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THE CONDITION FACTOR OF *Mugil incilis* HANCOCK (PISCES: MUGILIDAE) AND ITS SEASONAL CHANGES IN THE CIENAGA GRANDE DE SANTA MARTA (COLOMBIA)

Jacobo A. Blanco Racedo

RESUMEN

Se ha estudiado la variación anual de la condición de la lisa **Mugil incilis** Hancock en la Ciénaga Grande de Santa Marta (CGSM), la mayor laguna costera del Caribe Colombiano, haciendo énfasis en la influencia ejercida por factores ambientales como la salinidad, la temperatura y la transparencia de las aguas sobre la condición de esta especie de Mugilidae. Las diferencias estacionales observadas en la condición de **M. incilis** están evidentemente relacionadas con su desarrollo gonadal y dependen de la disponibilidad de alimento. La dieta de **M. incilis** se basa en detritos y su suministro de alimento parece ser muy afectado por el aporte fluvial a la CGSM, el cual es también responsable de los cambios en la salinidad de la laguna, esto explica la relación inversa ($r = -0.82$) hallada entre la salinidad y la condición de **M. incilis** expresada por $C = 0.9949 - 0.0057\ S(°/oo)$. La variación anual de la salinidad sigue un patrón rítmico de cambios estacionales, no precisamente "in situ", sino en regiones continentales distantes: las cabeceras de los tributarios de la CGSM. Estas lisas desovan en aguas del Caribe adyacente a la CGSM y su período de migración (dic-marzo) comienza con su mejor condición física, y retornan a sus áreas de alimentación en la CGSM 2 a 4 semanas después, hasta el final de la migración, con su condición mínima ya que al parecer estas lisas no se alimentan durante su migración de desove. No se observaron cambios relacionados con las variaciones de la temperatura. Las aguas más turbias coincidieron con los sitios de alimentación de **M. incilis.**

ABSTRACT

The annual variation in condition of the mullet **Mugil incilis** Hancock has been studied in the Ciénaga Grande de Santa Marta (CGSM), The largest coastal lagoon on the Colombian Caribbean, with emphasis on the influence of such environmental factors as salinity, temperature and trasparence of the waters on the condition of this species of Mugilidae. Seasonal differences observed in condition of **M. incilis** are evidently

related to gonadal development and depend on food availability. The diet of **M. incilis** is based on detritus and its food supply seems to be very influenced by river discharge which also accounts for the salinity changes in the lagoon, this explains the inverse correlation ($r = -0.82$) found between salinity and condition of the mullets expressed as $C = 0.9949 - 0.0057\ S$ (°/oo). Annual salinity variation follows a rhythmic pattern of seasonal changes, not precisely "in situ", but in distant continental regions: the headwaters of the tributaries of the CGSM. These mullets spawn in Caribbean waters adjacent to the CGSM and their migration period (Dec-March) begins with their best physical condition, returning to their feeding areas in the CGSM 2 or 4 weeks later, until the end of the migration, with their lowest condition since these mullets apparently do not feed at all during the spawning migration. No change related to temperature variations was observed, and turbid waters were the rule in **M. incilis** feeding sites.

INTRODUCTION

The ecology of Mugilidae has been studied in tropical and subtropical regions of the world by a number of workers and perhaps because of its wide distribution *Mugil cephalus* and *Mugil curema* are among the best known species of this family.

Mugil incilis Hancock is one of the most abundant species of Mugilidae in the Southern Caribbean (Thomson, 1978) and due to the importance of this group in coastal fisheries and fishculture in Colombia, it is being studied in order to obtain enough information to exploit this ressource in a rational way; this work forms part of these investigations including both biological and ecological aspects of these fishes in the Ciénaga Grande de Santa Marta (CGSM).

Even though condition is considered in many studies dealing with the biology of Mugilidae (Alvarez-Lajonchere, 1976), it has been seldom correlated with environmental variations in tropical areas, where this information can be a useful tool to understand the biology and behaviour of fishes and other organisms in a changing environment.

Condition factor has been utilized to describe the state of wellbeing of fishes and it can be used to define the seasonal changes in the condition of fishes and differences between the condition of the same species in different waters (Nikolsky, 1963). Since condition coefficient depends on ecological (abundance or lack of food) and physiological conditions (sexual maturity) (Albertini-Berhaut, 1975), it can hardly be considered as an index of wellbeing of juvenile fishes when growth in length is more important than weight gain; therefore, only adult mullets were consideed in this investigation.

Although condition factor gives only an approximation to the actual condition of the mullets, it is useful for a comparative analysis with

abiotic factors such as salinity, this factor is the most representative index among those that tipify the conditions of an estuarine environment (Mangelsdorf, 1967) as this brackish water lagoon called "ciénaga" from "cieno" the spanish word for muddy slime. Preliminary results from a study on food composition of *M. incilis*, to be published elsewhere, indicate that these mullets are detritus feeders like many other Mugilidae (Thomson, 1966); Odum, 1968, being part of a food chain which involves bacteria (Moriarty, 1976) shrimps, amphypods, crabs and snails among others (Adams & Angelovic, 1970).

DESCRIPTION OF THE AREA

The CGSM is the largest coastal lagoon of Colombia with approximately 450 km . Located on the Caribbean coast of the country in the Departamento del Magdalena, the CGSM is a rather shallow brackish lagoon with an average depth of 1.7 m, except to the North near the single outlet called "La Boca de la Barra" where water exchange with the sea takes place (Fig. 1). freshwater, organic material and clastic sediments are supplied by the Magdalena river through a system of old channels and interconnected smaller lagoons of the river's delta to the SW.; other sources are the rivers from the Sierra Nevada to the SE. The Sierra Nevada de Santa Marta, a pyramidal mountain formation rising from sea level up to glaciated peaks 6000 m high, is the highest coastal mountain system of the world; in its paramos and valleys are the headwaters of these tributary rivers, i.e. the Fundación, Aracataca, Sevilla and Río Frío rivers.

The regional climate is very dry (685 mm. yr^{-1} ; Anon., 1973), corresponding to an arid tropical coastal plain with xerophytic and halophytic vegetation; the CGSM is fringed by mangroves (*Rhizophora mangle, Avicennia germinans*) which account for local production of vegetal detritus; nervetheless, freswater macrophyta like *Eichornia* sp. and *Pistia* sp. are common near the rivers and during seasonal floods of the lagoon.

The CGSM supports an artisanal fishery based on fish, shrimp and oysters exploited by the inhabitants of the riverine villages of Cataca, Tasajera, Isla del Rosario and Pueblo viejo.

MATERIALS AND METHODS

Environmental data (salinity, temperature and Secchi depth) were recorded twice a month from October 1979 till September 1980 in ten stations distributed as shown in fig. 1.

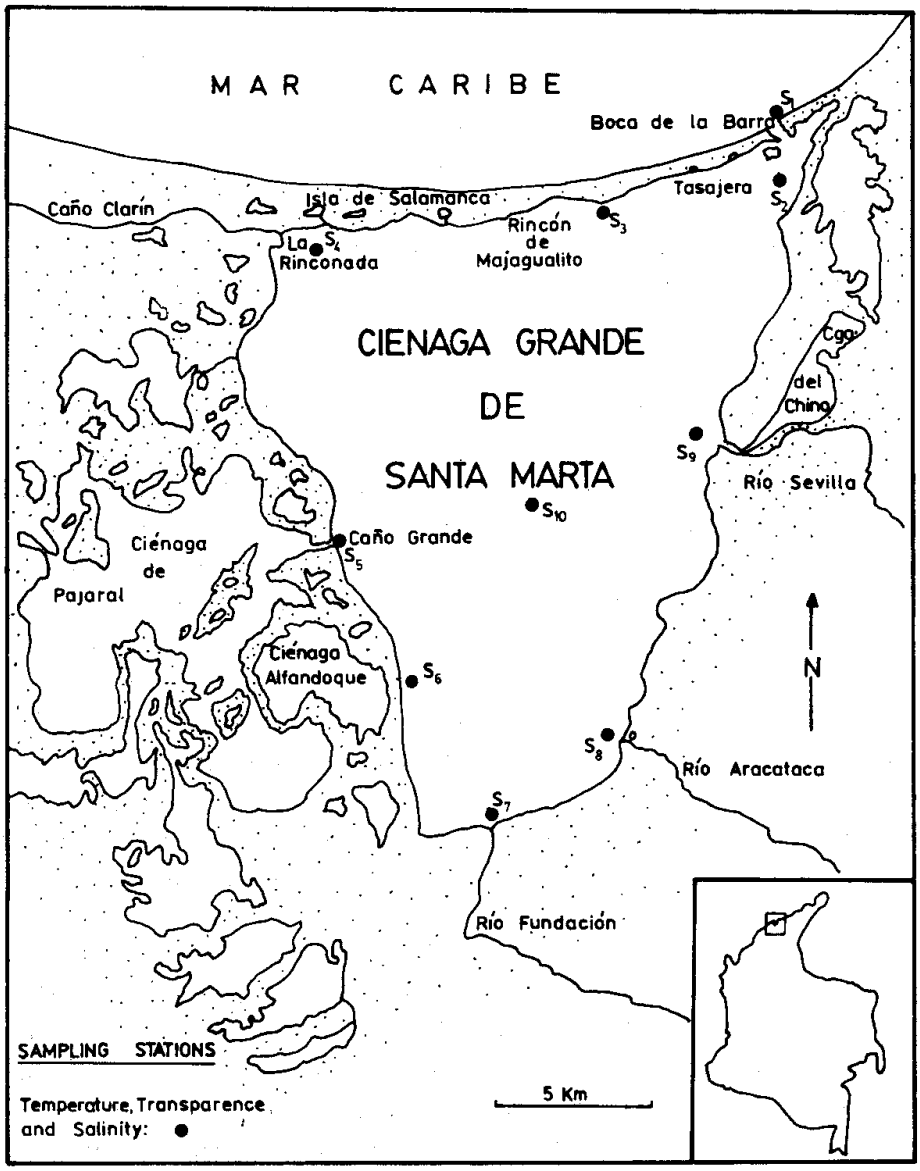

Figura 1. Ciénaga Grande de Santa Marta

Salinity was measured with aerometers and temperature-density-salinity tables (Mangelsdorf, 1967); temperature with a thermometer graduated in degrees Celsius with 0.1°C divisions.

A Secchi disc with a cable labeled every 10 cm was used to determine the transparence of the water.

Average monthly values from each station were used to calculate a mean value of the parameters in the CGSM, every month, during one year. Data to calculate the condition factor were obtained from 1233 adult mullets (Tl. $\geqslant$ 21 cm, length of first maturation) caught in the CGSM and in the sea by local firshermen, for the most part, and sampled before evisceration was perfomed.

Sampling was carried out regulary twice a month; total length of fishes was measured to the nearest centimeter using a 1.0 m long measuring board with 1 cm divisions. Weight data were obtained using string balances of 1000 capacity, with 10.0 g divisions. Monthly data of total length and weight were tabulated and their computed average values were used to calculate weighted means (Haber & Runyon, 1973) which were then replaced in the formulation of the condition factor (Fulton, 1902 in Nikolsky, 1963): $C = 100\,W/L$, to obtain the mean condition factor for every month during this study. Correlation was calculated by means of linear regression using the monthly mean values of condition factor and abiotic parameters computed during this 12 month study.

The significance of the obtained correlation coefficients was tested with the test of significance for Pearson's r (Haber & Runyon, 1973) transforming r in z distribution values ($\alpha = 0.05$).

RESULTS AND DISCUSSION

Temperature and transparence

Monthly average temperatures of the water ranged from 28.3°C to 33.0°C during the period studied (Table 1), the annual mean value was 30.7°C. These data do not show noticeable differences from those of previous studies realized in the CGSM (Wiedemann, 1973; Carmona, 1979). Thus, water temperature may be considered stable near 30.0°C and it is inferred that temperature variations here would have little, if any, effect on condition of *M. incilis,* whose juveniles have been observed living in shallow beach ponds where temperature rises above 38.0°C.

Average Secchi depths in the CGSM are presented in table 1. The highest mean monthly value ocurred September 1980 and the lowest in November 1979, when rivers discharged in the lagoon a great amount of sediments and organic material. Throughout this work, stations S_1

(Boca de la Barra) and S_9 (mouth of Río Frío) presented the clearest waters; however, in May and June 1980 the waters of the Río Frío showed a yellowish colour, which is likely due to humic acids (Gelbstoffe). The lowest transparence was observed in stations S_4 and S_5, to the west of the Cienaga Grande.

Data comparison with condition of *M. incilis* did not show any significant correlation with either temperature or transparence of the water. Even though the temperature tolerances and preferenda are not well known, mullets have been considered as a warm water group and *M. cephalus,* a well studied species, prefers waters where temperature is near 30°C (Thomson, 1966), similar to the annual mean observed in the CGSM. Mullets in general are well adapted to live and feed in turbid environments, so called "mullet water" (Thomson, 1966). Usually related to high productivity, turbid waters were the rule in *M. incilis* feeding areas in the CGSM. specially in the southeast, southwest and western sides of the lagoon, where mullets are captured by local fishermen.

Salinity and condition

Most mullets are typically euryhaline fishes (Thomson, 1966, 1978) and *M. incilis* is unlikely to be an exception. Lowest salinity values were observed in December 1979 with a monthly average of 3.3°/oo (Tab. 1), in April salinity rose to 30°/oo, being the highest mean monthly value for 1980 (Fig.2).

Table 1. Monthly average values for all stations of Temperature, Secchi Depth and Salinity, and Mean values of condition factor of **M. incilis** in the CGSM calculated during this study.

Month 1979/80	Temperature (°C)	Secchi Depth (cm)	Salinity (°/oo)	Condition Factor C.
October	29.7	33.1	10.0	0.91
November	29.3	28.2	10.3	0.94
December	30.5	17.5	3.3	1.00
January	28.3	22.3	15.1	0.91
February	28.5	27.6	21.1	0.87
March	31.4	32.0	21.8	0.83
April	30.1	35.6	30.0	0.85
May	32.5	38.6	25.0	0.85
June	33.0	40.7	16.0	0.86
July	32.2	41.3	18.2	0.91
August	32.0	45.3	17.0	0.95
September	31.4	46.7	16.4	0.90
Mean	30.7	34.1	17.0	0.90

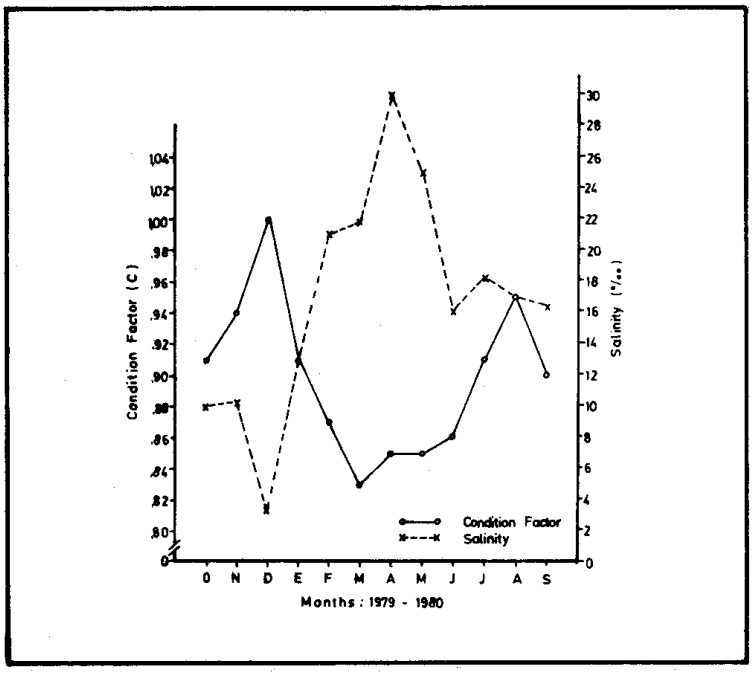

Figure 2. Changes in condition of *M. incilis* and Salinity in the Cienaga Grande de Santa Marta.

Relatively high salinity values were observed at the stations S_1, S_2 and S_3 in the northeastern sides of the CGSM (Fig. 1), on the other, hand, stations in the south (S_7, S_8, S_9) showed relatively low salinity levels throughout the year; middle and southern areas of the CGSM are governed by a reduced salinity regime due to freshwater inflow from eastern rivers, which together with the Magdalena river have an ouststanding effect on the rhythmic behaviour of annual salinity changes in the CGSM (Kaufman & Hevert, 1973).

The northern part of the country has two definite seasons in the year: a dry period (verano) beginning in December and ending in April, and a rainy one (invierno) from May to November, with a brief interruption in July, called "veranillo" (little summer). Notwithstanding, changes in the waters of the lagoon are noticeable with a delay of about one month, the explanation lies on the fact that river runoff is subject to seasonal changes in their hydrographic basins, quite far from the CGSM. Simultaneously with freshwater discharge, rivers deliver important amounts of detritic material, improving the availability of food for mullets and resulting in a better condition of these fishes. This accounts for the significant inverse

correlation (r = —0.82) found between salinity (in °/oo) and condition factor C and expressed as C = 0.9949 - 0.0057 S (Fig. 3).

Food chains in tropical estuaries are usually supported by local mangrove production (Odum & Heald, 1972; Mann, 1972), but material of different sources, such as plankton and rivers, accumulates in the sediments of the estuaries, being thus possible for iliophagic animals to exploit ecosystems located considerably far from them (Margalef, 1974), as the continental highlands where the headwaters of the tributaries of the CGSM are.

Towards the end of the year, when the spawing migration of *M. incilis* begins, the condition of the mullets is the best of the year (Tab. 1): they are fat and sexually mature; by this time the bottom of the lagoon becomes enriched with detritus and high bacterial productivity, even near the outlet. This abundance of food lasts till adult mullets return exhausted from the sea, about 2 or 4 weeks later, with their poorest condition; the spawning migration ends in March when the lowest mean condition was observed.

Alvarez-Lajonchere (1976) reports two increment periods in the condition of *M. curema* in Cuban waters, both related to spawning migrations; however, he points out that the highest condition values occur in winter (Nov-Jan), this observation is similar to the results of this study when the sigle spawing migration of *M. incilis* took place.

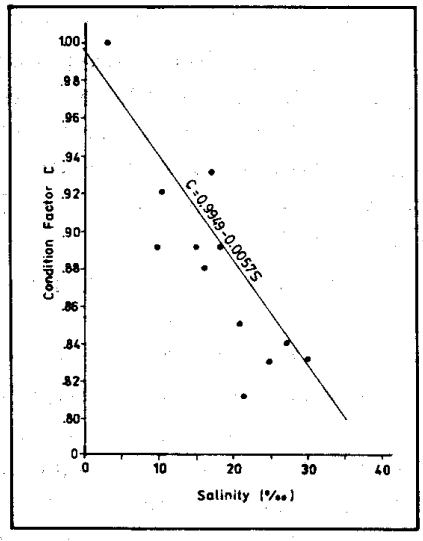

Figure 3. Relation between the average salinity in the CGSM (Oct. 1979 - Sept. 1980) and the mean condition of mullets *M. incilis* in the same period.

CONCLUSIONS

Temperature and transparence of the waters in the CGSM are indifferent to the condition of *M. incilis*.

The only parameter among those considered in this study that showed important variations in the year was salinity, which allowed a comparison with the changes in condition of these mullets.

More than on salinity itself, condition of *M. incilis* depends on food availability, which is affected by seasonal variations in river discharge of organic and clastic material, this is greatest when the highest amounts of freswater arrive in the CGSM, which on the other hand are reducing salinity; thus the indirect correlation between salinity and condition could be established.

The rhythmic pattern of seasonal changes in the hydrographic basins of the tributaries of the CGSM affects not only the condition but also the reproductive behaviour of *M. incilis*, since gonadal development seems to follow the same pattern of variation; research in this direction is strongly recomended.

Investigations on food composition of *M. incilis* have to be completed. Under the scope of mullet cultivation it is also necessary to determine the values of the primary or basic components -protein, carbohydrates and lipids - of *M. incilis* foodstuff in order to meet the nutritional requierments of these mullets in intensive fishcultures.

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Address of the author:
INVEMAR
Apartado 1016
Santa Marta (Mag.)
Colombia