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Microhabitat preference, diversity and ecology of aquatic mites in a municipal stream in the Niger Delta

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ABSTRACT
Objective: Information on water mite assemblages from afrotropical streams is scanty. This study investigates aspects of the ecology of the aquatic mites of the Orogodo River, Niger Delta, Nigeria.
Methodology and results: The study was carried out between January and June 2006. Water samples and aquatic mites were collected from four different microhabitats in Orogodo River, analyzed and studied. The water at the site of sampling was slightly acidic at pH 5.8 - 7.4, water temperature ranged from 24.6 to 33.7°C, dissolved oxygen 6.6 - 8.4mg/l and Biochemical Oxygen demand (BOD) 1.9 - 4.0mg/l. These parameters fluctuated within the normal range suitable for habitation of macroinvertebrates intolerant to organic pollution. A survey of different microhabitats in the stream revealed that water mites were widely distributed but relatively less abundant. A total of 386 mites belonging to five species in five families were recorded. *Arrenurus damkoehleri* and *Piona africana* were the dominant mites with the latter being the most ubiquitous species recovered from all microhabitats studied. *Encentridophorus* was the least abundant, recovered only from litter in riffle. Based on the ecological requirements, the mites fell into three groups namely, helocrene, rheocrenes and limnocrene. The number and diversity of mites were found to be more abundant in the macrophytes and riffle microhabitats compared to other microhabitats as indicated by the rather high Simpson dominance (0.755) recorded for the pool. Typical standing water dwellers represented only a small fraction of the species sampled. A principal component analysis clearly grouped the various mite species with the microhabitat having the greatest influence on their distribution.
Conclusion and application of findings: This study has elucidated the general paucity of aquatic mites in afrotropical streams with only five species recorded. Water mites were more common in macrophytes, possibly as a result of their association with plants for shelter and food. From an earlier investigation in this river, aquatic mites were only recorded from the present site of sampling as opposed to other stations of the river affected by organic pollution indicating that this group of organisms could be incorporated as indicator organisms for biomonitoring programmes especially in the afrotropical region.

Key words: Aquatic mites, *Arrenurus, Poina,* microhabitat, flow velocity, Orogodo River.

INTRODUCTION
Biomonitoring is a central component of water resource management worldwide (Rosenberg & Resh, 1993), and various groups of macroinvertebrates are currently used for this programme (Barbour *et al*., 1999; Buss & Salles 2007; Arimoro & Muller, 2009). Investigations of the ecology and distribution patterns of aquatic mites have been largely from lentic biotopes in the

temperate and Mediterranean countries (Heino, 2002; Wetzel, 2002; Di Sabatino *et al*., 2004). Studies of the ecology of water mites as bioindicators and as a special group of macrobenthic invertebrates are few in Nigeria. Information from literature concerns other macroinvertebrates (Ogbeibu & Victor, 1989; Edokpayi *et al.,* 2000; Ogbeibu & Oribhabor, 2002; Adakole & Annune, 2003).

Investigation on the macroinvertebrates of the Ikpoba River to assess the environmental impacts associated with road and bridge construction was undertaken by Ogbeibu and Victor (1989). They recorded five genera of aquatic mites in the river namely *Hydryphantes, Arrenurus, Encentridopohorus, Piona* and an unidentified species. *Arrenurus damkoehleri* was the most common species of mite encountered and the greatest number of mites was recovered from the bankroot biotope compared to other ecological microhabitats. Edokpayi *et al.* (2000) recorded a total of three genera of aquatic mites namely *Arrenurus, Encentridopohorus* and an unidentified species, Type A from Ibiekuma stream in Ekpoma, Edo State, Nigeria. These genera of mites were mostly common in areas of low flow velocity. Adakole and Annune (2003) recorded only one species of aquatic mite (*Hydrachna*) while working on the benthic macroinvertebrates of River Galma and Bindare stream in northern Nigeria. The low abundance of aquatic mites in their study was attributed to the high pollution level of the water body that prevented the less tolerant mites from surviving. Ikomi *et al.* (2005) recorded only two species, *Hydrachna* and *Hydrobates* from the unperturbed reaches of River Ethiope in the Niger Delta.

Mite species exhibit very narrow tolerance ranges for environmental factors such as dissolved chemicals and pH, and this has led several authors (Young, 1969; Smith & Cook, 1991; Williams & Williams, 1996; Smit *et al*., 2000) to advocate their potential as biomonitors of environmental change, both for man-made and natural water bodies. Some authors, notably Berhe (1989), Chindah *et al. (*1999), Dobson *et al* (2002) and Egborge *et al. (*2003) who worked extensively on the distribution and abundance of macrobenthic invertebrates in some Nigerian and African streams did not encounter any aquatic mite in their study, largely due to the deteriorating state of the water bodies studied.

Although the number and frequency of biomonitoring studies in Nigeria and indeed Africa has being on the increase in the last decade, great gaps still exist even in our basic knowledge. This study is therefore intended to provide some baseline information on the ecology of aquatic mites of Orogodo River in southern Nigeria. Studies of this nature will increase the understanding of group-specific requirements which will perceptibly extend the basis for future data analysis.

MATERIALS AND METHODS

Description of the study area: The Orogodo River is the longest river in the Ika-axis of Delta State in the southern part of Nigeria. It lies between latitude $5^{\circ}10^{1}$-$6^{\circ} 20^{1}$N and longitude $6^{\circ} 10^{1}$- $6^{\circ} 21^{1}$E (Fig. 1). The full description of the river and the sampling station are given elsewhere (Arimoro *et al.,* 2007a & b).

For the purpose of this study, aquatic mites were collected from four (4) distinct microhabitats from the river. These were riffle, pool, macrophytes, and under logs in the water at the site indicated in Fig. 1. The water depth at this point is about 0.72m and width of about 3.5m. The water velocity at this station is low (mean value=0.14m/s). The vegetation cover is thick with dense tunnel of trees, and consists mainly of emergent and floating macrophytes such as *Nympheae lotus, Pistia stratiotes, Azolla* sp. and *Utricularia* sp. The marginal vegetation is composed mainly of very tall oil palm (*Elaeis guineenis), Raphia vinifera* (P. Beauv.), *Havea brasiliensis* (Muell. Arg.) and *Cocos nucifera* (L). Human activities in this station include paddling of canoes and bathing.

Water sampling and collection of aquatic mites: Water samples and aquatic mites were collected from the sample site between 09.00 and 11.00 H on each sampling day. The sampling was carried out once on a monthly basis beginning from January to June 2006. Surface water temperatures were recorded with a thermometer. Conductivity, pH, total alkalinity, dissolved oxygen and biochemical oxygen demand (BOD_5) were determined according to APHA (1992) methods. Other parameters measured included water velocity using the flow method as described by Gordon *et al*. (1994). Measurements were taken in the mid channel on three occasions by timing a float (average of three trials) as it moved over a distance of 10 m. Nitrate-nitrogen (NO_3-N) and phosphate-phosphorus (PO_4-P) were measured spectrophotometrically after reduction with appropriate solutions (APHA, 1992).

For aquatic mite recovery, samples were collected by stirring up the bottom debris and catching the suspended material with a small dip net of mesh size 154µm in the pools and riffles. Handpicking, dip netting and washing out vegetation in enameled pan were used in sampling of the macrophytes and under logs in water. Aquatic mites collected were preserved in 70% ethanol, identified and enumerated using the identification guides (Pennak, 1978; Tachet *et al.,* 1980; de Moor and Day 2002).

Data analysis: The mean and standard error of means of the physicochemical parameters of the study sites were determined using Microsoft excel programme. Taxa richness, diversity and evenness indices were calculated using the computer BASIC programme SP DIVERS (Ludwig & Reynolds, 1988). Hutcheson T-test was used to compare the diversity indices of aquatic mites between the various microhabitats studied. A Principal Component Analysis (PCA) was performed to determine relationships between microhabitats and aquatic mite species. Values were standardized for normality and Log_{10} (x+1) transformed to achieve conditions of normality of the data. Ordination by cluster analysis with single classification was performed for the microhabitats.

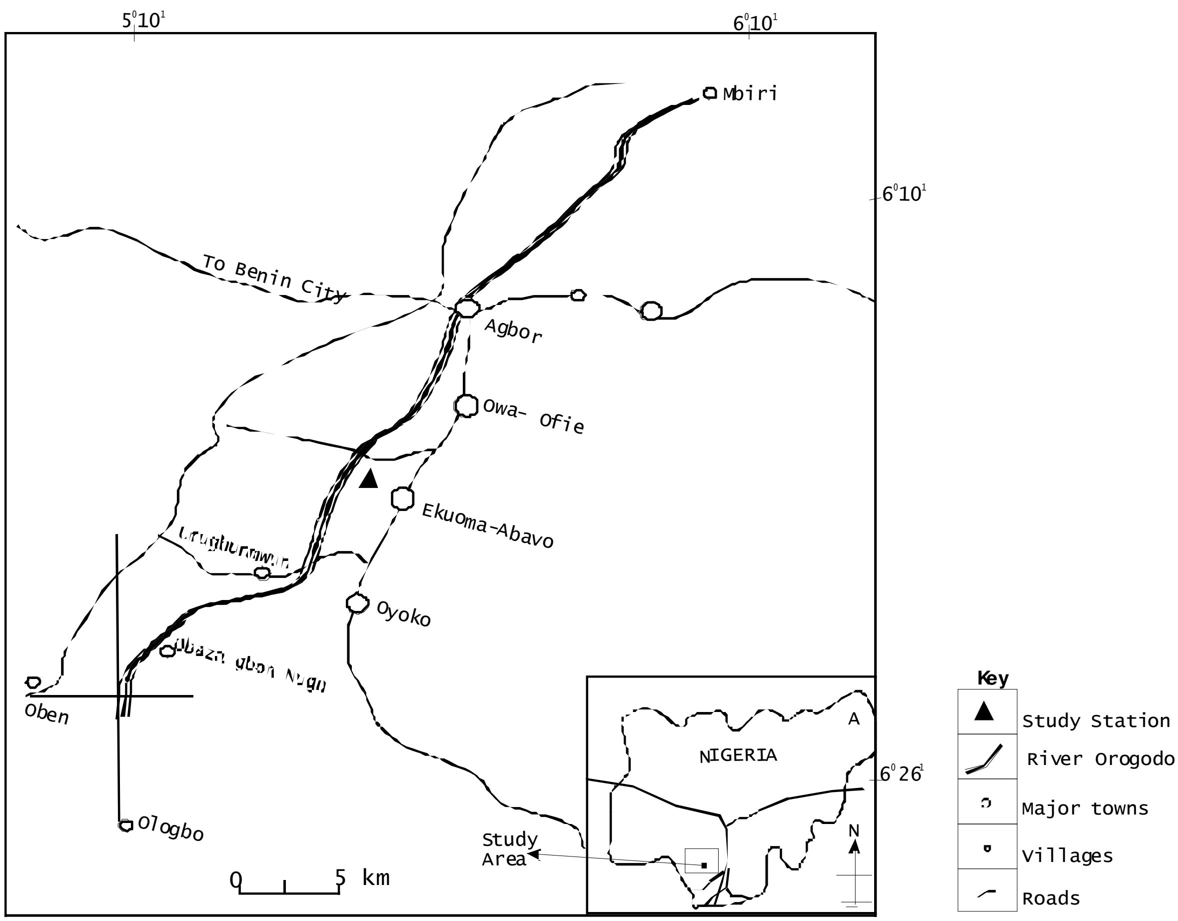

Figure 1: Map of the study area showing the sampling station.

RESULTS

The mean, minimum and maximum values of physical and chemical parameters are summarized in Table 1. Atmospheric and surface water temperatures were generally higher than water temperatures at the study site and at all sampling times except on rainy days when water temperatures were slightly higher. Air temperature fluctuated between 24.6 and 33.7^{o} C with a mean value of 25.9 ± 0.47 ^{o} C. Temperatures were generally higher in the dry season months and lower in the rainy season months of May and June.

Flow velocity was relatively low in the sampling stretch. At the riffle, the flow velocity was 0.2m/s and as low as 0.09 m/s in the bankroot biotope. Conductivity varied between 19.4 and 92.6 S/cm, while total alkalinity fluctuated between 8.06 and 10.62 with a mean of 9.29 ± 0.132 mg/l. The river was rich in nutrients, especially nitrates and phosphates. Nitrates fluctuated between 0.14 and 0.32 mg/l with higher values recorded in the dry season months. Biochemical oxygen demand was consistently low and the amount of dissolved oxygen remained between 6.6 and 8.4mg/l throughout the sampling period.

Table 1: Physico-chemical conditions of water in the sampling area of Orogodo River, Nigeria, between January and June, 2006.

Parameter	Range	Mean ±S.E.
Physical		
Air Temperature (^{0}C)	24.6 – 33.7	28.98 ± 0.47
Water Temperature (^{0}C)	24.4 – 30.4	27.16 ± 0.30
Water Depth (m)	0.54 - 0.96	0.76 ± 0.03
Flow Velocity (m/s)	0.09 - 0.26	0.143 ± 0.007
Conductivity (µScm^{-1})	19.4 – 92.6	38.52 ± 3.52
Chemical		
Dissolved Oxygen (mgl^{-1})	6.6 - 8.4	7.61 ± 0.12
BOD5 (mgl^{-1})	1.9 - 4.0	2.72 ± 0.119
Total Alkalinity (mgl^{-1})	8.06 - 10.62	9.29 ± 0.132
pH	5.8 - 7.4	6.43± 0.08
Nitrates (mgl^{-1})	0.14 - 0.32	0.250 ± 0.010
Phosphates (mgl^{-1})	0.018 - 0.026	0.024 ± 0.001

Composition, distribution and abundance of aquatic mites: A total of 5 species of aquatic mites belonging to five families were identified from the different microhabitats in the study station (Table 2). The total number of genera in the different microhabitats was 4, 2, 4, and 3 in riffle, pool, macrophytes and under logs, respectively. The total number of individuals collected from riffle, pool, macrophytes and under logs were 98, 14, 221, and 53, respectively. The overall abundance of aquatic mites was significantly different ($p< 0.05$) among the four microhabitats sampled. Macrophytes and riffles had significantly higher density ($p < 0.05$) of individuals than the other microhabitats studied. Macrophytes contributed 57.25% of the total aquatic mites density followed by riffle with 25.39%, and pool with only 3.63 % of the total aquatic mites' density.

Piona africana was ubiquitous and the most commonly encountered mite in all the microhabitats sampled. Although *Arrenurus damkoehleri* recorded the highest density (32.9%), it was completely absent from the pool collection. *Hydryphantes incertus* was mainly collected from macrophytes with only two individuals recorded in the pools while *Encentridophorus spinifer* was restricted to the riffles. The family most represented was Arrenuridae followed by Pionidae, while the family Unionicolidae was least represented in the river system (Fig. 2).

In order to determine which microhabitats were associated with mite species distribution a

Principal Component Analysis (PCA) was performed. PCA first and second axes were significant and accounted for 62.04 and 31.37% of the total variance explained, respectively. According to the PCA ordination (Fig. 3), the species *Arrenurus damkoehleri*, *Hydryphantes incertus* and *Hydrachna* sp were strongly associated with macrophytes and occurred on the negative group of the quadrant in axis 1. *Piona africana* had no quadrant preference while *Encentridophorus spinifer* was strongly associated with the riffle microhabitat. The pool was not associated with any mite species and is described as an outlier in the ordination. Similarly, ordination of the microhabitat by single classification (Euclidean) showed a clear separation of the riffle and macrophyte microhabitat from the pools and underlogs which were not much different from each other (Fig. 4).

Table 2: Composition, distribution and abundance of aquatic mites in Orogodo River, Nigeria.

Family	Taxon	Riffle	Pool	Macrophytes	Under logs
Hydryphantidae	*Hydryphantes incertus*	-	2	44	-
Arrenuridae	*Arrenurus damkoeleri*	46	-	67	14
Unionicolidae	*Encentridophorus spinifer*	11	-	-	-
Pionidae	*Piona africana*	22	12	52	27
Hydrachnidae	*Hydrachna* sp	19	-	48	12
	Total no. of individuals	98	14	221	53
	No. of Species	4	2	4	3
	Composition of individuals (%)	29.39	3.63	57.25	13.73

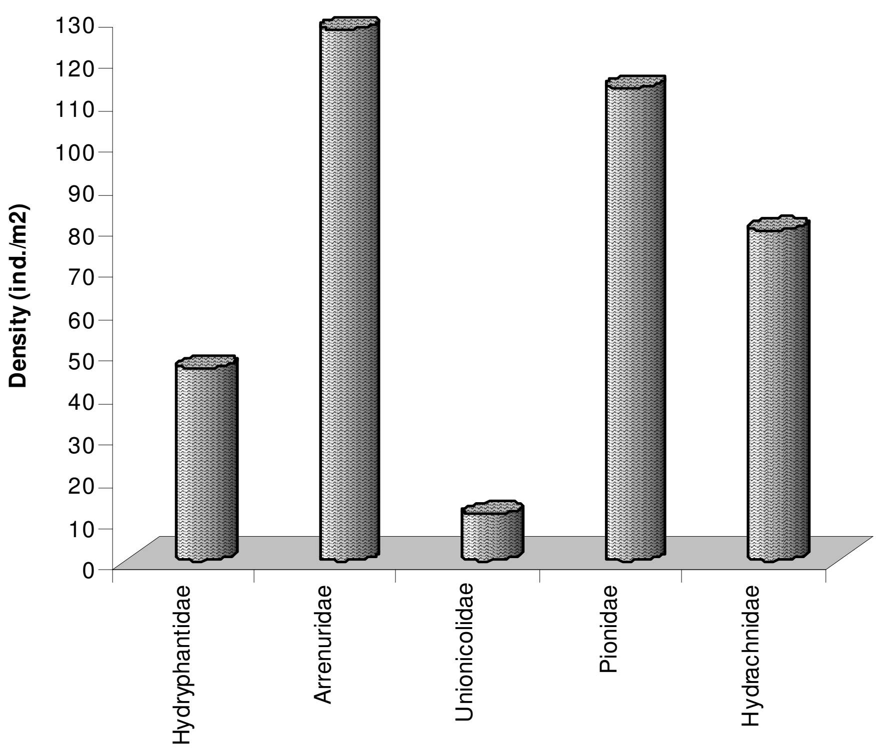

Figure 2: Major families' composition of aquatic mites in Orogodo River, Nigeria.

The diversity, taxa richness and evenness were better (0.561, 1.373 and 0.991, respectively) in macrophytes biotopes compared to the other microhabitats studied (Table 3). The riffles followed closely with taxa richness and diversity of 0.65 and 1.25, respectively. The pools recorded poor evenness values and diversity indices and very high dominance index (0.755). Comparing the diversity of the various microhabitats using Hutcheson T-test revealed that the diversity indices of the macrophytes and riffle microhabitats were similar and significantly (P<0.05) different from the diversity indices of the pools and under logs microhabitats. On the other hand, the under logs microhabitat had significantly better (P<0.05) diversity values than the pools.

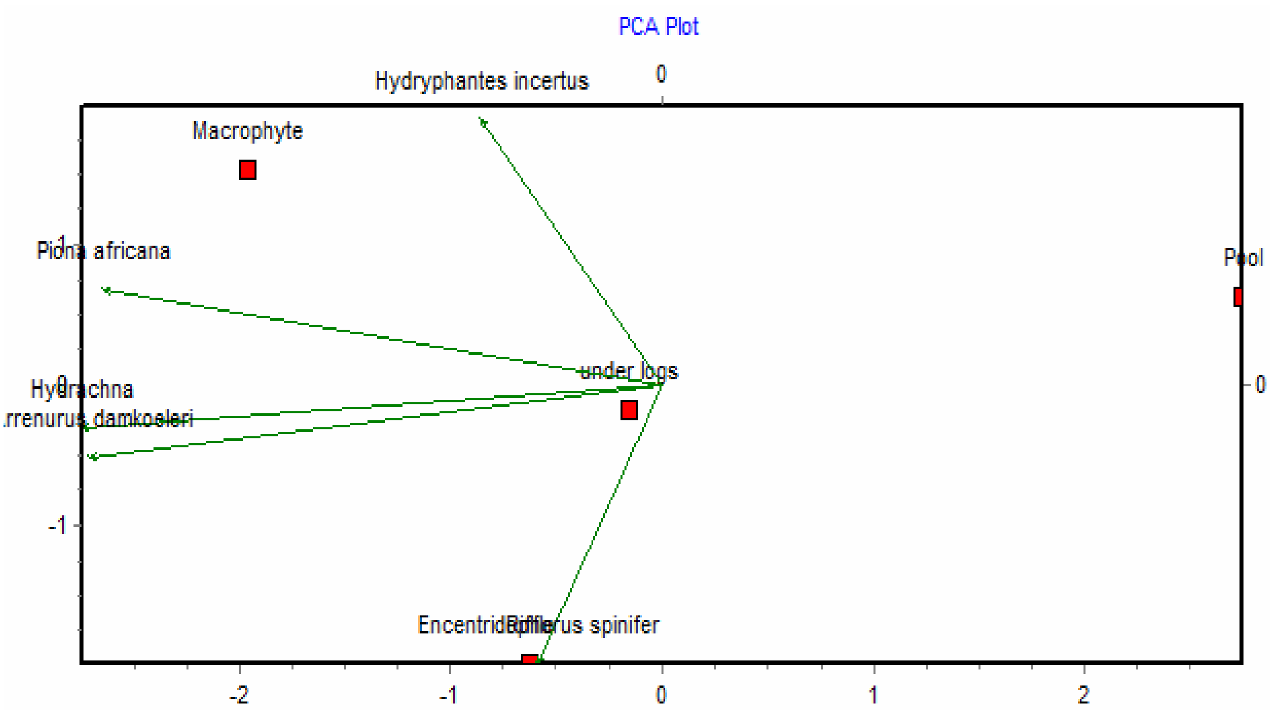

Figure 3. Principal Component analysis (PCA) ordination plots for microhabitats and aquatic mite species in Orogodo River, Nigeria

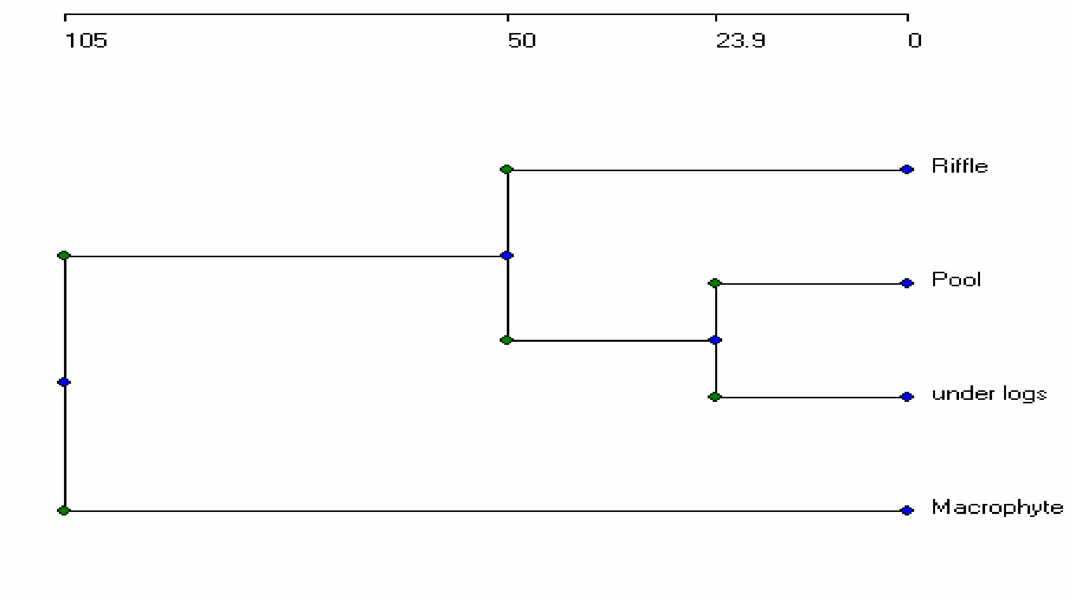

Figure 4: Dendrogram for hierarchical CLUSTER analysis of all microhabitat studied with respect to the distribution of aquatic mites in Orogodo River, Nigeria.

Table 3: Diversity, taxa richness, evenness and dominance indices of aquatic mites in River Orogondo, Nigeria.

Parameter	Riffle	Pool	Macrophytes	Under logs
No. of individuals	98	14	221	53
No. of species	4	2	4	3
Taxa Richness	0.654	0.379	0.561	0.504
Shannon diversity	1.254^{bc}	0.401^{a}	1.373^{b}	1.032^{c}
Evenness Index (E)	0.905	0.592	0.991	0.939
Simpson's Dominance	0.321	0.755	0.257	0.381

Note: Shannon diversity values with the same superscript are not significantly different using Hutcheson T- test for comparison

DISCUSSION

The results of this study showed that the physical and chemical conditions of the study site of Orogodo River fluctuated within normal range required for the survival of mites. According to Williams and Williams (1996), the factors that influence the occurrence of aquatic mites in freshwater are water chemistry, pH, water depth, current speed, riparian vegetation, aquatic vegetation, substrate size and texture, and water temperature, among others. Changes observed in air and water temperature as in most physical and chemical parameters were primarily governed by the local climatic conditions. For instance, rainfall is a major ecological factor, which influences the physical and chemical hydrology of rivers (Egborge *et al*., 1986). The dry season atmospheric temperatures were higher than those recorded during the wet season, which is typical of most tropical areas (Awachei, 1981). The low temperature recorded in January 2006 was probably due to the influence of the harmattan wind.

The pH range of 5.4 – 7.4 recorded in this study indicated that the water was generally acidic with occasional slight alkaline condition. Generally, rivers flowing through forest are acidic with pH ranging from 4 to neutrality (Awachei, 1981). The range recorded in this study is very close to those recorded in many Nigerian and other African water bodies (Odum, 1992; Ogbeibu & Egborge 1995; Ikomi *et al.,* 2003). Rundle (1990) reported that high acidity affects the distribution of aquatic mites in running waters. This may explain the low abundance of water mites recorded in this study and other studies in tropical forested zones of Africa. In addition, Fjellheim et al. (2000) demonstrated the negative impact of acidification on the diversity and distribution of some benthic invertebrates in some Alpine lake ecosystems. Alkalinity values of between 5.4 and 16.08 mg/ L $CaCO_3$ recorded in this study are indications of the low carbonate and bicarbonate ions in the water bodies, a reflection of the absence of limestone in the drainage basin. This value is higher than 2 to 4 mg/L $CaCO_3$ reported by Egborge *et al* (1986) for Benin River.

The values of nitrates obtained in this study 0.08 to 3.92 mg/L compares favorably to other Nigerian water bodies, e.g. 0.1 to 0.44 mg/ L in River Sokoto (Holden & Green, 1960) and 0.05 to 4.03 mg/L) in Nta-Wogba stream, Port Harcourt (Chindah *et al.,* 1999). The values of nitrates obtained in this study were however higher when compared to low titre values reported for similar natural unimpacted streams within southern Nigeria (Ogbeibu & Oribhabor, 2002; Edema *et al* 2002; Imoobe & Oboh, 2003). High nutrient levels could lead to eutrophication which will restrict the activities of aquatic mites in water (Di Sabatino *et al*., 2004).

Generally, the results of the physicochemical parameters measured were within the range permissible for the growth and survival of most aquatic macroinvertebrates including mites (Cheshire *et al.,* 2005). However, the low acidic nature of the river and moderately high nutrients level may have prevented the high species richness expected in the river. Most rivers in Africa are deficient in aquatic mites probably due to high nutrient levels resulting from organic pollution (Arimoro *et al.,* 2007a). However the low water depth and slow flow velocity levels recorded in this study is suitable for the habitation of aquatic mites (Williams & Williams, 1996). In addition, substrate composition and habitat heterogeneity are important factors which allow the presence of more diverse and species-rich invertebrate communities (Di Sabatino et al., 2004).

The overall composition and density of aquatic mites in the different microhabitats varied in response to the physical, chemical and biological factors of the environment. From this study, aquatic mites prefer waters of low current velocity. This is supported by Rawer-Jost *et al*. (1999) who reported that most macroinvertebrates including aquatic mites are generally found in reaches of slower water velocity mostly for energy reasons, as they need to feed on the plants remains.

More mites were collected from macrophytes and in-stream structures (under logs) than from the open pools. Ogbeibu and Victor (1989) had made similar observation in their study of the macroinvertebrates of Ikpoba River, Nigeria. According to Smith and Cook (1991) these mites have strong claws and body processes allowing them to cling to plants and certain in-stream structures where they are prevented from being washed away by water currents. The community of aquatic mites that were identified in each of the microhabitat studied reflected the tolerance and adaptation to the prevailing environmental factors and the colonization abilities.

For instance, following Smith and Cook (1991) classification, three ecological groups were recognized in this study. These were: (1)*Encentridophorus spinifer* which was collected only in the riffle microhabitat and fits well to mites characteristic of rheocrenes, adapted for living in running waters by clinging, crawling and exhibiting walking behaviours; (2) *Poina africana* which was the most ubiquitous mite collected from all the microhabitats studied, including from litter in the pools. This species fits well into Smith and Cook (1991) classification of mites' characteristic of limnocrenes, generally adapted to living in standing waters by exhibiting walking and swimming behaviour. In addition this species of mite is perhaps the mostly common in most freshwater systems of Nigeria (Ogbeibu & Victor, 1989 & 1995); (3) *Arrenurus damkoeleri* was also common but completely absent from the pools and more abundant among floating-leaved macrophytes particularly *Pistia stratiotes* and *Nymphaea lotus.*

The differences observed between the mite communities in the different microhabitats studied are consistent with studies reported elsewhere (Cheshire *et al.,* 2005). Information gathered from this work demonstrates aquatic mites value as water quality indicators as they are generally found in waters of fairly good quality and conditions. The microhabitat preference and tolerance of aquatic mites reported in this study is perhaps the first approach towards a biomonitoring program involving aquatic mite species distribution in the Niger Delta.

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