The white shrimp, Neinatopalaemon hastatus is an indispensable condiment in most Nigerian dishes. The catch is dried and sold as crayfish, which is milled and used as flavour, and to nutritionally enrich foods. "Crayfish" has 70% protein (dry matter) (Mba, 1980). The supply of this condiment from south eastern Nigeria comes from two fisheries in the region, where the catch is composed of more than 75% by weight of N hastatus. These two fisheries are those of the Niger Delta and the Cross-River estuary. The ecology, and statistics on catch and income of the Niger Delta fishery have been studied by Marioghae (1981). The sex ratio and fecundity of N hastatus have been studied in some parts of the Niger Delta by Deekae (1981). Scott (1966) gave information on annual landing from filter traps for N. hastatus in the Niger Delta area, and puts it at about 1125 tons. Nsentip (1985) estimated that catches from the N hastatus fishery in the Cross-River estuary accounted for 11% of national fish landings between 1980-1984. Enin et al (1991) found the fishery to have: a catch composition of an average of 81.5% N hastatus; catch per unit effort with peaks in March/June, October/November i.e. beginning and end of rainy season, and troughs from July-September i.e. during the rainy season. The catch rates had a maximum value of 5.3 kg/net. Ofor (year) (in press) found the fishery to have the following composition by weight: 75% N hastatus, 10% Parapaeniopsis atlantica (Balss, 1914), 5% Exhippolysmata hastatoides (Balss, 1914), and 5% fish by-catch. The catch rates were found to have peaks in May and November, and a trough in July. The maximum CPUE was 5.7 kg/net.

From these, it can be seen that the N. hastatus fishery in the Cross-River estuary is of significant productivity and economic importance. There is therefore, a need for management of the fishery. A knowledge of the dynamics of the population of N. hastatus on which the fishery is based is an important tool in management. A first step in the direction of an understanding of the dynamics of the population of N. hastatus that supports the productive artisanal shrimp fishery in the outer Cross-River estuary is a study of the spawning pattern of the species.

Kunju (1979) developed a maturation key for the ovaries of Nematopalaemon tenuipes. He also reported that the occurrence of various breeding stages (as a percentage of total breeding females) in N. tenuipes in the Bombay coast in India had peaks between July and October and a trough in June. He also reported that breeding was all year round. Sagua (1981), even though with restricted sampling (June-September), noted that N. hastatus in the Lagos area spawns near ly throughout the year but had peaks between June and September, during the rainy season. Marioghae (1980) stated that N. hastatus in the Niger Delta area has a year-round, semi-lunar spawning rhythm, with peaks between June and October. But Fox (1978) found different patterns of oocyte size-frequency (indicating different spawning patterns) in different populations of Cottus gobio.

Materials and Methods

The Cross-River estuary is located as shown in figure 1. The estuary is fringed by white mangrove (Rhizophora...
sp.), red mangrove (*Avicennia* sp), and nypa palms (*Nypa fruticans*), with *Acorastichum aureum* (a brackish water fern) also occurring. The largest fishing village (at the time) Okposso, was chosen as the sampling site because more catch is landed there than all the other villages combined. The village was visited on a twice-weekly basis. A total of 91 such visits were made over a twelve-month period, from March 1989, to February 1990. On each visit 2 kg samples were taken from randomly picked boats to ensure a representative sample. The sample was immediately fixed in 10% formalin solution and were later sorted. The different species were identified according to the identification keys of Fisher et al. (1981), and Powell (1982). The individuals of each species in the sample were examined with a hand lens for gravidity and the post orbital carapace length (POCL) measured, according to Powell (1982). To determine the spawning pattern, the *N. hastatus* in each sample was weighted. The gravid *N. hastatus* was sorted from this, weighed and the weight expressed as a percentage of the total weight of *N. hastatus* in the sample. This was done over a period of 12 months. The nature of the gear used in the fishery has been described by Enin et al. (1991). The fishing process has been described by Ofor (in press). Monthly rainfall pattern of the study area was obtained from the Department of Geography and Regional Planning, University of Calabar. Student’s *t*-test was used to compare the proportion of gravid *N. hastatus* by tide. The grounds of the *N. hastatus* fishery in the Cross-River estuary range from inside the estuary (about 1.7 metre depth) to about 5km off-shore (about 15metre depth).

**Results**

Figure 2 shows rainfall values for the study period, in the Calabar area. The eggs in formalin-fixed samples were found to undergo colour changes from light orange to dark-brown with maturation. Gravid females with eggs in different stages of maturation were observed in the samples all year round. Fig. 2 shows monthly variations in the proportion of gravid female *N. hastatus* (as a percentage of the *N. hastatus* in sample), and monthly variation of this ratio by tide of fishery. This proportion had two distinct peaks of near-equal magnitude in the months of June (28.26%), and November (29.89%). It had two distinct troughs in May (8.7%) and October (10.19%). The daily values of the proportion of gravid females in June and November had peaks of 51.33% and 55.21% respectively. These peaks also were isolated. There was no significant influence of tide of fishery on this proportion (*P* < 0.05) (table 1).

<table>
<thead>
<tr>
<th>MONTH</th>
<th>WEIGHT (g)</th>
<th>TIDE (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>April '89</td>
<td>62.25</td>
<td>Ebb Tide</td>
</tr>
<tr>
<td>May</td>
<td>14</td>
<td>Flood Tide</td>
</tr>
<tr>
<td>June</td>
<td>102.5</td>
<td></td>
</tr>
<tr>
<td>Aug</td>
<td>80</td>
<td>16.25</td>
</tr>
<tr>
<td>Oct</td>
<td>40</td>
<td>3.5</td>
</tr>
<tr>
<td>Nov</td>
<td>6</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Table 1: Catch of *Exhippopolyxantha hastatoides* by tide of fishery in the *Nematopalaemon hastatus* fishery in the Cross-River estuary.

The proportion of gravid *E. hastatoides* (as a percentage of gravid *E. hastatoides* in the sample) had peaks in April and June, though this was clearly a function of the tide of fishery, and the part of the estuary that was fished. Fishing in the inner part of the estuary, adjacent to the fishing villages during ebb tide, produced a catch of *E. hastatoides* that has a greater proportion of gravid females, and vice versa.

The minimum POCL at which gravidity was observed in *N. hastatus* was 6.0mm. The minimum size of *N. Hastatus* encountered was 3.5mm POCL. Most *N. hastatus* 11.0mm POCL and above were gravid. All *N. hastatus* 12.0mm POCL and above were gravid. The minimum size of gravidity was observed for *E. hastatoides* was 8.0mm POCL. The minimum size of *E. hastatoides* in the sample was 4.0mm. Most *E. hastatoides* 11.0mm POCL and above were gravid. All *E. hastatoides* 12.0mm and above were gravid. The maximum size observed for *E. hastatoides* was 15.0mm POCL. The minimum size of *P. atlantica* in sample was 6.5mm POCL. The maximum was 35mm POCL. No gravid *P. atlantica* was encountered in the study. Egg formation in *N. hastatus* and *E. hastatoides* was seen to start from the carapace end of the abdomen and extend posteriorly. There was no *Penaeus notialis* (Perez-farfante, 1967) in the samples.

**Discussion.**

The *N. hastatus* population on which the artisanal shrimp fishery in the Cross-River estuary is based, spawns all year round, but has spawning peaks in the months of June and November. It has troughs in May and October (fig.1). This is because gravid females were observed in samples all year round though their proportion reached a peak in June and November. The lowest value was observed in May and October.

Planning, University of Calabar. Student's *t*-test was used to compare the proportion of gravid *N. hastatus* by tide. The grounds of the *N. hastatus* fishery in the Cross-River estuary range from inside the estuary (about 1.7 metre depth) to about 5km off-shore (about 15metre depth).
The peaks observed in the proportion of gravid females were very distinct and isolated. This is because, the months that had the highest proportion of gravid females were immediately preceded by months that had the lowest values for this ratio. The monthly values show peaks very rapidly attained and just as rapidly diminished. According to Kunju (1979) maturation of ovaries to hatching in *N. temeipes* are likely to be accomplished in one month. He reported peaks in proportion of breeding females between July to October, and the least values in June. Furthermore, the daily values of this ratio in this study trebled within one week to attain the peaks obtained in June and November. These daily peaks had halved within 1 week in June and within 2 days in November, indicating the presence of a strong stimulus to spawn. According to Sagua (1981) the incubation period of *N. hastatus* with ovaries in the berried-not eyed stage under laboratory conditions was 12 days, indicating a weakening of this impulse under laboratory conditions.

Because of the rapidity in attainment of peaks in the proportion of gravid females, and the very short period of time the peaks lasted, frequency of sampling of the population is a key factor in the accuracy of detection of trends in the spawning pattern in the population of the species. Unfortunately, most earlier studies in Nigeria on this species have had problems of very low sampling frequency, or a restricted sampling period. The correction of this situation informed the adoption of a twice-weekly sampling frequency. This may help explain the differences in months in which peak values were observed, between Marioghae (1980) and Sagua (1981). The differences may also be explained by the finding of Fox (1978), of different patterns of oocyte size-frequency (indicating different spawning patterns) in different populations of *Cottus gobio*.

From Fig. 1 it can be seen that July, one of the two months that had the highest proportion of gravid females, had the heaviest rainfall (603mm). November, the other month, had a very low volume of rainfall (98.3mm), and falls within the dry season. Thus, contrary to some reports the trigger for spawning in the species may not be rainfall, or any short-term changes associated with it. At best, rainfall may be said to be one of the triggers for spawning in the population. The progression of the population, from very low proportion of gravid females to the attainment of peaks in this ratio is very rapid. The decrease in this ratio is equally rapid. This indicates the action of a very strong, short-lived cue or trigger for spawning in this population of the species. This cue or trigger might be endogenous/inherent, or environmental in origin, or a combination of both. The factors responsible for this spawning pattern need to be investigated.

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