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A study of physico-chemical water quality and caddisfly larvae abundance in Opa Reservoir Stream, South-Western Nigeria

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Abstract. This research was carried out at Opa Reservoir Stream in Ile-Ife, Nigeria, between 2004-2005. The study investigated the physico-chemical water quality and abundance of caddisfly larvae in the stream. The larvae were found to be unprecedentedly abundant when compared with other aquatic insects inhabiting the three stations selected at the stream. Hence the study focused on physicochemical parameters of the stream in relation to the abundance of caddisfly larvae. The sampling stations (Stations A, B and C) selected were based on the streambed morphology. Water samples were collected and analysed to determine the physicochemical characteristic of the stream. Samples of larvae were also collected and identified to the lowest taxonomic level. Only two species of caddisfly in different biotopes occurred at the three stations; *Cheumatopsyche digitata* larvae were found at Station A and *Macrostemum alienum* larvae inhabit both stations B and C. Data collected were analysed using relevant inferential statistics which include descriptive statistics and Pearson correlation coefficient. There was fairly high positive non-significant relationship between DO and abundance of *C. digitata* ($r = 0.55$) in Station A, while in Stations B and C, there was a positive significant relationship between DO and *M. alienum* larvae. This implies that the high concentration of DO favours the abundance of *M. alienum* than *C. digittata larvae*, which implies that *C. digitata* tolerate lower DO concentration than *M. alienum.* There was negative non-significant correlation between the two species at the three stations and chloride ion in the stream which suggest that the caddisfly species is not favourly disposed to high concentration of chloride ion at the stream. In conclusion since the stream accommodate caddisfly species which have low tolerant level for pollution, it is can therefore inferred as uncontaminated water.

Keywords: Caddisfly; Abundance; Physico-chemical; *Cheumatopsyche digitata*; *Macrostemum alienum*.

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Introduction

Freshwater is an important source of water for most living organisms and the habitat of lot of aquatic organisms. It is the domain of livelihood for many people in riverine areas in most underdeveloped and developing nations across the world. Freshwater is always under pressure due to over dependent on water by terrestrial and aquatic organisms. This has always resulted to water pollution and contamination. A study carried out in USA revealed that 44% of sampled stream miles were polluted (United States of Environmental Protection agency, USEPA, 2009). Paulsen et al. (2008) specifically stated that 42% of wade able streams and rivers in the United States of America were in poor condition and that only 25% can be said to be in good condition. The cause of this is simply overexploitation and abuse of water usage. As much as human population continue to grow, anthropogenic activity continues to stress the available resources in freshwater ecosystem thereby endangering aquatic biodiversity. This situation demands regular assessment of freshwater bodies so as to generate enough data that will assist in decision making. This study examines the assemblages of caddisfly larvae which is the most abundant benthic aquatic insects found occurring at the Opa Reservoir Stream and the physico-chemical characteristics of the water. Previous studies on aquatic insects of the Opa Stream revealed the occurrence of species of Ephemeroptera, Plecoptera and Trichoptera. For instance Ogbogu (2001a) worked on the micro-distribution and abundance of *Cleoen* and *Caenis* (Ephemeroptera) and also assessed the water quality and macro invertebrate abundance in the reservoir stream (Ogbogu 2001b). Nathaniel (2002) studied the macroinvertebrate fauna and bottom sediment of the reservoir in which he discovered that most of the macro invertebrate of the stream were aquatic insects which in include the Ephemeroptera, Plecoptera and Trichoptera (EPT). Reconnaissance visit to stream revealed abundance of caddisflies (Trichoptera) in the reservoir stream in comparison to other members of the group (EPT). The abundance of this insect order in comparison with other aquatic insects at the stream prompted this study. Paul and Nandi, (2003) stated that the characteristics of water bodies have strong influence on the diversity of macroinvertebrates. This study was carried out to investigate the physico-chemical characteristics of Opa Reservoir stream in relation to the abundance of caddisflies (Trichoptera) larvae occurring at the stream. The objectives of the study are to determine the species of caddisfly occurring at the three selected stations at stream and to determine the relationship between the caddisfly larvae and the physicochemical characteristics of the stream.

Materials and methods

Study area

This research was carried out at the Opa Reservoir Stream in Obafemi Awolowo University Ile-Ife. Opa Reservoir was formed in 1978 by the impounding of Opa River that took its source from Oke-Opa Hills. Oke-Opa Hills is a range of hills found along Ile-Ife - Ilesha Road in Osun State, Nigeria. The reservoir receives the bulk of water input from three rivers: Rivers Obudu, Mokuro, and Opa, the mainstream.

The river has a catchment area of about 116 km², extending over longitude 4° 31’ E to 40° 39’ E and latitude 7° 2’ N to 7° 35’ N. Derived Savanna is found in some areas of the ancient town, presumably as a result of human activities such as farming, and construction works. The temperature variation of Ile-Ife is relatively small. There are two major seasons in Ile-Ife. They are dry and rainy seasons. Heavy rains characterize the rainy season, while the dry season exhibits dryness, a period referred to as harmattan. There are two peaks of rainfall (in June and October) in the season. The dry season is controlled by tropical continental wind and is between November and February. The tropical maritime blow controls the rainy season and it prevails between March and October. The sun shines throughout the year and the average temperature is between 29.4 °C and 31.26 °C. The rainfall regime is characterized by double peaks; 1,005 mm in June and a little over 1,800 mm in October (Adu, 2007).

The water level of the reservoir is drastically reduced during the dry season whereas the rainy season is characterized by high water current resulting into floods. The floods virtually immerse the vegetation at the shoreline and water becomes turbid. The Opa Reservoir is walled with gravel dam of about 300 m long and 15 m from the foundation to the crest. The reservoir wall has two spillways, the mechanical and the auxiliary spillways. The auxiliary spillway automatically spills water over when water level is above 141 m. It is the spilled water that forms the stream where this study was carried out.

Sampling station

Three sampling stations (A, B and C) were selected along the stream. Station A is from the last spillway concrete barrier, Station B is 100 m away from Station A, the third station (Station C) is under road 1 bridge; this is the road that leads to the university main gate.

Station A (07° 30.20' N and 04° 31.73') was characterized with high water current velocity especially at the spillway barriers. The aquatic moss *Fontinalis* sp. (Bryophyta) was very abundant here and were found growing on top of the substrata (boulders and cobbles) in large quantity.

Station B is characterized by boulders, cobbles and sand without the presence of the moss (*Fontinalis* sp.) on top of the substrata as observed in Station A. The riparian vegetation at this station include *Commelina diffusa*, *Commelina erecta*, *Amaranthus hibridus* and *Acroceras zizaniodes*.

Station C (07° 30.00' N and 04° 31.41') is below the bridge along road 1 on the way to the University main gate, with the streambed characterized by boulders and cobbles. The boulders and cobbles were also without *Fontinalis* sp. as observed in Station B. The station is bordered at both sides by deciduous woodland trees which include *Daniella oliveri*, *Spondias mombin* and *Acacia* spp. The caddisfly larvae collected at this Station B were collected underneath the stones. The riparian vegetation of the study vegetation is made up of shrubs, short trees, herbs and tall grass. Insect larvae found in the station include those of caddisfly, Odonata and Hemiptera.

Sampling procedure

Collection of larval specimens was carried out between 10.00 am to 2.00 pm once a month throughout the 12 months duration of the study. Caddisfly larvae at Station A were found attached to the *Fontinalis* sp. in large quantity. An 'all out search method' was used in the sampling of the larvae in all the stations. This method was used since the larvae were not free living on surface of substratum but attached to the *Fontinalis* sp. (Station A) and under the stones and cobbles (Stations B and C). All detached larvae were placed in three labeled plastic bows meant for each station. This method involves searching for the larvae under the boulders, cobbles, stones, leaf litters and other substrata within a specific area for the duration of sampling period. All the caddisfly larvae collected from the stream were separated in the laboratory and counted in a white enamel tray. Enumerated larvae were stored in labeled sampling bottles (signifying the station of collection) with 70% ethanol and replaced with higher grade (80%) after 24 h to avoid degradation of the tissue and formation of caddisfly soup.

Water sample collection and laboratory analyses

Water samples were collected at the two stations in 2 L plastic bottle once a month for analyses. The pH of the water was taken in the field with a hand-held pHmeter. The water current velocity was estimated by displacement method in which a float, a meter rule and stop clock was used (Akindele et al., 2014). The water depth was measured by dipping a rod into the stream to touch the streambed and then the reading of the depth taken using a meter rule.

The conductivity of the water was determined with the aid of conductivity meter (Model 7020), results were expressed in μmhos/cm. The dissolved oxygen was determined using Winkler method. Chloride ion content of the stream water was determined by titration method using silver nitrate with potassium dichromate as indicator. The water temperature was taken with the use of mercury thermometer. Nitrate level was determined using colorimetric method, and absorbance was taken at 400 nm using visible spectrophotometer, model 201. The sulphate ion was determined by instrumentation using visible spectrophotometer model 201 and absorbance taken at 420 nm wave length. For the metals (calcium, sodium, potassium, and magnesium) bulk models 200A flame, Atomic Absorption spectrophotometer was used.

Identification of caddisfly larvae

Identification of the larvae was based on the key provided in Statzer (1984), Pescador et al. (1995) and Wallance (2003). Out of the preserved larvae from the three stations, 30 matured specimens were randomly selected for identification in the laboratory. The randomly selected larvae specimens were first examined in glycerin under binocular microscope for preliminary identification (i.e. to family and generic levels). The head capsule, nota, the fore-leg, mid-leg and hindleg of larva were also dissected out, prepared and mounted on slides, for observation using keys in Statzner (1984).

The larva of *Cheumatopsyche digitata* can be confused with those of other *Cheumatopsyche* spp. but can easily be separated by a deep notch on one side of the anterior margin of frontoclypeus and the tapered intersegmental sclerites below the prosternal plate (Statzner, 1984). The larva of *M. alienum* can be confused with those of other *Macrostemum* species, but is easily separated by looking at the nature of the anterior margin of the prosternal plate and the intersegmental sclerites associated with it. The prosternal plate has a ridge at the middle of the anterior margin, which is almost divided by a suture. The carina at the dorsal side of head cuts off a triangular portion at the apex of the frontoclypeal apotome (Ogbogu and Adu, 2006).

Data analyses

The analysis of the data involved the use of various statistical methods such as descriptive statistics, analysis of variance and correlation coefficient (Pearson correlation coefficient method). Analysis of variance (ANOVA) was used for the purpose of determining the seasonal variation in the physico-chemical parameters. For the purpose of determining the relationship between the density of insect larvae and physico-chemical parameters, Pearson correlation coefficient method was employed.

Results

Two species of caddisfly were found occurring at the three stations. The species belong to different genera but the same Family of Trichoptera: the genera are *Chuematopsyche* and *Macrostemum* of family Hydropsychidae, the two have different subfamilies; Hydropsychinae (*C. digitata*) and Macronematinae (*M. alienum*). The two species were sampled at different biotopes. *C. digitata* was found on the *Fontinalis* sp. (moss) that inhabit the top of bedrocks and boulders at Station A at the stream, while *M. alienum* larvae were found attached to the lower part of the boulders and stones at Stations B and C the substrata have to be turned over in order to collect the larvae.

A total of 2,830 larvae of caddisfly were sampled at the stream. The largest number (1,566) of caddisfly larvae were sampled at Station A, followed by Station C (750) while the least number of larvae were collected at station B (514). *C. digitata* was the most abundant caddisfly species in the stream despite occurring only in one station (A). *M. alienum* was sampled at Station B and C. Opa Reservoir Stream was completely dried in the months of January and February, 2005. The stream resumed toward the end of March, 2005. No larva was sampled at the three stations between January and June, 2006, except in Station A where only 41 larvae of *C. digitata* were collected in June (Table 1).

Table 1. Monthly collection of Caddisfly larvae at the 3 study stations in Opa Reservoir Stream in Ile-Ife, Nigeria.

Month	Station A	Station B	Station C
	C. digitata	***M. alienum***	***M. alienum***
Jul-2004	47	40	63
Aug-2004	65	115	165
Sep-2004	425	129	182
Oct-2004	407	133	190
Nov-2004	341	92	133
Dec-2004	240	5	17
Jan-2005	0	0	0
Feb-2005	0	0	0
Mar-2005	0	0	0
Apr-2005	0	0	0
May-2005	0	0	0
Jun-2005	41	0	0
Total	1,566	514	750

Copiousness of caddisfly larvae at Opa Reservoir Stream

The largest number of caddisfly larvae (both *C. digitata* and *M. alienum*) was sampled in September (736), this was closely followed by October in which 730 individuals were collected. Due to dry season that stated in November the number of specimens collected dropped. Eight hundred and twenty eight (828) larvae were collected in dry season while 2002 larvae were sampled in the wet season. No larva was sampled in January and February as a result of the dry season (stream was completely dried in January and February), after the resumption of the stream in March, caddislfly larvae were still not found at the 3 stations until June (last sampling month) when 41 larvae of *Cheumatopsyche digitata* was collected at Station A (Figure 1).

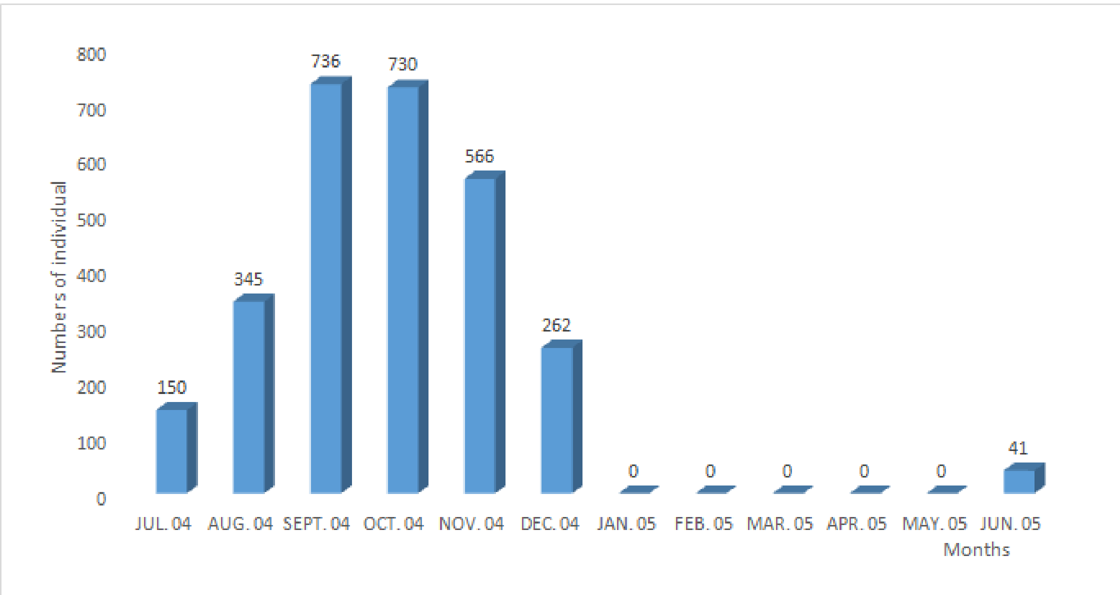

Figure 1. Monthly abundance of caddisfly larvae at the Opa reservoir stream, Ile Ife Nigeria.

Approximately, 70.74% of larvae collected in this study were sampled in the wet season while only 29.26% were collected in dry season. Tables 2 to 5 presented the mean values of the physico-chemical parameters at Opa Reservoir Stream Ile-Ife in wet and dry seasons, while the relationship between environmental factors and the caddisfly larvae are provided in Tables 6 and 7.

Table 2. Mean (±S.E.) values of some selected environmental variables in Opa Reservoir Stream, Ile-Ife Nigeria in wet season

Months	Flow rate ($m\ s^{-1}$)	Water depth (m)	pH	DO mg/L	Water temp (C)	Conductivity (µS/cm)
Jul-2004	0.62±0.01	0.28±0.01	7.2±0.12^{bc}	7.3±0.73^{c}	27±0.57^{a}	159.2±0.55^{bc}
Aug-2004	0.55±0.02^{c}	0.49±0	7.4±0.12^{bc}	7.1±0.12^{c}	27.2±0.25^{a}	150.63±0.86^{a}
Sep-2004	0.53±0.02^{c}	0.35±0.02	7.6±0.12^{c}	7.5±0.20^{c}	27.2±0.05^{a}	159.47±0.54^{bc}
Oct-2004	0.49±0.01^{b}	0.32±0.01	7.5±0.12^{c}	7.3±0.12^{c}	27.63±0.14^{a}	161.1±1.15^{c}
Mar-2004	0.04±0.01^{a}	0.08±0.05^{ab}	6.1±0.18^{a}	4.2±0.12^{a}	26.87±0.09^{a}	154.5±1.15^{ab}
Apr-2005	0.06±0.01^{a}	0.02±0.01^{a}	6.3±0.17^{a}	4.1±0.15^{a}	27.07±0.58^{a}	154.38±2.0^{ab}
Mar-2005	0.06±0.01^{a}	0.13±0.01^{bc}	7.0±0.12^{b}	6.6±0.12^{b}	27.17±0.12^{a}	208.67±1.76^{d}
Jul-2005	0.880±0.01^{d}	0.1667±0.01^{c}	7.4±0.12^{bc}	6.2±0.12^{b}	26.6±0.12^{a}	212±1.15^{d}

Table 3. Mean (±S.E) values of selected environmental variables in Opa Stream, Ile-Ife, Nigeria in wet season.

Months	Na^{+}(mg/L)	K^{+}(mg/L)	Mg2^{+}(mg/L	Ca^{2+}(mg/L)	Cl-(mg/L)	SO_4^{2-} (mg/L)	NO_3^{-} (mg/L)
Jul-2004	52.53±3.45^{ab}	17.67± 0.24^{ab}	16.6 ±0.23^{b}	15.7±0.18^{a}	2.83± 0.01^{c}	0.4 ±0.06^{b}	1.44±0.1
Aug-2004	18.4± 0.26^{a}	17.4± 0.12^{a}	20.67±0.20^{c}	14.67±0.24^{b}	2.83 ±0.01^{c}	0.37±0.01^{b}	1.40±0.0
Sep-2004	19.53±0.32^{ab}	17.53± 0.26^{ab}	16.53±0.14^{b}	15.9±0. 09^{b}	2.82± 0.01^{c}	0.03±0.01^{a}	2.13±0.3
Oct-2004	77.7±0.58^{cd}	18. ±0.24^{cd}	13.47±0.24^{a}	15.7 ±0.0^{b}	2.83± 0.01^{c}	0.01± 0.0^{a}	0.6± 0.02
Mar-2005	19.13± 0.17^{d}	19 ± 0.12^{d}	20.9±0.06^{c}	18.4±0.27^{d}	1.53± 0.03^{a}	1.91±0.02^{e}	0.95±0.0
Apr-2005	17.8± 0.12^{ab}	17.57± 0.23^{ab}	23.17±0.13^{ef}	16.3± 0.12^{b}	2.4 ±0.06^{bc}	1.13±0.03^{c}	0.59± 0.0
May-2005	21± 0.58^{a}	17.3 ±0.15^{a}	24.37±0.37^{e}	17.6 ±0.23^{c}	2.17± 0.44^{b}	1.05±0.02^{c}	0.5 ±0.01
Jun-2005	20.73±0.15^{bc}	18.13± 0.12^{bc}	22.4±0.66^{d}	17.2± 0.09^{c}	1.94± 0.04^{ab}	1.31±0.55^{d}	2.79±2.1

Table 4. Mean (±S.E.) values of some selected environmental variables in Opa Reservoir Stream, Ile-Ife, Nigeria in dry season.

Month	Flow rate ($m\ s^{-1}$)	Water depth (m)	pH	DO (mg/L)	Conductivity (µS/cm)	Temperature (°C)
Nov-2004	0.64±0.02	0.27±0.02	7.4±0.23	6.87±0.17	163.6±0.20	27.5±0.35
Dec-2004	0.14±0.01	0.06±0.001	7.4±0.11	6.5±0.11	171.1±0.8	27.4±0.37
Jan-2005	0	0	0	0	0	0
Feb-2005	0	0	0	0	0	0

Table 5. Mean (±S.E.) values of some selected environmental variables in Opa Reservoir Stream, Ile-Ife, Nigeria in dry season.

	Na^+ (mg/L)	K^+ (mg/L)	Mg^{2+} (mg/L)	Ca^{2+} (mg/L)	Cl^- (mg/L)	SO_4^{2-} (mg/L)	NO_3^- (mg/L)
Nov-2004	20.67±0.17	19.3±0.32	13.63±0.23	16.33±0.44	2.57±0.07	0.04±0.01	1.39±0.03
Dec-2004	21.43±0.26	18.37±0.14	15.53±0.13	13.66±0.18	2.9±0.15	1±0.21	1.24±0.24
Jan-2005	0	0	0	0	0	0	0
Feb-2005	0	0	0	0	0	0	0

Physico-chemical variables and their relationship with caddisfly larvae

Most of the physico-chemical variables investigated in this study showed non-significant positive relationship with the species of caddisfly (*C. digitata* and *M. alienum*) at the 3 stations (Tables 4 and 5). *C. digitata* showed non-significant negative relationship with chloride and sulphate ions and fairly high but non-significant positive relationship with water depth, dissolved oxygen and nitrate. There was positive significant correlation between *M. alienum* and water depth ($P < 0.01$), between *M. alienum* and dissolved oxygen ($P < 0.05$) and between *M. alienum* and nitrate ($P < 0.05$) at Stations B and C. A non-significant negative relationship was observed between *M. alienum* and chloride and between *M. alienum* and sulphate (Tables 6 and 7).

Table 6. Correlation coefficient values (r) between the Caddisfly larvae of Opa Reservoir Stream and physico-chemical variable.

Stations	Flow rate	Water depth	pH	Dissolved oxygen	Conductivity	Temperature
Station A (*Cheumatopsyche digitata*)	0.32	0.53	0.44	0.55	0.27	0.07
Station B (*Macrostemum alienum*)	0.45	0.89**	0.44	0.58*	0.2	0.15
Station C (*Macrostemum alienum*)	0.45	0.89**	0.45	0.59*	0.21	0.15

**Correlation is significant at the 0.01level (2-tailed).
*Correlation is significant at the 0.05level (2-tailed).

Table 7. Correlation coefficient values (r) between the Caddisfly larvae of Opa Reservoir Stream and physico-chemical variable.

Taxa	Na^+	K^+	Ca^{2+}	Cl^-	SO_4^{2-}	NO_3^-
Cheumatopsyche digitata (Station A)	0.38	0.38	0.28	-0.26	-0.25	0.56
Macrostemum alienum (Station B)	0.38	0.36	0.28	-0.25	-0.25	0.63*
Macrostemum alienum (Station C)	0.33	0.37	0.29	-0.26	-0.25	0.64*

*Correlation is significant at the 0.05 level (2-tailed).

Discussion

C. digitata was more abundant in Opa Reservoir Stream than *M. alienum.* The two hydropsychidae are dwellers of fast following water. The two species were found on two different biotope. The choice of biotope is one the adaptability mechanism for adapting to fast following stream. *C. digitata* are net spinners and filter feeders that attach their net to *Fontinalis* sp. (moss). The larvae positioned themselves on the top of rocks and cobbles at a point whereby the spun net can easily filter food particles from the fast flowing water. *M. alienum* larvae are scrappers which feed on algae on the rocks. The larvae built cases on the substrata on which they pupate.

Effect of physico-chemical factors

Temperature affects many of the physical, chemical and biological characteristics of the stream. It affects the amount of dissolved oxygen, rate of photosynthesis and metabolism of organisms that inhabit the stream. The minimum (26.6±0.12) and the maximum (27.63±0.14) water temperature were recorded in the wet season, this may be connected with the two months of dryness of the stream experienced in January and February at all the study stations. A previous study carried out at Opa Reservoir (not the reservoir stream) revealed that the maximum temperature was recorded in the dry season where water was available at the reservoir throughout the year unlike the stream which was intermittent (Nathaniel, 2002).

The pH of the stream was slightly alkaline most of the period of this study (7.0±0.12 - 7.6±0.12) which shows the buffer capacity of the water. The pH of the stream was below 7.0 in March (6.1±0.18) and April, 2005 (6.3±0.17), the slight acidity condition observed here could be as a result of runoff from surrounding farmlands. The pH recorded in March and April 2005 (6.1±0.18 and 6.3±0) fall below the optimal range for life (pH 6.5-8.2). Incidentally no caddisfly larvae was sampled within the months. However some caddisfly larvae can still thrive at that pH range below 6.5 (Technical Memorandum prep. Robertson-Bryan, Inc., 2004). The report states that some species of caddisfly can still survive at pH as low as 4.4 and maximum of 12.0, therefore the absence of the larvae may not be connected with the pH below the optimal range of life.

Obviously the water depth of the stream was significantly higher in the wet season than in the dry season. This was as a result of the high tropical rainfall peculiar to this season (Adu, 2007). As the dry season approaches, the volume of the stream water decreases, the reservoir water level fall, and water stop spilling from the automatic spillway as a result the stream stop flowing. This was the cause of the dryness of the stream observed in January and February 2005. As rainy season resumes and the reservoir water level rises above the brim, the stream resumes its flow.

The conductivity of the stream was relatively high during the rainy season. This was as a result of influx of floodwater, which flows over surrounding soil and rock. Sewage and farm runoff also contributed to high conductivity value recorded at the stream. Similarly shoreline erosion caused by the flooding brings in more nutrients into the stream, also influences the conductivity of the water.

Oxygen plays a very significant role in their survival of aquatic animals especially caddisfly larvae which depend on high concentration of dissolved oxygen (DO) in water for all their metabolic activities. The presence of barriers and rocky terrain at the streambed allow thorough mixing of dissolved oxygen which increase in the concentration dissolved oxygen. Generally the concentration of the dissolved oxygen was above 6.0 mg/l, the optimal level required for spawning, growth and wellbeing (Technical Memorandum, 2004). Based on the concentration of the dissolved oxygen in the stream, the stream could be said to be healthy. The low DO concentration recorded at the resumption of water flow after the drought could be as a result of the effect of the bacterial activities on untreated sewage as well as the agricultural materials, which run into the stream.

The Opa Stream is a fast flowing stream, with the highest velocity of 0.88m/s recorded during the rainy season. Water current velocity during the wet season was significantly higher than that of the dry season. During the dry season water was only sipping down from the spillway. This eventually stopped as the water of the reservoir fell below the spillway.

The maximum value of exchangeable cations (Ca^{2+}, Mg^{2+}, and K^+ except Na^+) and anion ($SO_4^{2-,}$ Cl^-, and NO_3^-) were recorded in the rainy season. This is contrary to the findings of Mathoko (1998) at a permanent Kenyan river and Nathaniel (2002) at Opa reservoir in Nigeria. At the two water bodies (Kenyan river and Opa dam), the maximum concentration of cation and anion were recorded in dry season. This concentration of exchangeable cation and anion during the dry season was attributed to the evaporation of the water.

Relationship between the physico-chemical factors and caddisfly larvae

Based on the correlation coefficient values (Table 6), there was positive non-significant relationship (r = 0.53) between the water depth and the total abundance of *C. digitata* larvae collected at Station A and also positive significant relationship between *M. alienum* collected at Station B (r = 0.89) and C (r = 0.89) which suggest that depth of the stream is associated with abundance of the two species in the stream, but with significant effect on abundance of *M. alienum* larvae. *M. alienum* larvae construct cases under substrata (boulders and cobbles) while *C. digitata* larvae are found on the top of their substrata (on *Fontinalis* sp. growing on top of the boulders and cobbles. There was positive non-significant relationship between DO and abundance of *C. digitata* (r = 0.55) in Station A, while in Stations B and C, there was a positive significant relationship between DO and *M. alienum* larvae occurring at the stations. This implies that the concentration of DO favour the abundance of *M. alienum* than *C. digittata* larvae, which also implies that *C. digitata* can tolerate lower DO concentration than *M. alienum.*

There was positive correlation (r = 0.63) between the nitrate ion and the abundance of *C. digitata*, and a positive significant relationship between the nitrate and *M. alienum* at the Stations B and C. This indicates that the presence of nitrate in the stream favour occurrence of the *M. alienum* larvae at the stream than *C. digitata* in station A. The presence of chloride ion in freshwater has a negative non-significant effect of both species of caddisfly occurring at the stream. It is an indication that the caddisfly species is not favourly disposed to high concentration of chloride ion at the stream. This explain why very few species of caddisfly are found in brackish and marine waters (Adu, 2007).

Conclution

This study has been able to identify the presence of two species of caddisfly inhabiting the Opa Reservoir Stream (*C. digitata* and *M. alienum*). *Amphipsyche* sp. which was discovered to be at stream was not sampled throughout the period of this study. The paucity of caddisfly species at this study may be connected with the two predominant biotopes occurring at the three stations, therefore there are possibilities of finding other species, genera and families of caddisfly inhabiting other biotopes at different locations in the stream.

Physico-chemical factors have a lot of influence on the abundance of caddisfly larvae. For instance there was positive significant correlation between some physico-chemical factors (water depth, dissolved oxygen and Nitrate) and caddisfly larvae which shows that the physicochemical factors have high effect on the abundance of the species at the stream. Finally the characteristic of physico-chemical factors existing at the stream is conducive for existence of species of Trichoptera, and it is expected that other species of the taxon could be hidden somewhere at a different biotope on the stream.

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Conflict of interest

Authors declare that they have no conflict of interests.

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