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Hydrographic Conditions and the Macrozoobenthos of a Coastal Wetland in Ghana

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ABSTRACT

The prevailing aquatic environmental conditions and their effects on the composition of the benthic macro-invertebrate community were investigated in a few ephemeral pools in coastal Ghana along the Kakum Estuary (about 2 km west of Cape Coast; 5° 6' N, 1° 18' W). Water and benthic sediments were sampled every month from five pools in the wetland from July 2009 to February 2010, and were analysed for six hydrographic parameters as well as the species composition and mean density of benthos.

Significant changes occurred in hydrographic conditions during the year. Water temperature, salinity, conductivity, turbidity, dissolved oxygen and pH were relatively low in July 2009 (27.9 °C, 0.7‰, 1,503 µS cm^{-1}, 78 mg L^{-1}, 3.5 mg L^{-1} and 6.9 respectively) but increased progressively to 46.6 °C, 5.7 ‰, 12,777 µS cm^{-1}, 304 mg L^{-1}, 5.7mg L^{-1} and 8.62, respectively, in January 2010. Chironomid larvae (Diptera) and oligochaetes were the only benthic fauna encountered. These organisms were abundant in the wet season (July –September 2009), with mean density of 258 to 1,375 individuals m^{-2} for diptera, and 81 to 203 individuals m^{-2} for oligochaetes. Their abundance and density however declined progressively during the dry season (November 2009 – January 2010) after which they were not found.

The increase in salinity stressed the macrozoobenthic fauna during the dry season leading to their extermination. The ephemeral nature of the environment conceivably resulted in the poor diversity of macro-zoobenthic fauna, and this could limit the development of the fish community.

Key Words: Marsh, Pools, Hydrographic Parameters, Benthic Macroinvertebrates, Composition, Density

INTRODUCTION

Lagoons, estuaries, seasonal and permanent rivers, streams, lakes, swamps, floodplains, marshes, ponds and pools are classified as wetland ecosystems under the "Ramsar Classification System for Wetland Type" (Ramsar Convention Secretariat 2007). These habitats share common features, the most important being the occurrence of continuous, seasonal or periodic standing water or saturated soils.

Macrozoobenthic fauna constitute a very important community in wetland ecosystems and are of immense ecological value due to their unique response to environmental changes. Reports have indicated that the composition and diversity of macro-zoobenthic community is closely linked to aquatic habitat conditions, with many species serving as biological indicators of pollution (Lafont et al. 1996, Richardson and Kiffney 2000, Arslan et al. 2007, Jenderedjian et al. 2007). Records of macrobenthic fauna are therefore used in assessing the biodiversity and environmental conditions as well as the ecological states of wetland systems.

Although the composition, diversity, biomass and density of benthic macrofauna of some wetland ecosystems in Ghana have been reported (Blay and Dongdem 1996, Gordon 2000, Yankson and Akpabey 2001, Lamptey and Armah 2008), these investigations focused on lagoons and estuaries, with no consideration for the adjoining coastal marshes. There is thus a paucity of information on the biodiversity of such ecosystems in Ghana, and the impacts of abiotic factors on their macroinvertebrate communities. Considering the fact that wetlands are dynamic systems with varying hydrological conditions (Acharyya and Mitsch 2001), and these changes in water quality, periods of anoxia and accumulating organic matter directly affect the macroinvertebrate and fish communities (Craft 2000), it is pertinent to understand the effects of the changing conditions on the aquatic fauna in a given locality. This study therefore seeks to provide information on the hydrographic conditions and the composition and density of the benthic macroinvertebrate community of a coastal marsh in the Central Region of Ghana.

MATERIALS AND METHODS

Study Area

The Kakum Estuary wetland is a coastal marshland and is located about 2 km west of Cape Coast in the Central Region of Ghana (5° 6' N, 1° 18' W) (Figure 1). The dominant flora include the saltwater couch *Paspalum vaginatum* (Poaceae), the sedge-grass *Cyperus articulatus* (Cyperaceae) and the bulrush *Typha australis* (Typhaceae). The thatch grass *Imperata cylindrica* (Poaceae) and coconut trees *Cocos nucifera* (Palmae) fringe the band of sandy beach separating the wetland from the Atlantic Ocean, while the western portion is bordered by mangroves. A characteristic feature of the area is flooding during the rainy season and isolated pools during the dry season. It is noteworthy that the mean monthly temperature over most parts of Ghana does not fall below 25 °C, with average annual temperature of 27 °C (Dickson and Benneh 1988). Absolute maxima approach 40 °C, especially in the north, with absolute minima descending to about 15 °C.

Aquatic Environmental Factors

The study was conducted from July 2009 to February 2010, covering parts of the rainy season and the dry season. Five pools in the wetland were selected and the surface area of each pool was estimated at the beginning of the study.The area (A) of the pools was determined from the measurements of the length and width or the diameter according to their shape. The maximum depth of each pool was also determined monthly at the deepest part using a meter scale.

Samples of benthic fauna and measurement of hydrographic parameters were undertaken between the 20th and 22nd of each month. Temperature, salinity and

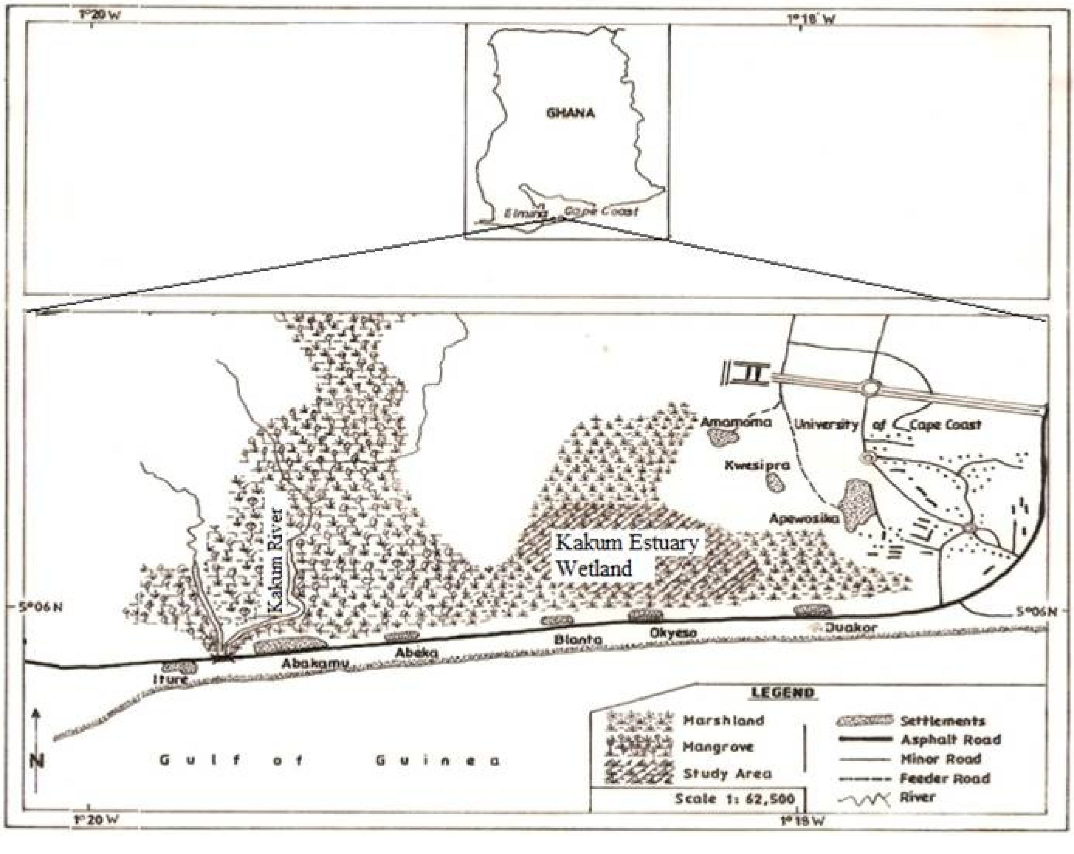

Figure 1. Map of Ghana showing the Kakum Estuary Wetland in Ghana

conductivity were recorded with aYSI Incorporated (Model 63) meter. Turbidity was measured with a turbidimeter (*TOA* Model TB-1A) and hydrogen ion concentration (pH) with a portable pH meter (Corning Incorporated Model 220). Dissolved oxygen (DO) content of pools was also determined by the modified Winkler's titrametric method using a HACH test kit (Model FF2). Three measurements of each parameter were taken at different points in each pool on a sampling date and the average value recorded.

Benthic Macroinvertebrates

Pool sediments were sampled in triplicate with an Ekman grab (15 × 15 cm) each month for esimating the benthos. The samples were screened in the field using a set of sieves (mesh size 4 mm, 2 mm and 0.5 mm), and the organisms retained in the sieves were preserved in 10% formalin for detailed examination in the laboratory. Prior to sorting out the organisms, the samples were dyed with Bengal rose to enhance their visibility. The macrofauna were identified with the help of manuals (Yankson and Kendall 2001, Hauer and Lamberti 2006). Counts of the different taxonomic groups were recorded for further analysis. The monthly percentage numerical composition of the different taxa of macrobenthos in the community was calculated. Due to the small number of grab samples (n= 3), counts of individuals belonging to each taxon in a sample were log transformed (Elliot 1977) for computation of the mean density of benthic organisms (number m^{-2}) in each pool.

RESULTS

Physico-chemical Factors

The surface area of the pools were 2680 m^2 (Pool V), 779 m^2 (Pools I) 759 m^2 (Pool III) 754 m^2 (Pool IV), and 661 m^2 (Pool II). The depth of the pools decreased steadily from the wet to the dry season months (Figure 2). Although the pools were generally shallow (< 100 cm deep), Pool V was deeper than the others throughout the study period. The pools dried between November 2009 and February 2010.

Figure 3 illustrates the monthly changes in the environmental parameters recorded. Water temperature increased from 27.9 °C in July 2009 to 42.1 °C - 43.6 °C in December 2009. In January 2010, the temperature of Pool V, the only remaining pool, was 46.6 °C. Monthly

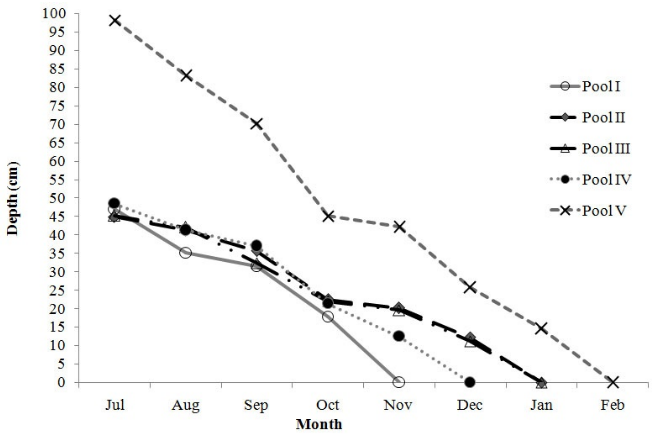

Figure 2: Changes in the depth of pools in the Kakum Estuary wetland in Ghana

salinity and conductivity of the pools did not differ much, with values ranging from 0.7 ‰ to 1.0 ‰ in July 2009, and increasing up to 5.7 ‰ in Pool V in January 2010. Conductivity was relatively low at the beginning of the study (1,503 to 2,302 µS cm^{-1}), but attained higher levels in December 2009 (11,387 to 11,930 µS cm^{-1}) and January 2010 (12,777 µS cm^{-1}). The turbidity also increased from 78- 91 ppm in July 2009 to 258-301 ppm in December 2009, and 304 ppm in January 2010 (Pool V). Dissolved oxygen in Pool V varied between 5.0 mg L^{-1} and 5.7 mg L^{-1} during the study period while the DO content of the other pools varied between 2.3 mg L^{-1} and 5.0 mg L^{-1}. The pH was slightly acidic to neutral in July-August 2009 but became alkaline after September (8.62 in Pool V).

Composition of Benthic Macroinvertebrates

Figure 4 illustrates the monthly composition of the macrozoobenthos in the five pools. Diptera (comprising exclusively of chironomid larvae) and Oligochaeta were the only representative groups in the benthos. In Pool I, the dipterans varied from 77.08 % to 88.68 % between July and September 2009, but declined to 9.76 % in October whereas the oligochaetes increased from 11.3-22.9 % to 90.24 % during the same period.

In Pool II also, Diptera (70 to 78.6 % of the total invertebrates) were most abundant during July to September 2009. Only two invertebrate specimens were collected in October, one of which was an oligochaete and the other a dipteran. No organism was found thereafter till the pool dried in January 2010.

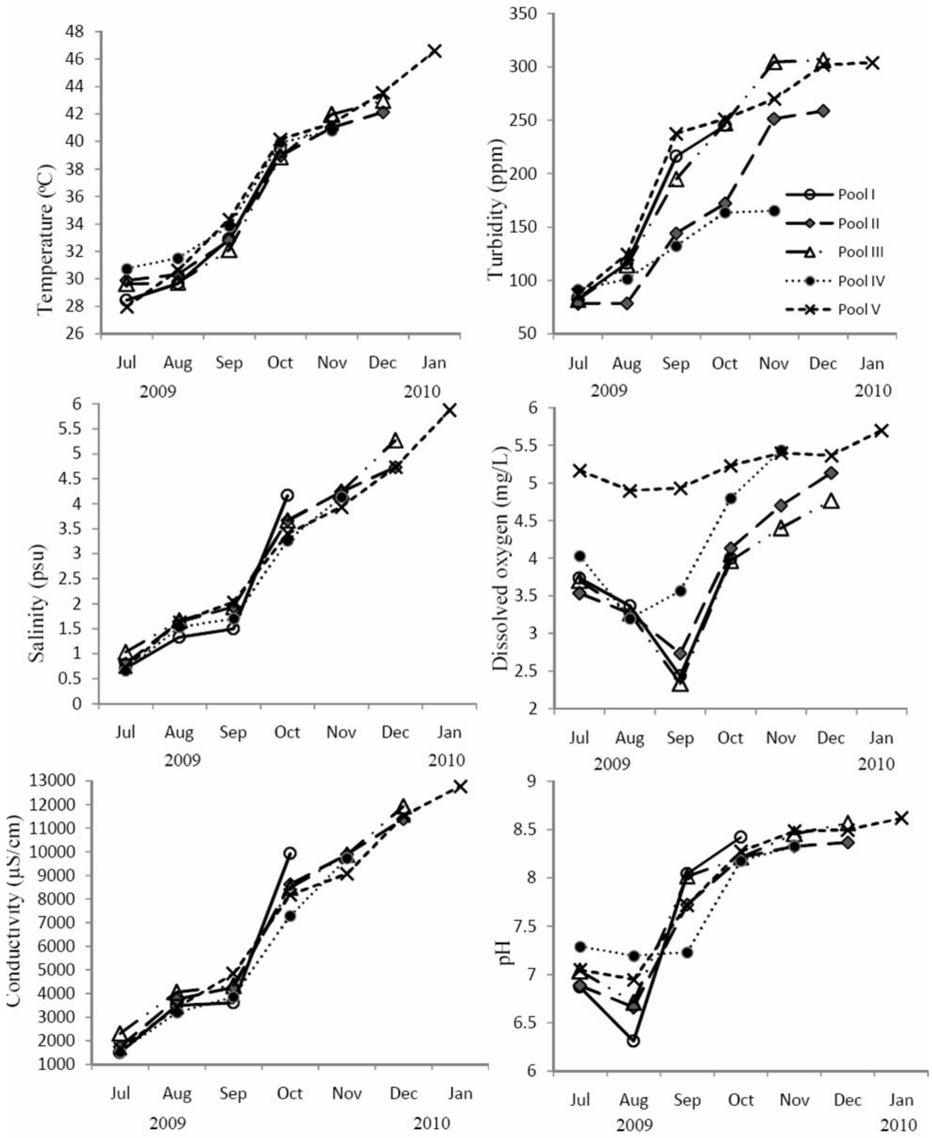

Figure 3. Changes in six environmental parameters of pools in the Kakum Estuary wetland in Ghana

In other Pools also the Diptera were the most abundant group during July to September 2009. In pool III, only seven individuals of oligochaetes were recorded in October 2009 and no benthic organism was found thereafter. In Pool IV and V, the chironomid larvae declined steeply in October whereas the abundance of oligochaetes increased sharply. There were only three individuals of oligochaetes in November, and only one survived in December 2009.

Variations in Density of Invertebrate Fauna

Figure 5 illustrates the changes in the densities of both diptera and oligochaetes. The mean density of dipterans in pool I ranged from 258 individuals m^{-2} to 648 individuals m^{-2} in July – September 2009, after which it declined to 71 individuals/m^2 in October. Oligochaete density increased from 81-112 individuals m^{-2} during July-September 2009 to 476 individuals m^{-2} in October.

In Pools II and III, the density of both the dipterans and oligochaetes declined gradually from July to October, after which they disappeared completely. The density of the two benthic groups followed nearly the same pattern also in Pool IV except that the density of oligochaetes increased slightly in October before dropping sharply in November. The mean density of dipterans

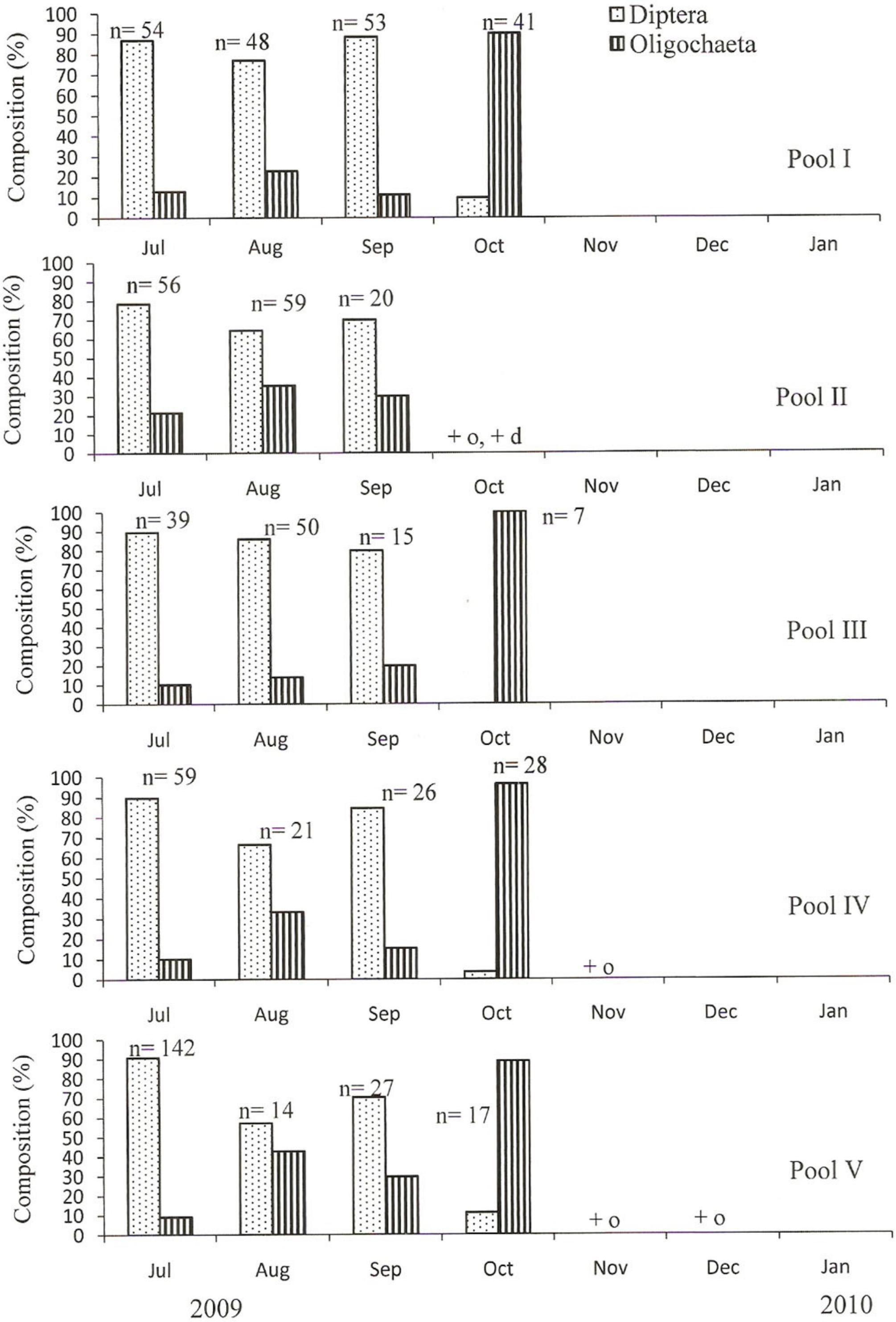

Figure 4. Percentage composition of benthic macroinvertebrates in the five pools in the Kakum Estuary wetland (n = number of benthic invertebrates, + o = 1 – 3 oligochaetes, + d = 1 dipteran)

in Pool V declined steeply from July to October 2009 after which no specimen was found. The density of oligochaetes varied during the study period.

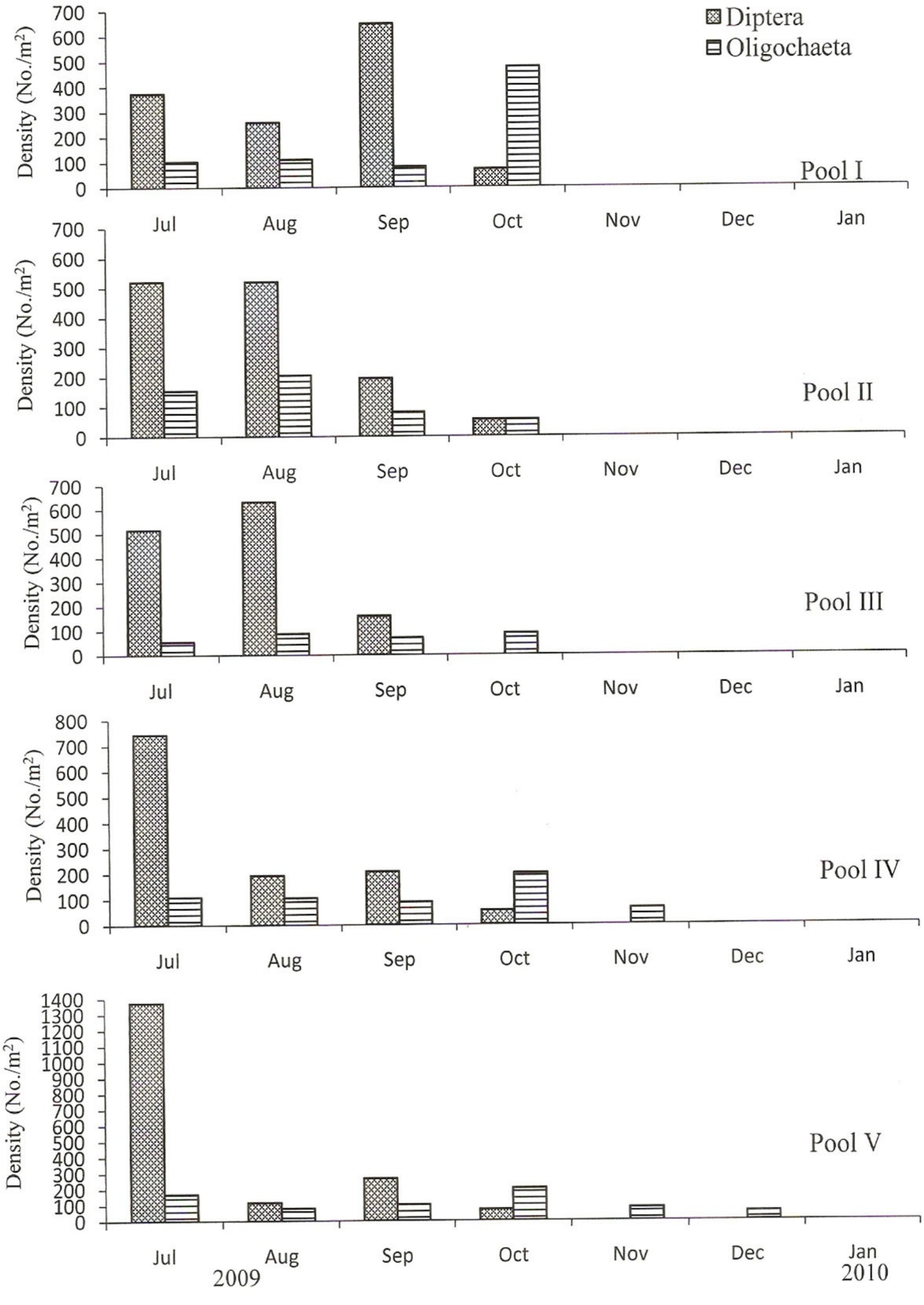

Figure 5: Monthly mean density of benthic macroinvertebrates in five pools in Kakum Estuary wetland in Ghana

DISCUSSION

The Kakum Estuary exhibits a highly dynamic and seasonal environment in which dry season pools occur for about eight months. There is no comparable information on the physico-chemical conditions of ephemeral pools in such coastal wetlands in Ghana. In our study, the pools started to dry up towards the latter part of the study possibly because of the sustained high water temperature enhancing evaporation. The increase in salinity and conductivity of the pool waters during the study period is similar to that reported for floodplain pools in Africa (Welcomme 1975) and is attributed to the concentration of dissolved ions with decreasing water volume (Rosenberg et al. 2001).

It is most likely that the increase in turbidity observed in all the pools was a result of increasing phytoplankton production during the dry warmer season (Howerton 2001). This is reflected in somewhat higher oxygen concentration during the same period. Similarly, the relatively low oxygen levels (≈ 2.5 mg L^{-1}) and the slightly acidic to neutral conditions (pH = 6.5 to 7.5) of the pools in the wet season may have been caused by increased rate of decomposition of allochthonous organic materials. These might as well be attributed to flows from the Kakum River which reportedly has a low pH (Bosque-Hamilton et al. 2004).

The oligochaetes and chironomid larvae were abundant in the wet season but gradually declined in abundance as the dry season progressed and the pools reduced in size. This may be attributed partly to the increasing salinity of the pools. Gordon (2000) and Lamptey and Armah (2008) reported a similar reduction in the abundance of macroinvertebrate community in Muni lagoon and Keta lagoon in Ghana. Bervoets et al. (1996) and Berezina (2004) reported the upper limit of salinity for survival of freshwater oligochaetes and midges as 6‰ to 8‰. In our study, the salinity was >4 ‰ during October 2009 to January 2010.

Poor representation of benthic invertebrate fauna in these pools is somewhat similar to that of the nearby Fosu lagoon which has only four species of gastropods and three insect larvae, including chironomids (Blay and Dongdem 1996).

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