1758
Sparidae	Archosargus rhomboidalis Linneaus, 1766
Syngathidae	*Sygnathus caribbaeus* Dawson, 1979 *S. scovelli* Everman y Kendall, 1859
Tetraodontidae	Tetraodontidae *sp.*1

4.15%, as a 0.72% could not be identified. Gobies and engraulids were present in all samples. The temporal distribution of the larvae showed two abundance peaks, early March (14.92%) and late May (35.00%), which gathered half of the larvae collected (table 8). There were significant differences ($p \leq 0.05$) for the number of larvae among the sampling dates; there were not significant differences ($p > 0.05$) for the number of larvae in each side of the net (table 9).

Environmental factors

The water temperature fluctuated between 28.0°C (Station 1) and 33.0°C (Station 2), while salinity oscillated from 24 UPS (Station 4) to 48 UPS (Station 2). The content of dissolved oxygen varied from 2.5 mL/L (Station 2) to 6.5 mL/L (Stations 1 and 5). In general, the recorded physicochemical parameters showed a tendency to reach extreme values at stations 2 and 4, being more attenuated at stations 1, 3 and 5, which are deeper and more exposed to the action of winds and tides.

Discussion

The taxonomic composition of La Restinga Lagoon showed the occurrence of resident species, like gobies, sparids and mugilids, relying on the area for reproduction and survival of early stages, as well as no resident species, like carangids, grammistids and pomatomids, using the lagoon as nursery ground. Villalba (19) in a fish larvae survey over the area between South Margarita and Cubagua Islands, during one year, registered 24 families. The most abundant

Table 7
Number of larvae, percentage (%), density (nº larvae/100m³) and frequency of occurrence (%) per family, collected in La Restinga Lagoon mouth station during the period January-June 1998

Taxa	Number of Larvae	%	Larval Density (nº larvae/100m³)	Frequency (%)
Gobiidae	3777	67.74	342.82	100
Engraulidae	1033	18.53	127.65	100
Blenniidae	298	5.35	27.05	86.6
Grammistidae	195	3.50	17.70	80.0
Soleidae	91	1.63	8.26	73.3
Carangidae	41	0.74	3.72	13.3
Clupeidae	24	0.43	2.18	20.0
Syngnathidae	22	0.39	2.00	73.3
Sparidae	19	0.34	1.72	6.70
Pomatomidae	17	0.30	1.54	20.0
Clinidae	8	0.14	0.73	13.3
Eleotridae	6	0.11	0.55	13.3
Tetraodontidae	4	0.07	0.36	20.0
Unidentified	40	0.72	-	-

Table 8
Temporal distribution of fish larvae collected in La Restinga Lagoon during the sampling period January-June 1998, expressed as number of larvae, percentage (%) and larval density (nºlarva/100m³)

Sampling Date	Number of Larvae	(%)	Larval Density (nºlarvae/100m³)
January 27	26	0.47	36.16
February 03	119	2.13	165.53
February 10	191	3.43	265.68
February 24	220	3.95	306.02
March 03	317	5.69	440.95
March 10	852	14.92	1185.14
March 24	53	0.95	73.72
March 31	177	3.17	246.20
April 07	342	6.13	475.89
April 21	243	4.36	338.01
May 05	339	6.08	471.55
May 19	254	4.56	353.31
May 26	1950	35.00	2712.47
June 02	256	4.60	356.09
June 11	255	4.57	354.70

Table 9
Two factors ANOVA for the larval abundance by sampling date and for each side of the net, for fish larvae collected in La Restinga Lagoon mouth station from January to June 1998

Source	SS	DF	MS	F	P-value
Main effects					
A: larvae date	1573469.7	14	112390.69	55.706	0.0000 SD
B: larvae net side	326.7	1	326.7	0.162	0.6977 NS
Residuals	28245.8	14	2017.557		
Total	1602042.2	29			

SD: significant differences. NS: no significant differences.

taxa were Clupeidae (30.77%), Gobiidae (28.00%) and Chaenopsidae (24.16%), which also occurred in all the sampling dates. After analyzing 103 samples of adult fish, collected in 17 stations of La Restinga, over a one year period, Jory (28) identified 32 families being the most abundant Engraulidae, Atherinidae, Clupeidae, Sparidae and Mugilidae, all families represented by the early stages in the current work. According with the results mentioned and taking in account that the current study did not cover a whole year, the number of families collected was representative of La Restinga Lagoon fish composition, and confirmed its value as spawning and nursery area for local fish.

Larval studies undertaken in other geographical areas, indicate that the number of families found in coastal environments, oscillates between 10 (29) and 32 (11), which collocates La Restinga Lagoon in between. The referred works also show that the most frequent families in coastal regions are Gobiidae, Engraulidae and Clupeidae, in agreement with the current research. Zhong (30) studying the immigration mechanisms of early stages documented the importance of estuaries as nursery grounds for coastal fish larvae and juveniles, which enter these areas to complete the ontogeny process.

Larval densities were similar to the intervals found in other coastal environments as well, which indicates that La Restinga Lagoon plays an important role in the production and survival of early fish stages (11, 13, 17, 18 and 28). Obtaining sample replicates is a limitation in plankton studies which can be overcome, as expressed by Esteve *et al.* (18) and demonstrated in the current work, by means of the bongo net equipped with same mesh size in both sides that allows for taking plankton replicates which in turn, increases sampling precision.

The spatial distribution of the larvae seemed to be affected by the environmental parameters which depend on the distances from the lagoon entrance to the sampling stations. The stations 1 and 5 located about the entrance channel of the lagoon, counted with a high number of larvae. The channel is the narrowest part, the unique path to get in/out and the place where the tide currents are stronger, facts that may contribute to concentrate the larvae around this part of the lagoon (31). On the other side, some species may spawn off the lagoon and gather about the mouth, where nourishment and protection from predators and sea currents may favor larvae survival. The values of the physicochemical parameters in these stations stayed closer to those of open sea. The station 2, the most recondite, had the lowest larval abundance, while stations 3 and 4 at the central lagoon, rendered intermediate values. As the stations become more intricate and less accessible, customary regis-

tered extreme values for the physicochemical parameters, and less larvae. On the other hand, small larvae depend mostly on passive transport; so that, in shallow areas with slow tidal currents, in addition to hostile conditions, chances to be transported are much lower (10, 13, and 32).

The temporal pattern of the larvae at La Restinga, is partially similar to the one reported by Villalba (19), for the South Margarita and Cubagua Islands, with abundance peaks during June, July and September. The author considers that most of the fish spawn during those raining months when the nutrients are abundant and temperatures are higher, factors that favor larval survival. Castro *et al.* (33), at Guanabara Bay, Brazil, explained the higher mean larval densities occurred in March, as consequence of the relatively high temperatures and low salinities that took place during that warm rainy month. It has been widely pointed out that most estuarine fish species have evolved spawning strategies to match the average hydrological and biological conditions that would lead to enhance the survival of their larvae (34).

Conclusions

La Restinga Lagoon is a spawning and nursery ground for resident fish species while no resident fish species rely on the area for survival of the early stages.

The spatial distribution of the larvae at La Restinga Lagoon was affected by the physicochemical parameters.

The temporal distribution of the larvae at La Restinga Lagoon showed peaks of abundance.

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