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?TEMPORAL, PATTERNS OP THE METAZOAN PARASITES

IN TIE Werte NoLLET, (COREMA VALENCIENNES

PROM sovuDa? LAGOOH, PUERTO AICO

by

Jorge R. carcSa

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CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

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TEMPORAL PATTERNS CF THE METAZOAN PARASITES

INTHE WHITE MULLET, MUGZL CUREWA VALENCIENNES

'FRON JOYUDR LAGOON, PUERTO RICO*

by

Jorge R. Garcfs

?This work was partially supported by

?The Marine Ecology Division of the Center for Energy and

Environment Research, University of Puerto Rico, Mayaguez

*MS Thesis, Marine Sciences, RUM UPR(19@1)

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Monthly prevalence, incidence and intensity of metazoan parasites

fron the white mullet, Yagil curena Valenciennes, were examined from

February 1979 to April 1980.

variations in the prevalence and incidence percentages dieplayed

by external parasites suggest patterns of periodical occurrence. ?The

periodicity of different parasitic populations is related to the

changes in relative abundance and sexual maturity of mullet, short-

korn salinity variations and interspecific associations of parasites.

Four new host-parasite

sociations were noted in Musil curcma:

Pseudohaliotrema mugilinus Hargis, 1955, Metamicrocotylea macracanthe

Alexander, 1954, Lernaeenicus longiventris Wilson, 1917, and Tra~

chelobdella lugubris Grube, 1840.

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ACRIOLEDG NENTS,

Tam indebted to the Marine Ecology Division of the Center for Energy and Environment Research for providing the cooperative personnel and research facilities for this investigation. I an specially grateful to Dr. Ernest H. Williams, Dr. José M. iépez, Dr. Luis R. Almodovar and Dr. Paul Yoshioka for the revision of this work. I would also 1ike to acknowledge the technical assistance provided by Carlos Bonafé, Edvin Gonzlez, Pablo Cabassa and Miguel Mieves. Also for Roberto Castro, Maio Perez, and Luis Negron for their cooperation and interest in this investigation. Finally, but most inportant I am very grateful to my parents and to my wife for their economic and moral support.

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Monthly variation in the incidence percentages of

the copepod, Ergacilus lizae, parasitic in the

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Monthly variation in the incidence percentages of

?the copepod, Lernacenicus longiventris, parasitic

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Monthly variation in the ineiéence percontages of,

the copepod, Bonolochus coneinnus, parasitic in

the white millet

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Figure KITT Monthly variation in the intensity of para:

Figure xlv

Figure xv

sitization of the copepod, Ergasiius Lizae.

on the white mullet

Monthly variation in the intensity of para-

Sitization of the monogenatic trenatode,

Metenicrocotylea macracantha, on the white

mullet.

Monthly variation in the intensity of para~

sitization of the copepod, Lemacenicus

Aonsiventris, on the white mullets ss...

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Table 1

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[DYTRODUCTION

Je importance of ocological studies in fish parasite populations has been increased by the developnent of aquaculture prograns with freshwater and marine fishes. Artificial culture conditions enhance the direct transfer of sone parasitic species and usually reduces the natural defense mechanisas 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 4 Fish which has potential for aquaculture. the specific objectives in this stuty were:

2) Te study the periodic occurrence and intensity of infection by metazoan parasites in the white mullet, occurring in Joyada Lagoon.

2) To examine the influence that changes in the external environ ment have on the parasitic fauna of the white mullet.

3) To determine the effect that spaming and possible migrations of the fish have on its parasitic composition.

4) To ada sone ecological and biological information about the white mullet.

5) To present a general description of the study site, Joyuaa Lagoon, and to evaluate the role of this particular ecosystem in the Life cycle of the white avllet.

?The White mullet is the most abundant anong four species of mullet reported in Puerto Rico. A typical inhabitant of estuaries

and brackish-water systens, the vhite mullet is the most common rep

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resentative of gray mullet in the Caribbean coast. Anderson (1957) Aescribed the carly development, spawning, growth and occurrence of the white mullet along the south Atlantic Coast of the United states. Yanez-Arancibia (1976) studied the feeding habits, growth, spaming Behavior and trophic relations of the white mullet in the Lagoonal system of Guerrero, on the Pacific Coast of Mexico.

Because of its size and abundance the white mullet, locally ymown as ?jarea", is a prominent comercial fish in Puerto Rico.

Besides being a comen food iten in some parts cf the island, mullet are highly prized as bait for sport fishing. White mullet are specially inportant because of theix potential for culture (Yashouy 1972, Tang 1975, Sebastian and Nair 1975, be Silva and Wijeyaratne asm).

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LITERATURE REVIEW

?The general biology and ecology, as well as scae parasitological information, is available concerning the striped mullet, Mugil

cephalus. This species has gained much attention since it is nore

broadly distributed and commercially important in the United states (anderson 1957), Rawson (1976) studied the population biology of parasites of Mugit cephalus in a tenperate area and found that the number of parasite species increased with the age of the host and that

initial infection was influenced by closeness of association of mullet,

age-classes. Skinner (1975) surveyed the parasites of Mugil cephalus in Biscayne Bay.

Recent studies have approached sone ecological aspects of fish parasite populations in natural ecosystens. However, most of this

work has been done in sub-tropical and tenperate areas. Overstrect

(1968) caloulated significant correlations between monthly means of temperature, salinity and size of the fish with mean number of parasites infecting the inshore Lizardfish, Synodus footens, from an estuarine canal in South Florida. Willians (1979) studied the seasonal inci dence of the costode Isoglaridacris visconsensis in its fish host, lypenteliun nigricans and associated low incidence of the parasite

with cold winter temperatures and decreased feeding by the fish.

Evans (1978) described an annual cycle of ocourrence and maturation

An the ?rouch? Rutilus rutilus by the cestode Asymphylodora kubanicum

An the Worcester:

sirminghan channel in England. Meskal (1966) reported

seatonal variations of parasites from the cod in coastal vaters of

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Norway and reluted fluctuations in the trematode population with the Seasonal abundance of a copepod, apparently acting as an intermediate host. Grimmes and Miller (1976) suggested a ?temperature dependent rejection response? as a possible factor involved in the seasonal periodicity of three species of caryophyllaeid cestodes in the creck ehubsucker, Erinozon oblongus, in North Carolina. Rawson (1972) reported seasonal abundance of monogenetic trematodes in the bluegill, Lepenis macrochirus, in a reservoir in Alabama. Other studies denon strate that differences in the habitat and geographic location are more important than seasonal varicbles in the parasitic composition of some fishes (Shroeéer 1970, Dowgiallo 1979).

Paperna (1975) stated that mortalities of gray mullet cultured in brackish and freshwater ponds which have resulted from massive ine fections by parasites, appear to be coupled with environmental stresses such as, declines in oxygen, critical changes in temperature or salin- Aty, or pollution.

?Taxonomical references on parasites infecting the white mullet

are scattered in the literature. Table 1 presents a list of parasit

which have been noted previously.

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MATERIALS AND 1=7HODS

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oyuda Lagoon (Figure 1) 4s a coastal brackish water systen located on the southwestern coast of Puerto Rico. The lagoon is ?epproxinately 1.6 km long and 0.8 km wide, covering an area of 121 hectares. A conspicuous band of the red ransrove, Rhizophora mangle, borders the lagoon. ?There is also sone development of the black

mangrove, Avicons

nitida, and white mangrove, Laguncularia racemosa, fon the western section, Water exchange between the lagoon and the sea ?occurs along a small channel bordered by mangrove which opens seavard Anto a sandy patch area of turtle grass with scattered coral growth. ?The average water depth of the lagoon is 1.3m, with a maximun depth of approximately 4m. The bottom substrate is composed of soft mud sediments and organic detritus, mainly derived from the mangroves.

jampling Procedures

Monthly samples of ten millet from Joyuda Lagoon were examined for netazoan parasites during the period of February 1979 through March 1980. Most of the collections were made with monofilament and nylon bottom gill nets 60 m long and 2.5 m high, with a equare mesh

@ianeter of 3.9 cx. Some individuals were captured with cast nets.

[ALL the sampling was done fron a 136" fiberglass boat povered by a small outboard potor. The nets were set at sunset and recovered at daw. Fish were placed in individual plastic bags and taken directly

to the laboratory for exanination.

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Figure I, Joyuda Lagoon and adjacent coastal features

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Salinity, temperature and dissolved oxygen measurements were ?obtained every month at five stations in the lagoon. These data vere recorded on sampling days at the tine of setting the nets with YSI meters from Yellow Springs Instruments Co. Model 33 S-C-T was used to measure salinity (to the nearest + 0.5*/,,) and temperature (to the nearest + 0.6 °C). Model 57 was used to measure dissolved oxygen (to the nearest 40.2 ppm). The instrunents were calibrated according to ?the instruction manual at least once a month.

Lanoratory Procedures

?te fish sarples were taken directly from the field to the 1abo- ratory facilities at CEER and examined within @ few hours of collec~ tion, ALL £ish were weighed and measured (standard length) and the ?gonads were renoved from the fish and weiched.

Parasitological examinations were limited to metazoan (multi- eollular) species and included the body surface, gills and alimentary tract of the fish. Gill arches were renoved and placed in separate Aiches, Munbors and species of parasites present were recorded for ?each gill arch, An incision was made on the right side of each fish and the aifferent organs separated into petri dishes. Fach organ was studied es a vhole unit for metazoan parssites. A saline solution was added to the dishes to avoid drying and facilitate the examination.

Observations and sey

ation of parasites were made with 2 dis:

ting

microscope.

?the relaxation, fixation an@ preservation of parasites followed

standaré procadures for each group. Crustacean parasites were reroved

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from the fish and placed into six-dram vials with 70% ethanol.

Monogenetic trematodes vere relaxed in 1/4000 formalin, preserved in

1o\ formalin and mounted on microscopic slides with glycerine jelly.

nenatodes and digenctic trenatedes vere relaxed and preserved in hot

10% formalin. Leeches were pressed between two microscopic slides in

?a 10% formalin bath, then transferred to vials with 108 formalin.

Acanthocephalans were relaxed in cold, distilled water ané later

preserved in 108 formalin, intemal worms and leeches were stained with semichon's carnine and mounted in permount.

Statistical Analysis

?me incidence percentage and intensity of infection by the Aifforent 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 values reprosent proportion between the total number of individuals of parasitic species and the total nunber of mullet exanined in a month. 1A togarithnic transformation (10g, 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 vere caleulated for every species except for the lwech, Trachelobdella Iwbrica, which only occurred once dering the study period. The correlation cosfficients vere obtained from a

progren of an Apple 1 cosputer, which also calculated the standard

exror of extinate.

poscible interrelations between paracitic groups were tested for

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significance in 2x2 contingency tables, The exact probabilities were

calculated by the formula Pox (A#8) 1(C:

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?ate and Cleland (1957) for seatl K values of less than 40 and

Esse) (BD)! as suggested by

expected frequencies of less than 5.

Data on the stage of sexiel maturity were obtained by using an

index of gonad development previously reported by Orange (1961) for

soveral species of tunas. ?This index 1s @ numerical relationship between the weight of the fish and the weight of both ovaries. It is

expressed as:

Gt. = wx 109

where G.1. = Gonad Index

w = Weight of both ovaries in gxans

W = Weight of fish in grams

?me relative abundance of white millet in Joyuda Lagoon was

expressed as a proportion between the munber of individuals of white

mullet and the total collection of fishes in the month, following

standard collection procedures:

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RESULTS AND DISCUSSION

ydrological Parameters

Salinity - The average salinity in Joyuda Lagoon for the period between February 1979 and April 1960 was 19.9 ppt. Monthly mean velues ranged between a rininm of 12.0 ppt in Cctober 1979 to rreximun of 30.0 ppt in April 2980. Figure 1: presents the monthly

fluctuations in salinity during the study period. Summer months

(way-October) averaged lower salinity values (Jv18.6) while the winter

period (tovenber-April) presented @ higher average value (%

20.8).

Monthiy mean values indicate that the salinity pattern in the tagoon is unstable and that moderate variability can occur in short tise intervals of less than one month, Salinity is nostly determined by the anount of precipitation and runoff, the texperature and wind effect on evaporation and the intrusion of sea water during high tides.

?Tenperature - The average water tenperature was 27.7°C. Monthly meen values ranged botweon maxima of 30.0%C in May and uly 1979 ang a minimm of 24.7°C in February 1980. Figure 11 presents the

monthly variation in mean temperature values. The average water

teoperature was higher during the sumer months (May-October) with

e20.8°C as compared to the winter months (Novenber-April) with

5e27.0%C. ?The gradual decrease of water tenperature started in

Septeaber and reached its lovest point by February. The pattern of

water tonperature is affacted by air temperature because of the

shatlow nature of the 2agoon and relatively stagnant condition of the

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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 1900. Although moderate variation occurred on a monthly basis, the sumer period registered a rather stable content of 0, in the vater

2 compared to the winter months in which the degree of variation from month to month was high (see Figure IV). If wo account for the temper- ature and ealinity effect on the different expected levels of 0, satu ration, the variation in the monthly percentages of 0, saturation must

be related to biological processes occurring in the lagoon. Table 17 presents the monthly values of the percentages of 0, saturation.

Relative Abundance of White Mullet in Joyuda Lagoon

?The relative abundance of white mullet in onthly samples indi~ cated a peak in February 1979 with 414 of the total capture in a sample aize of 193 individuals. Another high value was recorded in Soptenber 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 millet after February tends to support the theory of an offshore spavning migration of this fish, ?as has been already suggested by Anderson (1957), Moore (1974) and Yanez (1976). Index of gonad maturity (see Table IIT) indicated that 80% of the mullet exanined in Fobruary 1979 had an advanced stage of gonad developoont. In March 1979, all the individuals examined were

sexvally mature. The following months presented sone mature indi

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As in the collections until Septenber, in which no individuals

wore found to be suaually mature. The peak of adult white mullet

in coptenber with reduced gonad development may be indicative of a

return, in part, of the white mullet population af

cer the spawning had

token place in offshore waters. The overlapping date for the months

PI s

Dbruary and March 1980, axe not significant in this matter because

the individuals examined were act adult fishes (see Tigure VI). The

dow valuer in rele

Je abundance after October 1979 may be indicative

of the dotrinental effect of hurricanes David and Frederick in

September 1979, of to over-fishing of the adult mullet population in

the lagoon during theix period of prevspamming in February and March

1979 by local and comercial fishermen.

Host = Parasite Interactions

Six species of metazoan parasites were found to infect the vhite

mullet during the study period at Joyuda Lagoon. Texporal patterns of

Incidence percentages must be interpreted with caution due to small

sample size numbers. The Acanthocephalian parasite, Ploridosentis

usitis (Machado = Filho 1951) which is an internat parasite, local~

ised always in the intestine of the fish, wae present at least once in

?every ronthiy sample. Floridosentis mugilis registered 2 peak of

incidence in onthly collections of March 1979, and then in Decesber

1979, ganuary and March 1980. Figure VII presents the monthly fluctu-

ations in incidence percentages for this species. The pattern of

incidence percentages docs not acem to be directly determined by any

?external factor related to the water quality of the lagoon. The fact

that F. mugilig is transmitted by an intermediary host is indicative

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of the epparent availability of this intermediate host throughout

most of the year in the lagoon. Further studies on the life cycle of

@cuen about the short tem variability in the incidence percentages of

this species.

two monogenean trenatodes parasitized the gill filanent of the white mullet in Joyuds Lagoon. Fseudohaliotrona mugilinus Hargis 1955 prosented peaks in incidence percentages in February and tarch 1979, land then in Mach and April 1980, This monogenean parasite vas absent from hugust to October 1979, Nevertheless, st appeared with moderately hhigh incidence percentages throughout the study, specially during the winter period (Figure VIII), Low salinities, or perhaps the sudden decrease in salinity from August to Septeber, continuing inte October 1979, could have caused the absence of this parasite during these months.

Metanicrocotylea macracantha Alexander 1954 another monogenetic ?trematode which infects the gill f£lanents peaked in Novenber 1979 ang

March 1980, and was alco cownon in July and September 1979 and Pebrvary

1980. Metanicrocotylea gacracantha can withstand short tire salinity

variations and was present in Septenber 1979 (see Figure 2x) whon

eatinity 1

\ched its lowest point during the study (approx. 12 ppt).

?The presence of this monogenctic trenatode in Mugil curena was first

noted in May 1979, but continued to appear in tha rest of the study.

?This strongly suggcete that the parasite either ontored the Lagoon

after a cand bar formation opened in April-May with early craved

edult fensles, or with juvenile mullet which were probably new re~

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eruitments in the lagoon, However, after May, the short term vari-

?ations ef incidence on the host may be related to other factors, either environmental, biological or both.

Taree species of copepods of Aifferent genera vere found on the white mullet. Ergasilus lizeo Kedyer 1864 which occurred only in the gill filanents of the fich was more abundant in February 1979. tt prevailed until March 1979 and thon disappeared until October 1979 reaching another high incidence value during January 1980 (see Figure X). Although E. Ligee occurred during the winter period, ts incidence in the white mullet socns to be more related to the migratory pattern of the adult fish than to seasonally related hydrological conditions. Exgasilus Ligae survived in a wide range of tenperature and salinity variations in Joyuda Lagoon. Ite absence after March 1979 could be due to the migration of adult mullet to offshore waters. As a conse quence of this migration, the individuals examined during the re- maining summer months, did not possess this parasite because they were new recruitments composed mostly of juvenile fish. With the next

Smmigration of adult sullet after September 1979, the parasite became

?again a regular component of the parasitic population of the mullet

in Joyuda Lagoon.

?The parasitic copepod, Lernacenicus longiventris Wilson 1917 was

found partially enbedded in the fins and body surface of the white

mullet, Ite prevalence and ineidence percentages show a clear poak

Guring summer with consistently high incidence percentages for the

months of July, August and Septenber 1979 (see Figure XI). after a

lag period of two months, the parasite appeared again in the collec

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tions, reaching another peak during March 1980. The pattern of oc~ currence 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 dune 1979, one month after the migration of the fish, and then showed reduced in- eidence percentages in October 1979, probably as a result of non~ Anfected adult mullet examined in that particular monthly sample. Apparently, after being introduced by new recruitment into the lagoon during the sumer period, the parasite adapted well to the strongly variable hydrological conditions in the lagoon and persisted in the

samples despite a chenge of 17 ppt in

?Linity between October 1979

land april 1980.

Bamglochys coneinnus Wilson 1911 occurred mostly in the mucus of

the branchiostegal cavity with occasional presence in the branchio~

stegal filaments

Bonolochus concinnus appeared in nine out of 15 monthly samples, but 4i@ not show any distinct peak of abundance

based on reasonable sample size numbers. Its abundance during the rainy period in sumer (see Figure XIX) from August to October 1979

ay be indicative of low tolerance to the sudden salinity decr

associated to hurricanes David and Frederick.

Interactions Between Parasitic Species

Six species of external parasites and one endoparasite were present in white mullet at different tine periods throughout the study, ?The prevalence of these species in the white mullet is pre~ sented in Table 1V, It was observed that ectoparasites which occupied

sinilar microhabitats within the fish such as Metapicrocotylea

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TABLE av

Monthly prevalence of parasitic cpectes in the white mullet trom Joyuda

Lagoon, during the perio? between February 1979 and xpril 1900

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= Absence

4 Presence

Sp. 1 ~ Peeudohaliotrens mugilinus

Sp. 2 ~ Notamierocotylea macra

Sp. 3 ~ Bonolochus concinnus

sp. 4~ Eegasilus 1izae

sp. 5

Sp. 6 ~ Floridosentis mugilis

wha

~ Leracenicus longiventrss

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as

nacracantha ané Erossilus lizae, aid not occur together in wonthly samples. Both species are specialized parasites of the gill file monts. Table V detaits the presenco-absonce display of both species in monthly samples. These species show a significant negative association (p-0.017). Possibly one of these parasites is excluding the other in competition for focd and/or space. Their mutual exclusion in monthly samples could be affected by the seasonal periodicity of fone species or the other, their adaptations to withstand environmental stress, chance, or actual interspecific interactions between both species.

?The association between Peoudohaliotrans mugilinus and Ponolochus concinnus also suggests possible interactions between Gifferent parasitic populations. In thie case, a positive association resulted between both parasites (see Table Vz), the probability of association was highly significant (p=0.002). Pseudchalictrena nugilinus and B. concinnus are exposed to sinilar environmental condition

fas both are parasitic in the branchiostegal cavity, how

ever, each species occupied different niches or nicrchabitats within

the fish, Bonolochus concinnus was always found in the mucus layer

Of the branchiostegal flap, while Peeudohaliotrena mugilinus wi

always parasitic in the gill filanents. Different food and space

requirements can permit both species to co-exist together in the host.

Floridosentis mugilis, an acanthocephalian worn, was the only

internal parasite observed and it prevailed consistently in every

monthly sample (see Table IV). The presence of other endoparasites

in the elimentary tract is probably Limited by the lack of intermediate

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TABLE Vv

Contingency table representing the negative interspecific association

between the monogenetic trenatode Metanicrocotyles macracantha and the

copepod Ergasilue Lizae

Notamieroroty ian

Absent, 6 3 9

Exgastlus Lisae

Probability of association by chance (p) = 0.017

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HBL VI

Contingency table reproscnting the positive interspacific association

Betwoen the ronogenotic trorstede Pseudchaliotrems mugilinus and the

?copepod Remo lochwe coctanus

Present abeent

Present ° ° 2

Bonolochus cosimnus

Probability of association by chance (p) = 0.002

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hosts such as mollusks, which are rare in Joyude Lagoon. the possi-

Dility of competitive exclusion by the acanthocephalian ig contradicted

by the presence of 2,

jenetic trematodes which occur along with E.

Bugilis in collections of mullet examined in ba Parguera, Puerto Rico

(weINiams, PH, unpubl. data).

The consistent patterns of association between parasites constitutes evidence that their tenporal occurrence is real and not an artifact of sampling variability,

Parasite-Heosystem Interactions

Simple and multiple regression analyses 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 ecto-Parasitic species in yugil curema withstand sone degree of variation in Salinity ond temperature (see Tables VIZ, VIII and 1X). 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 parancters on the parasite composition of Hugi gurena were observed for abrupt salinity variations in August through October 1979. Most species of external parasites presented Low inci=

dence or were absent during this period. ?The effect of short tem variation is probably nore important in determining the prevalence of

sone par:

tic species than seasonally related variations which are gradually experienced by external parasites. If we consider the wide Tange of tolerance that mullet have for salinity variations it is suggestive that the external parasitic fauna has also adapted to

variable salinities.

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The periodic occurrence of parasitic speci

uch as the copepods

Lernaeenicus longiventris and Erqasilus lizse is explained by the

migratory behavior and relative abundance of adult mullet in Joyuda

Lagoon rather than seasonally determined by tenperature and/or «:

nity.

?The influence of monthly variations in water temperature and salinity

may play an inportant role in particular interspecific interactions

between two species in competition for similar habitats in the fish.

For example, E. liste presented higher intensity of parasitization

Guring the winter period (see Figure XII1), while M. macracantha had

high intensity of infection in two sonthly collections in sumer and

also prevailed in samples fron Septenber 1979 (see Figure XIV). This suggests that M. macracantha is more tolerant to high tenperatures

?than E. Ligne in Joyuda Lagoon. L. longiventris also displayed a

trend of occurrence during the sumer months with high intensity of

Parasitization in higher water temperatures than the average for the

econysten (8

Figure xv).

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concuusrons

the range of tolerance observed by parasitic species to tempera

ture and salinity variations in Joyuda Lagoon 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 millet to offshore waters and their eventual return to the lagoon accounts for much of the varia: bility observed in the periodic occurrence of some parasitic species in white millet.

Seasonally related variations in water tenperature and salinity

are not relat

13 to the incidence and intensity of infection by Parasitic species. Nevertheless, suéden salinity variations are

Getrimental to some ectoparasitic populations which are apparently

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tolerant than their host to rapid, low salinity stress.

Negative interspecific interactions between parasitic species ?ecourred betwoen populations which occupy similar microhabitats within the host. This type of association was significant for the

copeped Eegasilus liz:

land the monogenetic trenatode Metanicrocotylea

rantha, ?Their actual competition and mutual exclusion may explain the short-term variations that these species present in their patterns of occurrence,

Yoyuda Lagoon 1s a detritus-based ecosystem which provides high food availability and protection for juvenile and adult millet. the Population proportion of adult mullet is higher during the winter

Period prior to ther peak of sexual maturity, This fact suggests that

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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 millet during periods

of high wave energy and low food availability in the coast.

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