



SJMLS-3(4)-005

Macroinvertebrate colonization of Catfish (*Clarias gariepinus*) carcass of River Ethiope, Delta State, NigeriaErhenhi, O.H.^{1*} and Francis, O.A.²

Department of Animal and Environmental Biology, Delta State University, Abraka, Nigeria ¹,
Department of Biological Sciences, Federal University of Technology, Minna, Niger State ²

Author for Correspondence *: osarohilda@gmail.com/+234-703-052-5710

Abstract

A field survey was carried out in two microhabitats (riffles and pools) at River Ethiope, Delta State, Nigeria to determine macroinvertebrate colonization of catfish (*Claria gariepinus*) carcass. The carcasses were held in place by scavenger proof cases at the bottom of shallow portions of riffles and pools in the River. During this period the ambient temperature of air and water were monitored daily along with other physicochemical parameters using standard methods as well as insect colonizers until the carcasses were completely decomposed. The result of physicochemical parameters showed that temperature, pH and conductivity recorded were not significantly different ($p > 0.05$) in both microhabitats while velocity, dissolved oxygen and biochemical oxygen demand (BOD) were significantly different ($p < 0.05$). A total of 112 individuals representing fourteen (14) species of macroinvertebrate were collected in the pools with *Tabanus sp.* and *Chironomus sp.* being the preponderant organisms while in the riffles a total of 229 individuals representing sixteen (16) species were collected with *Caridina africana* (Decapod) occurring as the most dominant species followed by *Bugilliesia sp.* and *Cloeon sp.* (Baetidae). The rapid macroinvertebrate colonization on the fish carrion decomposition and function feeding group also suggest a better understanding of the decomposition in the River which are important resources for macroinvertebrate representing abundance and colonization hotspot. Also, this study will be valuable for forensic investigation in estimating elapsed time of submergence and in identifying

the environment in which the decomposition occurred.

Keywords: Colonization, carcass, macroinvertebrate, decomposition, microhabitats

Introduction

A carcass, whether human or animal, goes through a large series of biological, chemical and physical changes as it decomposes from the fresh to the skeletal state, and these stages of decomposition process are attractive to different species of insects. The decomposition of a body on land and interaction between the body and insect fauna have been well studied, and predicted insect development and colonization patterns have been described from many countries' geographical regions, habitats and seasons (Anderson, 2009). Merrit and Wallace (2000) reported the colonization of human carcass by blackfly (Simuliidae) immature in a submerged car containing murdered victim pulled from a river. Analysis of species composition and life stages led to an accurate estimate of submersion interval. Vance *et al.* (1995) in early summer documented strictly aquatic insects recovered from decaying pig carcasses in an Iowa fresh water lake. Twenty species of insects from twelve families in five orders were documented along with water mites (Arachnidae; Acari) and amphipods (Crustacea; Amphipoda). The rate of carcass decomposition and macroinvertebrate colonists can be used to determine the time of death (Denno and Cothran, 1975).

Macroinvertebrates certainly play a key role in the decomposition of carrion in stream systems and valuable in estimating elapsed time since submergence, identifying the environment in which the body has decomposed. Aquatic insects accounts for the majority of macroinvertebrates in most rivers and streams. Most do not spend their entire lives in water, only their larvae stage is long compared with a relatively brief adult period. Aquatic insect species could also prove useful in research involving forensic entomology, but have not received sufficient attention. Corpses are usually found in aquatic habitats including suspected homicides victims (Hawler *et al.*, 1989). Aquatic insects have not been used for determining submersion interval during these investigations primarily because information on the role of insects in the decay process has not been available (Catts *et al.*, 1990). A previous report (Haskell *et al.*, 1989) noted that most studies have concentrated on blowflies and other strict terrestrial species associated with carrion in water.

However, aquatic environment studies show how organisms may colonize a substrate depends on factors such as size, position, exposure to current, water temperature, current speed, water depth, the presence of algal communities or detritus. Certain aquatic insects such as the Chironomid midges (Diptera, chironomidae) and the Caddisflies (Trichoptera) are capable of colonizing immersed bodies. Many corpses however, are found in aquatic habitat which prevents oviposition and subsequent development of terrestrial sarcophagus insect larvae. The primary problem in the aquatic environment is that there are no purely sarcophagus insects to compare with the common terrestrial indicator species such as Blowflies (Calliphoridae), Carrion beetles (Silphidae) or the cheese skipper (Pliophilidae, *Prophilia casei*, L). Facultative sarcophagy however, has been reported for some aquatic insect (Brusen *et al.*, 1969).

Despite the lack of specific indicator species in the aquatic environment, there is tremendous potentials for determining the submerged interval for human body, pig, fish and other animal carrion. Some factors that may help in

determining submersion interval are progression in development on the carcass which includes deposition of silt, presence of specific life stage of aquatic insects, presence of specific structures built by aquatic insects and the presence of species known to inhabit certain microhabitats (Brusen *et al.*, 1969).

The forensic pathologist or entomology may estimate the post-mortem interval and may assist in providing information on the time since colonization which can ultimately be used to substantiate a portion of the post-mortem interval (Keiper and Casamatta, 2001). A well-respected forensic entomologist was assigned to a case involving the discovery of a decomposing body found on a boat half a mile from shore. Upon collection of the maggot, only one insect, *Chrysomya megacephata* was discovered. He concluded that water barrier accounted for the scarcity of other flies. He also noted that flies will not attempt to trek across large bodies of water unless there is a substantially influential attractant (Goff, 2000).

Arimoro (2013) studied the insect succession on decomposing remains of the rat (*Rattus rattus*) in Ethiope River, Southern Nigeria to better understand the colonization of these invertebrates on human corpses. Dipterans were the early colonizers followed by the Ephemeropterans, Trichopterans and Hemipterans were only sporadically present at the last stage of the decomposition process.

This work seeks to carry out the macroinvertebrate colonization in catfish (*Clarias gariepinus*) carcass of River Ethiope, Delta State, Nigeria, since sparse research is known about macroinvertebrate colonizing carion organisms in aquatic environment. Therefore, the objective of this study is to determine the abundance, diversity, biomass of macro-invertebrate colonists and physicochemical conditions of the rifles and pool microhabitats.

Materials and Methods

Study Area:

This study was carried out *in-situ* in Ethiope River, Ethiope East Local Government Area of

Delta State, Nigeria which lies approximately between longitude 6° 05' 59" E of the Greenwich Meridian and latitude 5° 46' 54" N of the equator. Ethiope River is one of the two main tributaries of the Benin River, the other being the Jamieson River. From its source Umuaja, it flows a westerly direction for approximately 100 km through the evergreen forest zone and enters the

Benin River at Sapele (Figure 1). The dry season is from November to March and the wet season is from April to October. The mean annual temperature is about 23°C, while the mean annual relative humidity is 85%. Some anthropogenic activities in the River include fishing, recreational activities, washing of clothes by the locals.

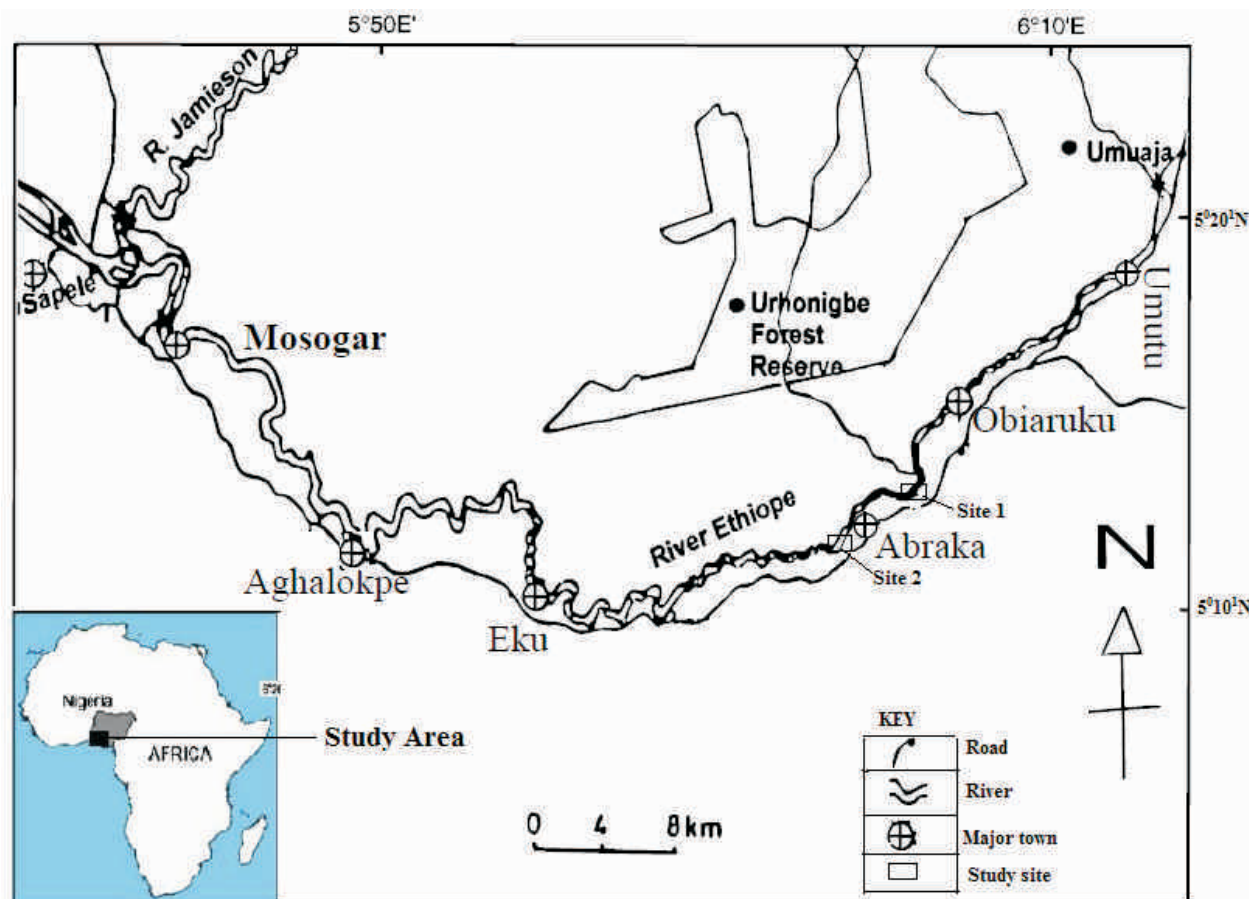


Figure 1. Map of River Ethiope showing the location of the sampling sites. Inset; Map of Africa showing the location of the study area in Nigeria.

Description of Sampling Microhabitats

Pool: This is the pool station that consists of partly decomposed plants that readily disintegrates. The stream bed is predominantly sand and silts and substratum is clay. Floating macrophyte *Lemna* sp., are common here. The submerged vegetation includes *Salvinia* sp., and *Ceratophyllum submersum*.

Riffles: The stream bed is predominantly fine sand and coarse silt. The riparian vegetation consists of several tree species mainly *Matrygyna ciliate*, *Fussigera repens* and *Xylopia*

species. The floating macrophyte here include *Lemna* spp. The submerged vegetation includes *Matrygyna* sp. and *Ceratophyllum submersum*.

Methods: Riffles and pools of different water depth, substrates and plant communities were chosen. Both microhabitats were large enough to contain 28 suspension frames each with a minimum intermittent distance of 1.2 metres to prevent disturbance of neighboring units during individual carcass removals. The suspension frames with net were used to hold the fish carcasses during decomposition. Frame

consisted of a base and an L-shaped arm from which the net was suspended. The base, constructed of 61 cm section of 5x10 cm (2 x 4 inch). The pine surrounded a central, upright 152 cm section. On top of this central support was attached an arm that extended 61 cm toward the net and 30.5 cm away from the net. The arm was stabilized on the side opposite the net by a 46cm section of 5x5 cm pine attached diagonally to the upright 152 cm section. The entire structure was stabilized by a concrete block which rested on the base and surrounded the upright section. The holes of the netting were sufficiently large to allow Macroinvertebrates complete access to the fish carcasses.

Suspension frames and nets were placed in the river bed for five (5) days before carcasses were added to allow time for disturbance effects to subside. Carcasses were retrieved by moving very slowly through the water within 2.5 m of the suspension frame then bringing a large fine mesh net up from below to surround the entire wire basket and contents. The net was built from a 182.9 cm (80 inch) diameter ring of a galvanized wire and muslin cloth. The fabric component of the net was 70 cm (24 inch) tall with straight sides and the bottom was 425 µm mesh sized to the same diameter of the ring. After being brought to shore, the net containing the fish carcass was removed and placed in a white plastic tray. The net was thoroughly inspected with the aid of a magnifying glass until representatives of all visibly differing insects present were collected. After the net was

thoroughly inspected, the wire net was removed from around the fish carcass and searched. The fish carcass was obtained by rinsing with distilled water. Also the insect larvae were carefully collected with forceps from the mouth, interiors and external surface and stored in 70% ethanol. Visual assessment of each fish carcass was made and recorded upon removal.

Data Analysis

The statistical method employed was student t-test (paired t-test) between the physical and chemical parameters of the surface water at the riffles and pools microhabitat. The macroinvertebrate colonizing the fish clarion of these two microhabitats was carried out using the TexaSoft WINKS SDA Software (2007).

Results

Ambient temperature of the river and air were taken to record the temperature required for decomposition of the fish clarion by bacteria and macroinvertebrate activities varied for 26.1 – 28.3°C with a mean ± SE of 26.36 ± 0.13 in riffles and in pools 27.64 ± 0.27 (Table 1). Temperature, pH and conductivity were not significantly different (p>0.05) in both microhabitats while velocity, dissolved oxygen and biochemical oxygen demand (BOD) were significantly different (p<0.05). The duration of each decomposition stages (fresh, blot, wet, dry and skeletal stage) of the fish clarrion (*Clarias gariepinus*) was very rapid and lasted for four days

Table 1: Physical and chemical parameters (mean ± SE, range) of riffle and pool environments measured during the sampling period.

<i>Physical Parameters</i>	Riffles	Pools	t-test	p-value
Temperature (°C)	26.36±0.13 (26.1-26.8)	27.64±0.27 (26.9-28.3)	5.2	0.00667
Water level (m)	2.26±0.05 (2.10-2.40)	0.70±0.01 (0.66-0.73)	37.9	1.45E-06
Flow velocity (m/s)	0.23±0.005 (0.22-.25)	0.006±0.002 (0.00-0.01)	29.3	7.4E-06
Conductivity (µScm ⁻¹)	63.18±2.88 (55.6-68.2)	63.48±2.81 (54.6-70.2)	0.21	0.84
<i>Chemical Parameters</i>				
DO (mg/L)	5.8±0.13 (5.5 -6.2)	4.3 ±0.11 (4.0 -4.6)	9.6	0.0007
BOD (mg/L)	1.16±0.05 (1.0-1.3)	2.12±0.04 (2.0-2.2)	16.0	8.9E-05
Ph	5.3 (5.2- 5.4)	5.3 (5.2- 5.4)	1.0	0.19
Nitrates (mg/L)	0.15±0.004 (0.14-0.16)	0.22±0.006 (0.20-0.23)	15.6	9.7E-05
Phosphates (mg/L)	0.05±0.004 (0.04-0.06)	0.13±0.004 (0.12-0.14)	9.8	0.006

Macro Invertebrate Assemblages

A total of 112 individuals and 14 species were collected in the pool microhabitat, while in the riffles a total of 229 individuals and 16 species were also found in the decomposition process. Ephemeroptera was the most abundant order followed by Tabanidae, Diptera, Odonata and Decapoda, while Trichoptera, Coleoptera, Hemiptera and Arachnidae (Pisauridae) occurred sporadically in the pool microhabitat. The fresh stage of decomposition of the catfish carrion showed abundance of *Tabanus* sp. were found colonizing the carrion. The Chironomidae; *Chironomus* sp appeared on day 2 and continued to day 4. This was followed by Coenagrionidae; *Pseuagrion spematum*, as shown in Table 2 in the pool microhabitats, while in the riffles microhabitats, Decapoda was most abundant, followed by Ephemeroptera colonizing the fish carrion, showing on day 3, two different species, *Bugilliesia* sp. and *Cloeon* 2 sp. Also, in the riffle, day 2 witnessed the Trichoptera; (Hydroptilidae) *Leptonema* sp. and Odonata; *Pseuagrion spematum* and *Zyxomma* sp were recovered. Hemiptera sporadically occurred in both microhabitats. Early colonizer arrived during the fresh stage occurring from the

moment of death to the onset of bloat. Bloat stage consist of persistent early colonizer which increased gradually in numbers. As the dry stage gave way to the skeletal stage where macroinvertebrate became sparse. In Table 2, day 1 shows the fresh stage of decomposition, day 2 and 3 represent the bloat and wet stages of decomposition, while day 4 shows the skeletal stage of decomposition in both microhabitats.

Percentage density of macro invertebrate functional feeding group

The percentage density of taxa and individuals' macroinvertebrates presents at the pool and Riffles microhabitat are shown in Figure 1 and 2. At the pool microhabitat collector/gatherers comprised of 59% of all individuals and were the most dominant of all taxonomic group followed by others Arachnidae (Pisauridae, Tabanidae) which accounted for 24%. Predators accounted for 17% of all individual as shown in Figure 1. The riffles microhabitat accounts for 86% collector/gatherers which were the most dominant of all the taxonomic groups. The predators 9% Shredders 1% others 4% (Pisauridae and tabanidae Arachnidae) as shown in Figure 2.

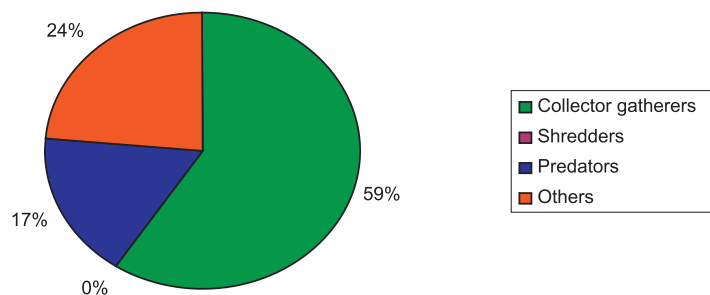


Figure 1: Percentage Density of Macroinvertebrate Functional Feeding Groups in the Study Station Ethiopie River (Pool)

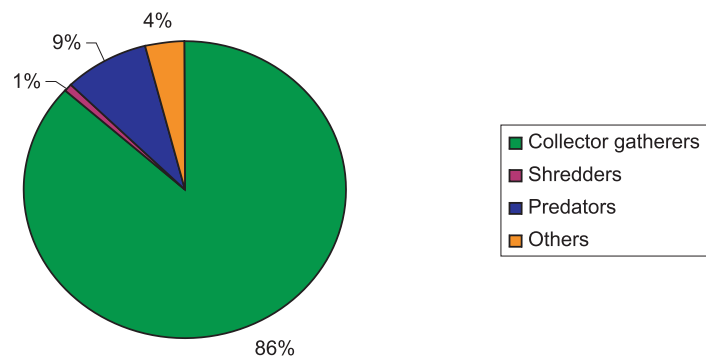


Figure 2: Percentage Density of Macroinvertebrate Functional Feeding Groups in the Study Station Ethiopie River (Riffle).

Table 2: Species Composition, Distribution and Abundance of Macroinvertebrate Functional Feeding Groups in the Study Stations of Ethiopie River.

ORDER	FAMILY	SPECIES	FFG	POOL					RIFFLE				Total species
				Fresh Stage	Bloat and Wet Stage		Skeletal Stage		Fresh Stage	Bloat and Wet Stage		Skeletal Stage	
				Day1	Day 2	Day 3	Day 4		Day 1	Day 2	Day3	Day4	
Diptera	Chironomidae	<i>Chironomus sp</i>	PDR	0	6	10	7	23	0	0	7	0	7
Trychoptera	Hydroptilidae	<i>Leptonema sp</i>	Sh	0	0	0	0	0	0	2	0	0	2
Coleoptera	Dytiscidae	<i>Philaccolus sp</i>	PDR	0	3	0	0	3	0	0	1	0	1
Hemiptera	Belostomatida	<i>Appasus sp</i>	PDR	0	1	0	0	1	0	0	1	0	1
	Nepidae	<i>Ranatra sp</i>	PDR	0	0	0	0	0	1	0	0	0	1
	Mesoveliidae	<i>Mesovelia sp</i>	PDR	0	0	0	0	0	1	0	0	0	1
	Naucoridae	<i>Naucoris sp</i>	PDR	0	0	0	0	0	0	0	1	0	1
Odonata	Coenagrionidae	<i>Pseudagrion spematum</i>	PDR	0	2	9	3	14	0	4	0	4	8
	Libellulidae	<i>Brachythemis lacustri</i>	PDR	0	1	0	0	1	0	0	0	0	0
		<i>Zyxomma sp</i>	PDR	0	0	0	0	0	0	0	4	4	8
Decapoda	Atyidae	<i>Caridina Africana</i>	CG	0	5	2	0	7	0	16	98	32	146
	Palaemonidae	<i>Macrobranchiou m dux</i>	CG	0	2	0	0	2	0	0	0	0	0
	Amphipoda		CG	0	0	3	1	4	0	0	0	0	0
Ephemeroptera	Leptophlebidae	<i>Adenophlebiodes</i>	CG	0	4	3	3	10	0	0	3	0	3
	Baetidae	<i>Cloeon sp</i>	CG	0	2	0	7	9	0	0	0	8	8
		<i>Bugilliesa sp</i>	CG	0	0	0	0	0	0	0	16	0	16
	Baetidae	<i>Cloeon 2 sp</i>	CG	0	0	10	0	10	0	0	15	0	15
		<i>Cloeon 1 sp</i>	CG	0	0	0	0	0	0	2	0	0	2
Arachnidae	Pisauridae	<i>Thalassius sp</i>		0	0	1	0	1	2	1	2	4	9
	Tabanidae	<i>Tabanus sp</i>		10	15	0	0	25	0	0	0	0	0
Diptera	Ceratopogonidae	<i>Allodomyia sp</i>		0	2	0	0	2	0	0	0	0	0
Total Number				10	44	28	21	112	4	25	148	52	229
No. of individual								112					229
No. of species								14					16

Discussion

The decomposition of catfish carcasses (*C. gariepinus*) in two microhabitats (pools and riffles) showed that the colonizing faunal assemblages clearly differed in both abundance and taxonomic composition. In a similar study elsewhere Fenoglio *et al.* (2002) reported rich variety of macroinvertebrates colonizing trout carcasses placed in riffle and pool environment of a NW Italian stream. Diptera of the Family Chironomidae and the Ephemeroptera; *Serratella ignita* (Ephemerellidae) and *Habrophlebia sp.* (Leptophlebiidae) were the most abundant taxa constituting respectively 29, 27 and 10% of total mean abundance; the flatworm *Dugesia sp.* and the stonefly *Protonemura sp.* were also abundant. This study showed Decopoda of the family Atyidae; *Caridina africana* as the most numerous

macroinvertebrates by the 3rd day of submersion (Ephemeroptera; *Cloeon sp*, *Bugilliesa*, *Cloeon sp*, Odonata (*Pseudagrion spematum*) were the most abundant.

Chaloner *et al.* (2002) reported 27 invertebrate taxa found on salmon carcasses; Tabanidae (*Tabanus sp*), (Diptera; Chironomidae) South-eastern Alaska Streams, Chironomid midges, Zapada, Capnidae (Plecoptera), Baetis (Ephemeroptera: Baetidae), Sweltsa (Plecoptera: Chloropelidae), and Onocosmoecus (Trichoptera: Limnephilidae) larvae were most common. Borchardt (1996) found that higher water temperature to a limit may also increase metabolic and development rate of macroinvertebrate and ultimately affecting their production. Furthermore, differences in carcasses size are known to encourage

successive colonization of carcasses by different macroinvertebrate and potentially the insect fauna on the carcasses.

The macroinvertebrate assemblages clearly differed between pool and riffle carcasses. The taxa abundance was almost constant in riffles, while it increased slightly over time in pool carcasses. However, in the five sampling periods the number of sampled individuals and species were higher in riffles than in pools. This could be as a direct expression of greater natural abundance of erosive microhabitats and also the inhabitation of the hyporheic zone. The findings of this research collaborate with the account of Mullner and Schager (2003) that invertebrates probably feed on detritus and biofilms derived mainly from allochthonous input and on the associated microflora fine particulate organic matter sustains a high number of collector-gatherers. The riffle microhabitat had a larger proportion of collector-gatherers whereas those in the pool had more of predators. This agrees with the findings by previous authors (Chaloner and Wipfil, 2002; Haskell *et al.*, 1989).

The collector-gatherers functional feeding groups was dominant in riffle and pool environment. This has been consistent in previous studies showing the importance of these organisms in transferring energy and materials from carrion to the rest of the lotic food web. The findings of this present investigation however disagree with Merritt and Wallace (2000) who reported that carcasses in the riffle habitat supported comparatively more scrapers and predators, whereas those in the pool habitat had a larger proportion of collector-gatherers and shredders. This was further affirmed by Keiper and Casamatta (2001) who stated that the pool and riffle habitats produce different macroinvertebrate assemblages, colonization patterns and functional feeding group composition.

The high abundance and distribution of chironomidae, chironomus sp and high dominance of chironomid in this study supports the claims of Keiper and Casamatta (2001) who had earlier reported that midge larvae are

probably the most important benthic invertebrates to forensic studies because they are numerous and thus likely to colonize a body in appreciable numbers after a short period of submersion. Keiper *et al.* (1997) reported a total of 21 genera of chironomidae representing >95% of the macroinvertebrates collected during their study to document the colonization by macroinvertebrates of adult rat carcasses in a woodland stream riffle and pool during the spring over time. The *Chironomus* species were also in high abundance colonizing the catfish carrion. Occurrence had begun by day 2 and established by day 4 in the pool, while in the riffle microhabitat occurrences was only on day 3. This research collaborates well with other studies (Chaloner *et al.*, 2002; Wipfil *et al.*, 1998), Chironomidae midges were abundant but did not constitute the dominant taxon in either the pool or riffle habitats. This increase may prove useful in forensic investigation if it is replicated in future studies involving carcasses in an aquatic environment. The species are also dominant species in freshwater systems in the Niger Delta and increase in abundance in organically polluted streams (Arimoro *et al.*, 2011; Arimoro, 2009). This study illustrate how aquatic insect colonization can be used during investigation for the cause of death of an aquatic organism and the time it occurred.

Levels of dissolved oxygen were between 4.0 and 6.2 mg/l in both riffle and pool microhabitats. The high dissolved oxygen levels (5.5 to 6.2 mg/l) in the riffle must have prompted the colonizing of Ephemeroptera which are oxygen loving organisms. Anderson (2009) reported that the anoxic conditions of bottom of deep-water bodies only permit the colonizing of few species as compared to the shallower portions with much higher oxygen and higher species diversity. Trichoptera and Coleoptera were represented with only one taxon each. Flatworms were not found in this study as compared with previous studies where they could play a role in the decomposition of fish carcasses mainly by secreting enzymes (proteases) through their eversible pharynx into the flesh of the trout, making it more soluble in water (Reynoldson and Young, 2000).

Conclusion

The research undertaken on daily variation of physiochemical parameters and macroinvertebrates colonization of catfish (*Clarias gariepinus*) in Ethiopie River, Delta State showed that there was rapid colonization of the fish carcasses which are important resources for microinvertebrates representing abundance and colonization hotspot. Most invertebrate fauna were opportunistic scavengers and fed on dead carcasses at all time until no soft tissue was left. Furthermore, the rapid macroinvertebrate colonization of the fish carrion, the decomposition and functional feeding group do suggest a better understanding of decomposition in rivers. The proportion of each functional feeding group of fish carcass during collection may provide valuable data for benthologic research and for forensic investigation in estimating elapsed time since submergence and in identifying the environment in which the decomposition occurred.

References

- Anderson, G.S. (2009). Insect succession on carrion and its relationship to determining the time since death. In: Byrd, J.H. Castres, J.L. (eds). *Forensic entomology: the utility of arthropods in legal investigations*. 2nd edn. CRC, Boca Rton, Florida: 201-250.
- Arimoro, F.O. (2009). Impact of rubber effluent discharges on the water quality and macroinvertebrate community assemblages in a forest stream in the Niger Delta, Nigeria. *Chemosphere*; 77:440-449.
- Arimoro, F.O. (2013). Colonization and invertebrate succession on mammalian carcasses in Ethiopie River, Niger Delta, Nigeria. *Applied Science Research Journal*; 1(1):1-13.
- Arimoro, F.O., Nwadukwe, F.O. and Mordi, K.I. (2011). The influence of habitat and environmental water quality on the structure and composition of adult aquatic insect fauna of Ethiopie river, Delta State, Nigeria. *Tropical Zoology*; 24(2):159-171.
- Borchardt, M.A. (1996). Nutrients. In *Algal ecology*. Edited by R.J. Stevenson, M.L. Bothwell, and R.L. Lowe. Academic Press, San Diego, California: 183-227.
- Brusen, M.A. and Scoggan, A.C. (1969). Sarcophagus Habits of Trichoptera Larvae on Dead Fish. *Entomology News*; 80(4).
- Catts, E.P. and Haskell, N.H., (1990). *Entomology and Death (A Procedural Guide)*, Joyces Print Shop, Inc. Clemson South Carolina:182.
- Chaloner, D.T. and Wipfli, M.S. (2002). Influence of decomposing Pacific salmon carcasses on macroinvertebrate growth and standing stock in south-eastern Alaska streams. *Journal of the North American Benthological Society*; 21: 430-442.
- Denno, R.I. and Cothran, W.R. (1975). Niche relationship of a guild of necrophagus flies. *Annals of Entomological Society of America*; 68:741-751.
- Fenoglio. S.P., Agosta, T.B. and Cucco, M. (2002). Field experiments on colonization and movements of stream invertebrates in an Apennine river (Visone, NW Italy). *Hydrobiologia*; 474:125-130.
- Goff, M.L. (2000). *A fly for the prosecution*, Cambridge Massachusetts: Harvard University Press.
- Haskell, N.H., Moshaffrey, D.G., Hawleg, D.A. Williams, R.E. and Pless J.E. (1989). "Use of Aquatic Insects in Determining Submersion Interval" *Journal of Forensic Science*; 34(3):622-632.
- Hawley, D.A. Haskell, N.H., Meshaffery, D.G., Williams R.E. and Pless J.E. (1989). Identification of a Red Fiber Chironomid Larvae. *Journal of Forensic Science*; 34:617-621.
- Keiper, J.B. and Casamatta, D.A. (2001). Benthic organisms as forensic indicators. *Journal of Northern American Benthological Society*; 20(2):311-324.
- Keiper, J.B., Chapman, E.G. and Foote, B.A. (1997). Midge larvae (Diptera: Chironomidae) as indicator of postmortem submersion interval of carcass in woodland stream: a preliminary report. *Journal of Forensic Science*; 42:1074-1079.
- Merritt, R.W. and Wallace, J.R. (2000). The role of aquatic insects in forensic entomology. In Byrd, J. H. and Catner J. L. (eds), *Forensic Entomology: The Utility of Arthropods in Legal Investigations*. CRC Press, Boca Raton, Florida: 177-222.
- Muller, A.N. and Schagerl, M. (2003).

Abundance and vertical distribution of the phytobenthic community within a pool and riffle sequence of an Alpine gravel stream. *International Review of Hydrobiology*; 88:243-254.

Reynoldson, T.B. and Young, J.O. (2000). A key to the freshwater Triclad of Britain and Ireland, with notes on their Ecology, FBA Scientific Publication: 58.

Taxasoft (2007). Winks SDA software, 6th edition, Cedar Hill, Texas, 2007.

Vance, G.M., VanDyk, J.K. and Rowley, W.A. (1995). A device for sampling aquatic insects associated with carrion in water. *Journal of Forensic Sciences*; 40(3):479-482.

Wipfi, M.S., Hudson, J.P. and Caouette, J.P. (1998). Influence of salmon carcasses on stream productivity: response of bioflim and benthic macro-invertebrates in southeastern Alaska, USA. *Canadian Journal of Fisheries and Aquatic Science*, 55:1502-1511.

Citation: Erhenhi, O.H., Francis, O.A. Macroinvertebrate colonization of Catfish (*Clarias gariepinus*) carcass of River Ethiope, Delta State, Nigeria. *Sokoto Journal of Medical Laboratory Science*; 3(4): 37 - 45

Copyright. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.