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Some aspects of the physical hydrology of a prawn habitat in the Benin River, Southern Nigeria.

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ABSTRACT: Air temperature, water temperature, water level, transparency and flow velocity were studied at the Benin River, Southern Nigeria, for a period of two years. Samples were taken at fortnightly intervals from five stations along a five-kilometre stretch of the study River.

Water temperature, water level, transparency and flow velocity were significantly different ($P < 0.01$) at all stations in the first year (March 1986 – February 1987). In the second year (March 1987 – February 1988), only water temperature and flow velocity were significantly different ($P < 0.01$) between the study stations.

In spite of the proximity of the study stations, data from this study indicate that each station was controlled by a set of unique local conditions, emphasizing the importance of site specific study in prawn ecology.

Key Words: Benin River; Physical Hydrology; Prawn habitat; Koko Town.

Introduction

Culture of prawns in ponds is being practised since ancient times along the coasts of the Indo- Pacific region (Tang, 1986). The most advanced nation this field is undoubtedly Japan, where the estimated production of cultured prawns increased from 200 tones in 1965 to 1,300 tones in 1974 (Hirasawa and Walford, 1976). Cultured prawns, assumed importance in international trade only recently (Wickins, 1982). The strong market demand from the West, especially the united states, influenced the development of prawn culture along the Pacific coasts of Latin America, particularly Ecuador (Tang, 1986).

The intensive culture of prawns in Nigeria is not economically feasible at present because of the difficulties in rearing larvae. Powell 919°20 suggested the direct development and management of wild populations through habitat alterations as feasible alternatives.

The American prawn *Macrobraciumi rosenbergii* had been successfully cultured in different parts of the world (Hanson and Goodwin, 1877). Its African relatives, *Macrobrachium macrobrachion* Herklots, 1851 and *Macrobrachium vollenhovenii* Herklots, 1857 are two species of high culture potential in Nigeria (Powell 1982).

The Benin River and its associated creeks in the vicinity of Koko, Delta State supports a thriving artisanal prawn fishery. The two common and abundant species at these sites are *M. macrobrachion and M. vollenhovenii*. Attempts at culture and management of these two species could be tried at these sites. The feasibility of any such venture requires a thorough understanding of the habitat conditions of these two species. This paper, based on a study conducted for a period of two years, between March 1986 and February 1988 provides this much needed synthesis not available from previous literature.

Materials and Methods

The Study Area.

This study was carried out in 5km stretch of the Benin River at Koko (6^{o} 00N; 5^{o}30E). The Benin River (Fig. 1a) is an estuary through which many rivers drain into the Atlantic Ocean (Udo, 1970). The upstream of this river is completely freshwater, while at Koko, there the tidal fluctuations of the sea are observed it is characterized by low salinity, which increase downstream towards the ocean.

Koko town is a linear settlement 63km south of Benin City- (Fig.1b.). It is situated along the northern bank of the Benin River (Fig.1c.). The river is bordered on its Southern bank by a-secondary rain forest with scattered fishing camps (Omagbemi, 1986). koko settlement is divided into four, not clearly demarcated parts, linked together by one road (Fig.1c.).

The present study stretch represents the transitional upper zone of the Benin River. It was chosen because of the occurrence and high abundance of *M. macrobrachion* and *M. vollenhovenii.* The completely freshwater upstream of this stretch is dominated by prawns of the family Atyidae and some Palaemonidae such as *Desmocaris trispinosa Aurivillius,* 1898 and *Leander tenuicornis* Sars, 1818; the downstream, characterized by high salinities is dominated by prawns of the family Panaiedae such as *Parapenaeopsis atlantica* Balss, 1914, *Pendeus kerathurus* Forskal, 1975 and *Penaeus notialis* Perez, Farfante, 1967.

Koko experiences a distinct seasonality in weather typical of the humid tropical climate. This is characterized by a rainy season lasting for eight months (March-October) and a dry season with duration of four months (November-February. Figure 2 presents the data obtained for the rainfall, relative humidity and atmospheric temperature in the vicinity of Koko during the study period. The total monthly rainfall during this study in the rainy season ranges from 52 - 722mm (Fig.2). In August, a distinct period of about 10 - 12 days of no rain account for the 'August break'. This seasonality results from the month -south movement of a broad discontinuity between the humid maritime air mass blowing across Atlantic Ocean and the dry continental air mass blowing across the Sahara desert (Hare & Carter, 1984). When the discontinuity of air mass lies to the south (November - February), the dry (R.H. $< 40\%$) northerly "Harmattan" winds predominant resulting in the dry season. There was little (< 70mm) or no rainfall during this period (Fig.2).

The mean monthly atmospheric temperatures at koko ranged from 24.C^{o}C to 31.8^{o}C, during the study period (Fig.2). The lowest mean temperature (24.0^{o} C) was recorded in December 1986 and the highest (31.8^{o} C) in April 1987.

The sedimentary formation of Koko area is Quaternary and the specific age of this formation is Holocene. It is basically alluvium of lower delta made up of a combination of sand, clays and gravels The vegetational cover is dominated by the mangrove trees such as *Rhizophora mangle* Linn., *Rhizophora harrisonii* Leechmam and *Rhizophora recemosa* Meyer; a light forest composed of fern like *Acrosticum aureum*Linn. and tree such as *Avicennia africana* P. Beauv., *Raphia vinifera* P. Beauv., and *Elaeis guinmensis* Jacq., occurs on the firmer ground.

The aquatic vegetation in general was made up of submergents, emergent and floaters. Submergent and emergent plants were restricted to the main channel of the main river. *Ceratophyllum submersum L.* and *Utricularia* Sp. accounts for the submergents, while the only emergent was the water lily, Nymphea odorata AIT. The floating vegetation made up of the water lettuce, Pistia stratiotes L., and Azolla africana Desv. occurred both in the creeks and the main river channel. However, the water hyacinth, *Eichhornia crassipes* (Mart.) Solms -Laub., a dominant floating plant which invaded the river during the later part of the sampling (Mid 1987) was never found in the creeks.

Five sampling stations were selected for this study. Three stations, I, III and V are located along the main channel, while the other two stations, II and IV are along the creeks (Fig. 1cc).

Station I is situated about 50m downstream of the koko port. The river at this point is approximately 1,500m wide. The sampling area closer to the north bank is calm with no measurable flow velocity. The

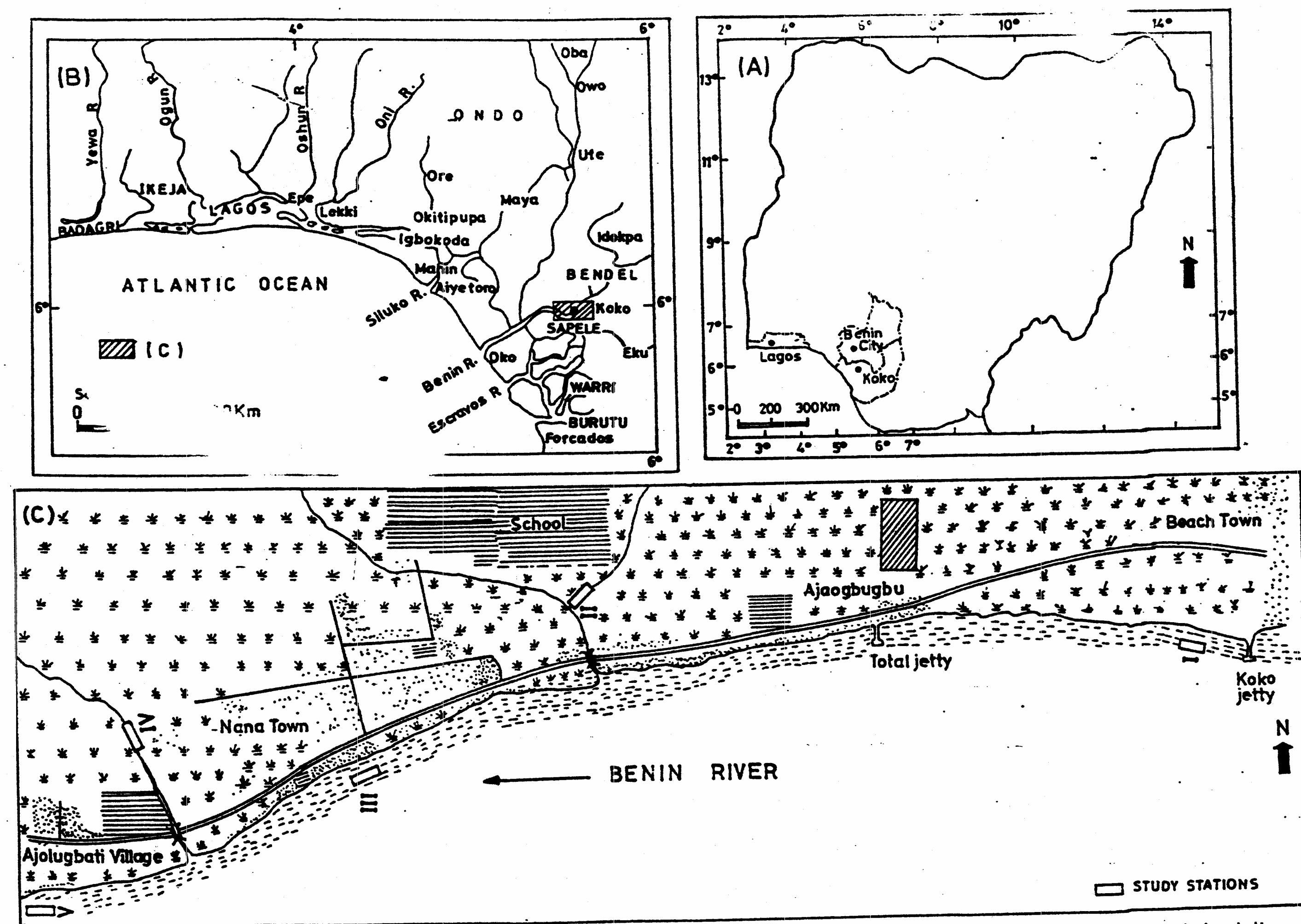

Fig. 1: Map of the study area; position of Koko in Nigeria (A), location of Benin River (B), Study stretch showing the location of study stations (C).

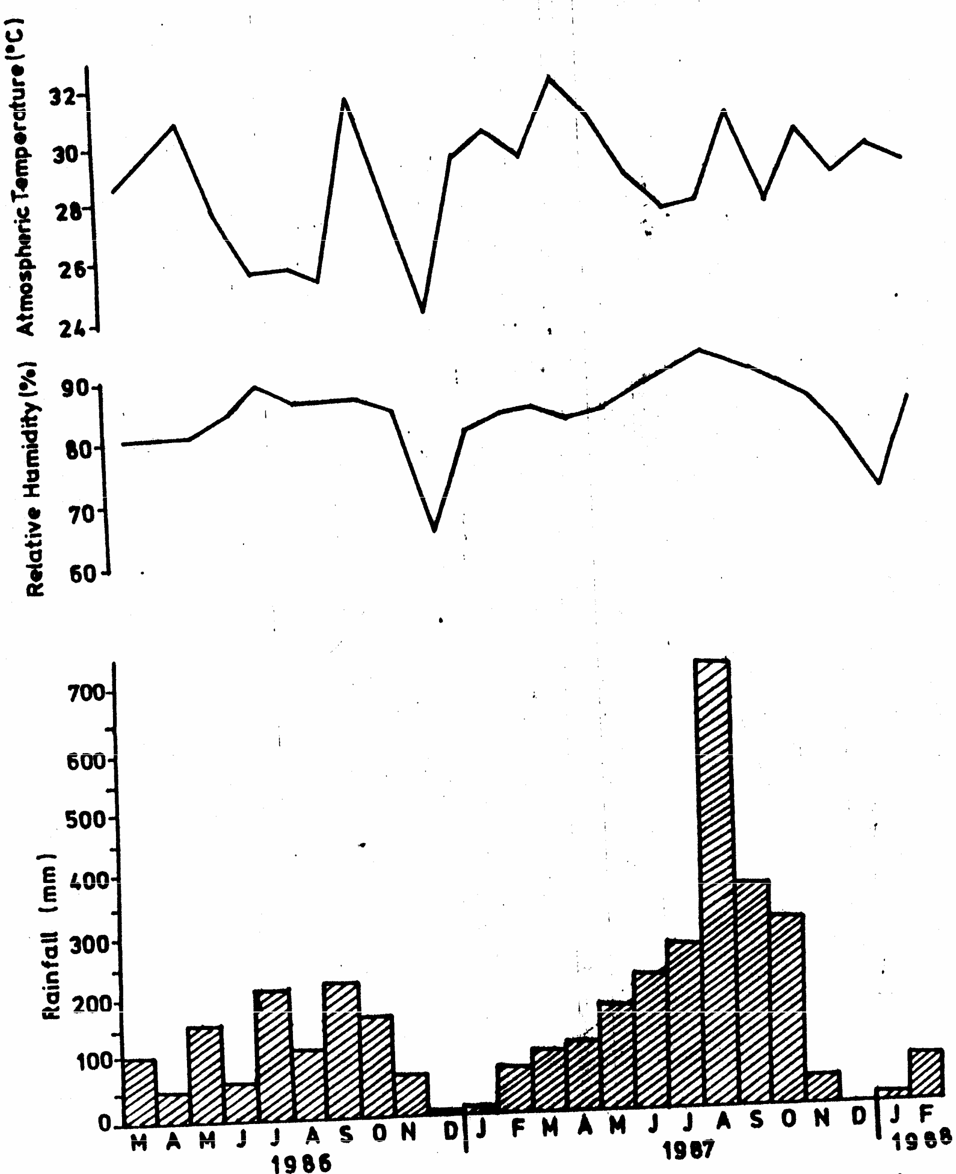

Fig. 2: Monthly variations in the mean atmospheric temperature (°C) mean relative humidity (%) and the rainfall (mm) at Koko from March 1986 to February 1988.

substratum is sandy, covered with a thin layer of mud. This station was relatively undisturbed with no humans activities.

Station II is located about 2.0km downstream of station I in the Otuepo creek, about 200m north of the main channel. The creek is fast flowing and its average width is 4m. The substratum is muddy with large quantities of allochthonous matter, mainly leaves from the surrounding vegetation. Human activities at this creek include fishing, mainly for prawns; the artisanal fisherman, children and women use baskets and dragnets during ebb tides.

Station III is situated along the main channel, about 3.5km downstream of station
1. The approximate width of the river at this location is 2,000m. The substratum near the north bank is fine sand covered with silt. This station was highly disturbed by human activities, which include fishing, washing of clothes and household utensils, bathing, defection and the various activities-associated with the local transport terminals.

Station IV is located in the Nana creek about 0.8km downstream of station III and about 200m north of the main channel. This creek has an average width of 6m and the flow velocity is slower than that of the Otuepo creek. The substratum is muddy with allochthonous matter, mainly leaves and fallen tree trunks. human activities include fishing for prawns and collection of water for domestic purposes.

Station V is located about 2.0km downstream of station III. This station is relatively calm at its north bank with no measurable flow velocity. The width of the river at this site is approximately 2800m. the river substratum at this station is fine sand covered with silt. Human activities are minimal, restricted mainly to fishing and occasional activities associated with idol worship.

Methods

A total five physical conditions were measured at fortnightly intervals for a period of two years. All were done in the field on each sampling on each day. The rainfall and relative humidity data were collected from the Meteorological Station, Benin Airport, Benin City, Nigeria. Air and surface water temperatures were recorded at each sampling station using dry bulb centigrade mercury-in glass thermometer to the nearest 0 .1^{o}C. A calibrated weighted line was used to measure the water level at predetermined points. Secchi disc visibility was used to measure the water transparency. The flow velocity was determined by the float method (Carlsson *et. at.,* 1974).

All statistical procedures were adopted from Zar (1984). the method for evaluating thermal astatism is that of Kamler (1965). Routine calculations were carried out with computer using Instant software.

Results

Table 1 show the summary of some physical conditions in the Benin River study stretch throughout the study period. The mean, maximum and minimum values for each parameters are given. The results of the analysis of variance (ANOVA) and the Duncan's new multiple range test are also presented.

The fortnightly and longitudinal variations in air water temperatures at all five stations are shown in Fig, 3. the mean water temperatures were generally higher than mean air temperatures at all stations in the first year and at stations 1, III and downstream of station I,III and V in the second year (Table 1). Variations in the air temperatures were similar at all stations (Fig.3). Generally, the air temperatures were low (< 27^{o}c) between June and September and relatively high (> 28$^{oc)}$ between February and March throughout the study period.

Variations in the water temperatures were similar to those of air temperatures at all stations (Fig. 3.) The water temperature (37^{o}c) was recorded at station III in late February 1986 and lowest (24^{o}c) at station II in early July 1986 (Fig. 3).

The highest water temperature (37^{o}c) was recorded at station III in late February 1986 and lowest (24^{o}c) at station II in early July 1986 (Fig. 3).

Table 1: Summary of some physical characteristics of the Benin River study stations for the first (March 1986 – February 1987) and second (March 1987 – February 1988) year study period.

		Station I			Station II			Station III			Station IV			Station V			ANOVA
		Mean ± S.E.	Max	Min	Mean ± S.E.	Max	Min	Mean ± S.E.	Max	Min	Mean ± S.E.	Max	Min	Mean ± S.E.	Max	Min	F-Value
March 1986 – February 1987	AT(°C)	27.77 ± 0.49	34.0	23.0	27.27 ± 0.46	33.0	22.0	27.42 ± 0.54	34.0	23.0	27.11 ± 0.49	31.0	22.0	27.48 ± 0.56	33.0	22.0	0.03
	WT (°C)	29.33a ± 0.31	33.0	27.0	27.83b ± 0.45	31.0	24.0	29.88a ± 0.40	37.0	27.0	27.73b ± 0.40	31.0	24.0	29.67a ± 0.40	35.0	25.5	6.22*
	WL (m)	0.56 ± 0.03		0.26	0.60e ± 0.04	0.96	0.27	0.92d ± 0.03	1.18	0.51	0.53c ± 0.03	0.80	0.23	0.69c ± 0.04	1.09	0.30	21.00*
	TP (m)	53.62e ±	87.0	62.0	4.38 ±	86.0	27.0	80.46f ± 3.50	110. 0	51.0	50.54c ± 3.50	78.0	30.0	61.61e ± 3.50	90.0	29.0	4.60*
	PV (Cms^{-1})	1.61g ± 3.53	12.4	0.0	10.49h ± 1.57	34.1 3	0.0	0.02^{l} ± 0.01	0.18	0.0	14.06^{l} ± 1.30	34.1 3	6.80	1.15g ± 0.50	9.10	0.0	32.40*
March 1987 – February 1988	AT(°C)	29.25 ± 0.38	35.0	25.0	28.56 ± 0.30	32.0	25.0	29.15 ± 0.50	35.0	25.0	28.65 ± 0.4	35.0	25.0	28.86 ± 0.4	34.0	25.0	0.51
	WT (°C)	30.35a ± 0.35	34.0	28.0	28.27b ± 0.40	34.0	25.0	30.19a ± 0.40	34.0	28.0	28.42 ± 0.4	34.0	26.0	30.38a ± 0.3	34.0	28.0	8.46*
	WL (m)	0.55 ± 0.42	0.95	0.14	0.57 ± 0.38	0.89	0.26	0.65 ± 0.51	1.10	0.19	0.49 ± 0.38	0.85	0.24	0.61 ± 0.48	1.05	0.20	1.97*
	TP (m)	52.35 ± 3.86	95.0	14.0	53.83 ± 3.6	85.0	19.0	56.35 ± 3.9	90.0	20.0	43.77 ± 3.3	85.0	8.0	54.04 ± 4.0	90.0	20.0	1.67
	PV (Cms^{-1})	0.19c ± 0.19	5.0	0.0	15.82d ± 1.38	30.0	2.0	0.0c ± 0.0	0.0	0.0	13.79 ± 1.4	25.0	0.0	0.0c ± 0.0	0.0	0.0	49.36*

Number of samples (n) = 26; * indicates significant difference ($P < 0.01$, ANOVA). Means with the same lower case letters in the same row are not significantly different ($P > 0.05$, Duncan's New Multiple Range Test).

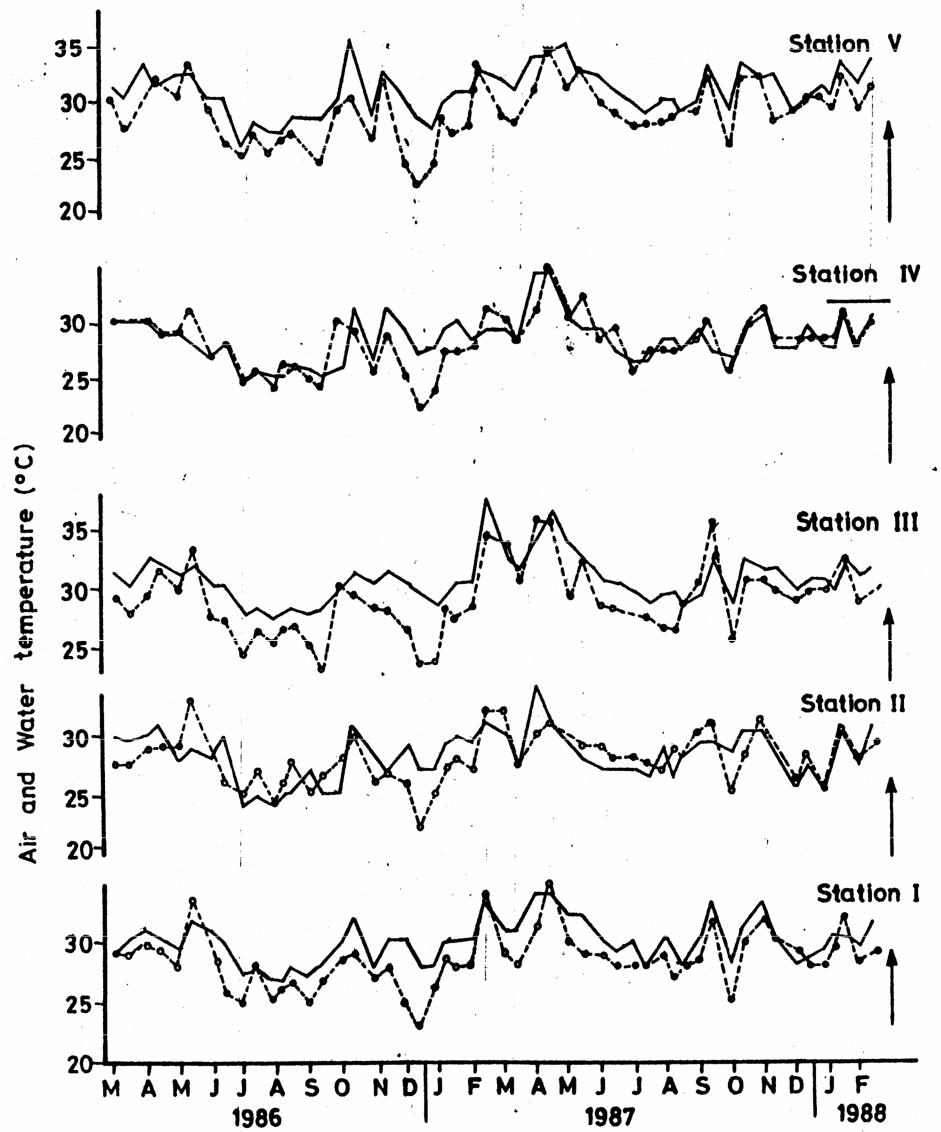

Fig. 3: Fortnightly variations in Air (o——o) and Water (——) temperatures, Benin river study stations March 1986-February 1988, arrows between stations indicate flow directions

The air temperatures were however, significantly different ($P < 0.01$) at all stations in both years (Table 1). Water temperatures at station II and IV were similar, but were significantly lower ($P < 0.05$) than water temperatures at stations I, III and V (Table 1).

The coefficient of thermal astarism for stations I-V respectively in the first (1.2,1.4,1.2,1.3,1.2) and second (1.2,1.3,1.4,1.3,1.4) years were similar.

Fluctuations in transparency at the study stations were irregular throughout the study period (Fig. 4). Transparency at the study stations was significantly different ($P< 0.01$) only in the first year (table 1). Transparency at station III was statistically higher ($P< 0.01$) than all other stations during this period.

Irregular fluctuations in water level were observed at all stations (Fig. 5). Relatively high water level (>0.70m) was recorded at all stations in September 1986. Low water level (< 0.50m) was observed at all stations in April 1986. There was statistical difference ($P< 0.01$) in the water level at the study stations in the first year (Table 1). Water level at station III was significantly higher ($P< 0.05$) than all other stations during this period (Table 1). The flow velocity values shown in figure 6 were significantly different ($P< 0.01$) at all stations throughout the study period (Table 1). Flow velocity at stations II and IV were similar and statistically higher ($P< 0.01$) than that of stations 1, III and V in both years (Table 1).

Discussion

The study stretch is located in the transitional of the Benin river estuary. Although this stretch is regarded as the upper brackish zone, the water was essentially fresh during the rainy season as indicated by the low salinity values observed during this period. However, the influence of high and ebb tides on this stretch was distinct. The conductivity range observed here also overlaps the values known for fresh and brackish water in Nigeria coastal delta (Courant *et. al.,* 1987).

Air and water temperature showed distinct seasonal fluctuations. The observed high temperature during the dry season and low temperatures during the rainy season are typical of the west African rivers (Awachie, 1981). The dry low air temperatures observed in the month of December during both years of the study were due to the cold, dry 'harmattan' wind. The influence of 'harmattan' period on the water temperature has earlier been reported (Egborge, 1972; Hare & Carter, 1984).

Fluctuations in the surface water temperatures generally follow that of the ambient air temperatures (Welcomme, 1979). The slight variations observed in this study were probably influenced by vegetation cover, rain run-off inflow, flow velocity and water level (Egborge, 1972, 1979; Bishop, 1973; Smith, 1975). The water temperature ranges recorded here were similar to those observed for other rivers and creeks in the Niger delta (Courant et. al., 1987; Fufenyin, 1987) and at Koko Courant et. al., 1987).The river water in this stretch is however, thermally stable, as indicated by the low coefficients of thermal astatism (Kamler, 1965) similar to those recorded for the thermally stable Gambak river in Malaysia (Bishop, 1973).

Distinct seasonal changes in transparency were not observed. The wave action along the banks of the main channel and the turbulent flow in the creeks agitating particulate matter from the substratum are reasons for the low transparency recorded here.

The water level in the stretch was influenced by the tides, thus accounting for the irregular fluctuations. The duel and seasonal fluctuations of tides in this river were not studied. The consistently high water level at station III was due to the location of this station, towards the mid-channel from the riverbank. The high values recorded at this station accounted for the significant differences $P < 0.05$) in water level when all stations were statistically compared in the first year; this influence, was however, not pronounced in the second year.

The flow rate observed at the boundary of the main river channel is characteristics of a river with laminar flow (Morisawa, 1968; Townsend, 1980; Ikusima *et al*., 1982). However, the streaming turbulent flow (Townsend, 1980) observed at the creeks flowing into the main channel was because of the slope.

In summary, however, the discussion on the physical environment of the study stretch that each station is controlled by a set of unique local conditions despite their proximity, thus emphasizing the importance of site-specific studies in the ecology of prawns in the Benin River.

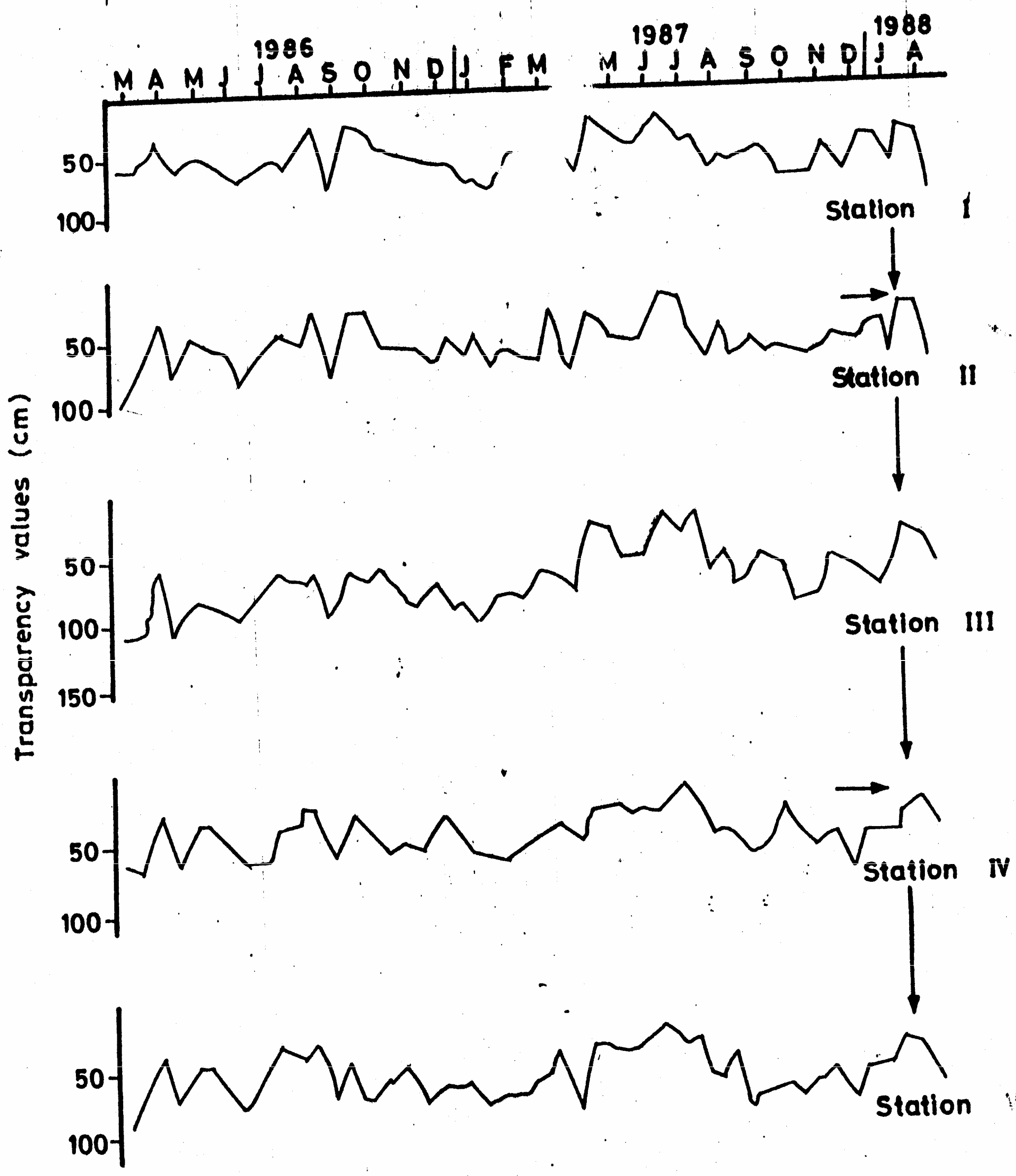

Fig. 4: Fortnightly variations in Transparency, Benin river study stations, March 1986 - February 1988, arrows between stations indicate flow directions.

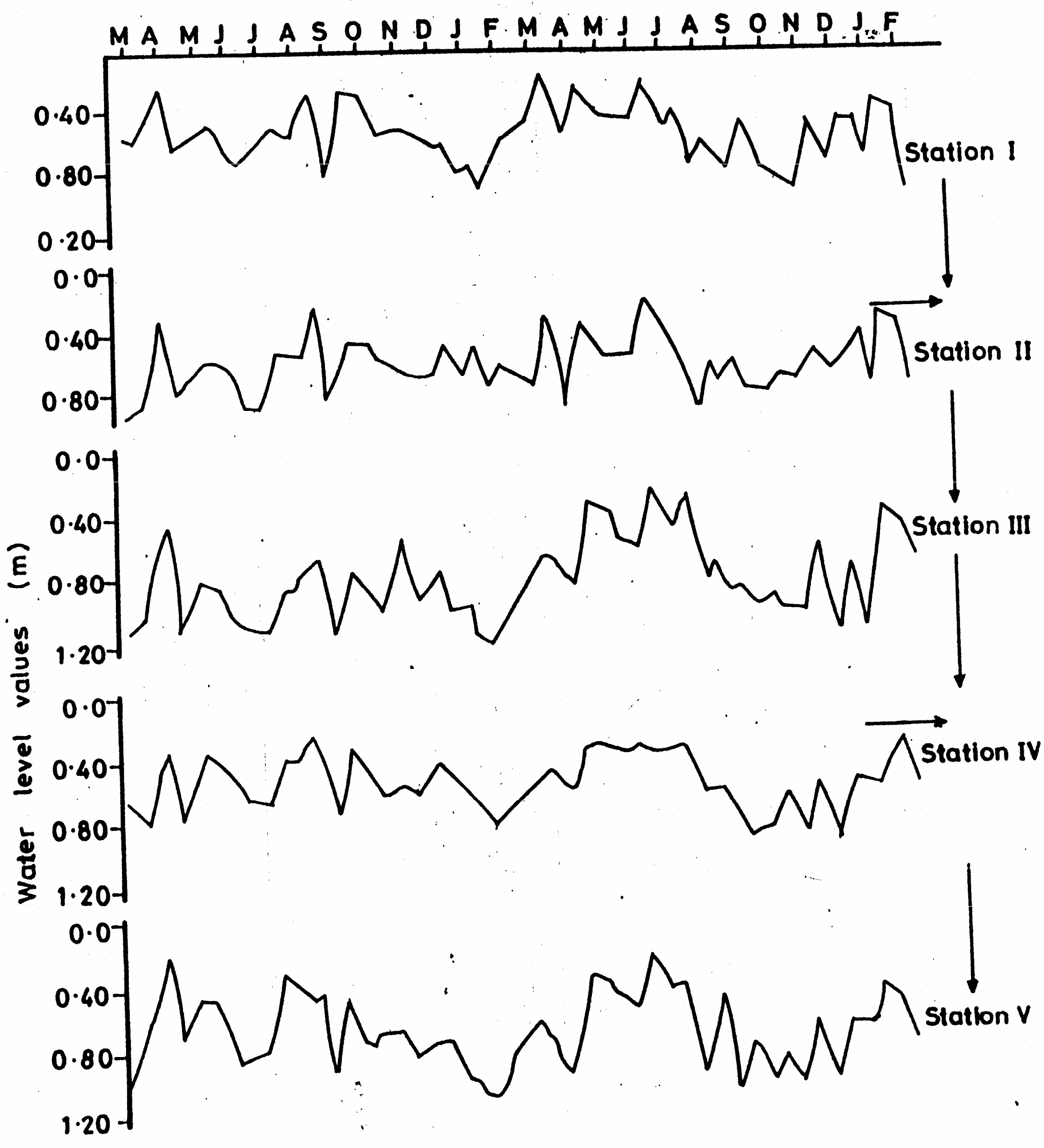

Fig. 5: Fortnightly variations in Water level, Benin river study stations, March 1986 - February 1988, arrows between stations indicate flow directions.

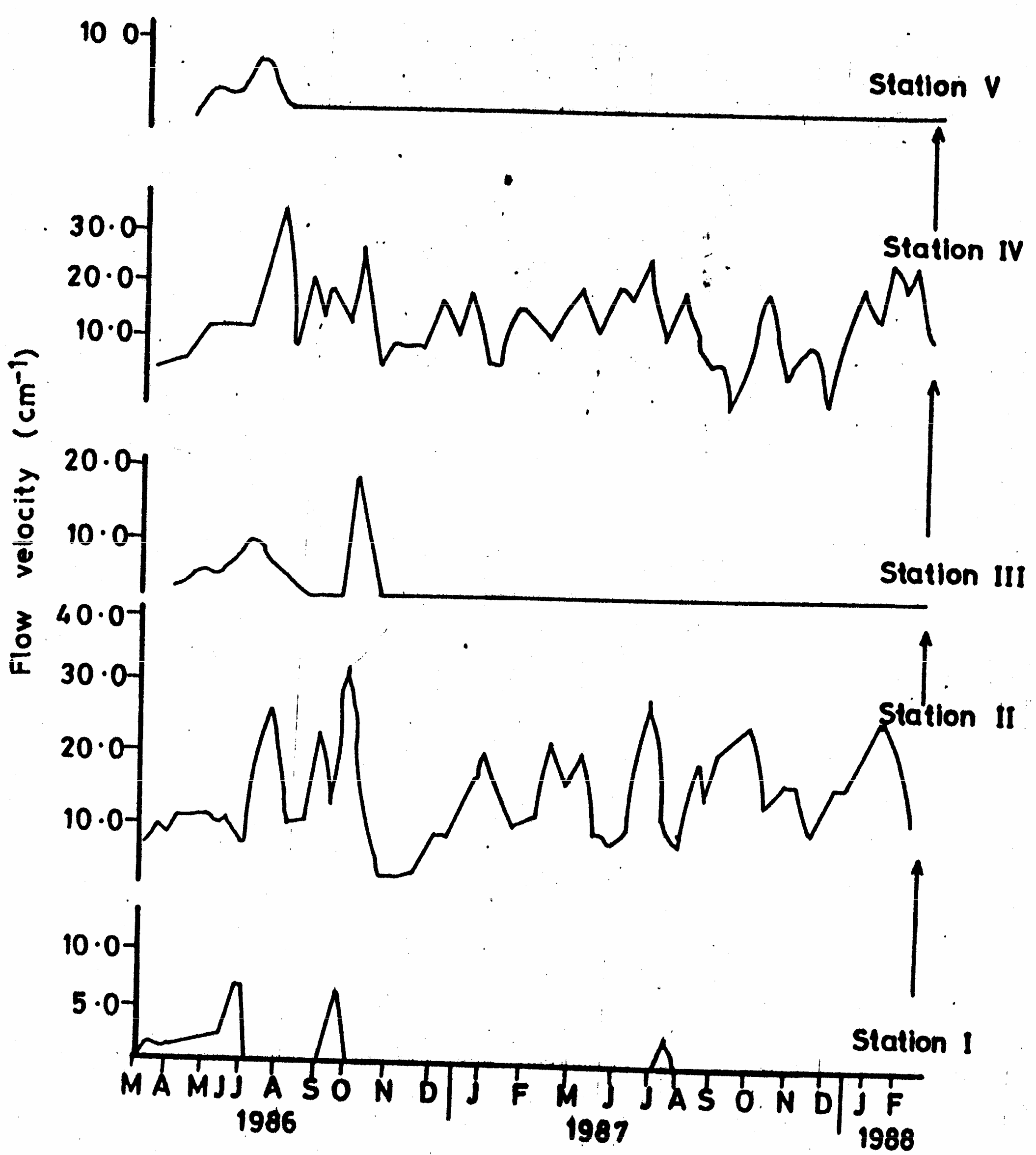

Fig. 6 : Fortnightly variations in Flow velocity, Benin river study, stations March 1986-February 1988; arrows between stations indicate flow direction.

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