CEER-M-152 PATTERNS OF TEMPORAL DISTRIBUTION IN THE METAZOAN PARASITOLOGY OF THE WHITE MULLET, MUGIL CUREMA IN JOYUDA LAGOON - Jorge R. Garcia Sais, MARINE ECOLOGY DIVISION, CENTER FOR ENERGY AND ENVIRONMENT RESEARCH, UNIVERSITY of PUERTO RICO, US DEPARTMENT OF ENERGY

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Introduction: The importance of ecological studies in fish parasite populations has increased due to the development of aquaculture programs with freshwater and marine species. 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. Neckal (1966) reported seasonal variations of parasites from the cod in coastal waters of Nona. Overstreet (1968) calculated significant correlations.

Between monthly ranges of temperatures, salinity, and size of the fish with mean numbers of parasites infecting the inshore Lizardfish, Synodus foetens, from an estuarine canal in South Florida. Roxshall (1874) found a regular annual cycle of abundance in the ectoparasitic copepod Lepeophtheirus pectoralis, from a population of voles 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 parasitic composition of some fishes (Stwoeder 1970, Dowgiallo 1973). In addition to providing baseline parasitological information about Mullet species, 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 1), 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, Avicennia 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.

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 with

Monofilament and nylon bottom gill nets were used. 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 were as follows: Fish samples were taken directly from the field to the laboratory facilities at CER. 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., Garcia, 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 the mean number of parasites per fish and the total number of individuals of a parasitic species and the total number of fish examined in a month. A logarithmic transformation (e.g., ND) was applied to the monthly values of intensity of infection. Prevalence

The text 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=(A+B) ! (C+D) ! (a+c) + (B+D) as suggested by Tate and Clelland (1987) 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. = w/W x 100 where G.I. = Gonad Index, w= Weight of both ovaries in grams, W = Weight of fish in grams.

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

RESULTS AND DISCUSSION

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 1972 to a maximum of 30.0 ppt in April 1980. Figure 1 presents the monthly fluctuations in salinity. Summer months (May-October) averaged lower (8.6), while the winter period (November-April) presented higher average values (R=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, wind effect on evaporation, and the intrusion of seawater during high tide.

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 24.0°C in February 1980. Figure II presents the monthly variation in mean temperature values. The average water temperature was higher during the summer months (May-October) with 28.0°C as compared to the winter months (November-April) with 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.

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 7 ppm in March 1980 and 7.2 ppm in April and December 1990. Although moderate variation occurred on a monthly basis, the summer period registered a rather stable content of oxygen in the water as compared to the winter months in which the degree of variation from month to month was high (see Figure III). To account for the temperature and salinity effect on the different expected levels of oxygen saturation, the variation in the monthly percentages of oxygen saturation must be related to biological processes occurring in the lagoon. Table I presents the monthly values of the percentages of oxygen 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 8% 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...

To support the theory of an offshore spawning migration of this fish, this has already been suggested by Andersen (1957), Yoore (1974), and Yanez-Arencibia (1976). The index of gonad maturity (see Table 1) indicated that 80% of the mullet examined in February 1978 had an advanced stage of gonad development. In March 1978, all the individuals examined were mature. The following months presented some mature individuals in the collections until September.

The mean and range of dissolved oxygen values at Joyuda Lagoon are shown. Figure V presents the relative abundance of Mugil curema in monthly samples at Joyuda Lagoon, with confidence limits to the 95%.

Table presents monthly means of salinity(‰), temperature (°C), dissolved oxygen content (mg/L), and percentage saturation at Joyuda Lagoon. Index of gonad development in Mugil curema is also provided.

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 the overfishing 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

The acanthocephalian parasite, Flonidosentis elenbatus (Wactado-Filho, 1981), which is an internal parasite, is always localized in the intestine of the fish. It was present at least once in every monthly sample. Flonidosentis clongetus registered a peak of incidence in monthly collections of March 1972, and then in November 1979, January and March 1980. Figure VI 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. clongetus is transiently an intermediary host is indicative of the apparent availability of its 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.

Ssravoaro Letters (ex) FIGURE VE. Standard length distribution of Moat in monthly samples at Joyeda Lagoon. FIGURE VIT. Monthly incidence percentage of Floridosentis.

Statements can be given about the short-term variability in the incidence percentages of this species. Two monogenean trematodes were found parasitizing the gill filaments of the white millet in Joyuda Lagoon. Pseudohalotrema mysilinus Harps 1861 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 1978, could have caused the absence of this parasite during these months. Metanicrocotylea 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. Metanicrocotyles macracantha can withstand short.

Tiny salinity variations were present in September 1979 (see Figure IX), when salinity reached its lowest point during the study (approx. 12 ppt). The presence of this nonogenetic trematode in the white mullet was first cited in May 1978, but continued to appear throughout the rest of the study. This strongly suggests that the parasite either entered the lagoon after a sandbar formation opened in April-May with early spawned adult females, or with juvenile mullets which were probably new recruits 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.

Various species of copepods of different genera were found on the white mullet. Ergasilus lizae Kryer 1864, which occurred only in the pituitary gland of the fish, was more abundant in February 1978. It prevailed until March 1979 and then disappeared until October 1979, reaching another high 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 1879 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, Lemmavenicus 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 are shown in Figure XI. After a two-month lag period, the parasite reappeared in the collections, peaking again in March 1980. The pattern of occurrence of this parasitic species is indicative of the different populations of mullet sampled during the study period. The parasite first appeared in monthly collections from June 1979, one month after the fish migration, and then showed reduced incidence percentages in October 1979, likely due to the examination of non-infected adult mullet 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 significantly 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 Ergastus.

FIGURE XI. Monthly incidence percentage of Lernaeenicus longiventris.

Bemploctus concinnus Wilson 1811, occurred mostly in the mucus of the branchiostegal cavity with occasional presence in the branchiostegal filament. The Bemploctus 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 indicate low tolerance to the sudden salinity decrease associated with hurricanes David and Frederick.

Table III presents the monthly distribution of infection intensity by parasitic species of Hs cuwna. The monogenean trematode of the gill filaments, F. marginatus, was the most abundant parasite with a mean number of parasites per fish of 85. 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 embedded in the pelvic and caudal fin tissues. Interactions between parasitic species were noted. Five species of external parasites and one endoparasite were present in white mullet at different time periods throughout the year. The prevalence of these species in the white mullet is presented in Table IV. It was observed that ectoparasites, such as Metamicrocotylea macracantha and Dngasilus Liza, which occupied similar microhabitats, did not occur together in any of the fishes examined. Figure XIII evidences this, showing 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 these species in monthly samples is described.

FIGURE XII: Monthly incidence percentage of Bomolochus consi
FIGURE XIII: Distribution of individuals of Exgasitus lizae and Microcotylea macracantha in the branchiostegal arcs

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

Sp 1. Sp2___sp3sp4@ sp5
Fa + - + +
Sp. 2 - Metamicrocotylea macracantha
Sp. 3 - Bomolochus consi
Sp. 5 - Lernacenicus longiventris

Bomolochus consi = Floridosentis elongatus

TABLE V: Contingency table representing the negative interspecific association between M. macracantha and B. lizas.

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Probability of association by chance (p) = 0.017

Contingency table representing the positive interspecific association between P. mugilinus and E. concinnus.

Pseudochalit rena mogilin Bomolochus concinnus

Probability of association by chance (p) = 0.002

The 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.

"Factors and their adaptations to withstand environmental stress up to actual competition and consequent exclusion by one species or the other. The association between Pseudchaliotrene mugilinus and Bomolocus concinnus also affects populations. In parasites, there are possible interactions between different parasitic species. In this case, a positive association resulted between both. The probability of association was highly exposed to similar environmental conditions, as both are parasitic in the branchiostegal cavity. However, each species occupied different niches or microhabitats within the fish. Bomolocus concinnus was always found in the mucus layer of the branchiostegal flap, while Pseudchaliotrena mugilinus was always parasitic in the gill filaments. Different food and space requirements can permit both species to co-exist together in the host. Heterosentis elongatus, an acanthocephalan 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 Joywa Lagoon. The possibility of competitive exclusion by the acanthocephalan is contradicted by the presence of digenetic trematodes which occur along with H. elongatus in collections of mullet examined in La Parguera, Puerto Rico (Williams, E. H., unpublished data). The consistent patterns of association between parasites constitute evidence that their temporal occurrence is real and not an artifact of sampling variability. The aspect of competition among parasitic species has been extensively discussed by Halvarsen (1976) and constitutes a significant phenomenon in the ecology of parasites. Parasite-ecosystem interactions 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..."

There is some degree of variation in salinity and temperature (see Tables VII, VIII, and IX). Consequently, the spread of points on 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 1978. 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. This 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, Rhabdosynochus concinnus and Pseudohaliotrema cupilinus 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 necessary means.

Table VIII: Analysis of simple linear regression between monthly means of temperature and intensity of parasitization by metacercarial parasites.

The parasitic species' tolerance 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

The behavior of adult mullets in 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 occur between populations which occupy similar microhabitats within the host. This interaction was significant for the copepod, Ergasilus lizae, and the trematode, Metanicrocotyles 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 store enough energy for their spawning migration. Joyuda Lagoon may also function as a shelter for juvenile and adult white mullet during periods of high wave energy and low food availability in the coast.

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