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Estuarine fish: possible use as models for experiment with drugs

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ABSTRACT

Ecology and breeding of two genera of Estuarine fish are presented. These fishes can be used for testing different drugs. A thorough ecological study with respect to the breeding of *Taenioides buchanani* (Day) and *Odontamblyopus rubicandus* (Ham.) in the muddy estuary of Bay of Bengal, off Rasulpur river (lat. 21 48'N and long. 87 53' E) Dist. Midnapore, West Bengal, India, has been made.

The variations of the different physico-chemical factors such as rainfall, turbidity, salinity, pH, dissolved O₂, temperature, plankton, dissolved carbon dioxide have been considered in this investigation twice a month especially on the full moon and the new moon, starting from the year September 1976 to September 1977.

The bulk rainfall in this coastal area is brought about by the south-west monsoon which commences in mid June and last till the end of September. This monsoon period is also the breeding season of the gobioid fishes.

The relationship between the rate of precipitation and the transparency is direct. The salinity depends largely on the amount of estuarine water that is diluted by the rainfall or the amount of estuarine water that is concentrated by evaporation. The estuarine water is always alkaline but during monsoon month the pH is towards neutrality. The dissolved oxygen content has a variable range. No dissolved CO₂ could be

traced. Plankton growth is also influenced seasonally and more or less cyclical in character. The surface water temperature in this estuary exhibits two maxima and two minima. The atmospheric temperature also shows a double oscillation. However, during the monsoon the surface temperature remains uniform at the same optimum level.

The ecology of estuarine water during the breeding of these fishes is characterized by increased rainfall, lowering of salinity, increased turbidity with planktonic density, decline of pH towards neutrality, optimum air and surface temperature or permanent thermocline and fluctuating dissolved oxygen content. Rainfall simply stitches on the process of activation and orientation of this physiochemical make-up of the estuarine water.

INTRODUCTION

West Bengal, particularly the southern district of Midnapore and 24- Parganas abounds in varied types of gobioid fishes. These fishes have been seen to inhabit all forms of waters-fresh, brackish and saline. Sporadic works on the breeding biology of some gobioids, have been undertaken by some earlier workers but a detailed study with respect to hydrography, ecological factors, nest -building, spawning, breeding behavior etc. is wanting.

Topography of Breeding grow

The present investigation incorporates the ecological study with respect to the breeding of such gobioid fishes as *Taenioides buchanani* (Day) and *Odontamblyopus rubicandus* (Ham.) in the muddy estuary of Bay of Bengal, off rasulpur river (lat. 21 48' N and long. 87 53' E). Midnapore, West Bengal, India. This is one of the largest monsoon rivers in the district of Midnapore and has a total length of about

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36,000 yds (33.1 km.) and estuarine stretch of 280 yds (0.257 km.) (fig. 1)

MATERIALS AND METHODS

The seasonal variations of some of the following hydrographical and meteorological factors of this estuarine area have been studied twice a month especially on the full moon and new moon from September 1976 to September 1977, covering a period before, during and after breeding conditions of these gobioid fishes; the following hydrographical and meteorological factors were considered; 1) Rainfall 2) Turbidity 3) Salinity, 4) pH, 5) Dissolved Oxygen, 6) Temperature of both air and surface water, 7) Plankton 8) Dissolved carbon-dioxide and 9) Weather condition.

For the breeding biology of these gobioids an approach towards the correlation between physico-chemical factors and maturation and depletion of gonads has been made to establish the breeding ecology, breeding time and breeding habits of these fishes. For the estimation of ripe and spent conditions of gonad microscopic examination is made upon fresh testis, ovary and seminal vesicle every twice a month throughout the period of investigation. A through observation and an extensive field study have been made in their own natural breeding grounds to determine the breeding habits of these fishes.

OBSERVATIONS

BREEDING ECOLOGY

The bulk of the total annual rainfall (96%) is brought about in this coastal area by the south-west monsoon which commences in mid-June and usually lasts till the end of September. With the gradual retreat of monsoon the amount of precipitation becomes comparatively very negligible. The summer monsoon period is lengthy, raining is almost continuous, very

often with thunderstorms whereas during the other months of the year rainfall days are more numerous than the rainy day. Absolute draught is found in the month of December 76, January and April 77. Hence the rainfall in this coastal belt is mainly influenced by the s. w. monsoon.

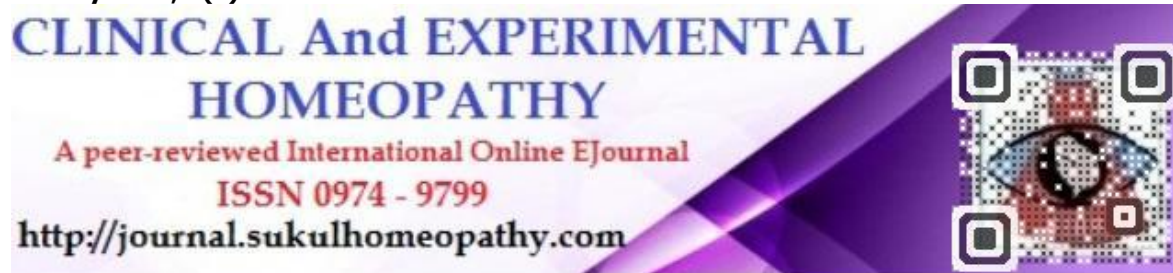
With the onset of rainfall, during the s.w. monsoon, increase turbidity, planktonic growth and to some extent the dissolved oxygen content, on the contrary, decreases pH, salinity and temperature of both surface water and air.

During breeding season, the rainfall is almost continuous and increasingly thick and heavy culmination into flood of muddy water that lengthens the estuarine stretch due to greater embayment.

During monsoon months the average turbidity is about 9.5 cm and during the months of November 1976 to early June 1977 i.e. during the dry months it is 19.7 cm

From February the transparency of this estuarine water gradually decreases and during the period from last quarter of August to the 2nd week of September 77 the water was least transparent due to rough sea, winds of high velocity and floods. The continuous erosion mainly by raining, throws a heavy load of silt into the estuarine water. The light penetration, as a result, is inversely proportional to turbidity. Transparency had increased slightly during the middle of September 76, owing to cessation of rainfall and less disturbed condition of the estuary. The differences in the turbidity reading between September 76 and September 77 is also due to the differences of the total annual rainfall.

Turbidity does not take any part in the depletion of the planktonic growth in any way or does not hamper the dissolved oxygen content of this estuary, as evidenced by the coincidence of the maximum



turbidity reading and the maximum planktonic density during late August and September 77.

During the breeding season the estuarine water is increasingly more turbid than of the non-breeding season.

The range of salinity depends largely on the amount of estuarine water that is diluted by rainfall or the amount that is condensed by the evaporation. The narrowest variation (60-400ppm) is found from mid January to the first week of June 77 and widest variations (2000- 5000 ppm) in the succeeding last of the June at the height of the monsoon.

The salinity level of this estuarine water gradually rose from early October 76 up to the last half of June 77 and that value was maximum for that year. During this period, the evaporation was greater than precipitation. Again from the mid June the salinity peak abruptly came down and decreased gradually to its yearly minimum mark during the month of September 77.

Salinity shows an inverse relationship with the surface air temperature during the period from October to January 76-77 and also during mid August to September 77. So the salinity cycle of the year indicates a lower concentration of salts of this estuarine water during the monsoon and this coincides with the breeding of the gobioids.

This estuarine water is always alkaline is character and the seasonal fluctuation in pH exhibit a fairly close relationship with the monsoon and dry month. The minimum pH value (7.2) is found twice, first in early September, 1976 and then in mid September 1977, when the maximum average turbidity (9.3 cm) is registered. Hence lower value of pH is observed when maximum turbidity is found and this inverse relation in between the two is more or less constant

only during the s.w. monsoon period and also during early may 1977.

Dissolved oxygen value ranged from 5.04 ppm in late January to 9.62 ppm in late October. Unstable conditions were recorded during May to September, 1977 while a relatively more stable condition prevailed from February to April 1977. In other months condition is transitional in character. The concentration of dissolved oxygen gradually rises from September '76 to last half of October. A gradual fall of dissolved oxygen during the breeding season the value of dissolved content is not stable but fluctuation within a moderately higher concentration. However, the fishes concerned are secondarily adapted to an amphibious mode of life as indicated by the presence of accessory respiratory organs, and as a result, the effect of dissolved oxygen on these fishes might be neglected.

The surface water temperature has shown two maxima, one in between late May and early June (36.3°C) and two minima one in late January (22.2°C) and other in late July (28.7°C). Atmospheric temperature has also shown double oscillation with two maximum in late September (34.8°C) and in between late May and early June (37.4°C). However during the monsoon period temperature remained almost uniform. The temperature of the surface water is higher than that of the atmosphere by $0.5-1.3^{\circ}\text{C}$, except during mid June to September '76-77, when the temperature of the surface water goes down than that of the atmospheric temperature by $1.1-1.3^{\circ}\text{C}$.

Though the two maximum and the minimum of the atmospheric temperature are found to coincide exactly with those of the surface temperature yet the surface temperature is not influenced by the atmospheric temperature. The fall of surface temperature, recorded during S.W. monsoon period cannot be attributed to the effect of atmospheric

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temperature which remains itself above the surface temperature.

From the data it is clear that in this coastal belt. Where the winter and summer are so clearly discrete, the only time when the temperature conditions remains uniformly at the optimum level is that as the monsoon showing a thermocline.

Seasonal planktonic cycle indicates that the zooplankton reachest its maximum during the mid summer especially in the s.w. monsoon period starting from late June to September '77, but as it exhausts its phytoplankton food supply, it also decline gradually up to the month of October. During spring to early summer particularly from April to mid June, phytoplankton similarly increases to maximum for the year ant the zooplankton at this time abounds in immature stages. Phytoplankton consequently declines rapidly for the lack of nutrients, increasing turbidity and being consumed by the increasing zooplanktonic population.

From November to January the relationship amongst the surface temperature, plankton, dissolved oxygen and turbidity is direct, because they show a sharp declining tendency and again a direct relationship amongst them is found from February to April when they are more or less increasing. Particularly during winter months starting from December 1976 to January 1977, when the average surface temperature is much lower than that of the s. w. monsoon, planktonic crop is not found at all, hence the surface temperature controls the quantitative value of plankton.

This estuarine water is completely devoid of the dissolved CO₂. As soon as CO₂ is produced by any mean it reacts with the salts present in water to form HCO₃ or it is reduced by the chlorophyll bearing the organisms to carry on their carbon assimilation and in return liberate oxygen.

The spawning season of these gobioid species under study has been found to generally coincide with the monsoon conditions, i.e. from June/July to September/ October. Developmental condition of the gonads indicates that spawning season of these fishes is protracted with intense reproductive activity probably occurring during August- October. (Text fig.- 6).

PHASES OF GONADAL CYCLE

With the onset of breeding season (June/July) the gonads of the fishes start enlarging. During the peak breeding period completely mature and motile spermatozoa along with the maturing stages of development, are very characteristic in male specimens. On the other hand, in the female fishes during this period, mature eggs are found along with ripe eggs which are comparatively larger in diameter and opaque. Prior to spawning the superficial blood vessel supplying the gonads, became enlarged and conspicuous. During post –breeding period the gonads gradually fecede and collapse to an inactive condition when neither gametes are found nor gametogenesis take place.(Text fig.-6,7,8).

BREEDING HABIT

Both these species normally during the non breeding period live inside the deep mud of the low lying tidal swamps of the estuary in a more or less hibernating state and during the breeding season during the return of the monsoon, they came out of the holes to the surface water of the estuary in search of partners. At the muddy swampy bank, a little above the water level the male with the help of his head then forms a two mouthed 'U' shaped tunnel in which the female deposits her eggs, probably to be milted by the male immediately. Hence it is presumed that the fertilization is external. Elaborate courtship is followed by holding and springing round the body of the female in a most determined manner. After a long

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lapse of time the pressure is released and the female is led to the entrance of the hole where she deposits her eggs.

The upper end of the tunnel is generally closed by a porous mud-lid through which air can pass in and out. The subterranean water with deficient oxygen is expelled out at regular intervals with the help of the mouth of the male fish. Peculiarly, more than one hole may be dug and the eggs when disturbed by the predator, are transported to another hole by mouth, also by the male. The sex relation is polyandry type.

No perennial spawning and lunar periodicity in spawning been observed in these fishes.

DISCUSSION

Ecological investigation with relation to fish breeding has been conducted by earlier workers such as (Khan 1926, 1942, 1958; Breeder 1935; Mazumdar 1940; Mookherjee 1942, 1945; Mookherjee, Mazumdar, Dasgupta, 1944; Das and Dasgupta 1945; hora 1945; Alikhahi 1951; Saha *et al* 1957; Sircar and Har 1973; and Har and Sircar 1979). These investigations reveal different conflicting views. These views may be broadly classified as biological, chemical, physical and meteorological. Apparently the main factors influencing the spawning of these gobioid fishes under discussion are physic-chemical and meteorological rather than biological or endocrinological. Viewing the data as a whole it has been established that spawning of these fishes requires certain factors which can be called as prerequisites for breeding of estuarine fishes particularly these gobioids. The chief pre-requisites for breeding of these fishes studied are characterized by increased rainfall, lowering of salinity, increased turbidity with planktonic density, decline in pH towards neutrality optimum air and surface water

temperature and fluctuating dissolved oxygen content.

Earlier workers studying Indian fishes from different ecological niches have similarly reported that generally coincides with the onset of the rainy season (Day 1873, 1877, Hora 1936, Jones 1946, James 1964, Sircar and Har 1973, Har and Sircar 1979). Hora (1936) while dealing with the ecology and bionomics of the gobioid fishes of the gangetic delta reports that *A. bato* probably breeds with first showers of s.w. monsoon; *P. lanceolatus* breeds during s.w. Monsoon when the burrows are flooded. Jones (1937), while studying the breeding time and development of brackish water fishes of Adyar river, stated that the eggs of *A. viridipunctatus* could be obtained from Adyar throughout the year, which showed it as a perennial breeder. Gibson (1970) while working on the giant body, *Gobius cobitus* reported that breeding in the species been observed in any one of the gobioids studied here. It has also been observed that the fishes studied here might spawn in succession during definite breeding season. Our work substantiates the work of Jhingran (1961). Saigal (1964) and Parulekar and Bal (1971), with regard to prolonged breeding season and series of spawning burts during one breeding period. The fishes under study have been seen to spawn more than once in a breeding season which is protracted in nature, but no periodicity in spawning could be seen.

In a review of the existing knowledge of the Indian gobioids, the paucity of information about their breeding habits particularly with regards to migration, gives us no accurate data which may throw light on this aspect. In Inland waters of the India the fishes which are mainly marine very often seek fresh water and brackish water fir breeding or other purposes (Hora, 1936, Jones, 1950). No data on migration in these two fishes under discussion is available.

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Jones (1937), worked out the breeding and development of *A. viridipunctatus*, *A. neill* and *B. boddarti*. In all these fishes he observed that the male parent remained inside the shell of crevices as the case may be caring the eggs and guarding them against other egg-eating fishes. The mother was never found near the eggs except at the time of oviposition. The present observation with regards to *T. buechanani* or *O. rubicandus* accord in general with the finding of Jones (1937). Herms (1935) while studying the breeding biology of *Periophthalmus* sp. and *Boleophthalmus* sp. stated that both the fishes were oviparous in habit. But Jones (1937) denied the presence of developing embryos in the ovary of *B. boddarti*. In the present study viviparity is wanting. These fishes can be used for drug testing.

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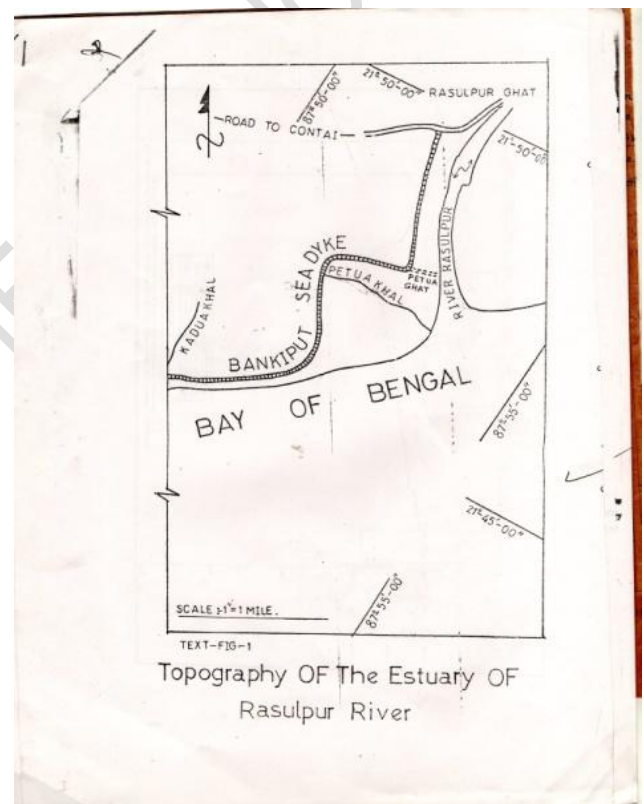
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TEXT-FIG: 6 - DURATION OF DIFFERENT STAGES IN GONADAL CYCLE.

SPECIES	SEX	PREPARATORY PERIOD	BREEDING PERIOD	PEAK BREEDING PERIOD	POST BREEDING PERIOD
TALINIDIS	MALE	MARCH - MAY	JUNE - SEPTEMBER	AUGUST - SEPTEMBER	OCTOBER - FEBRUARY
BUCHANANI	FEMALE	APRIL - JUNE	JULY - SEPTEMBER	AUGUST - SEPTEMBER	OCTOBER - MARCH
ODONTAMBLYCUS	MALE	MARCH - MAY	JUNE - SEPTEMBER	AUGUST - SEPTEMBER	OCTOBER - FEBRUARY
PUS RUBICANDUS (HAM)	FEMALE	APRIL - JUNE	JULY - SEPTEMBER	AUGUST - SEPTEMBER	OCTOBER - MARCH

TEXT-FIG: 7 - CHARACTERISTICS OF DIFFERENT PHASES OF GONADAL CYCLE.

GONAD	PREPARATORY PERIOD	BREEDING PERIOD	PEAK BREEDING PERIOD	POST BREEDING PERIOD
TESTIS	STRUCTURAL DIFFERENTIATION STARTS WITH A FEW EARLY STAGES OF SPERMATOCYTES.	1. INCREASED VASCULARIZATION. 2. MATURING SPERMIDS WITH LITTLE AMOUNT OF MATURED SPERMATOCYTES.	COMPLETELY MATURED & MOTILE SPERMATOCYTES ALONG WITH A FEW MATURING STAGES OF DEVELOPMENT	1. ORGAN GRADUALLY RECEDES TO AN INACTIVE CONDITION. 2. NEITHER SPERMATOCYTES NOR ANY SIGN OF SPERMATOGENESIS.
OVARY	1. GRADUAL INCREASE IN SIZE. 2. INITIATION OF OOCYTE MATURATION.	1. GRADUAL APPEARANCE OF RESPECTIVE COLOUR & FORM. 2. CONTAINS ONLY PRIMARY & SECONDARY OOCYTES.	1. SUPERFICIAL BLOOD VESSELS ENLARGED 2. THE MATURED EGGS ARE FOUND ALONG WITH RIPE EGGS.	1. UNSPAWNED OVARIAN EGGS GRADUALLY ABSORBED & DISAPPEAR. 2. OVISAC COLLAPSES & LOOSES ITS RESPECTIVE COLOUR.
	3. NO REMNENT OVA OF THE PREVIOUS SPAWNING CYCLE.			

TEXT-FIG: 8 - PROGRESSIVE GROWTH OF OVA

SPECIES	RANGE OF AVERAGE OVA DIAMETER (mm)
	BREEDING PERIOD PEAK PERIOD
TALINIDIS BUCHANANI (DAY)	0.4 - 0.9 0.9 - 1.4
ODONTAMBLYCUS RUBICANDUS (HAM)	0.6 - 1.2 1.2 - 1.6