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PATTERNS OF TEMPORAL DISTRIBUTION IN THE METAZOAN PARASITOLOGY OF THE WHITE MULLET, *MUGIL CUREMA* IN JOYUDA LAGOON

Jorge R. García Sais
MARINE ECOLOGY DIVISION

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH
UNIVERSITY OF PUERTO RICO — U.S. DEPARTMENT OF ENERGY

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Introduction

The importance of ecological studies in fish parasite populations has been increased by the development of aquaculture programs with freshwater and marine fishes. Artificial culture conditions enhance the transmission of some parasitic species and usually reduces the natural defense mechanisms of the hosts against parasitic infections.

Knowledge about fish-parasite interactions in their natural ecosystem provides useful baseline information for aquaculture research. The present study was conducted to provide such baseline information in a fish which has potential for aquaculture. The specific objectives in this study were:

1. To study the temporal distribution and intensity of infection by metazoan parasites in the white mullet (Mugil curema) occurring in Joyuda Lagoon.
2. To examine the influence, that changes in the external environment, have on the parasitic fauna of the white mullet.
3. To determine the effect that spawning and possible migrations of the fish have on its parasitic composition.
4. To add some ecological and biological information about the white mullet.
5. To evaluate the role of Joyuda Lagoon in the life cycle of the white mullet.

Recent studies have approached some ecological aspects of fish parasite populations in natural ecosystems. However, most of this work has been done in sub-tropical and temperate areas. Meskal (1966) reported seasonal variations of parasites from the cod in coastal waters of Norway. Overstreet (1968) calculated significant correlations between monthly means of temperatures, salinity and size of the fish with mean numbers of parasites infecting the inshore lizardfish, Synodus factens, from an estuarine canal in South Florida. Boxshall (1974) found a regular annual cycle of abundance in the ectoparasitic copepod Lepeophtheirus pectoralis, from a population of plaice in Yorkshire. Rawson (1976) reported seasonal abundance of monogenetic trematodes in the bluegill, Lepomis macrochirus, in a reservoir in Alabama. Other studies demonstrate that differences in the habitat and geographic location are more important than seasonal variables in the parasitic composition of some fishes (Shroeder 1970, Dowgiallo 1979).

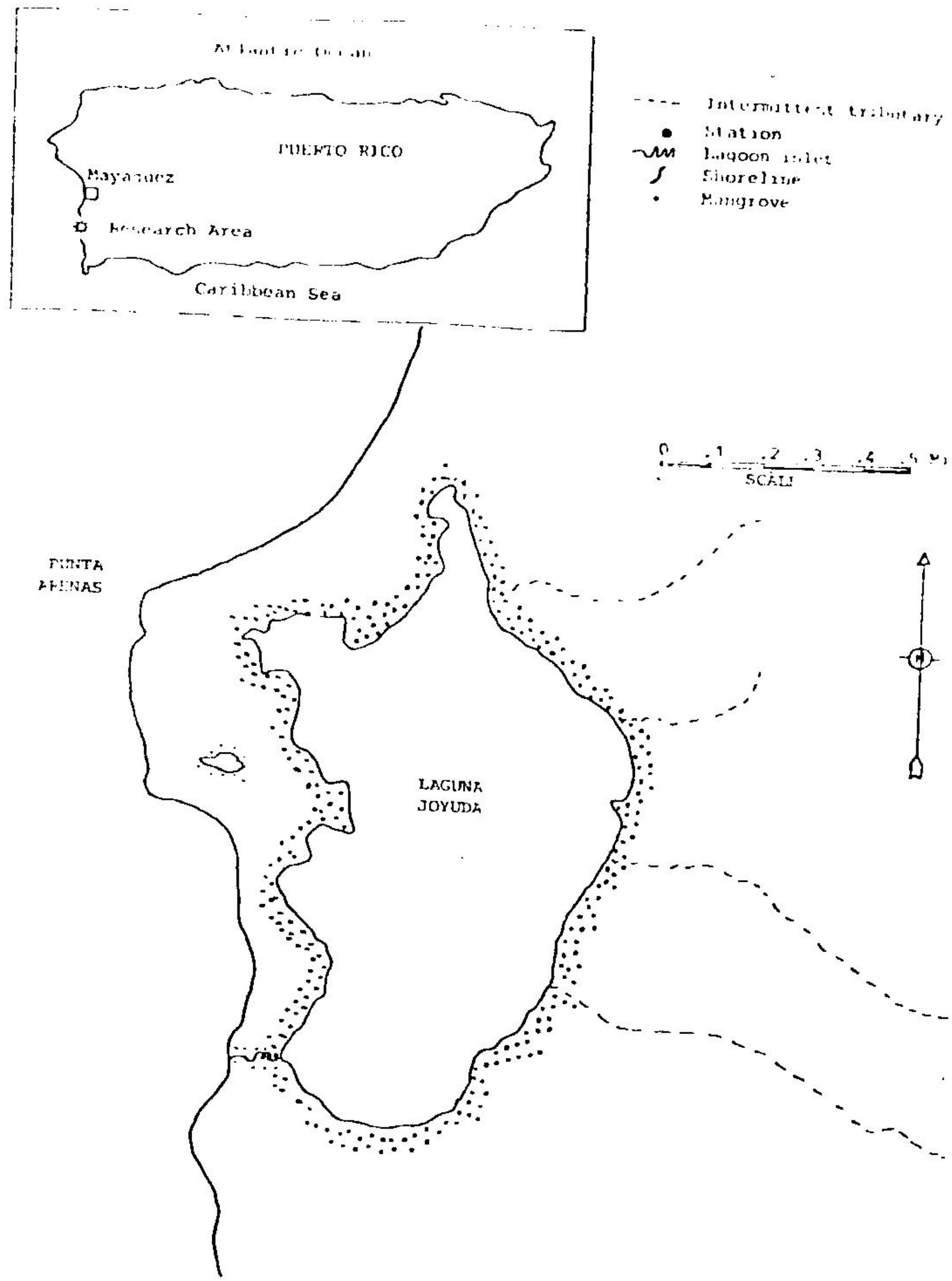
In addition of providing baseline parasitological information about Mugil curema, this study is directed to test the hypothesis that seasonally related factors in Joyuda Lagoon such as salinity variations dictate the pattern of abundance in the ectoparasitic fauna of its host.

MATERIALS AND METHODS

The study area

Joyuda Lagoon (Figure I) is a coastal brackish water system located on the southwestern coast of Puerto Rico. The lagoon is approximately 1.6km long and 0.8km wide, covering an area of 121 hectares. A conspicuous band of the red mangrove, Rhizophora mangle, borders the lagoon. There is also some development of the black mangrove, Avicenia nitida, and white mangrove, Laguncularia racemosa, on the western section. Water exchange between the lagoon and the sea occurs along a small channel bordered by mangrove which opens seaward into a sandy patch area of turtle grass with scattered coral growth. The average water depth of the lagoon is 1.3m, with a maximum depth of approximately 4m. The bottom substrate is composed of soft mud sediments and organic detritus, mainly derived from the mangroves.

FIGURE I. Joyuda Lagoon.



Sampling procedures

Monthly samples of ten mullet from Joyuda Lagoon were examined for metazoan parasites during the period of February 1979 through April 1980. Most of the collections were made wiht monofilament and nylon bottom gill nets. The nets were set at sunset and recovered at dawn. Fish were placed in individual plastic bags and taken directly to the laboratory for examination. The time lapse between the collection of samples and the parasitological examinations never exceeded a 16 hour period.

Salinity, temperature and dissolved oxygen measurements were obtained every month at five stations in the lagoon. These data were recorded on sampling days at the time of setting the nets.

Laboratory procedures

The fish samples were taken directly from the field to the laboratory facilities at CEER. All fish were weighed and measured (standard length) and the gonads were removed from the fish and weighed.

Parasitological examinations were limited to metazoan (multicellular) species and included the body surface, gills and alimentary tract of the fish. Gill arches were removed and placed in separate dishes. Numbers and species of parasites present were recorded for each gill arch. An incision was made on the right side of each fish and the different organs separated and placed in petri dishes. Each organ was studied as a whole unit for metazoan parasites. A saline solution was added to the dishes to avoid drying and facilitate the examination. Observations and separation of parasites were made with a dissecting microscope. A description of the methods used for relaxation, fixation and preservation of parasites are discussed elsewhere (e. g. García, 1981).

Statistical analysis

The incidence percentage and intensity of infection by the different parasitic species were noted as monthly values for the 15 month period. Incidence percentages represent the proportion of fishes infected by a particular parasite. Intensity of infection was expressed as mean number of parasited per fish and the total number of individuals of a parasitic species and the total number of mullet examined in a month. A logarithmic transformation (Log_{10} N) was applied to the monthly values of intensity of infection. Prevalence represents the presence of a parasite in a monthly sample. Simple and multiple regression analysis between the temperature and salinity means and the intensity of infection values were calculated for every species. The correlation coefficients were obtained from a program of an Apple II computer, which also calculated the standard error of estimate.

Possible interrelations between parasitic groups were tested for significance in 2 x 2 contingency tables. The exact probabilities were calculated by the formula $Po = \frac{(A+B)!\,(C+D)!\,(A+C)!\,(B+D)!}{N!A!B!C!D!}$ as suggested by Tate and Clelland (1957) for small N values of less than 40 and expected frequencies of less than 5.

Data on the stage of sexual maturity were obtained by using an index of gonad development. This index is a numerical relationship between the weight of the fish and the weight of both ovaries. It is expressed as:

$$G.I. = \frac{w}{W} \times 100$$

where G.I. = Gonad Index

w = Weight of both ovaries in grams

W = Weight of fish in grams

The relative abundance of white mullet in Joyuda Lagoon was expressed as a proportion between the number of individuals of white mullet and the total collection of fishes in the month, following standard collection procedures.

RESULTS AND DISCUSSION

Hydrological parameters

Salinity - The average salinity in Joyuda Lagoon for the period between February 1979 and April 1980 was 19.9 ppt. Monthly mean values ranged between a minimum of 12.0 ppt in October 1979 to a maximum of 30.0 ppt in April 1980. Figure II presents the monthly fluctuations in salinity during the study period. Summer months (May-October) averaged lower salinity values ($\bar{X}$=18.6) while the winter period (November-April) presented a higher average value ($\bar{X}$=20.8).

Monthly mean values indicate that the salinity pattern in the lagoon is unstable and that moderate variability can occur in short time intervals of less than one month. Salinity is mostly determined by the amount of precipitation and runoff, the temperature and wind effect on evaporation and the intrusion of sea water during high tides.

Temperature - The average water temperature was 27.7°C. Monthly mean values ranged between a maximum of 30.0°C in May and July 1979 and a minimum of 24.°C in February 1980. Figure III presents the monthly variation in mean temperature values. The average water temperature was higher during the summer months (May-October) with $\bar{X}$=28.8°C as compared to the winter months (November-April) with $\bar{X}$=27.0°C. The gradual decrease of water temperature started in September and reached its lowest point by February. The pattern of water temperature is affected by air temperature

FIGURE II. Monthly means and range of salinity at Joyuda Lagoon.

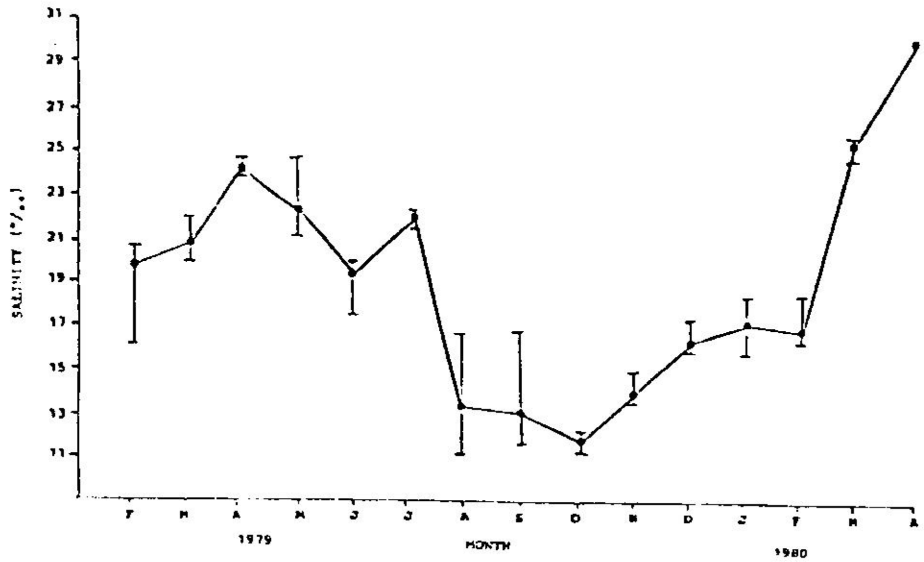
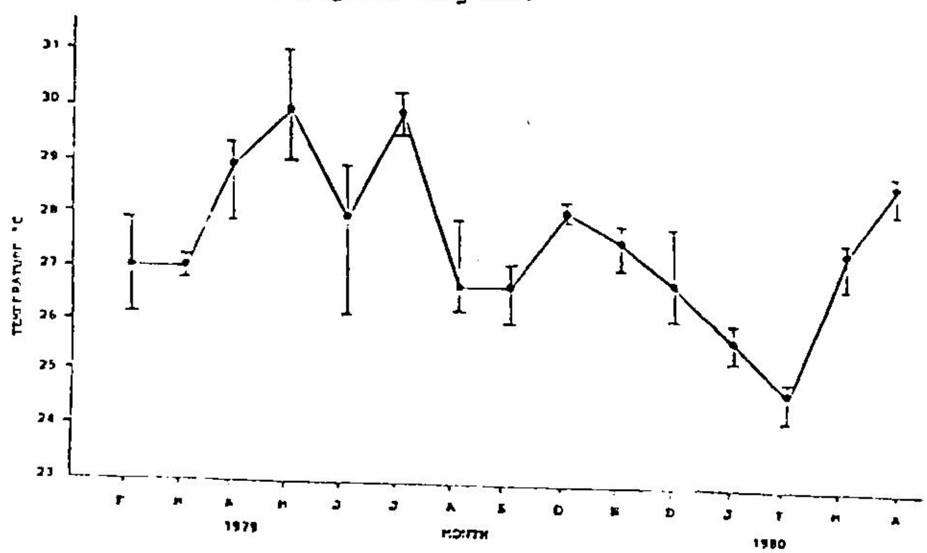


FIGURE III. Monthly means and range of water temperature at Joyuda Lagoon.



because of the shallow nature of the lagoon and relatively stagnant condition of the water. Short term variation in water temperature may occur as a result of heavy precipitation and the drain of cold freshwater from the runoff of adjacent mountains.

Dissolved Oxygen - The content of dissolved oxygen in the water ranged from 4.7 ppm in March 1980 and 7.2 ppm in April and December 1980. Although moderate variation occurred on a monthly basis, the summer period registered a rather stable content of O_2 in the water ss compared to the winter months in which the degree of variation from month to month was high (see Figure IV). If we account for the temperature and salinity effect on the different expected levels of O_2 saturation, the variation in the monthly percentages of O_2 saturation must be related to biological processes occurring in the lagoon. Table I presents the monthly values of the percentages of O_2 saturation.

Relative abundance of white mullet in Joyuda Lagoon

The relative abundance of white mullet in monthly samples indicated a peak in February 1979 with 41% of the total capture in a sample size of 193 individuals. Another high value was recorded in September 1979 with 32% in a sample size of 49 individuals. Figure V presents the monthly variation in relative abundance of white mullet. The sudden decrease in abundance of white mullet after February tends to support the theory of an offshore spawning migration of this fish, as has been already suggested by Anderson (1957), Moore (1974) and Yanez-Arancibia (1976). Index of gonad maturity (see Table II) indicated that 80% of the mullet examined in February 1979 had an advanced stage of gonad development. In March 1979, all the individuals examined were mature. The following months presented some mature individuals in the collections until September, in which no

FIGURE IV. Means and range of dissolved oxygen values at Joyuda Lagoon.

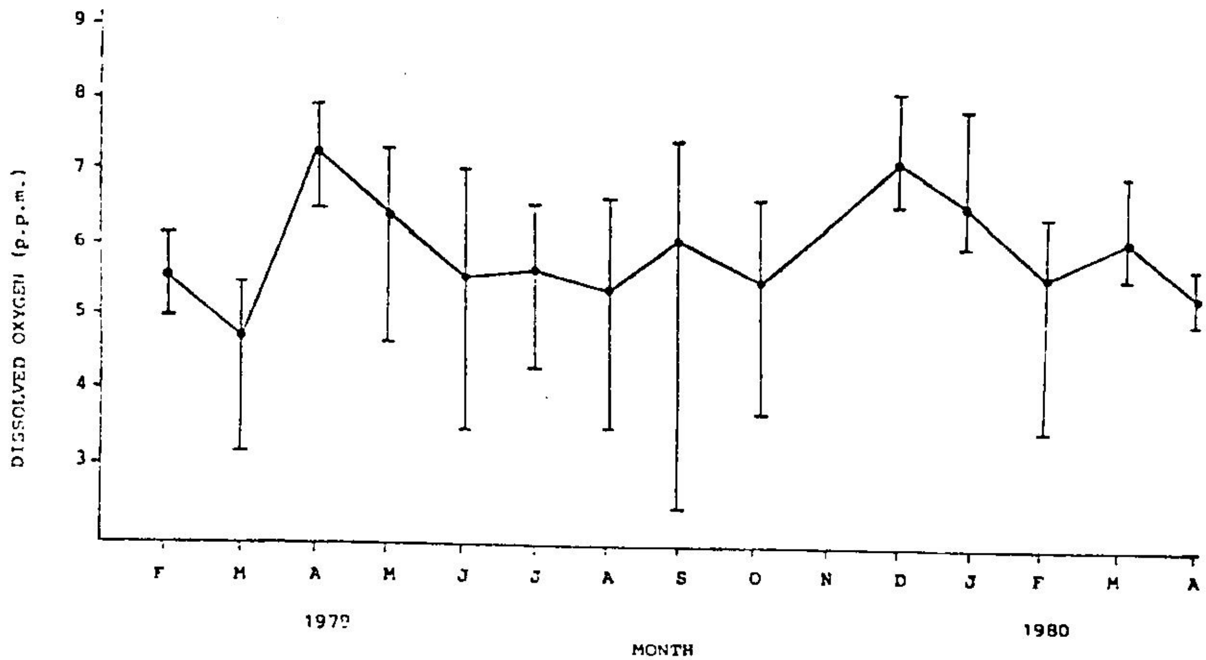


FIGURE V. Relative abundance of Mugil curema in monthly samples at Joyuda Lagoon, with confidence limits to the 95%.

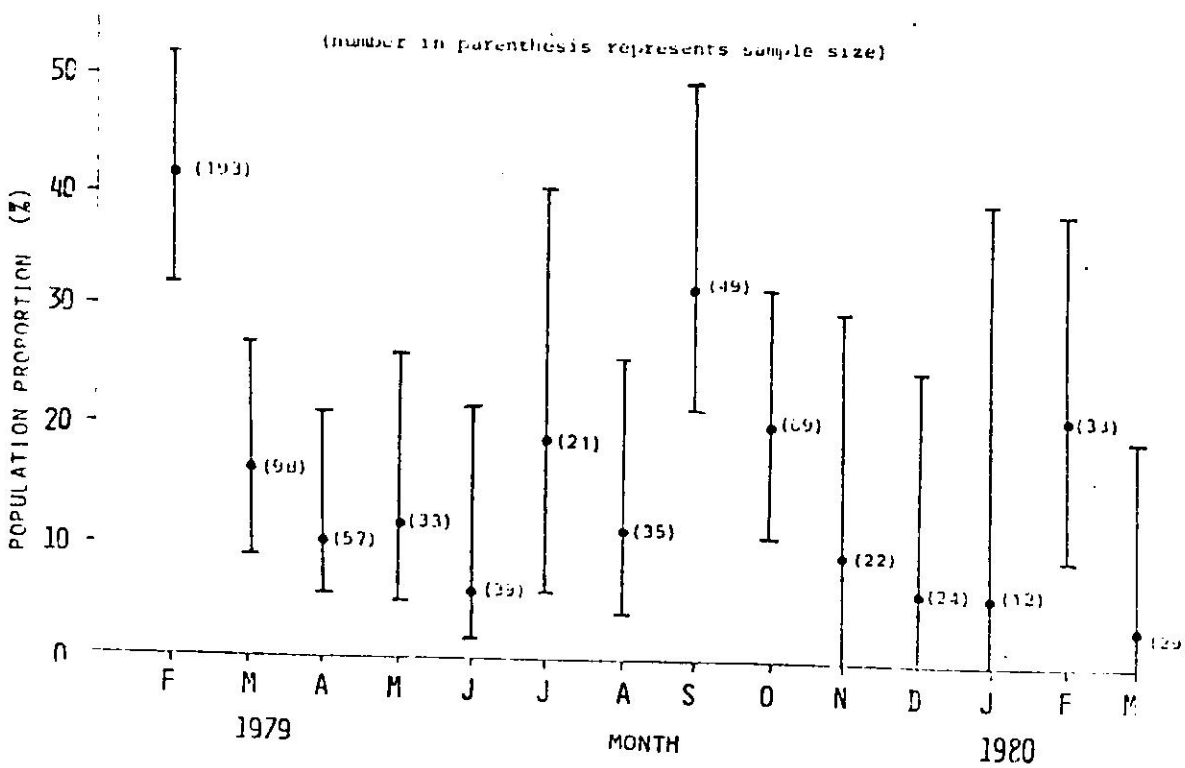


TABLE I. Monthly means of salinity (°/..), temperature (°C), dissolved oxygen content (ppm) and % of D.O. saturation at Joyuda Lagoon.

MONTH	SALINITY p.p.t.	TEMPERATURE °C	D.O. p.p.m.	D.O. SATURATION (p.p.m.)	% D.O. SATURATION
FEB	20.0	27.1	5.6	7.3	76.7
MAR	20.9	27.1	4.7	7.3	64.4
APR	24.2	28.9	7.2	6.8	> sat. point 113.5%
MAY	22.7	30.0	6.4	6.8	94.7
JUN	19.3	28.0	5.6	7.1	78.9
JUL	22.3	30.0	5.7	6.9	82.6
AUG	13.6	26.7	5.5	6.5	84.6
SEP	13.2	26.6	6.1	7.7	79.2
OCT	12.0	28.4	5.6	7.5	74.7
NOV	14.5	27.7	-	7.1	-
DEC	16.4	26.8	7.2	7.3	98.6
JAN	17.6	25.7	6.7	7.4	90.5
FEB	17.0	24.7	5.7	7.6	75.0
MAR	25.7	27.5	6.1	6.9	88.4
APR	30.0	28.8	5.4	6.6	81.8

TABLE II. Index of gonad development in *Mugil curema*.

1979

FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
1.38	5.[illegible]2	0.54	5.90	1.26	0.62	5.03	0.66	0.35
8.15	3.[illegible]	10.72	0.32	0.31	0.39	0.43	0.48	0.22
0.73	3.9[illegible]	5.40	0.11	0.46	0.57	0.36	0.49	1.53
2.47	9.05	6.90	0.32	0.73	0.84	0.49	0.28	0.20
4.76	6.20	0.44	0.49	0.23	0.25		0.23	0.37
3.18	3.9[illegible]	0.61	0.18	0.32	0.31		0.40	0.81
0.24	2.17	0.25	0.11	0.31	0.54		0.15	0.39
1.76	6.83	0.20	0.93	0.48	8.22		0.63	0.17
3.63	8.19	0.52	0.48	0.23	2.35		0.38	3.18
3.92	6.30	0.86		0.48	0.82		0.40	6.74
x̄ = 3.02	5.53	2.64	0.88	0.48	1.49	1.58	0.41	2.20

1980

NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL
3.00	1.[illegible]	0.43	2.70	0.09	0.17
2.32	6.[illegible]	0.24	0.11		0.31
	9.[illegible]		1.18		0.23
			0.09		
			0.09		
			0.09		
			8.00		
x̄ = 2.66	5.5[illegible]	0.34	1.76	0.09	0.24

individuals were found to be sexually mature. The peak of adult white mullet in September with reduced gonad development may be indicative of a return, in part, of the white mullet population after the spawning had taken place in offshore waters. The overlapping data for the months of February and March 1980, are not significant in this matter because the individuals examined were not adult fishes (see Figure VI). The low values in relative abundance after October 1979 may be indicative of the detrimental effect of hurricanes David and Frederick in September 1979, or to over-fishing of the adult mullet population in the lagoon during their period of pre-spawning in February and March 1979 by local and commercial fishermen.

Host - parasite interactions

Six species of metazoan parasites were found to infect the white mullet during the study period at Joyuda Lagoon. Temporal patterns of incidence percentages must be interpreted with caution due to small sample size numbers. The Acanthocephalian parasite, Floridosentis elongatus (Machado - Filho, 1951) which is an internal parasite, localized always in the intestine of the fish, was present at least once in every monthly sample. Floridosentis elongatus registered a peak of incidence in monthly collections of March 1979, and then in December 1979, January and March 1980. Figure VII presents the monthly fluctuations in incidence percentages for this species. The pattern of incidence percentages does not seem to be directly determined by any external factor related to the water quality of the lagoon. The fact that F. elongatus is transmitted by an intermediary host is indicative of the apparent availability of this intermediate host throughout most of the year in the lagoon. Further studies on the life cycle of this parasite must be assessed before any conclusive

FIGURE VI. Standard length distribution of <u>Mugil curema</u> in monthly samples at Joyuda Lagoon.

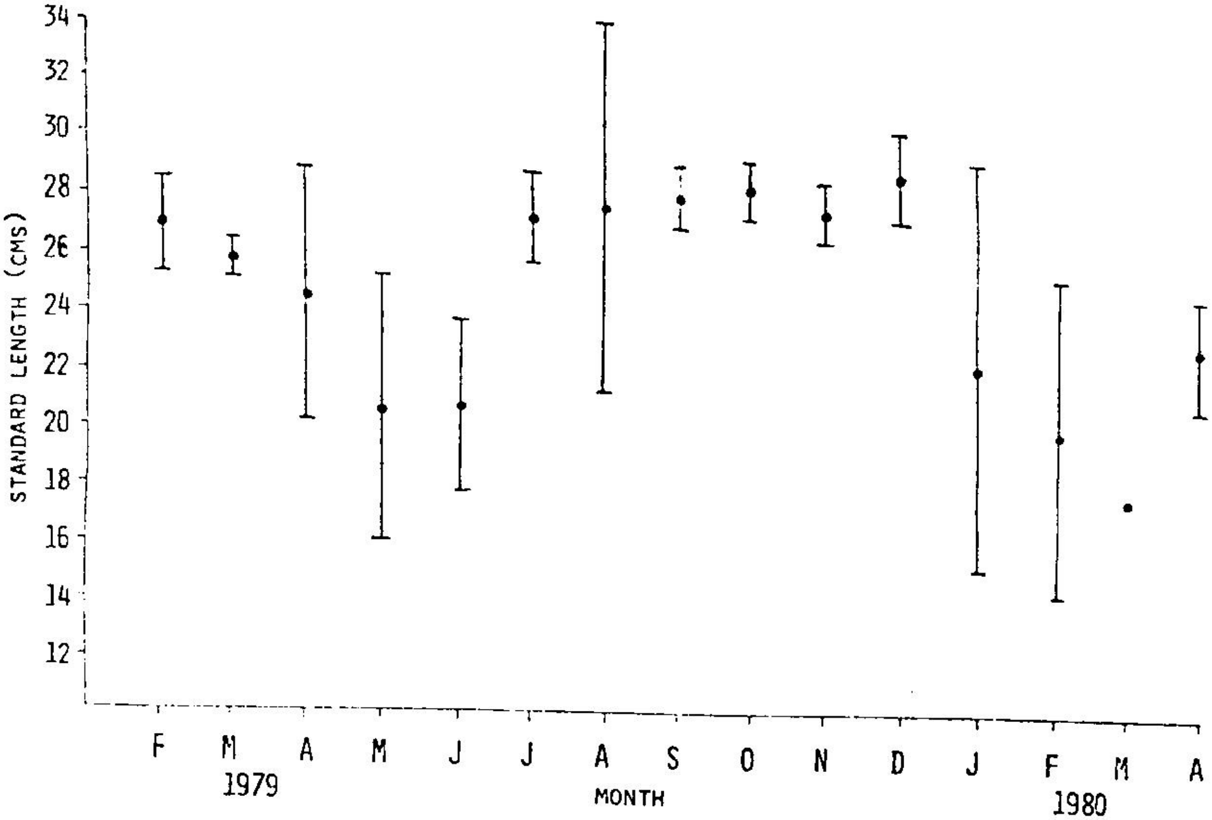
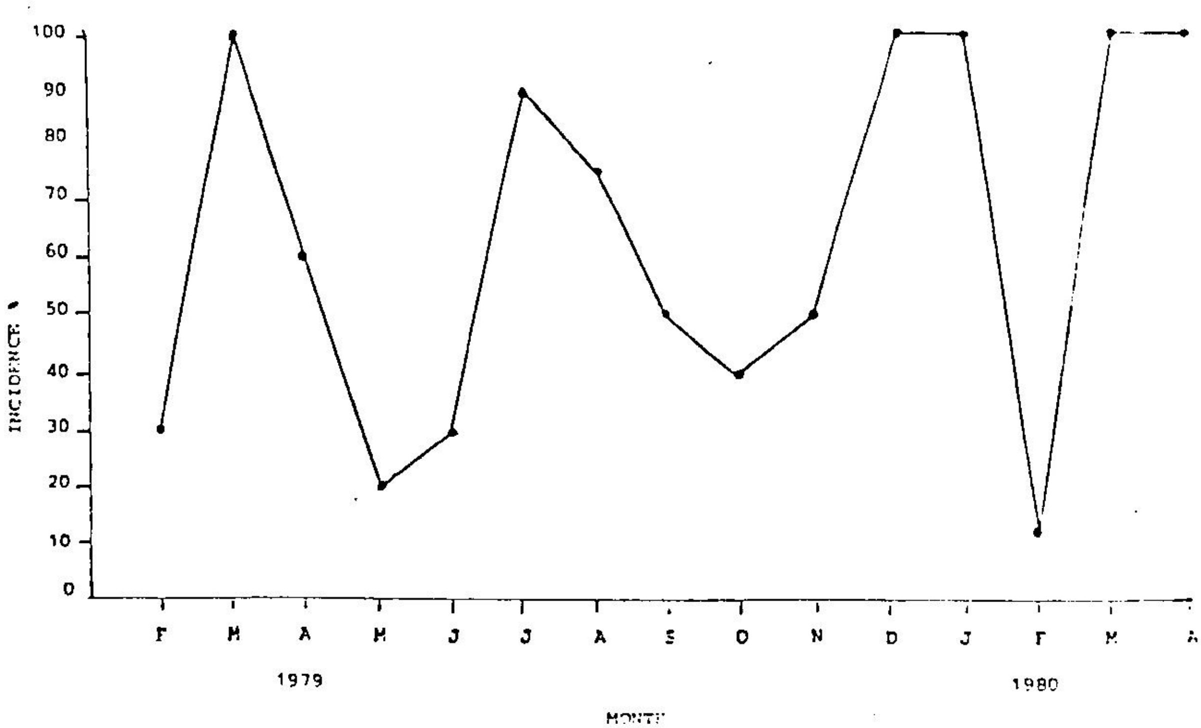


FIGURE VII. Monthly incidence percentage of <u>Floridosentis elongatus</u>.



statements can be drawn about the short term variability in the incidence percentages of this species.

Two monogenean trematodes were found parasitizing the gill filament of the white mullet in Joyuda Lagoon. Pseudohaliotrema mugilinus Hargis 1955, presented peaks in incidence percentages in February and March 1979, and then in March and April 1980. This monogenean parasite was absent from August to October 1979. Nevertheless, it appeared with moderately high incidence percentages throughout the study, especially during the winter period (Figure VIII). Low salinities, or perhaps the sudden decrease in salinity from August to September, continuing into October 1979, could have caused the absence of this parasite during these months.

Metamicrocotylea macracantha Alexander 1954, another monogenetic trematode which infects the gill filaments peaked in November 1979, and March 1980, and was also common in July and September 1979 and February 1980. Metamicrocotylea macracantha can withstand short time salinity variations and was present in September 1979 (see Figure IX) when salinity reached its lowest point during the study (approx. 12 ppt). The presence of this monogenetic trematode in the white mullet was first noted in May 1979, but continued to appear in the rest of the study. This strongly suggests that the parasite either entered the lagoon after a sand bar formation opened in April-May with early spawned adult females, or with juvenile mullet which were probably new recruitments in the lagoon. However, after May, the short term variations of incidence on the host may be related to other factors, either environmental, biological or both.

Three species of copepods of different genera were found on the white mullet. Ergasilus lizae Kryer 1864, which occurred only in the gill filaments of the fish was more abundant in February 1979. It prevailed until March 1979 and then disappeared until October 1979 reaching another high

FIGURE VIII. Monthly incidence percentage of *Pseudohaliotrema mugilinus*.

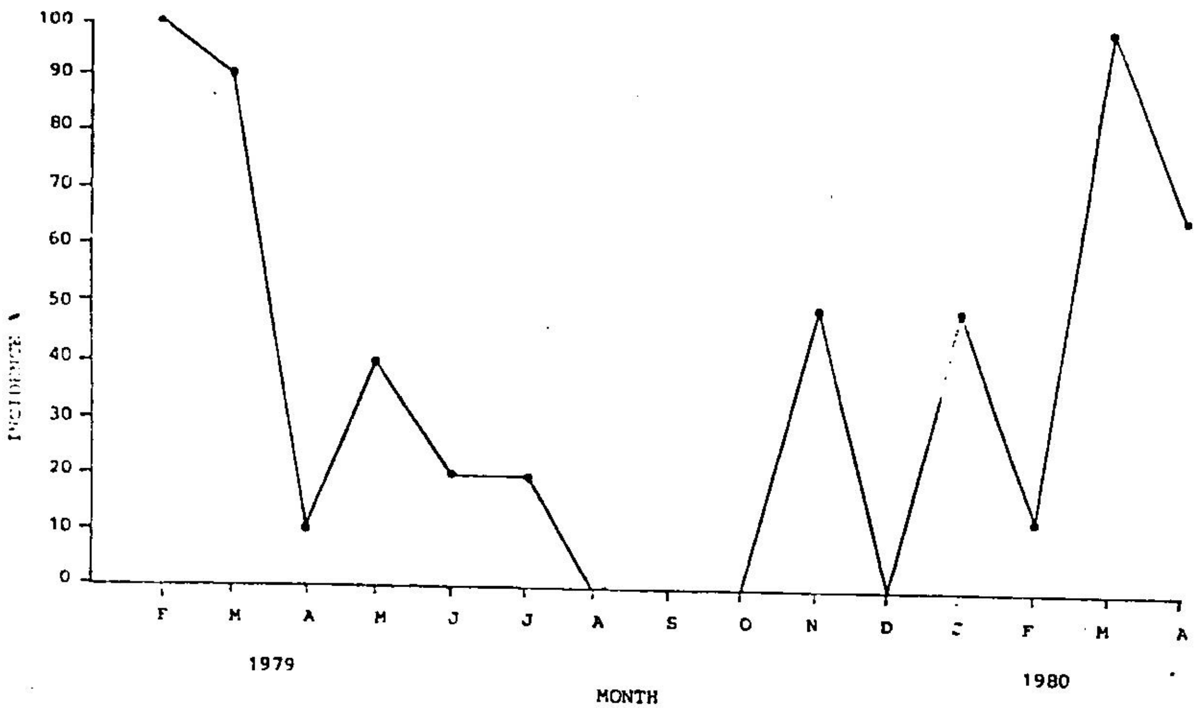
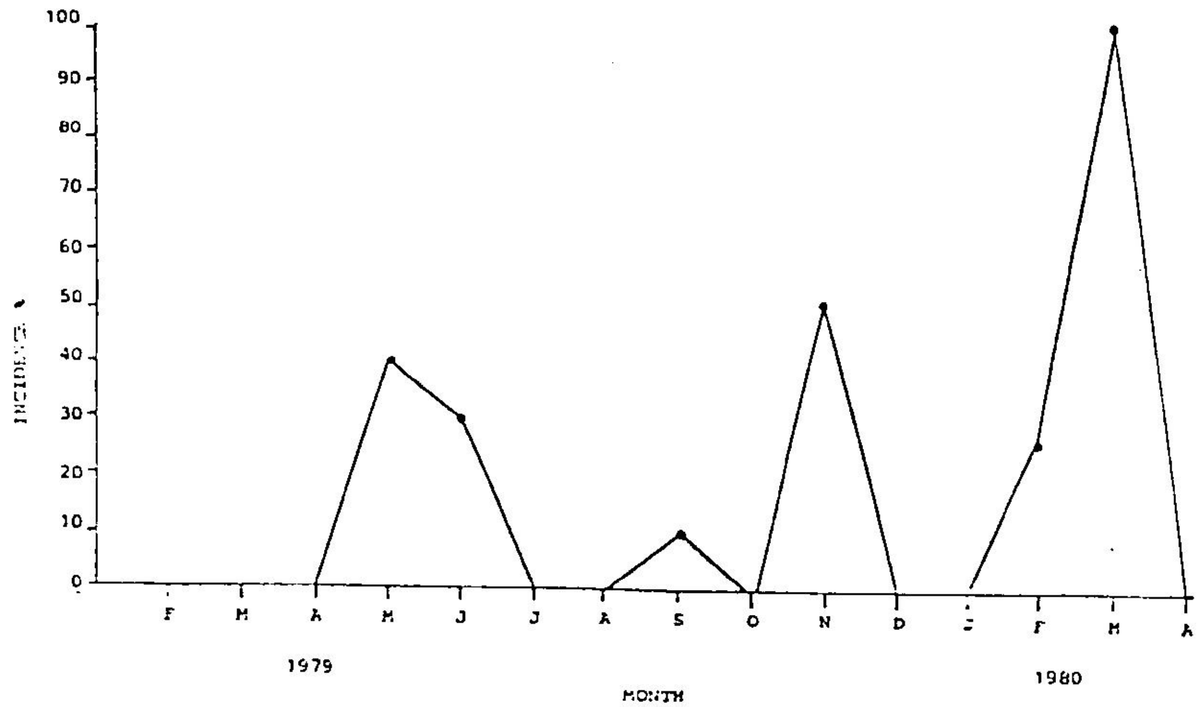


FIGURA IX. Monthly incidence percentage of *Microcotylea macracantha*.



incidence value during January 1980 (see Figure X). Although E. lizae occurred during the winter period, its incidence in the white mullet seems to be more related to the migratory pattern of the adult fish than to seasonally related hydrological conditions. Ergasilus lizae survived in a wide range of temperature and salinity variations in Joyuda Lagoon. Its absence after March 1979 could be due to the migration of adult mullet to offshore waters. As a consequence of this migration, the individuals examined during the remaining summer months, did not possess this parasite because they were new recruitments composed mostly of juvenile fish. With the next immigration of adult mullet after September 1979, the parasite became again a regular component of the parasitic population of the mullet in Joyuda Lagoon.

The parasitic copepod, Lernaeenicus longiventris Wilson 1917, was found partially embedded in the fins and body surface of the white mullet. Its prevalence and incidence percentages show a clear peak during summer with consistently high incidence percentages for the months of July, August and September 1979 (see Figure XI). After a lag period of two months, the parasite appeared again in the collections, reaching another peak during March 1980. The pattern of occurrence of this parasitic species is again indicative of the different populations of mullet which were sampled during the study period. The parasite first appeared in monthly collections from June 1979, one month after the migration of the fish, and then showed reduce incidence percentages in October 1979, probably as a result of non-infected adult mullet examined in that particular monthly sample. Apparently, after being introduced by new recruitment into the lagoon during the summer period, the parasite adapted well to the strongly variable hydrological conditions in the lagoon and persisted in the samples despite a change of 17 ppt in salinity between October 1979 and April 1980.

FIGURE X. Monthly incidence percentage of <u>Ergasilus lizae</u>.

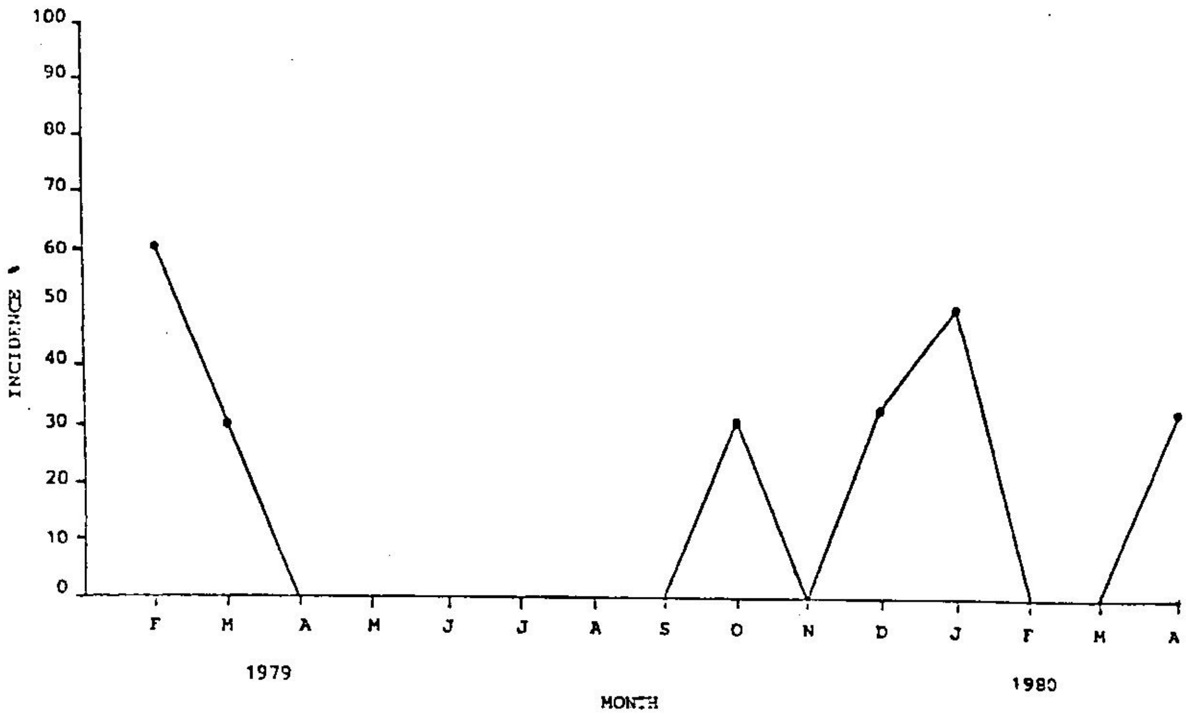
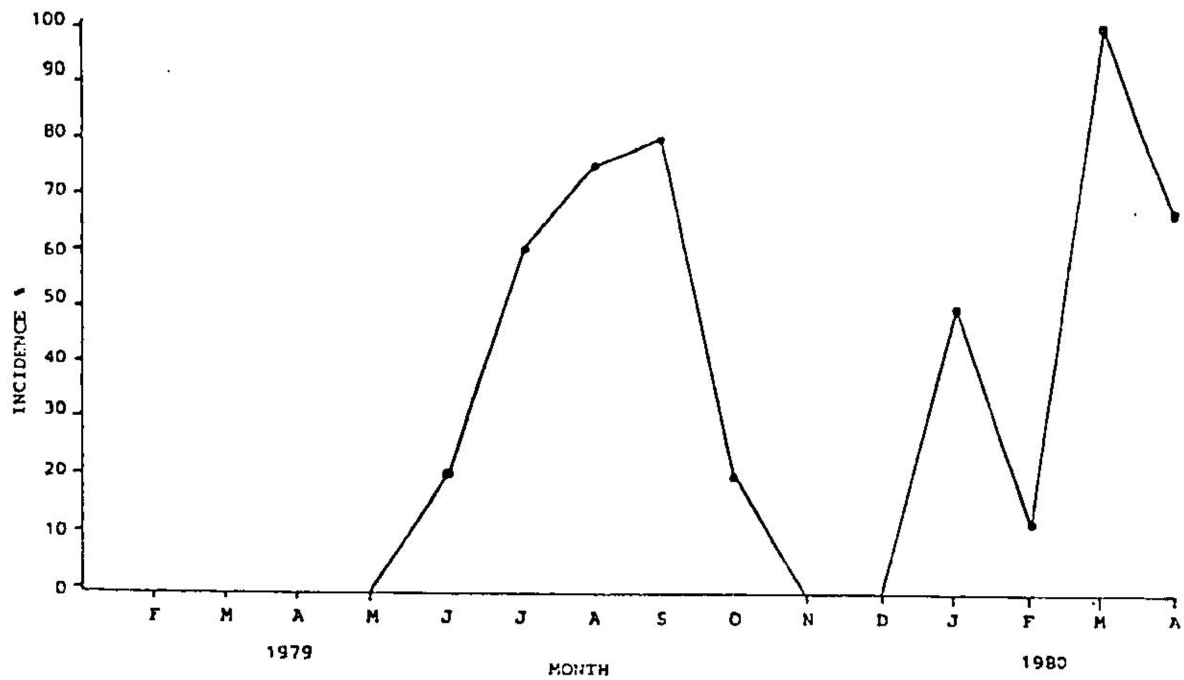


FIGURE XI. Monthly incidence percentage of <u>Lernaeenicus longiventris</u>.



Bomolochus concinnus Wilson 1911, occurred mostly in the mucus of the branchiostegal cavity with occasional presence in the branchiostegal filaments. Bomolochus concinnus appeared in nine out of fifteen monthly samples, but did not show any distinct peak of abundance based on reasonable sample size numbers. Its low abundance during the rainy period in summer (see Figure XII) from August to October 1979 may be indicative of low tolerance to the sudden salinity decrease associated to hurricanes David and Frederick.

Table III presents the monthly distribution of infection intensity by parasitic species of M. curema. The monogenean trematode of the gill filaments F. mugilinus was the most abundant parasite with a mean number of parasites per fish of 8.5. The acanthocephalan F. elongatus had a mean number of parasites per fish of 2.2 and was present in 93% of the monthly collections. None of the parasitic species were observed in epizootic conditions. The copepod L. longiventris was observed to cause moderate lesions in the caudal fin of the fish hosts as it occurs deeply embeded in the pelvic and caudal fin tissues.

Interactions between parasitic species

Five species of external parasites and one endoparasite were present in white mullet at different time periods throughout the sutdy. The prevalence of these species in the white mullet is presented in Table IV. It was observed that ectoparasites which occupied similar microhabitats within the fish such as Metamicrocotylea macracantha and Ergasilus lizae, did not occur together in any of the fishes examined. Figure XIII evidences the similarity in site selectivity of both species on the branchiostegal arcs of the white mullet. Table V details the presence-absence display of both species in monthly samples. The distribution of those species in monthly

FIGURE XII. Monthly incidence percentage of *Bomolochus concinnus*.

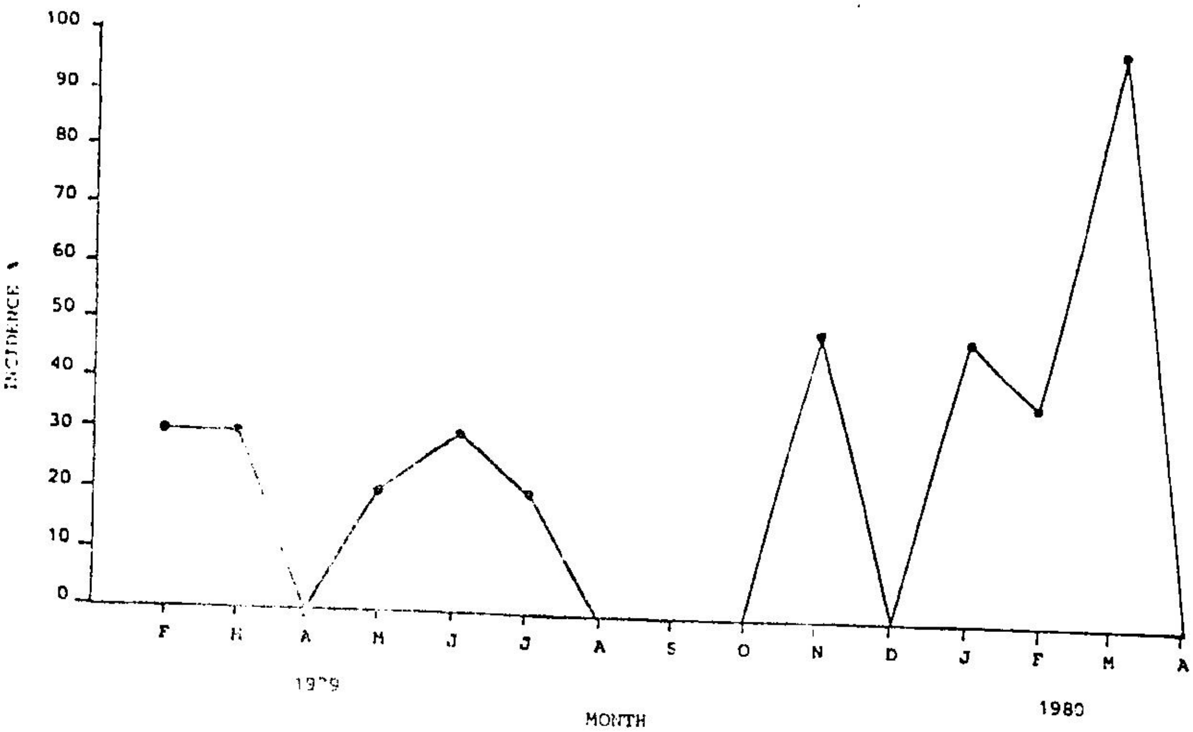


FIGURE XIII. Distribution of individuals of *Ergasilus lizae* and *Metamicrocotylea macracantha* in the brachiostegal arcs of *Mugil curema*.

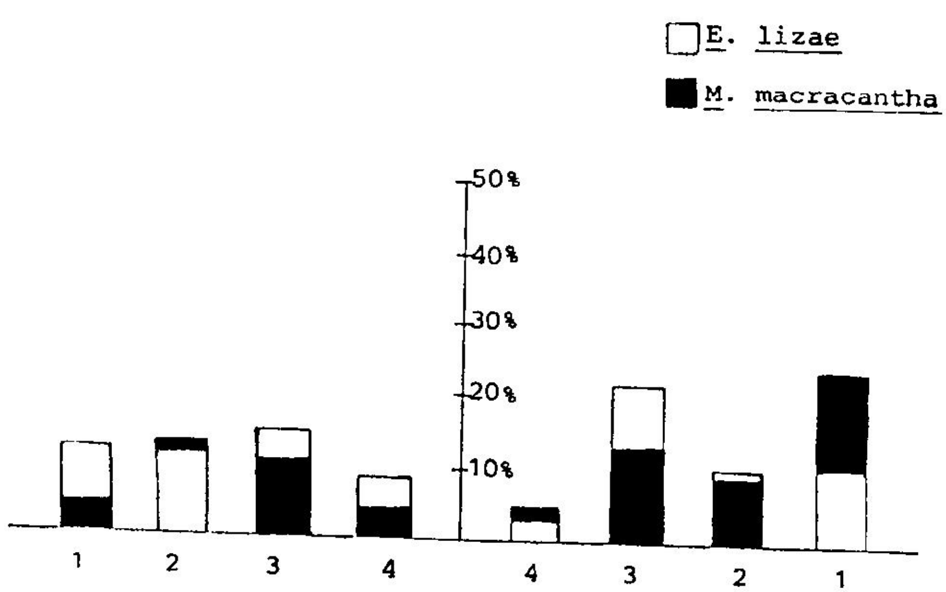


TABLE III. Intensity of infection by metazoan parasites in _M. curema_.

SPECIES	MEAN # OF PARASITES/FISH F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	TOTAL PARASITES	TOTAL FISH	MEAN # OF PARASITES/FISH
Pseudohaliotrema mugilnus	13.1	23.1	1.6	31.8	0.2	4.4	0	0	0	61.0	0	1.5	.14	2.0	0	870	102	8.53
Metamicrocotylea macracantha	0	0	0	1.3	0.6	0	0	0.2	0	3.5	0	0	0.57	1	0	33	102	0.32
Ergasilus lizae	1.5	0.4	0	0	0	0	0	0	1.4	0	0.67	0.5	0	0	3.33	46	102	0.45
Bomolochus concinnus	1.0	0.4	0	0.2	0.4	0.8	0	0	0	0.5	0	1.5	0.71	3.0	0	40	102	0.39
Lernaeenicus longiventris	0	0	0	0	0.6	2.2	2.25	2.8	0.5	0	0	0	0.29	6.0	2.0	84	102	.82
Floridosentis elongatus	0.8	6.0	3.9	0.5	1.0	2.0	0.75	1.8	0.9	1.5	4.33	12.5	0.29	3.0	3.33	228	102	2.23

TABLE IV

Monthly prevalence of parasitic species in the white mullet from Joyuda Lagoon, during the period between February 1979 and April 1980

MONTH	Sp 1	Sp 2	Sp 3	Sp 4	Sp 5	Sp 6
FEB	+	-	+	+	-	+
MAR	+	-	+	+	-	+
APR	+	-	-	-	-	+
MAY	+	+	+	-	-	+
JUN	+	+	+	-	+	+
JUL	+	-	+	-	+	+
AUG	-	-	-	-	+	+
SEP	-	+	-	-	+	+
OCT	-	-	-	+	+	+
NOV	+	+	+	-	-	+
DEC	-	-	-	+	-	+
JAN	+	-	+	+	+	+
FEB	+	+	+	-	+	+
MAR	+	+	+	-	+	+
APR	-	-	-	+	+	+

\- Absence

\+ Presence

Sp. 1 - *Pseudohaliotrema mugilinus*

Sp. 2 - *Metamicrocotylea macracantha*

Sp. 3 - *Bomolochus concinnus*

Sp. 4 - *Ergasilus lizae*

Sp. 5 - *Lernaeenicus longiventris*

Sp. 6 - *Floridosentis elongatus*

TABLE V. Contingency table representing the negative interspecific association between M. macracantha and E. lizae.

		Metamicrocotylea macracantha		
		Present	Absent	
Ergasilus lizae	Present	0	6	6
	Absent	6	3	9
		6	9	15

Probability of association by chance (p) = 0.017

TABLE VI. Contingency table representing the positive interspecific association between P. mugilinus and B. concinnus.

		Pseudohaliotrema mugilinus		
		Present	Absent	
Bomolochus cocinnus	Present	9	0	9
	Absent	1	5	6
		10	5	15

Probability of association by chance (p) = 0.002

samples indicate a significant negative association (p=0.017). Possibly one of these species is excluding the other for food and/or space. The presence of one species or the other in their fish host may be dictated either by water quality related factors and their adaptations to withstand environmental stress or to actual competition and consequent exclusion by one species or the other.

The association between Pseudohaliotrema mugilnus and Bomolochus concinnus also suggests possible interactions between different parasitic populations. In this case, a positive association resulted between both parasites (see Table VI), the probability of association was highly expose to similar environmental conditions, as both are parasitic in the branchiostegal cavity, however, each species occupied different niches or microhabitats within the fish. Bomolochus concinnus was always found in the mucus layer of the branchiostegal flap, while Pseudohaliotrema mugilnus was always parasitic in the gill filaments. Different food and space requirements can permit both species to co-exist together in the host.

Floridosentis elongatus, an acanthocephalian worm, was the only internal parasite observed and it prevailed consistently in monthly samples. The presence of other endoparasites in the alimentary tract is probably limited by the lack of intermediate hosts such as mollusks, which are rare in Joyuda Lagoon. The Possibility of competitive exclusion by the acanthocephalian is contradicted by the presence of digenetic trematodes which occur along with F. elongatus in collections of mullet examined in La Parguera, Puerto Rico (Williams, E. H., unpubl. Data).

The consistent patterns of association between parasites constitutes evidence that their temporal occurence is real and not an artifact of sampling variability. The aspect of competition among parasitic species has been extensively discussed by Halvorsen (1976) and constitutes a significant phenomenon in the ecology of parasites.

Parasite - Ecosystem interactions

Simple and multiple regression analysis between monthly means of temperature and salinity and the intensity of infection by parasitic species were non-significant at the 0.05 level. Evidently, most ectoparasitic species in the white mullet withstand some degree of variation in salinity and temperature (see Tables VII, VIII, and IX). Consequently, the spread of points in both sides of the regression lines result in high standard error and low correlation coefficients. Deterministic effects of hydrological parameters on the parasitic composition of the white mullet were observed for abrupt salinity variations in August through October 1979. Most species of external parasites presented low incidence or were absent during this period. The effect of short term variation is probably more important in determining the prevalence of some parasitic species than seasonally related variations which are gradually experienced by external parasitic fauna has also adapted to variable salinities. It is possible that such acute and short term salinity variations may induce a threshold **response** on some species of parasites in the white mullet.

CONCLUSIONS

The hypothesis that ectoparasitic species in the white mullet (*Mugil curema*) display, a distribution pattern which is seasonally related to salinity variations in Joyuda Lagoon, was not evident in the present study. However, two ectoparasitic species, *Bomolochus concinnus* and *Pseudohaliotrema mugilinus* were apparently affected by the sudden drop in salinity during the rainy season. The range of tolerance observed by

TABLE VII. Analysis of simple linear regression between monthly means of salinity and intensity of parasitization by metazoan parasites in *M. curema*.

Parasite Species	Coefficient of Determination (R^2)	Coefficient of Correlation (R)	Standard Error of Estimate	Significance of Correlation Coefficient to the 95% Level for N=14, R=.497.
Pseudohaliotrema mugilinus	.016	.126	1.067	P> .05, N.S.
Metamicrocotyla macracantha	.013	.116	.539	P> .05, N.S.
Ergasilus lizae	6.15×10^{-3}	.078	.557	P> .05, N.S.
Lernaeenicus longiventris	.063	.251	.654	P> .05, N.S.
Bomolochus concinnus	5.12×10^{-3}	.072	.545	P> .05, N.S.
Floridosentis mugilis	.046	.214	.442	P> .05, N.S.

TABLE VIII. Analysis of simple linear regression between monthly means of temperature and intensity of parasitization by metazoan parasites in *M. curema*.

Parasite Species	Coefficient of Determination	Coefficient of Correlation	Standard Error of Estimate	Significance of Correlation Coefficient to the 95% Level for N=14, R=.497
Pseudohaliotrema mugilinus	.045	.212	1.051	P> .05, N.S.
Metamicrocotyla macracantha	4.62×10^{6}	2.15×10^{-3}	.543	P> .05, N.S.
Ergasilus lizae	5.89×10^{-3}	.077	.558	P> .05, N.S.
Lernaeenicus longiventris	.054	.232	.658	P> .05, N.S.
Bomolochus concinnus	.172	.414	.497	P> .05, N.S.
Floridosentis mugilis	.012	.111	.449	P> .05, N.S.

parasitic species to temperature and salinity variations is indicative of the adaptations that these parasites have developed in order to withstand similar environmental gradients to which the host is adapted.

The migratory behavior of adult mullets to offshore waters and their eventual return to the lagoon accounts for much of the variability observed in the distribution of some parasitic species.

Negative interspecific interactions between parasitic species occurred between populations which occupy similar microhabitats within the host. This type of association was significant for the copepod, *Ergasilus lizae*, and the monogenetic trematode, *Metamicrocotylea macracantha*. Their actual competition and mutual exclusion may explain the short-term variations that these species present in their distribution patterns.

Joyuda Lagoon is a detritus-based ecosystem which provides high food availability and protection for juvenile and adult white mullet. The population proportion of adult white mullet is higher during the winter period prior to their peak of sexual maturity. This fact suggests that the mullet concentrate in the lagoon in order to feed extensively and storage enough energy for their spawning migration. Joyuda Lagoon may also function as shelter to juvenile and adult white mullet during periods of high wave energy and low food availability in the coast.

LITERATURE CITED

Anderson, W. W.: Early development, spawning, growth and occurence of the silver mullet (Mugil curema) along the South Atlantic coast of the United States. Fishery Bulletin. No. 57 (119): 397-414. 1957.

Boxshall, G. A.: The population dynamics of Lepeophtheirus pectoralis (Muller): seasonal variation in abundance and age structure. Parasitology. 69: 361-371. 1974.

Dowgiallo, M. J.: Variation of metazoan parasites of the french grunt, Haemulon flavolineatum (Demarest) (Osteichthyes: Pomadasyidae), by habitat type and season with an analysis of competition among parasites. Master Thesis, Department of Marine Sciences, RUM, Mayaguez, Puerto Rico. 1979.

García, J. R.: Algunos aspectos ecológicos de la comunidad de peces en la Laguna Joyuda. San Juan, Puerto Rico, 1981. (in press). 1981. 8vo Simposio del Departamento de Recursos Naturales de P.R.

Halvorsen, O.: Negative interaction among parasites. In: Ecological Aspects of Parasitology, C. R. Kennedy (ed.). North-Holland Publishing Co., Amsterdam. p. 99-113. 1976.

Kryer, H.: Bidrag til kundskab om snyltekrebsene naturhistoriches tidsskrift. 2(1-2): 75-320. 1864.

Machado-Filho, D. A.: Uma nova éspecie do genero Atactorhynchus, Van-Cleave, 1935. (Acanthocephala, Neoechinorhyachidae). Revista Brazileira de Biología 11: 29-31. 1951.

Meskal, F. H.: Seasonal fluctuations in the population of two common trematode species from the stomach of the cod. Sarcia. 26: 13-20. 1966.

Moore, R. H.: General Biology, distribution and relative abundance of Mugil curema and Mugil cephalus on the South Texas coast. Contributions in Marine Science. 18: 241-255. 1974.

Overstreet, R. M.: Parasites of the inshore lizardfish Synodus foetens, from South Florida, including a description of a new genus of cestoda. Bulletin of Marine Science. 18(2): 445-469. 1968.

Rawson, M. V.: Population biology of parasites of striped mullet, Mugil cephalus L. I. Monogenea. Journal of Fisheries Biology. 9: 185-194. 1976.

Schroeder, R. E.: Ecology of the intestinal trematodes of the gray snapper, Lutjanus griseus. Near lower matacumbe key, Florida, with a description of a new species. Studies in tropical Oceanography. Number 10, 151-223. 1970.

Tate, M. W. and R. C. Clelland: Nonparametric and shortcut statistics. Interstate Printers and Publishers Inc. Illinois: 72-74. 1957.

Yanez-Arancibia, A.: Observaciones sobre Mugil curema Valenciennes en áreas naturales de crianza, México. Alimentación, crecimiento, madurez y relaciones ecológicas. Anales Centro Ciencias del Mar y Limnología. Universidad Autónoma de México, 3(1): 93-124. 1976.