THE ROLE OF FRESHWATER ECOLOGY IN WATER SECURITY AND HUMAN WELLBEING

BY

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Protocol

The Vice-Chancellor,

Members of the University Governing Council,

The Registrar,

The University Bursar,

Visiting Vice-Chancellors and Representatives of other tertiary Institutions,

Provost, Deans and Directors,

Distinguished Professors and other members of the University Senate,

Heads of Departments,

Other Academic, Administrative and Technical staff of the University,

Traditional Title holders in our midst,

My Lovely wives and children,

Distinguished Invited Guests,

Gentlemen and Ladies of the press,

Good evening to you all.

Preamble

I have had the opportunity to listen to a number of inaugural lectures from eminent professors of this University since 2022, and perhaps read a few from other Universities. A number of views have been expressed as to the focus of an inaugural lecture. Professor Okoli (2003) is of the view that it is primarily an academic ceremony aimed at introducing a new professor to his/her professorial chair. It also affords a new professor an opportunity to publicly declare what he/she professes.

Vice-Chancellor Sir, it is a great privilege, honor and deep sense of fulfillment that I stand before you to present the first Inaugural lecture from the Department of Biological Sciences, the 5th of the Faculty of Science and the 15th of Gombe State University. I do share the view that a professor's responsibility in an inaugural lecture is to tell his audience what significant contributions he had made in his field of specialization that have earned him the title of a professor. This invariably conforms to the traditional pattern where the professor has to reflect on his own contributions to knowledge.

The delay in giving my inaugural lecture till date is rather a blessing in disguise. Time opportunity has been put to good use in gaining more field experience in the area this lecture will focus. In fact, the content of this lecture is practically-oriented with emphasis on case studies and local content. Let me therefore take this opportunity as a freshwater ecologist to give my thoughts concerning the role of freshwater in water security and human wellbeing in Nigeria with some emphasis on the North east geopolitical zone.

1.0 Introduction

Fresh water is vital to human life and wellbeing. Along with food and shelter, it forms our most basic need. So vital, in fact, that access to drinking water is commonly considered a fundamental right for all humanity. Healthy, functioning freshwater ecosystems provide reliable and quality water flows upon which these basic human needs depend. Energy, food and health, all indispensable to human development – rely on the water services provided by natural ecosystems. Freshwater ecosystems, such as wetlands and rivers, also provide crucial regulating services, such as water purification, flood mitigation and the treatment of human and industrial wastes. Now, more than ever, we must incorporate the value of water-related environmental services in our water management decisions. Eradicating poverty and hunger among the billions living in deprivation today and those in the future will depend fundamentally on water security – for both people and ecosystems.

Water is central to the functioning and resilience of the biosphere. Its availability and variability strongly influence the diversity and distribution of biomes and habitats that harbor the wealth of plant and animal life on Earth. Water of specific quantity and quality is required to preserve the state and stability of ecosystems and build their resilience to localized disturbance and to global change. It mediates the persistence of ecosystem types, their composition and function, and facilitates the migration of species and habitats as key environmental conditions such as temperature, rainfall, and soil moisture change.

Water's central role in the biosphere has long implied that several of the most important challenges confronting human development are related to fresh water (e.g., Falkenmark, 1990). This has been true for decades and Healthy freshwater ecosystems: an imperative for human development and resilience will only intensify without a change in the course of human water use. For too long, conventional approaches to water planning have focused narrowly on economic productivity, largely ignoring the costs of overdrawing water from ecosystems or disrupting natural flow regimes with hard infrastructure. If we are serious about meeting human development objectives for this century, the way we plan and manage water resources must change.

Freshwater ecosystems are vital for human well-being and water security because they provide water purification, flood control, and other essential services. Healthy, functioning freshwater ecosystems provide reliable and quality water flows upon which these basic human needs depend. Energy, food and health, all indispensable to human development, rely on the water services provided by natural ecosystems.

Freshwater ecology is the study of the structural and functional interrelationships of organisms of fresh waters as they are affected by their dynamic physical, chemical, and biotic environments. These are essential for maintaining healthy ecosystems.

Healthy freshwater environments supply water for drinking, growing crops, manufacturing, energy and transport. They also help to prevent erosion, dispose of waste and provide natural protection from flooding

Freshwater ecosystems, especially vegetated wetlands, play an important role in mitigation against climate variability. They do so through a number of ecosystem functions including flood control, water purification, shoreline stabilization and sequestration of carbon dioxide.

Water is vital to our health. It plays a key role in many of our body's functions, including bringing nutrients to cells, getting rid of wastes, protecting joints and organs, and maintaining body temperature. Without healthy freshwater environments, many of our unique living organisms such as fish, birds, and plants won't be able to survive. We can't live without water to drink and it's important that the water we drink is clean and safe from things like bacteria that can cause disease. Freshwater directly supports land-based life by enabling physiological processes such as photosynthesis and aquatic life, by providing freshwater habitats such as rivers, lakes, wetlands, and coastal systems.

1.1 Global Water Crisis

The world freshwater resources are unevenly distributed; at one extreme, the deserts, where almost no rain falls and at the other are the most humid regions, which can receive several millimeters of rainfall in a year. Most of the flow is in a limited number of rivers: the Amazon carries 16% of global runoff, while the Congo – Zaire River basin carries one-third of the river flow in all Africa. The arid and semi-arid zones of the world, which constitutes 40% of the landmass, have only 2% of global runoff (UN, 1997a). Due to interactions of geographical, environmental and financial factors as well as increasing pollution from wastes generated by humans, only about one-third of the world's potential freshwater can be accessed to meet human needs. As pollution increases, the amount of useable water decreases. It is pertinent to state that no region on earth will be spared from the impact of global water crises especially as it affects human health. Whilst supplies are falling, the demands for water are steeply rising all over the world. According to UN-ministerial declaration in the regions of moderate to high water stress, it is estimated that two-thirds of people will live in water-stressed conditions by 2025 (WBGU, 1999 and UNEP, 1999). When the global water is examined at country level, some countries still have large amounts of water per capita, but others are already facing serious difficulties. As at early 2003, more than 180 countries in the world were already listed as hard-hit by severe water shortage crisis. Leading this pack as the poorest in terms of water availability is Kuwait with $10m^3$ of water per person per year. It has been reported that, "at the beginning of the 21st century, the earth, with its diverse and abundant life forms, including over 6.1 billion humans, will be facing a serious water crisis. All the signs suggest that it is getting worse and will continue to do so, unless corrective actions are taken. The crisis is one of "water" (UNESCO-WWAP, 2003).

Figure 1: River channelized for irrigation

1.2 Freshwater Ecosystem

An ecosystem characterized by low-salt content, making a suitable environment for various plants and animals is known as a freshwater ecosystem. The freshwater ecosystem is mainly divided into three types based on its region – Lotic, lentic, and wetland freshwater ecosystem.

The primary producers of energy in fresh water communities are **bacteria and algae as well as mosses and liverworts**, which all utilize sunlight. These are then consumed by primary consumers which typically include insects, mollusks such as snails, crustaceans such as freshwater crayfish and worms.

1.3 Types of Freshwater Ecosystems

Freshwater ecosystems can be divided into three main categories: **rivers** and **streams**, **lakes and ponds**, and freshwater wetlands. Rivers, streams, creeks, and brooks often originate from underground water sources in mountains or hills. Near a source, water has plenty of dissolved oxygen but little plant life.

1.4 Characteristics of Freshwater Ecosystem

Freshwater is defined as having a **low salt concentration, usually less than 1%**. Plants and animals in freshwater regions are adjusted to the low salt content and would not be able to survive in areas of high salt concentration (i.e., ocean).

1.5 Proportion of Freshwater Available for Human Use

The oceans constitute 97.3% of all water sources on the Earth. Thus, the percentage of freshwater sources is only 2.7%. Of all the freshwater sources, only **2.9%** of it is available to us in the form of freshwater lakes, rivers, and groundwater *Umar et al*., (2014).

1.6 Important Ecosystem Services of Freshwaters include;

i. **Food:** Although we first think of fish when we think of food from the water, the spectrum is actually large and ranges from animals (mammals, Amphibians, Fish, Reptiles and birds) to plants and microorganisms.

ii. **Animal and plant products:** Materials from freshwater are used to make utilitarian and ornamental items, such as clothes made from fish leather, nail files from fish scales and scissors from piranha teeth. Aquatic plants are used as building materials and furniture.

iii. **Health and genetic resources:** Algae, aquatic plants and animal products – from collagens from fish to secretion products from frog skin – are used in medicine and pharmacology.

iv. **Protecting human health**: Some pollutants pose risks to human health. Water quality standards protect human health and avoid the costs related to medical care, productivity loss, and even loss of life.

v. **Recreational value:** The recreational activities enabled by freshwater biodiversity are considered cultural services. Swimming and boating take place where the water quality is considered good. This is directly related to the living organisms in the water body, which can prevent algal blooms, for example.

vi. **Culture, religion and spirituality:** Almost all cultures around large lakes or rivers have rituals and traditions linked to the living creatures there.

vii. **Education and technological advancement:** Formal curricula in primary schools to targeted extracurricular activities for youth – all help to build connections and foster a lifelong commitment to freshwater conservation and responsible stewardship.

viii. **Climate regulation:** Freshwater ecosystems are critical for carbon and methane storage and sequestration.

ix. **Catchement integrity:** Riparian and aquatic plants reduce water velocity, improve bank stability, retain sediments and filter nutrients and pollutants.

x. **Self-purification of water and nutrient cycles:** Billions of microorganisms, plants, algae and animals clean the water by filtering excess nutrients, pathogens and pollutants. This is crucial for drinking water production, among other things.

xi. **Water for humans and wildlife**. Healthy freshwater environments supply water for drinking, growing crops, manufacturing, energy and transport. They also help to prevent erosion, dispose of waste and provide natural protection from flooding.

xii. **Support high level of biodiversity:** makes species and ecosystems stronger and more stable. For example, an ecosystem with a high amount of diversity can adapt better to a wide variety of conditions, like climate change, disease, and extreme weather.

2.0 Freshwater Ecological Issues

Increasing human population, deforestation, construction and man-made climate change are likely to exacerbate the negative effects on freshwater ecosystems and species endangerment. Consequently, the biodiversity of freshwater continues to dwindle at an alarming rate.

Draining of wetlands for development depletes habitats. Overexploitation and pollution threaten groundwater supplies. Invasion of exotic species can harm native animals and plants. Global warming may lead to devastating floods and droughts. The loss of an ecosystem's ability to recover from a disturbance, whether due to natural events such as hurricanes or volcanic eruptions or due to human influences such as overfishing and pollution endangers the benefits (e.g., food, clean water, and aesthetics) that humans derive from that ecosystem.

Figure 2: River channelized for hydro-electricity power generation

2.1 Humans Impact on the Water Cycle

Human activity, such as **burning fossil fuel, contributes to the Earth's rising temperature**. An increase in temperature means an increase in evaporation and rapid melting of ice sheets, such as glaciers, which causes sea levels to rise and impacts other critical processes of the water cycle.

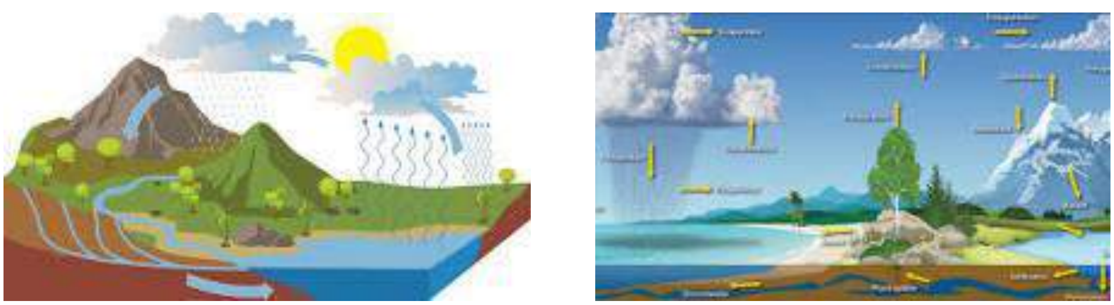


Figure 3: Water cycle

2.3 Positive Human Impacts on Freshwater Ecosystems

By taking better care of our freshwater habitats – from restoring wetlands, to planting trees in water catchments, to reconnecting rivers with their floodplains – we can reduce the risks of flooding, water shortages and hunger, as well as adapt to the impacts of climate change. And our watery wildlife will benefit too.

Figure 4: A) bush fire deliberately burning grassland and forest, B) cattle in a forested stream, C) farmer washing maize in stream and D) stream channelized for irrigation.

3.0 Research Activities

Vice-Chancellor Sir, in the last 20 years of research activities, my research interest has been mostly focused in limnology; that is the study of inland waters - lakes (both freshwater and saline), reservoirs, rivers, streams, wetlands, and groundwater. Limnology is the study of physics, chemistry and biology of inland waters (Rivers, streams, lakes and ponds). Also, the circulation patterns of lakes, which the water mixes vertically, from top to bottom, during the course of a year. In this presentation I wish to highlight some of my contributions to tropical highland streams, as follows;

i. Response of benthic invertebrates to a land use gradient in tropical highland streams
ii. Freshwater invertebrates
iii. Riparian land use and litter decomposition in streams
iv. Food web structure in tropical highland stream ecosystems
v. Biotic index for Nigerian highland streams
vi. Aquatic pollution
vii. Aquaponics

3.1 Response of Benthic Invertebrates to Land Use Gradient in Tropical Highland Streams:

The response of benthic invertebrate diversity and communities to a gradient of land use change was investigated. 55 streams ranging from pristine forest to intensive cropping and grassland were studied in order to improve our understanding of how tropical stream ecosystems change in response to land use. I see such understanding as a major priority for better management and conservation of Nigerian streams and rivers.

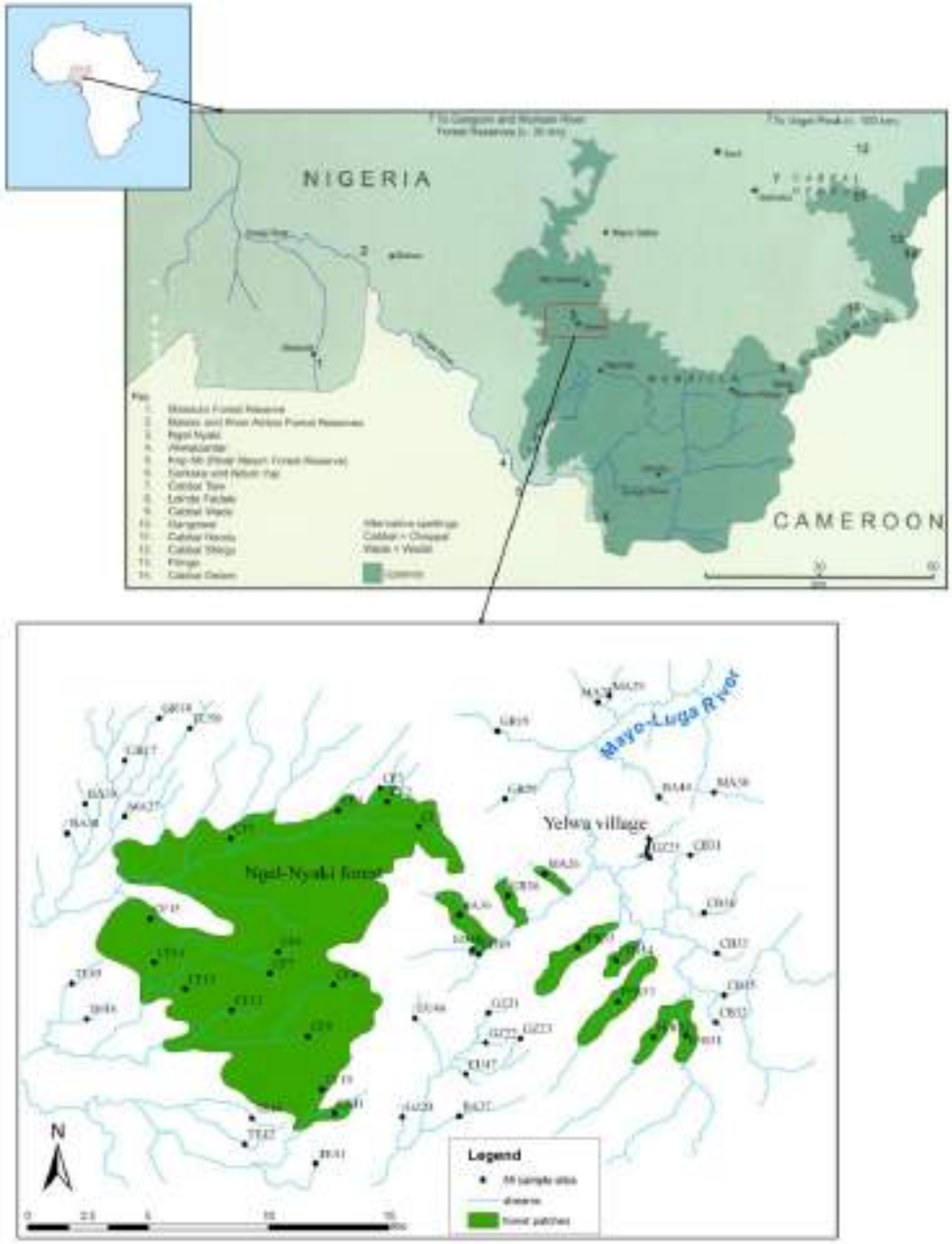


Figure 5: Map of the Mambilla Plateau, north-east Nigeria. Study streams are located near Yelwa village

Figure 6: Streams affected by a range of land uses occur on the Plateau and includes (A) maize (B) tea, (C) cabbage, (D) *Eucalyptus* plantation, (E) banana plantation and (F) grassland with livestock grazing.

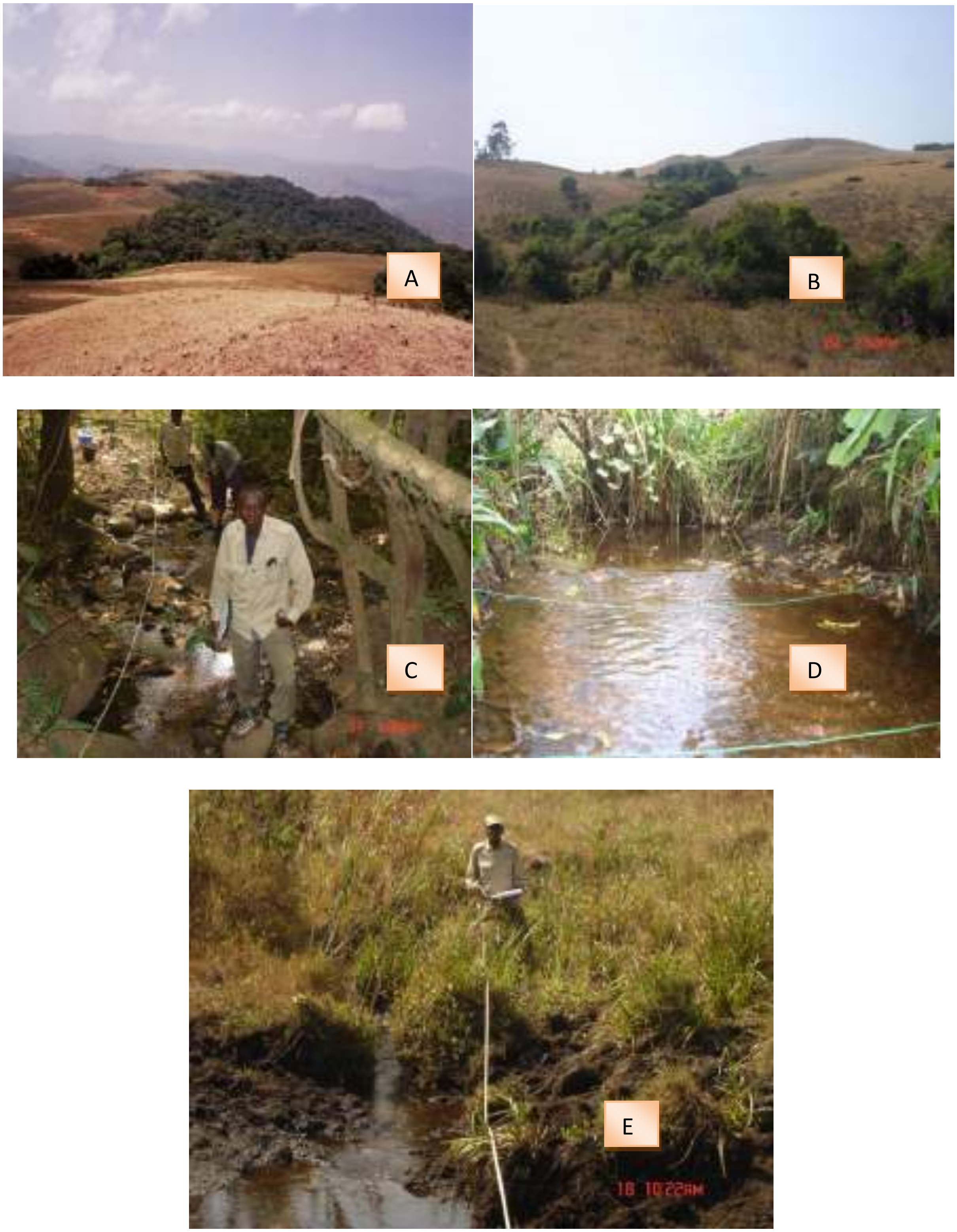


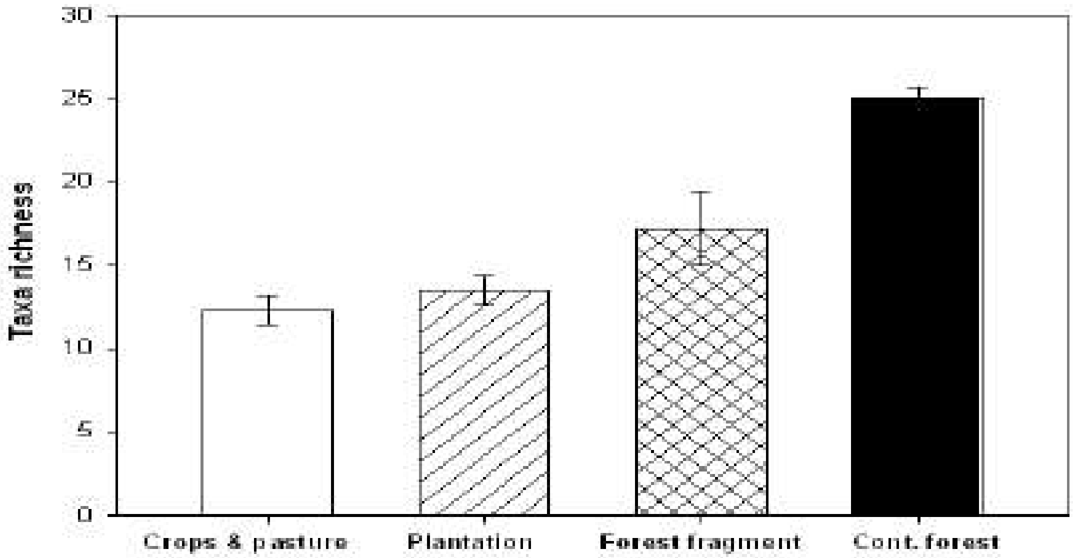
Figure 7: (A) The montane forest of Ngel Nyaki Forest Reserve (B) Riparian Forest fragments are common along streams in grassland catchments surrounding the Ngel Nyaki forest (C) Substrates dominated by boulders and cobbles in a forest stream, (D) sandy substrate and (E) soft mud in an open pasture stream on the Mambilla Plateau.

Invertebrate Metrics and Community Composition

A total of 76 taxa in 13 orders were collected. Taxonomic richness was significantly higher at the continuously forested sites compared to the forest fragment, plantation and crop and pasture streams (Fig. 6). The highest overall site richness of 21 was recorded in three continuous forested streams, whereas no taxa were found in three streams surrounded by maize crops. Invertebrate densities were also higher in both continuously forested and forest fragment stream types than in crop and plantation streams, with mean density in continuous forest streams reaching 260 m^{-2} (Fig. 2). Pollution sensitive taxa, Ephemeroptera, Plecoptera and Trichoptera (EPT) varied across the four land uses, with the highest number of EPT taxa being nine at a continuously forested site where they averaged 27% of all taxa. (Figs. 9A, B).

Figure 8: A) Forested stream B) stream channelized for irrigation

A)



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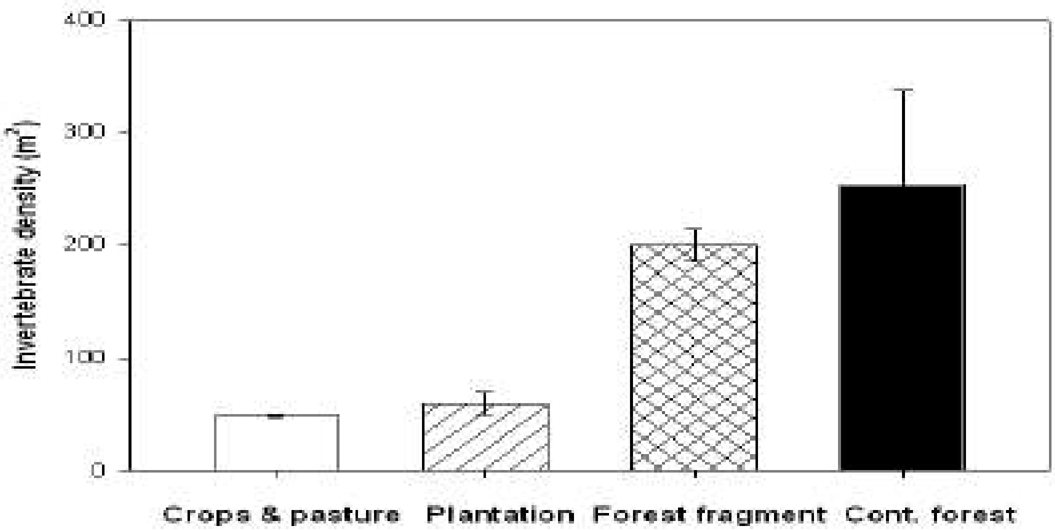
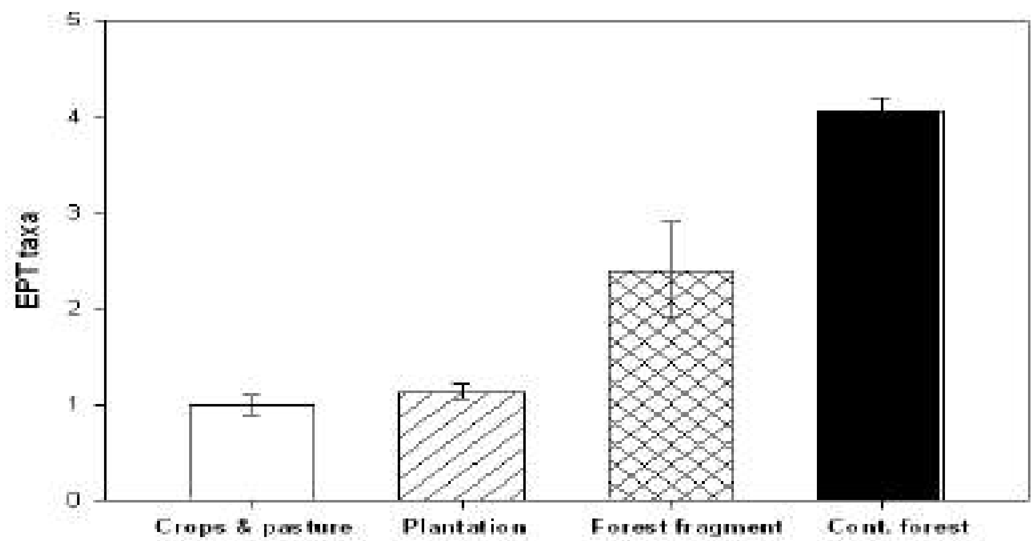


Figure 9: Stream benthic invertebrates sampled in streams flowing through catchment with four land uses between October 2009 and March 2010 on Mambilla Plateau (A) mean invertebrate taxonomic richness and (B) mean invertebrate density. Crop and pasture n = 20, plantation n = 15 forest fragments = 5 and continuous forest = 1. Error bars are 1±SE.

A)



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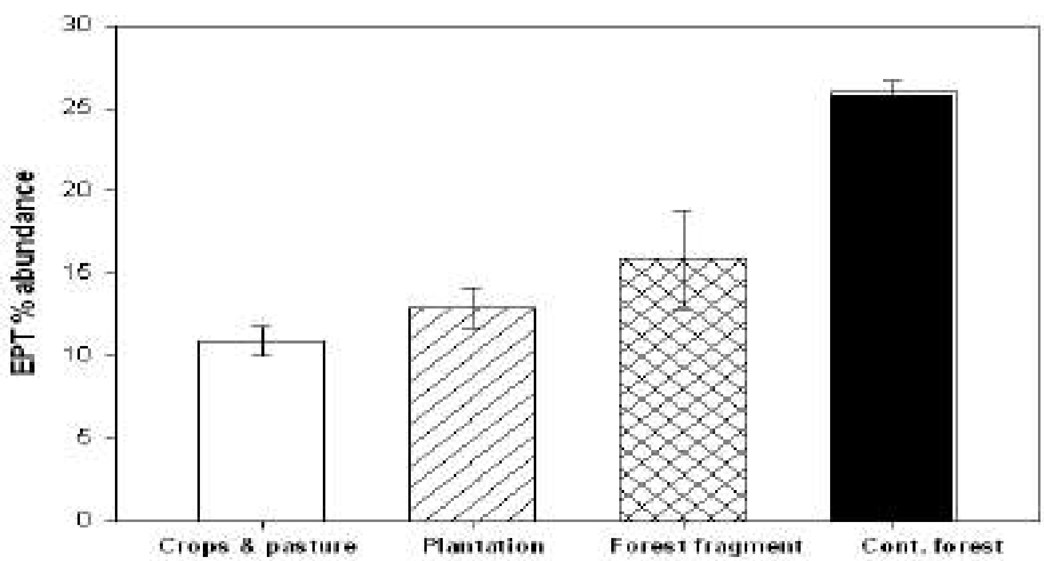
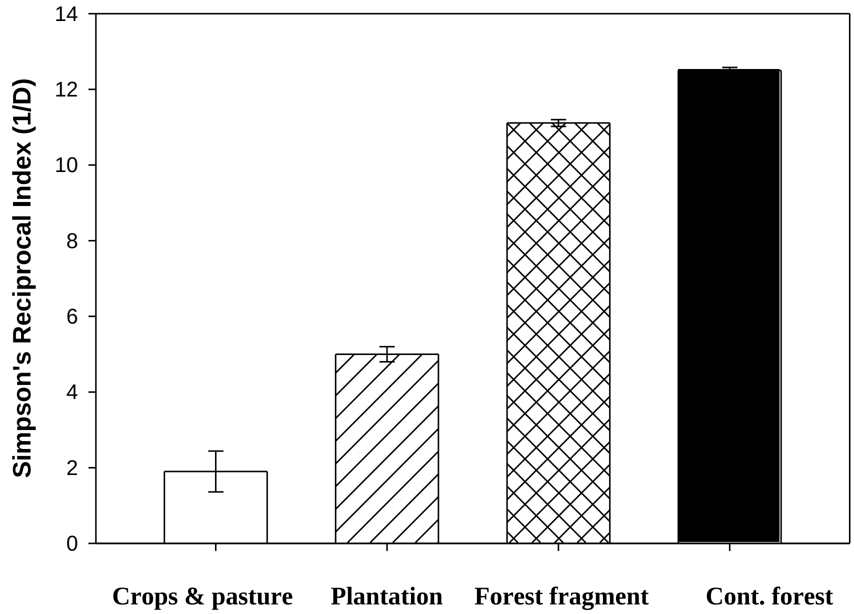


Figure 10: Pollution sensitive taxa, mayflies, stoneflies and caddisflies, i.e., EPT) taken from streams flowing through catchments with four different land use between October 2009 and March 2010 on Mambilla Plateau (A)mean EPT taxa and (B) mean EPT % abundance. Error bars are 1±SE.

A)



B)

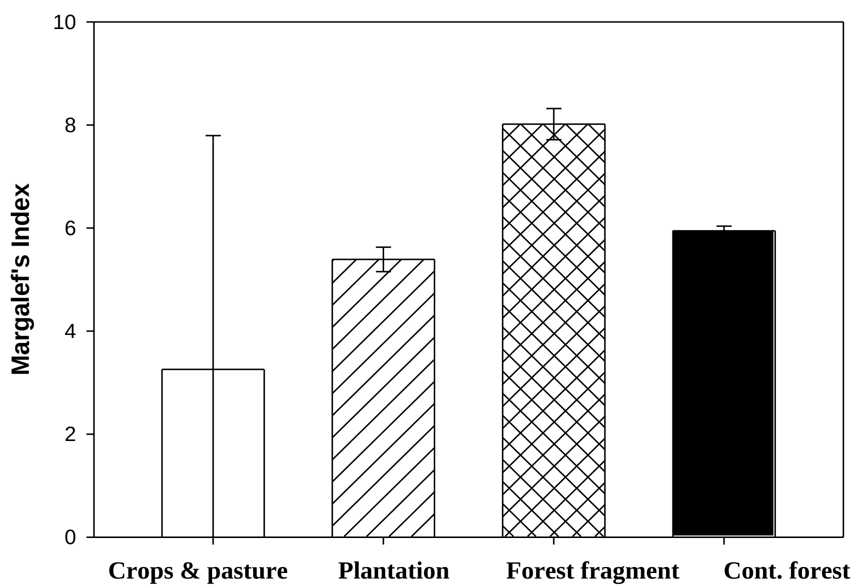


Figure 11: (A) Mean Simpson's and (B) mean Margalef diversity indices for benthic invertebrates taken from streams flowing through catchments with four land uses on Mambilla Plateau between October 2009 and March 2010 on Mambilla Plateau. Error bars are 1±SE.

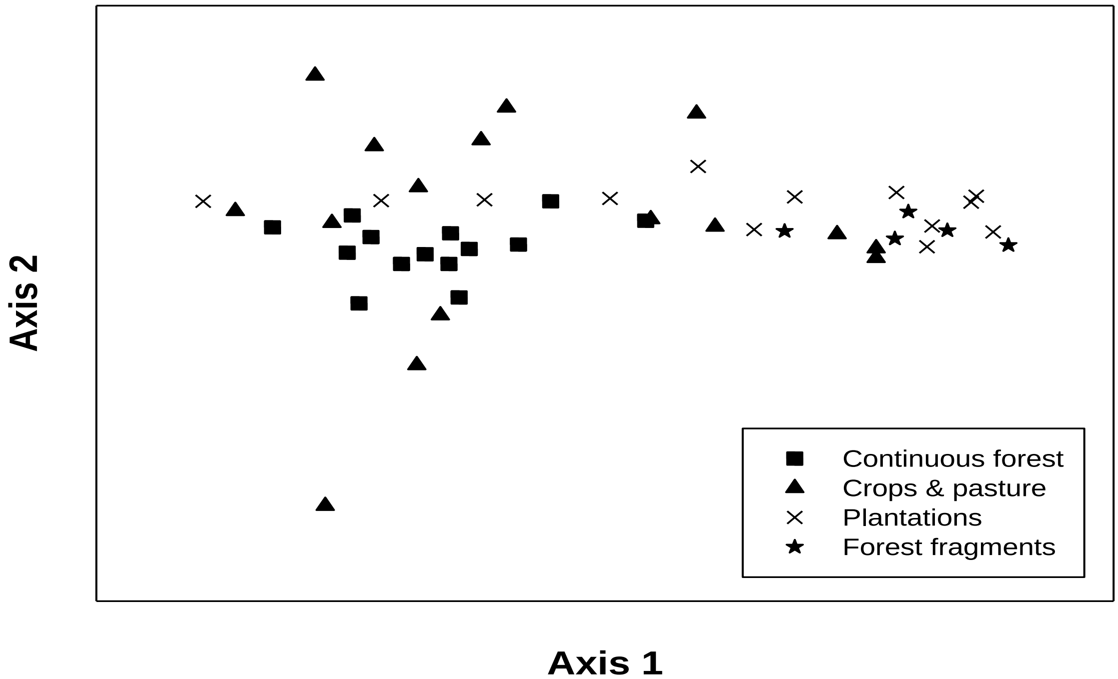


Figure 12: Detrended Correspondence Analysis (DCA) performed using quantitative benthic invertebrate's data. Communities in streams flowing through continuous tropical rain forest, forest fragments, plantations and crops and pasture are given different symbols.

3.2 Freshwater Invertebrates:

Work was conducted on the Mambilla Plateau in the south east corner of Taraba State, north eastern Nigeria, between October 2009 and February 2012. During the study, an extensive field survey and a series of experiments were conducted in the field. Due to the paucity of information on the taxonomy and ecology of stream invertebrates in highland areas in Nigeria, I developed a photographic guide to the aquatic animals and provided brief notes on their ecology and habitats (Umar *et al.*, 2013).

Taxonomic classifications used in this presentation:

Kingdom (e.g., Animalia)
Phylum (e.g., Arthropoda)
Class (e.g., Insecta)
Order (e.g., Diptera)
Family (e.g., Tipulidae)
Subfamily (e.g., Limoniinae)
Tribe (e.g., Hexatomini)
Genus (e.g., *Paralimnophila*)
Species (e.g., *Paralimnophila skusei*)

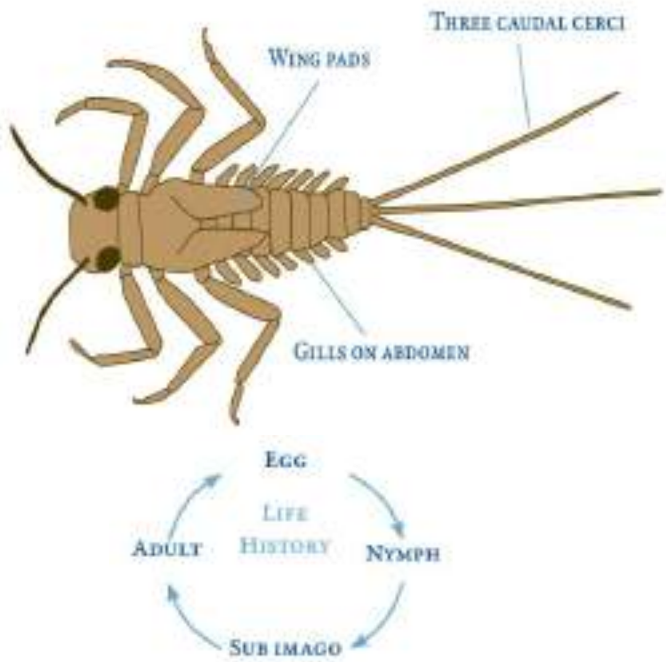


Figure 13: A generalized mayfly and life history.

Family: Oligoneuriidae

A single species which may be *Elassoneuria* Eaton 1881 (Gillies, 1974) is common in some streams. A species of this genus (*E. candida*) was described from Nigeria by Eaton in 1913. It has a streamlined, fish-like, nymph with a body length of up to 20 mm. This mayfly has abundant gills, including leaf-like structures on abdominal segments and a prominent tuft of maxillary gills beneath the head; thoracic gills are also present (Fig. 14). Initially it looks like a small fish as it darts around the stream.

Figure 14: (A) Oligoneuriidae: *Elassoneuria,* with leaf-like abdominal gills and (B) maxillary gills beneath the head. This mayfly can be up to 15 mm long.

Family: Heptageniidae

Nymphs are strongly flattened with large plate-like gills. When viewed from above the mandibles are hidden beneath the flattened head. There are two slender tail filaments (though they are easily broken). Nymphs usually attach closely to stream substrate and can swim awkwardly; body length up to 20 mm **(**Fig. 15).

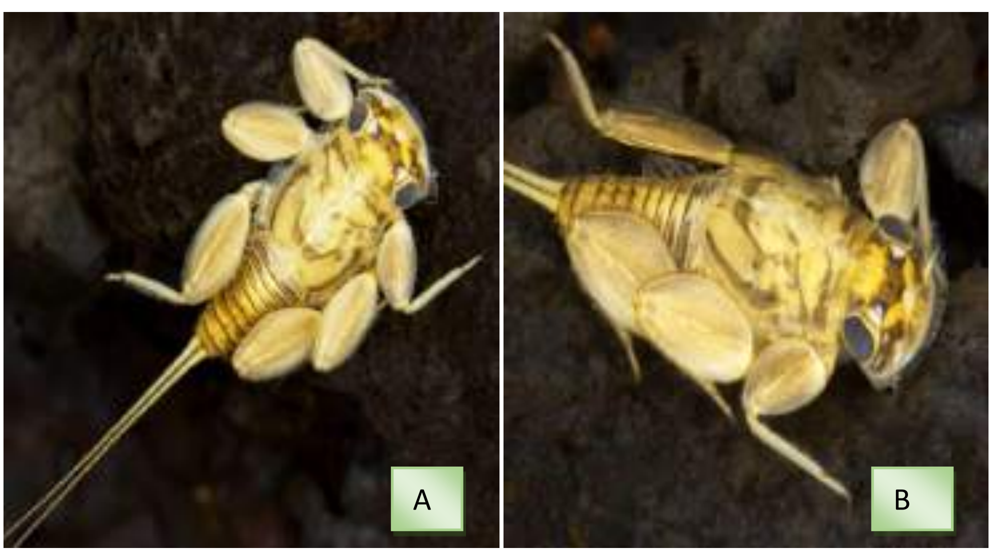


Figure 15: (A & B) Heptageniidae nymphs.

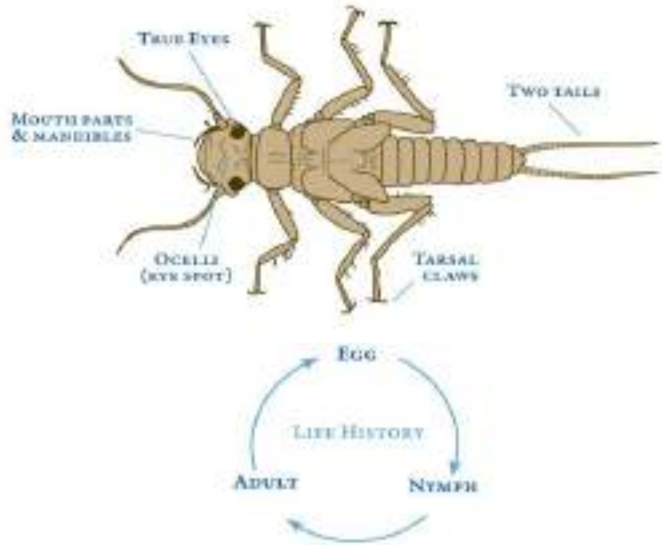


Figure 16: A generalized stonefly nymph and life history.

Family: Perlidae

A single genus, *Neoperla*, has been found on the Mambilla Plateau but it may be represented by more than one species. Nymphs have branched filamentous gills at the bases of each leg, and at the bases of each caudal cerci ("tails"). The nymph (Fig. 17) resembles that of the unidentified *Neoperla* species reported in Nigeria by Ogbogu (2006).

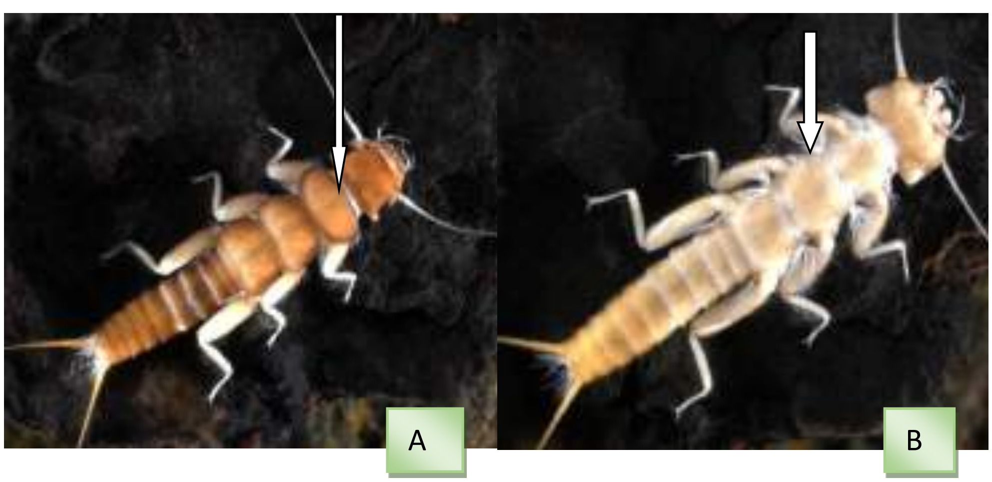


Figure 17: Perlidae genus resembling *Neoperla* showing (A) the pair of ocelli on head (B) filamentous gills, at the base of each leg and at caudal cerci.

Order: Trichoptera (caddisflies)

Caddisflies are holometabolous insects, meaning the life cycle includes a larva, a pupa and an adult. Larvae have biting mouthparts with well-developed mandibles, very small antennae, and the abdomen lack prolegs on its middle segments unlike the caterpillars of Lepidoptera. Many caddis larvae have portable cases made from sand grains, fragments of leaves and other materials. Others have a fixed retreat, whereas still others have no case or retreat and are described as free-living (Fig. 19).

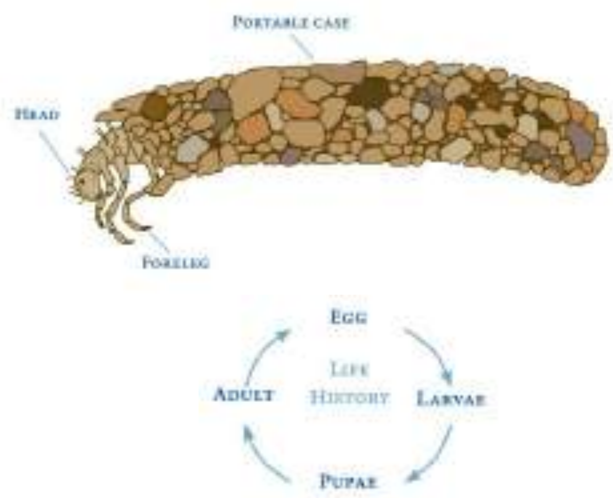


Figure 18: A generalized caddisfly and life history.

Family: Hydropsychidae (net-making caddis)

Several species belonging to this family, and the subfamily Hydropsychidae, occur on the Plateau. They can be recognized by the presence of branched gills on the ventral surfaces of seven or eight abdominal segments, and the prominent brush extending from the base of each anal claw. Larvae live in retreats (small stone houses) attached to rocks and wood and spin a capture net at the retreat entrance. Larvae are poor swimmers and may be up to 15 mm long (Fig. 19 & 20).

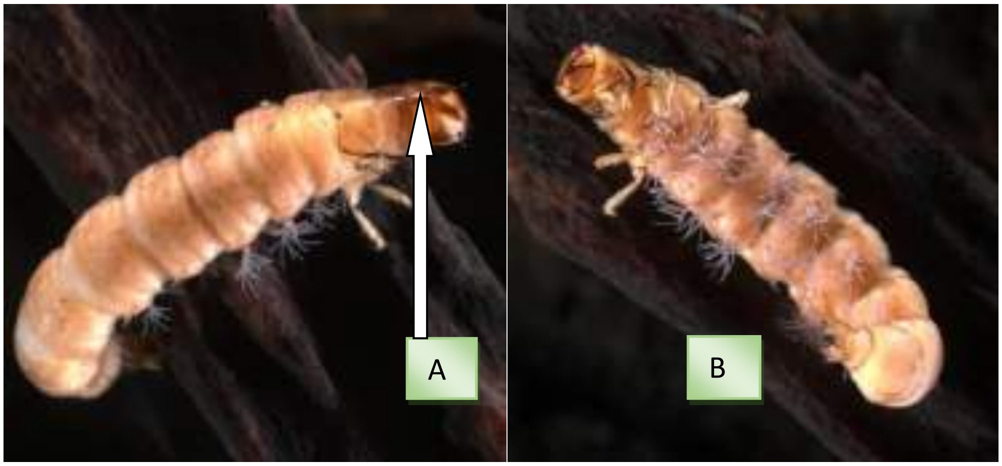


Figure 19: Hydropsychidae sp. showing (A) pattern on the head (B) ventral view showing the branched gills.

Figure 20: Hydropsychidae sp. B (A) has no pattern on the head and (B) dorsal view.

Family: Leptoceridae

Larvae build a great variety of cases from pieces of wood, leaf fragments and mineral particles. The hind legs are very long. The family identity can be confirmed by examining the antennae, which although small are about six times as long as wide (Figs. 21).

Figure 21: (A & B) Leptoceridae in portable leaf case.

Anisoptera (dragonflies)

Family: Gomphidae

The mask of gomphid larvae is almost flat and the abdomen is short and broad. Features that can be used to identify gomphid are the 4-segmented antennae (the third segment is much longer than the others), and the 2-segmented tarsi of the middle legs (Fig. 22).

Figure 22: Gomphidae (A) Dorsal view and (B) Anterior view.

Order Coleoptera (beetles)

Beetles are holometabolous insects whose larvae and adults can be aquatic. However, pupation is usually on land. Most adult beetles have chewing mouthparts and hard wing covers (elytra) which meet in a straight line over the thorax and abdomen. Larvae show a wide variety of forms and typically have 3 pairs of jointed thoracic legs but no prolegs on the abdomen.

Family: Dytiscidae (diving beetles)

Both adult and larvae of dytiscids (Fig. 23) are aquatic. Adults have streamlined bodies and their legs may have long fringes of swimming hairs. The metasternum in front of the hind legs is covered by large plates often described as "wings", and are characteristics of the family. Several species have been found on the Mambilla Plateau including the large black *Dytiscus* which is about 12 mm long. Other species are less than 10 mm long and one has longitudinally striped elytra.

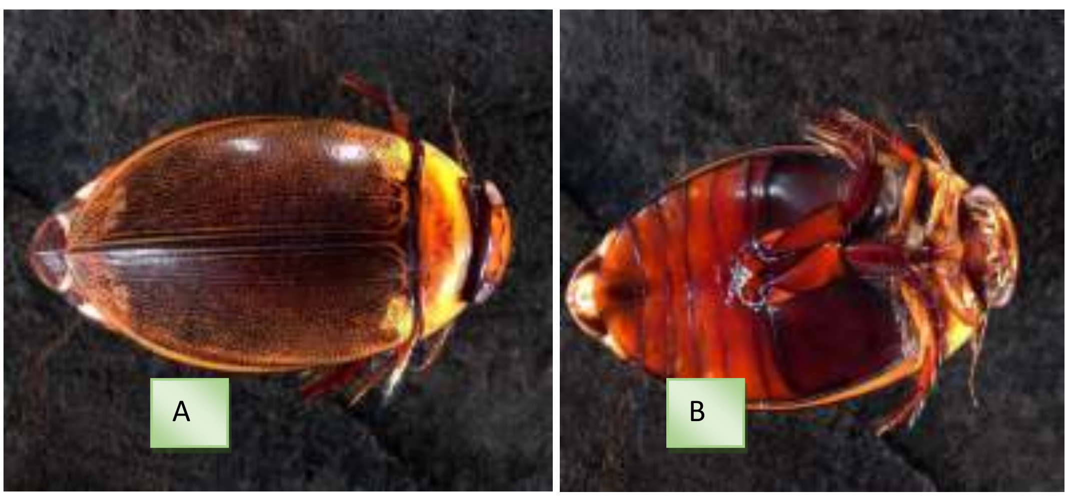


Figure 23: Dysticidae adult (A) dorsal view and (B) ventral view.

Order: Hemiptera (bugs)

All aquatic hemipterans belong to the suborder Heteroptera, which is considered to be an order by some authorities. They are hemimetabolous insects with sucking mouthparts that are formed into a tube or rostrum (Fig. 24 & 25).

Figure 24: Nepidae (water scorpion), (A) dorsal view and (B) head with compound eyes and stylet.

Figure 25: *Ranatra* (A) dorsal view and (B) ventral view.

Phylum: Annelida

Class: Oligochaeta

Oligochaetes are segmented worms with 4 sets of chaetae on each segment (visible only with a microscope). Aquatic species resemble small earthworms but most are in different families. The most common family is the Naididae (which now includes Tubificidae). They frequently colonize soft sediments and may be very abundant in poor quality, polluted waters.

Phylum: Mollusca

Freshwater molluscs have one or two shells (valves) and no legs. The class Gastropoda contains the species that live in a single shell; the class Bivalvia, those with two valves. Some species have the ability to tolerate a wide range of osmotic pressures and salinities and are described as euryhaline (Winterbourn, 1973).

Gastropod families known from Nigerian freshwaters include Lymnaeidae, Planorbidae, Physidae, Ampullaridae and Thiaridae. The large conical species (Fig. 26) is the thiarid *Melanoides tuberculatus*, an introduced species that is now widespread and abundant in many parts of the world. The upper whorls of the shell have a trellis pattern of crossing spirals and transverse ridges and are brown in colour, although adults can have black incrustations, and an eroded apex. The shell grows to 38 mm high. The globular species in (Fig. 27) is the planorbid *Bulinus globosus* which is widespread in many freshwater systems in Nigeria. Its shell is up to 5 mm in height and is a brown-yellow colour. *B*. *globosus* is known to be an intermediate host of the trematode *Schistosoma mansonii*, the cause a human parasitic disease (schistosomiasis).

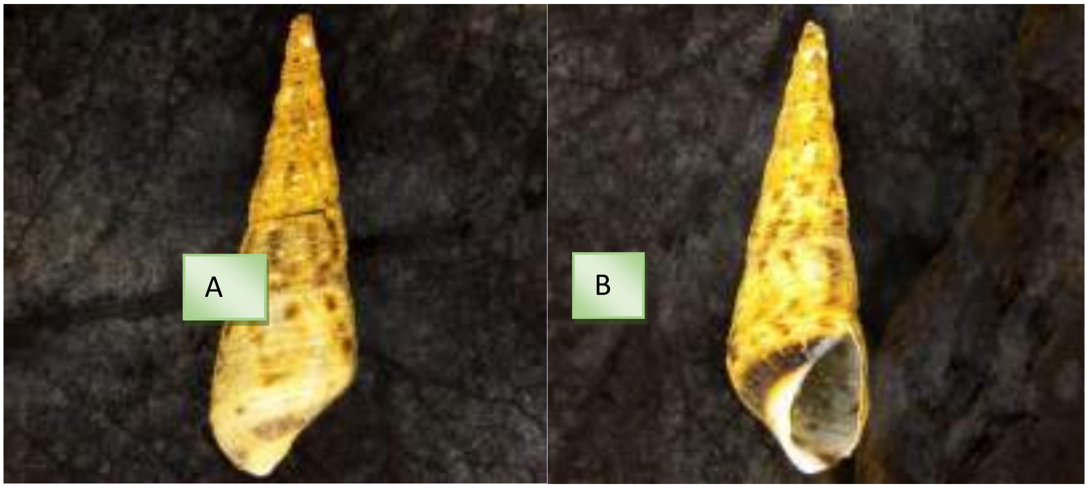


Figure 26: (A) *Melanoides tuberculatus* and (B) the aperture mouth and columella area.

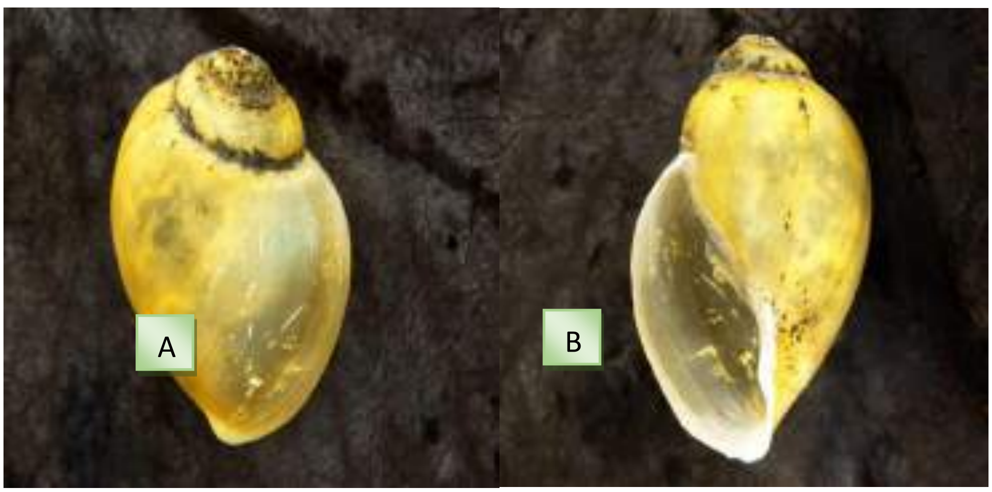


Figure 27: (A) *Bulinus globosus,* showing body whorl and globe-like shape and (B) aperture.

4.0 Riparian Land Use and Litter Decomposition in Nigerian Streams:

The importance of riparian land use and its relationship between benthos and leaf litter decomposition was investigated. Leaf litter decomposition experiments were carried out in nine selected streams; three in forest, three in maize farm and three in tea plantations between 2010 and 2011 to determine the rate of decomposition of organic matter, and describe an ecosystem process in streams across the contrasting land uses.

Figure 28: (A) *Syzygium guineense* leaves being air dried (B) dry leaves on digital weighing scale, (C) onion mesh bags (mesh size 30 mm) filled with 6 gm dry weight leaves and (D) leaf mesh bags being placed in a stream.

Results

Physico-Chemical Variables

Physico-chemical variables were generally similar between forest, tea plantation and maize streams. However, not surprisingly canopy cover was higher in the forest than in the tea and maize streams (88% and 5% respectively) and water temperatures were significantly higher in the maize and tea plantation streams than in the forested streams (26°C and 16°C respectively) (Table 1) (Umar et al., 2018).

Table 1: Mean (± 1 SE) physico-chemical characteristics of streams sampled in March 2012, on the Mambilla Plateau Nigeria (n = 3 for each of maize, tea and Continuous Forest). Statistics are result of one-way ANOVA.

Parameters	**Maize fields**	**Tea**	**Forest**	**F-stat**	**P-value**
Chemical					
Temperature °C	26.3 (0.3)	21.7 (0.6)	16.6 (0.15)	3.25	0.02*
pH	6.3 (0.2)	6.6 (0.2)	7.1 (0.1)	3.91	0.01*
%DO	51.2 (0.3)	49.2 (1.5)	79.6 (4.7)	7.23	≤0.001*
Conductivity (μScm^{-1})	100 (16.6)	252 (62)	217 (17.5)	5.32	≤0.001*
Turbidity (m)	0.3 (0.02)	0.5 (0.03)	0.7 (0.03)	4.33	0.02*
Nitrate (mg/m^2)	0.02 (0.01)	0.00 (0.0)	0.02 (0.01)	1.04	0.38
Phosphate DPR (mg/m^2)	0.04 (0.08)	0.04 (0.02)	0.04 (0.04)	0.43	0.73
Physical					
Velocity ($m\ s^{-1}$)	0.23 (0.02)	0.17 (0.01)	0.26 (0.03)	9.55	0.09
Wetted width (m)	6.0 (0.3)	4.34 (0.3)	5 (0.3)	19.68	1.31
Substrate size (mm)**	4.0 (6)	5(2)	65 (22)	17.28	7.14
Channel stability	73 (4.5)	78 (2.7)	71 (6.8)	13.05	0.07
%forest	5.0 (0.0)	28.3 (7)	88 (4.4)	15.8	0.06
%pasture	61 (28)	60 (22)	16 (2)	15.8	0.06

*: Indicate significant difference ($p < 0.05$) ANOVA; values are means with standard error in parentheses.
**: substrate size class index values

The pH in all streams was circum neutral but statistically significantly higher in forested streams and Dissolved oxygen concentrations were significantly lower in maize and tea plantation streams compared to forested streams (49% and 79%, respectively) (Table 1). However, conductivity was significantly higher in tea plantation and forested streams than maize field streams (Table 1). Stream width and velocity were similar across land uses, with streams ranging from four to five metres wide. Substrate was much finer in maize and tea plantation streams (i.e., gravel and sand) compared to forested streams, which had boulders and cobble substrates.

Leaf Breakdown

During the first few days, leaf litter weight loss was probably rapid as significant number of soluble compounds were leached from leaves into the streams (Nykvist, 1961a). After two weeks between 20–50% weight loss had occurred (Fig. 29). However, between four and six weeks the rate of weight loss seemed to decline in maize and tea plantation streams. After six weeks the overall leaf weight loss was similar across stream types (Fig. 29a) and not significantly different (One-way ANOVA, $F_{2, 24} = 0.525$; P = 0.597). Breakdown rates (-*k*) from 0.001 - 0.0011 per day indicated slow rates of leaf breakdown according to Petersen and Cummins (1974), i.e., less than 0.005 day^{-1}. Similarly, leaf toughness did not differ among the three stream types but decreased with time in the stream (Fig. 29c).

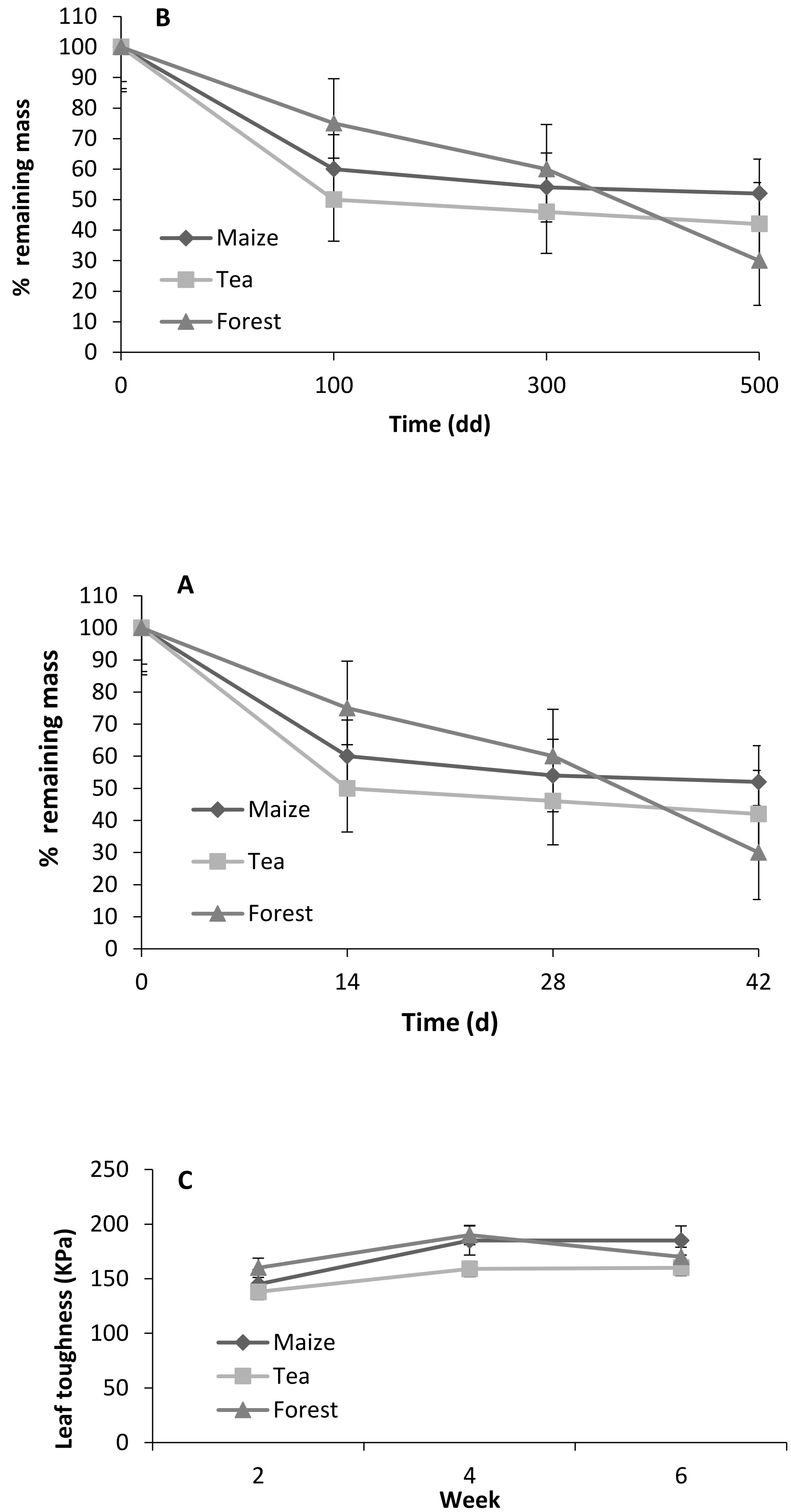


Figure 29: Mean (± 1 SE, n = 3) mass loss relative to time expressed as (A) days, (B) degree days and (C) changes in leaf toughness of *Syzygium guineense* leaves during the leaf-litter breakdown experiment in three types of streams over six weeks in the dry season (February–March, 2011) on Mambilla Plateau Nigeria.

Benthic Invertebrates

Invertebrate taxa in leaf bags differed significantly between forest, tea plantation and maize fields sites (ANOVA, $F_{2,\ 15} = 8.399$; $P = 0.003$). Taxonomic richness was significantly higher in forest (mean 30 per leaf pack) than tea (17) and maize (10) (Fig. 4a), and Simpson's diversity index showed that forested stream communities had higher evenness (0.10) than tea plantation streams (0.05) and maize field streams (0.02) respectively. Invertebrate densities were higher in leaf packs from forested streams than tea plantation and maize streams (Fig. 4b) although variation among forested streams was high.

In the leaf packs taxon richness did not change significantly over the six weeks of the experiment. Shredders were collected in leaf bags from all stream types but few were found in bags from tea plantation and maize field streams (Fig. 29c). Shredder taxa were significantly more abundant in forest than tea plantation and maize fields stream bags (Fig. 30c). In contrast, predators and scrapers were significantly more abundant in maize field streams than in forest and tea plantation streams. However, the relative contribution of FFGs differed significantly between forest, tea plantation and maize field stream reaches.

The most abundant invertebrate families represented in leaf bags taken from the forest streams were the dipteran Tipulidae and the caddis families Calamoceratidae (*Anisocentropus* sp.) and Lepidostomatidae, whereas in the tea plantation and maize streams, the dominant families were the beetle Elmidae, caddis Hydropsychidae and snails Thiaridae (*Melanoides tuberculatus*) all collector scrapers.

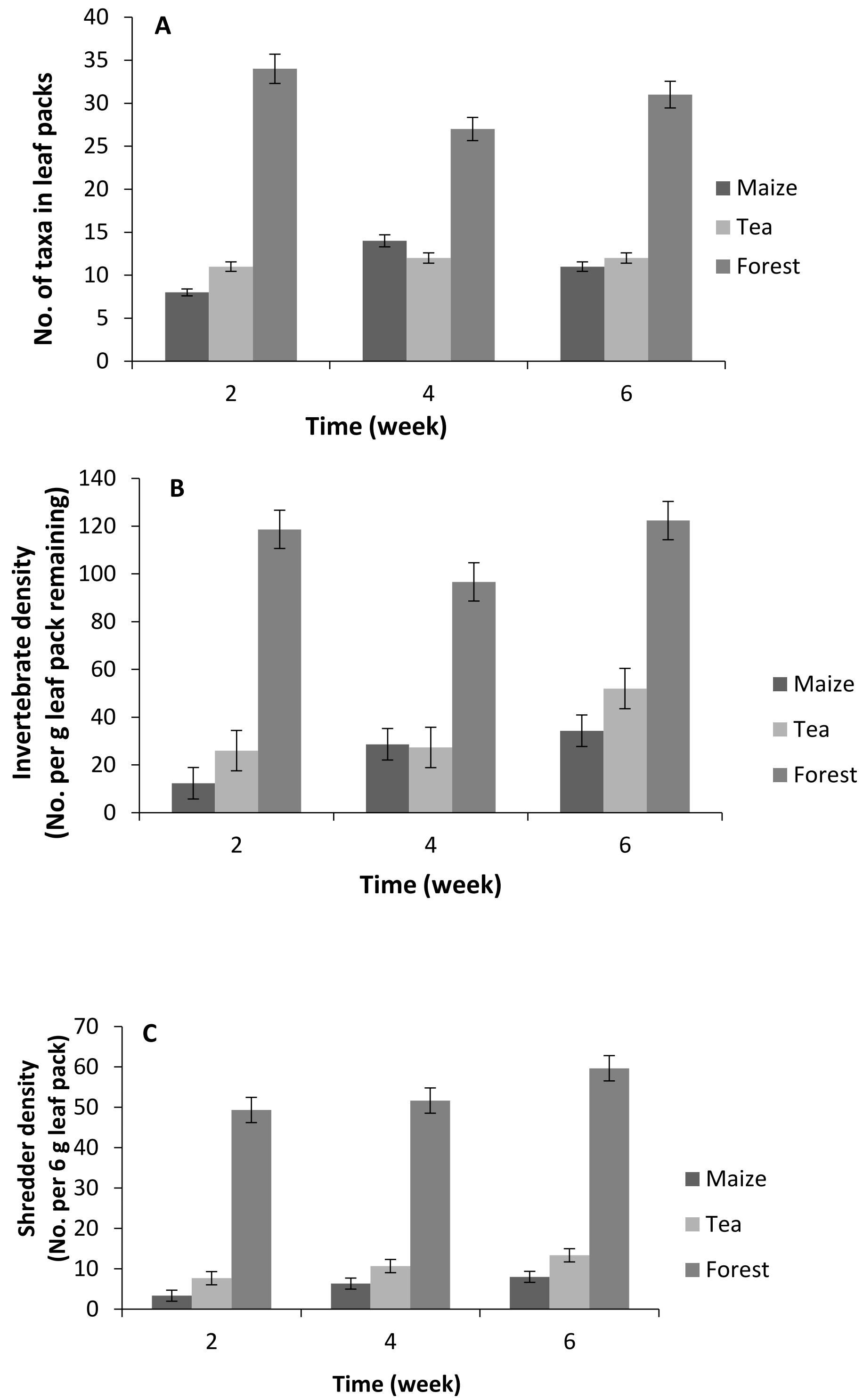


Figure 30: Mean (± 1 SE, n = 3) A) taxonomic richness, B) number of invertebrates and C) number of shredders in leaf bags in the three streams types on three sampling occasions between February and March 2011 on the Mambilla plateau, Nigeria.

5.0 Food Web Structure in Tropical Highland Stream Ecosystems:

As the saying goes "You are what you eat". The structure of stream food webs in nine streams across Mambilla plateau was investigated. Understanding the fate of energy and nutrients and the nature of the complex interactions among producers and consumers is a fundamental theme in ecology (Cohen *et al.*, 1986; Pimm and Kitching, 1987; Polis, 1994). However, this knowledge is also an essential pre-requisite for the sustainable management of aquatic and terrestrial ecosystems, because many human activities affect food web structure and hence important ecosystem process (Douglas *et al.*, 2005).

5.1 Functional Feeding Groups

Invertebrate species can eat by a number of different methods, we term these functional feeding groups (FFG). The relative abundance of invertebrate feeding functional groups can reflect the types of food available in a stream for example a forested stream full of leaves may have invertebrates which are shredders i.e., they shred the leaves. Dominance of, or loss of, a particular group may indicate a change in the ecological status of the waterway. The ideal "healthy" aquatic habitat would have representative of several functional feeding groups. The functional feeding groups listed below are adapted from Merrit and Cummins (1996).

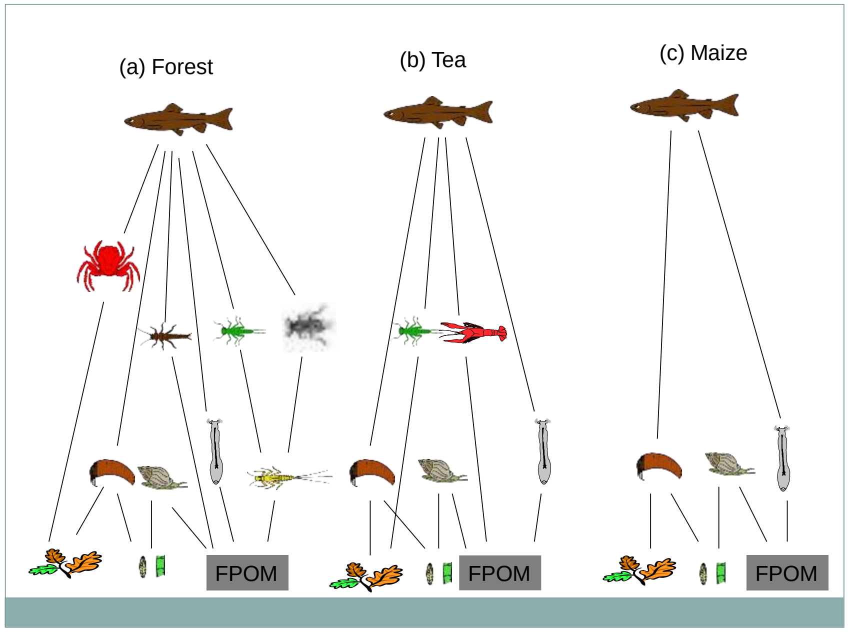


Figure 31: Simplified food web diagrams for streams in a) forest, b) tea plantations and c) maize fields. Links are based on gut content analyses. Each node represents a combination of several species (e.g., stonefly represents multiple predatory invertebrate species).

Table 2: Feeding functional groups used in this study

FFG	**Food**
Shredders	Decomposing plant tissue e.g., leaves and wood.
Filtering feeders	Suspended fine particulate organic matter (FPOM) e.g., small particles of leaves or algae that are in the water column.
Collector-gatherers	Deposited decomposing fine particulate organic matter (FPOM) e.g., particles in the stream bed.
Scrapers (or grazers)	Biofilm i.e., periphyton, bacteria, fungi.
Predators (scavengers)	Living animals. Scavengers feeding on dead animals are generally rare.
Macrophyte piercers	Living vascular plant and algal fluid.

Results

Basal Food Resources - Algae and Detritus

Significant differences in the biomass of CPOM and algae were found among streams. Thus, CPOM was significantly higher in forest than tea plantation and maize fields' streams, whereas, forested streams had the lowest algal biomass and maize streams the highest (Table 1).

Table 3: Mean (± SE, n = 3 streams per land use). CPOM = coarse particulate organic matter, FPOM = fine particulate organic matter * indicates significant difference $p < 0.05$ and ** $p < 0.01$.

Sites	Forest	Tea	Maize	F - stat	P - value
CPOM (g/m^2)	6.0 (1.0)	3.2 (0.3)	2.0 (0.2)	8.727	0.016*
FPOM (g/L)	4.0 (1.3)	3.0 (0.2)	1.3 (0.1)	0.187	0.834
Algae (g/m^2)	2.2 (0.3)	3.0 (1.0)	5.0 (0.4)	37.599	< 0.001**

Gut Contents

Fourteen benthic invertebrate taxa were used for gut analysis. They represented 75% of the total benthic invertebrates collected. If large numbers of individuals of a particular taxon were available (e.g., the mayfly *Elassoneuria*), three to five individuals of up to three size classes were used to assess variation in gut content with animal size. The diet of the snail *Melanoides tuberculatus* differed at forest, tea plantation and maize field sites. Individuals from the forest streams had guts filled with FPOM (65%) and diatoms (3%) and those from the tea plantation and maize sites had filamentous algae as the dominant food items (80%) and small contribution from diatoms (10%). Guts of the mayfly Oligoneuridae were dominated by FPOM and diatoms in all streams and the filter feeding hydropsychid caddisflies had a mixed diet of FPOM (45%) and diatoms (25%). In contrast, the gut contents of perlid stoneflies were dominated by animal parts (50–90%) indicating they were predators. Chironominae and Baetidae made up most of the prey of the perlids. Potamonautid crabs consumed a wide variety of food items. Their gut contents were composed of FPOM (10%) and CPOM (80%) of which 10% was wood and 70% leaves. The predominance of CPOM in gut contents indicated it was primarily a detrital shredder. However, in maize field streams where CPOM was not abundant, filamentous algae and FPOM dominated crab gut contents.

Guts of the gomphid dragonflies were dominated by animal fragments (70%), FPOM (10%) and diatoms (10%) and Chironominae were the dominant items (20%). The tipulid *Leptotarsus* (Tipulinae) had ingested mainly CPOM (90%) 80% of which comprised leaf fragments and 10% wood, whereas gyrinid beetles had a mixed diet of FPOM (30%), diatoms (20%) and animal parts (40%), especially Chironominae (20%).

The two fish species *Clarias lazera* and *Tilapia zilli* consumed mainly animals (40–80% relative abundance) but also some CPOM. Dissected fish contained an average of three prey items per gut, predominantly mayfly and stonefly larvae (55–60%).

Amorphous materials of unknown origin were also found in many guts and were ignored in determining proportion of gut contents. These may have included accidental or "by catch" food, as well as body organs from animals dissected. Overall, FPOM (30%), filamentous algae (25%), CPOM (20%), diatoms (15%) and fungi (10%) were the most frequently encountered basal food items in the animals examined. Oligoneuridae (9%) and Gomphidae (8%) were the most frequently encountered prey in gut contents

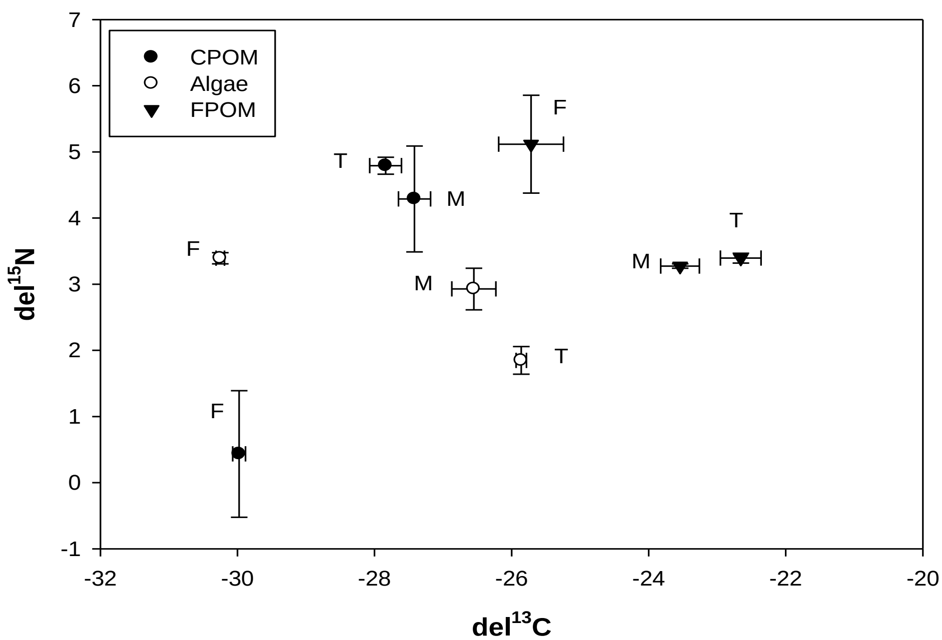


Figure 32: $\delta^{13}C$ and $\delta^{15}N$ biplots of basal resources collected from riffles in streams flowing through; F = continuous forest, T = tea plantation = and M = maize field on the Mambilla Plateau. Mean ± SE, n = 3.

Stable Isotope Values of Basal Food Resources- Algae and Detritus

Biplots of $\delta^{13}C$ and $\delta^{15}N$ for basal food resources collected from riffles in forest, tea plantation and maize streams showed that FPOM had the most enriched $\delta^{13}C$ values and CPOM was generally least enriched. Mean $\delta^{13}C$ values for algae were intermediate in maize and tea streams but less enriched than CPOM at forested sites (Fig. 2). Mean $\delta^{15}N$ signatures for CPOM were lower in forest stream than maize fields and tea plantation. In contrast, the highest $\delta^{15}N$ signature for FPOM was found in the forest streams indicating it was not derived solely from CPOM. Algal $\delta^{15}N$ signature had a narrow range (~2–3.5 ‰) in the three.

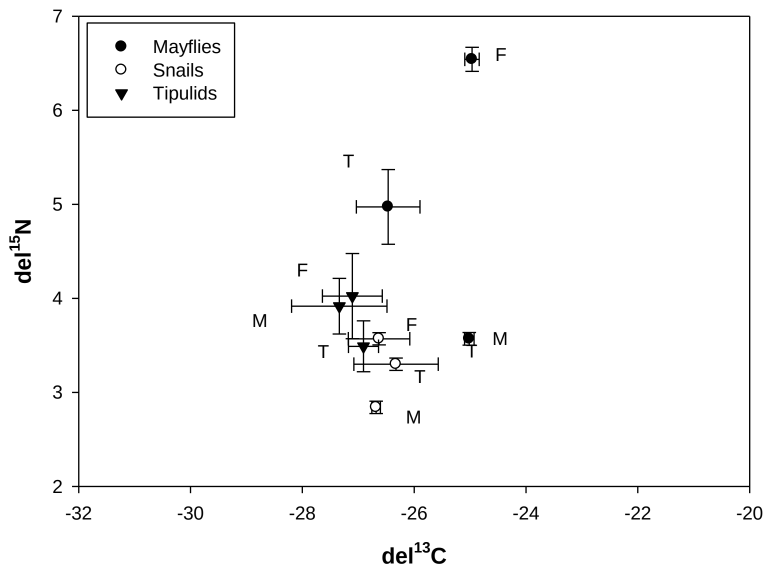


Figure 33: Stable isotope biplots of primary consumers collected from riffles in streams flowing through; forest = F, tea plantation = T and maize field = M on Mambilla Plateau. Values are mean ± SE, n = 3.

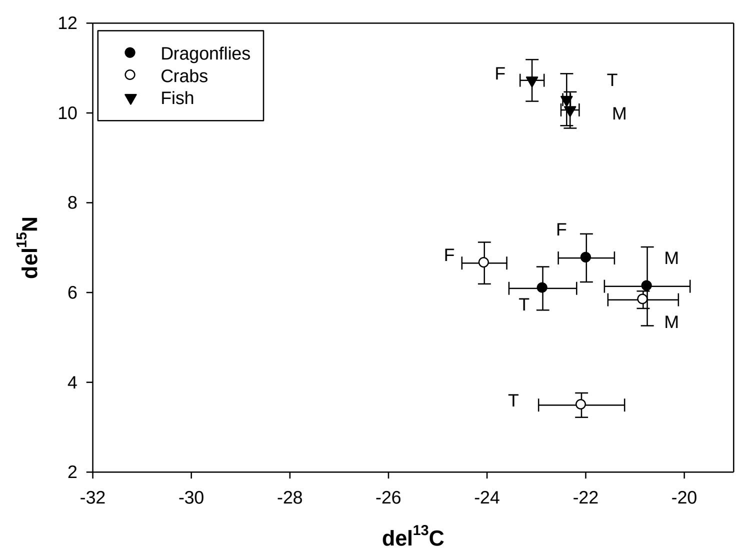


Figure 34: Stable isotope biplots of predators (dragonflies [Gomphidae] and fish) and a macro-shredder (potamonautid crab) collected from riffles in streams flowing through; forest = F, tea plantations = T and maize fields = M on Mambilla Plateau. Values are mean ± SE, n = 3.

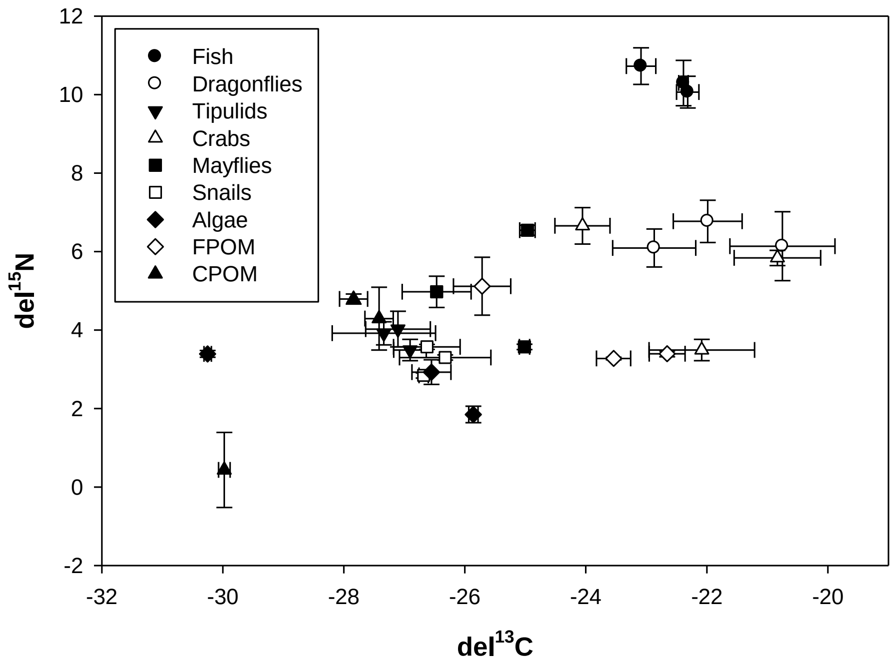


Figure 35: Stable isotope bi-plots for all primary and secondary consumers collected from riffles in streams flowing through forest, tea plantations and maize fields on Mambilla Plateau. Values are mean ± SE, n = 3.

Plots of the raw data incorporated in the mixing models are shown in Fig. 36. Mean values for the two food sources (algae and leaves) are shown in colour along with their standard deviations. Isotopic values for consumer taxa from each stream were tightly distributed for the forest streams (Fig. 36a) but more variable in tea and maize plantation streams (Figs 36b, c). Because the $\delta^{13}C$ signatures of algae and leaves overlapped strongly in the forested and tea plantation streams the raw data plots provided little indication as to the relative importance of the two food sources in the diets of consumers. However, because $\delta^{15}N$ signatures of consumers tended to be more aligned to those of leaves, this suggests a greater use of allochthonous food sources in all three stream types. Boxplots showing the proportions of algae and leaves incorporated by consumers as estimated by the mixing models (Figs. 37) confirm that algae appear to be less important than leaves, although as indicated by the credibility intervals the evidence is not strong. Interestingly, the predatory taxa, dragonflies and fish, were supported more strongly by algal-based webs.

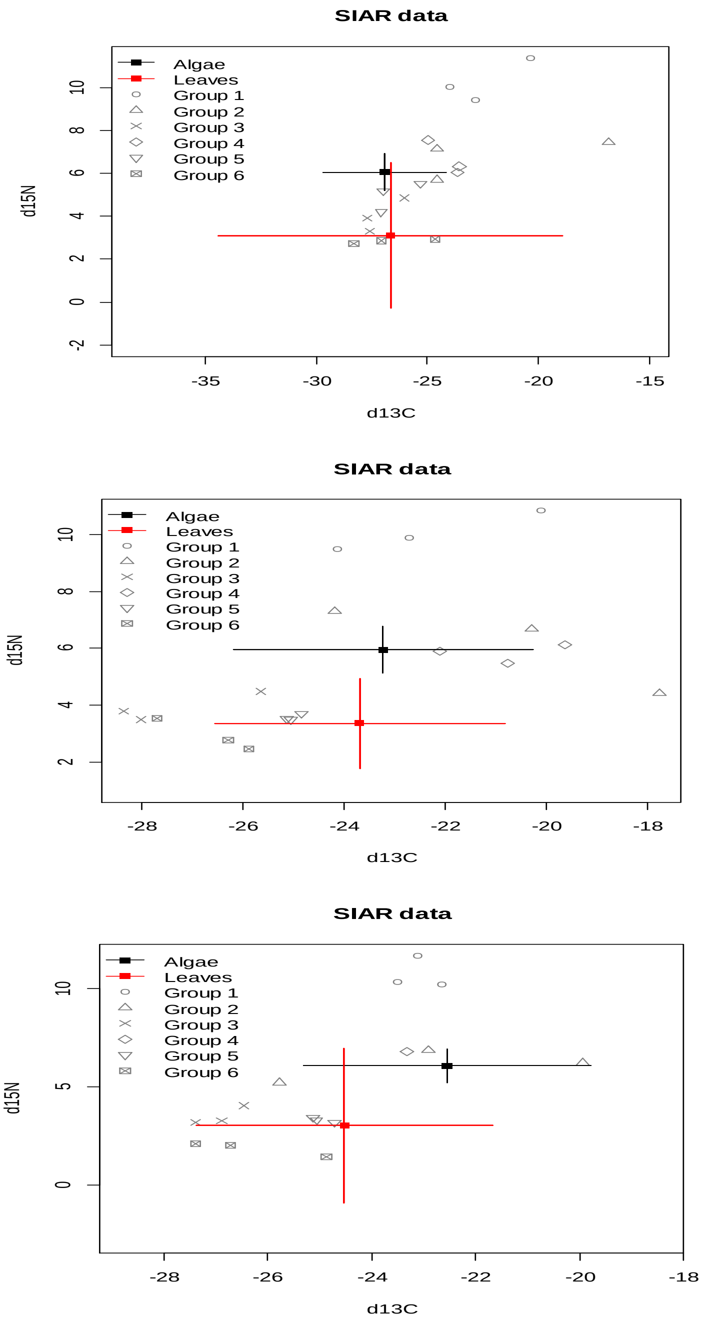


Figure 36: Biplots of $\delta^{15}N$ and $\delta^{13}C$ showing the raw data used in the mixing models. (1 = fish, 2 = dragonflies, 3 = tipulid, 4 crabs, 5 = mayflies

and 6 = snails). Values for algae (black) and leaves (red) are means and standard deviations, in streams running through (A) forest (B) Tea plantations and (C) Maize field on Mambilla Plateau.

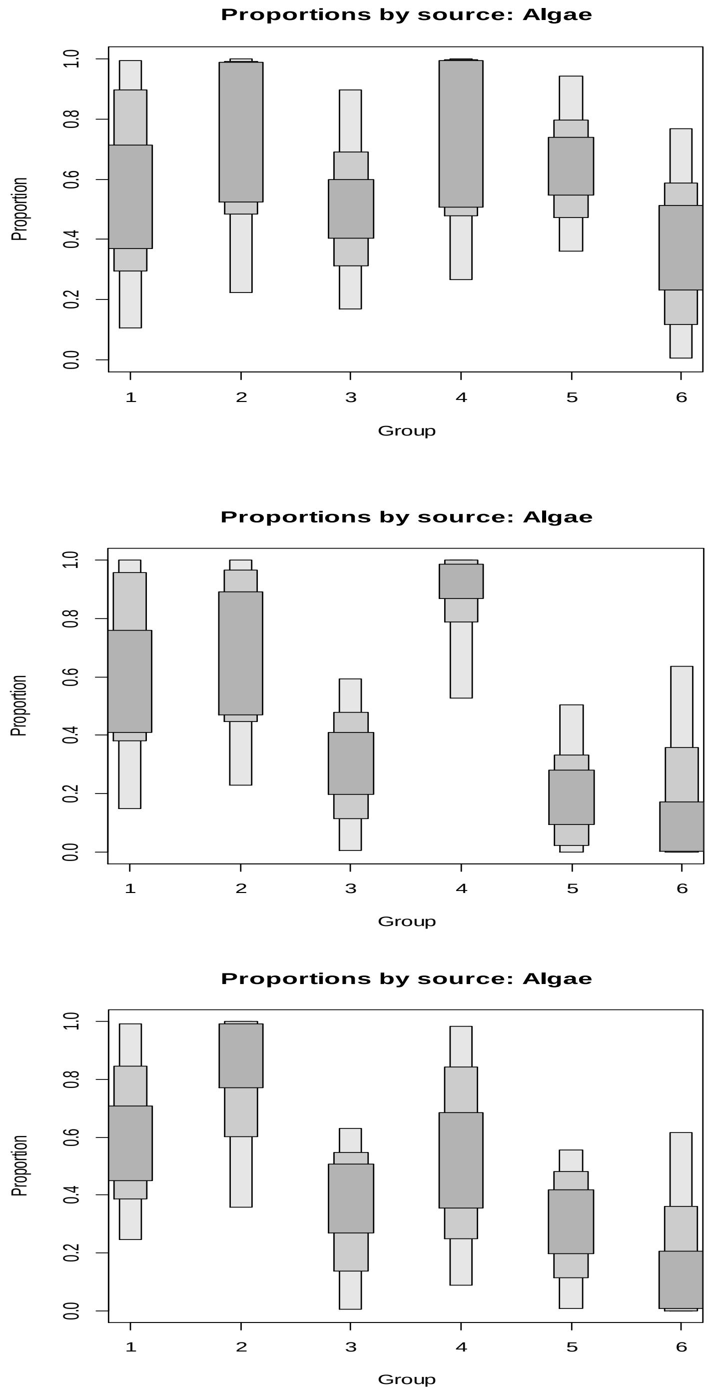


Figure 37: Boxplots showing estimated proportion of algae in the diets of consumer groups (1 = fish, 2 = dragonflies, 3 = tipulid, 4 = crabs, 5 = mayflies and 6 = snails) in streams running through (A) forest, (B) Tea plantations and (C) Maize field. The boxplots show 5, 25, 50, 75 and 95% credibility intervals.

Web Properties

Food web attributes differed significantly between land uses (one way ANOVA, web size $F_{2, 6}$ = 15.509, P = 0.004; number of linkages $F_{2, 6}$ = 6.347; P = 0.033; predator: prey ratio $F_{2, 6}$ = 17.337, P = 0.003 and linkage complexity $F_{2, 6}$ = 8.812, P = 0.016) respectively (Table 3). Forested streams had significantly larger food webs (a mean of 26 species) compared to tea and maize which had means of 17 and 16 species, respectively.

Other food web properties including the number of links (L) and maximum and mean chain length (CT), realized connectance (CR), linkage density (L/S), linkage complexity (SCR) and the predator prey ratio. Simplified food web diagrams for streams in the three land uses show that forested streams had more complex food webs with more links, species interactions and trophic levels than tea plantation streams. In contrast, maize field streams had markedly simplified food webs with few species and less trophic diversity, primarily due to a loss of secondary consumers (Umar *et al*., 2018).

6.0 Developing a Biotic Index for Nigerian Highland Streams

The use of biotic indices as a rapid assessment tool for streams has been adopted in many countries during the past 30 years Rosenberg & Resh,1993). Such indices typically use presence/absence data, and sometimes abundance data, of numerous macroinvertebrates (generally insects, mollusks, worms and crustaceans) that represent a wide range of tolerance/sensitivity to pollutants and stress (Hawkes,1977; Reynodson *et al*., 1977; Barbour *et al*.,1999).

However, the stream invertebrate fauna of Mambilla plateau was completely unknown at the start of our investigation, so to undertake the work I needed to invest considerable time in sampling and identification of the fauna along the land use gradients (Fig. 39). This study interestingly led to a major breakthrough by discovering a species of mayfly that may be new to science Umar, *et al*., (2013). Effort is being made to produce a biotic index for highland tropical Nigerian streams soon.

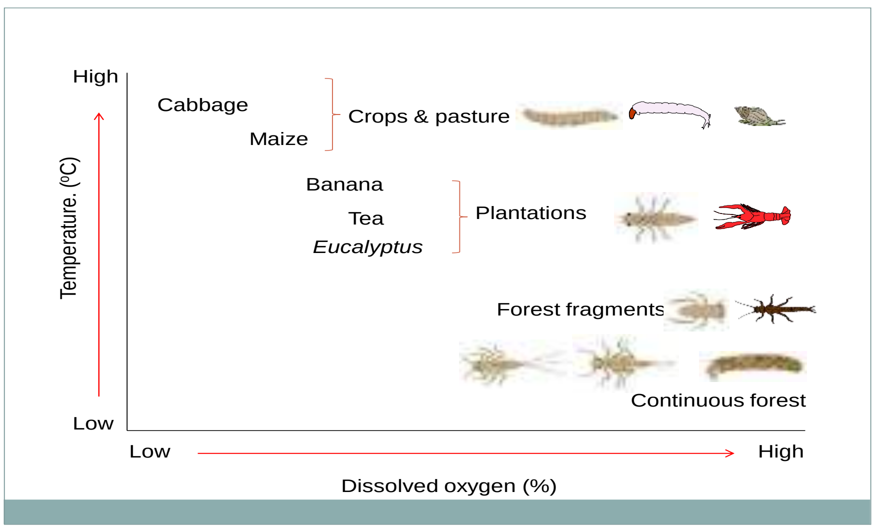


Figure 39: Simplified diagram showing the different land uses along a temperature-oxygen gradient

7.0 Meeting Ecological and Societal Needs for Freshwater

Human society has used freshwater from rivers, lakes, groundwater, and wetlands for many different urban, agricultural, and industrial activities, but in doing so has overlooked its value in supporting ecosystems. Freshwater is vital to human life and societal well-being, and thus its utilization for consumption, irrigation, and transport has long taken precedence over other commodities and services provided by freshwater ecosystems. However, there is growing recognition that functionally intact and biologically complex aquatic ecosystems provide many economically valuable services and long-term benefits to society. The short-term benefits include ecosystem goods and services, such as food supply, flood control, purification of human and industrial wastes, and habitat for plant and animal life-and these are costly, if not impossible, to replace. Long-term benefits include the sustained provision of those goods and services, as well as the adaptive capacity of aquatic ecosystems to respond to future environmental alterations, such as climate change. Thus, maintenance of the processes and properties that support freshwater ecosystem integrity should be included in debates over sustainable water resource allocation.

7.1 Security and Human Wellbeing

Vice Chancellor Sir, Water security is a powerful concept that has gained much traction in research and policy. The global scope of its applications –from geopolitics to human health—indicates the diverse ways in which it applies to water policy, practice and governance, across multiple levels and scales. Across the breadth of its use, the common, central object to be secured is most often understood as material water (H_2O) –whether for productive purposes (agriculture, industry, resource extraction), conservation (ecosystem services, recreational uses), or most often, for reproductive needs (domestic use, human health). Certainly, water security operationalized in these ways brings issues of water resources sustainability to the fore in useful ways.

Yet, we contend that it is time to reorient the concept of water security away from a utilitarian focus on material water and towards a critical approach based on water-society relations. Rather than securing water *per se*, we argue that water security should be about transforming water-society relations to promote human wellbeing and empowerment. In other words, water security is less about obtaining water, and more about fostering human capabilities as they relate to water. What are the social, cultural, and political relationships with water resources and flows that advance a life that fosters human dignity? And, how are those relationships secured to facilitate the freedom to achieve wellbeing, fulfilling social arrangements, and human flourishing?

From this perspective, water security, then, is not simply a *state* of adequate water - however defined - to be achieved, but rather a *relationship* that describes how individuals, households, and communities navigate and transform hydro-social relations to access the water that they need and in ways *that support the sustained development* recognize that our focus on human wellbeing sets aside some critical questions related to sustainability *of human capabilities and wellbeing in their full breadth and scope*. The, ecosystem function, or other biophysical considerations, which also can be important to a recasting of water security. In conclusion, therefore, a relational approach to water security that is designed to incite reflection about *what* is being secured, *how*, and to *what* end, can inspire new inroads into water security research and practice that seek to enhance the capacities to achieve human dignity for all.

7.2 Conclusion

The most critical security lessons learned from the global experience in water security are as follows:

i. Water that crosses international boundaries can exacerbate relations between nations that share the basin. While the tension is not likely to lead to warfare, early coordination between riparian states can help ameliorate the issue entirely.

ii. Once international institutions are in place, they are tremendously resilient over time, even between otherwise hostile riparian, and even as conflict is waged over other issues.

iii. More likely than international "flashpoints" is a gradual decreasing of water quantity and/or quality, which overtime can affect the internal stability of a nation or region, and act as an irritant between ethnic groups, water sectors, or states/provinces. The resulting instability can spill into the international arena.

iv. The greatest human security threat of the global water crisis comes about not from the threat of warfare, or even from political instability, but rather from the simple fact that millions of people lack access to sufficient quantities of this critical resource at sufficient quality for their wellbeing.

7.3 Recommendations

Given these lessons, what can the international community do? International Institutions: Water dispute amelioration is as important, more effective, and less costly than conflict resolution. Watershed commissions should be developed for those basins that do not have them, and strengthened for those that do. Three traits of international waters – the fact that conflict is invariably sub-acute, that dangerous flashpoints can be averted when institutions are established early, and that such institutions are tremendously resilient over time –inform this recommendation. Early intervention is also beneficial to the process of conflict resolution, helping to shift the mode of dispute from costly, impasse-oriented dynamics to less costly, problem-solving dynamics. In the heat of some flashpoints, such as the Nile, the Indus, and the Jordan, as armed conflict seemed imminent, tremendous energy was spent just getting the parties to talk to each other. In contrast, discussions in the Mekong Committee, the multilateral working group in the Middle East and on the Danube, have all moved beyond the causes of immediate disputes on to actual, practical projects that may be implemented in an integrative framework.

There is a need for more effective protection of the forest, both in terms of preventing cattle from entering the main forest and from using stream side forest for watering and shelter. Provision of water reservoirs for washing harvested crops would help reduce crop contamination in streams. Furthermore, ensuring waste water drained into the ground and away from streams would help in reducing this type of pollution.

Finally, there is the need for more research by ecologists and scientists on the benthic ecology of the tropical region in Nigeria. Government should as a matter of priority provide adequate support to researchers towards conservation and management of freshwater systems in Nigeria.

Dedication

This work is dedicated to my late parents, **Mal. Umar Lamido Muhammad** and **Aishatu Sumaya Aliyu** May Allah (SWT) Grant them

eternal rest in Jannat Firdausi. And to all less privileged scholars past and present.

Acknowledgements

Vice Chancellor, Sir, I wish to begin first by thanking Allah SWT for all the endowments bestowed on me. I sincerely thank my parents for my upbringing and support, May Allah reward them with Janat Firdous.

I wish to sincerely thank the Acting Vice Chancellor Prof. Sani Ahmed Yauta a humble person and brother for all the support and encouragement.

I appreciate the support I got from former Vice-Chancellors of this great University particularly late Prof. Abdullahi Mahadi of blessed memory; may Allah (SWT) rest his soul in perfect peace. Prof. Ibrahim Musa Umar and Prof. Aliyu Usman El-Nafaty for their support and mentorship. They all played pivotal roles in shaping my positions today.

I wish to thank Prof. Hajjagana Hamza, Prof. Seydou Hankouraou. Professor Muhammad Gurama Dukku, Chairman University Ceremonies Committee and his team members, rendered support and encouragement in making this event possible and colorful.

To my colleagues in Biological Sciences, Botany and Zoology Departments I say thank you. To friends and well-wishers from other departments and Faculties in Gombe state University thank you. Finally, I wish to especially thank my PhD. Supervisors at the University of Canterbury New Zealand, Prof. Jon Harding, Prof. Hazel Chapman, Prof. M. J. Winterbourn and Matt Walters.

Finaly I most sincerely thank my entire family for the perseverance and being there for me always. Thank you all and God bless.

Professor Danladi M. Umar's Family, Photo-from Left-Right

Maryam A. Umar, Abba A. Umar, Asiya A. Umar (wife), Prof. Danladi, Hajiya Talatu A. Umar (wife), Al'amin A. Umar, Aishatu A. Umar, Zahira A. Umar, and Suleiman A. Umar.

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Citation On Professor Danladi Mohammed Umar

Professor of Freshwater ecology, Environmental Consultant, former Deputy Dean Faculty of Science, Head of Department of Biological Sciences Gombe State University, Director Nigerian Montane Forest Project Mambilla, Chairman Taraba State Green Wall Committee, Technical Facilitator (TCT) TETFund Research & Development Standing Committee (RDSC) and currently Deputy Vice-Chancellor (Administration) Gombe State University.

Professor Danladi Mohammed Umar hails from Gombe Local Government Area of Gombe State Nigeria. He was born on December 1st 1962 in Bukuru, Jos South Local Government Area of Plateau State. He attended R.C.M school Gyel from1969 to 1974 and Juladaco High school Kassa from 1974 to 1979 and obtained the First School Leaving Certificate and the West African School Certificate (W.A.S.C) respectively. In 1982 He went to the School of Basic Studies (A.B.U) Zaria and obtained I.J.M.B Science. Professor Umar later furthered his education and obtained degrees; B.Sc. (Ed) Biology in 1987 at the University of Jos, M.Sc. Fisheries and Hydrobiology in 1990 in same University of Jos and PhD in Freshwater ecology in 2014 at the University of Canterbury, New Zealand.

Professor Danladi Mohammed Umar started his Career as a Biology Teacher with the then Bauchi State Ministry of education in 1989. He joined the Services of Gombe State University as an Assistant Lecturer in 2005 and rose to the rank of Professor in 2021. In the University, Professor Danladi M. Umar has made discernible landmarks in research and development through student research supervision at undergraduate and postgraduate levels, including PhD theses. He has written many Journal articles, technical reports, reviews and has published a book on the Nigeria's highland Macroinvertebrates fauna in 2013. Professor Danladi Mohammed Umar has distinguished himself in several administrative positions, as Head of Department of Biological Sciences (2015 – 2021), Deputy Dean of Faculty of Science (2014 – 2020), Deputy Director Research & Development and the Deputy Vice Chancellor Administration Gombe State University. He has been the Director Nigerian Montane Forest Project Mambilla Plateau since 2019, a Linkage Programme between the University of Canterbury, New Zealand, Chester Zoo London and Gombe State University. He has served as Chairman of many Committees, Member of University Senate and Governing Council (4^{th} ,5^{th} and 6^{th} Council).

Prof. Danladi M. Umar had attended several Leadership workshops including; Workshop at the Institute of African Leadership Dayton University, Ohio U.S.A in 2015, Senior Academic Leadership Training (SALT PHASE II) organized by the Carnegie Corporation of New York, U.S.A in 2017 among others. He is Fellow Strategic Institute for Natural Resources & Human Development (FSI) 2014; Fellow, Institute of African Leadership Dayton, Ohio, USA (FIAL) 2015; Fellow, Institute of Corporate Administration (FICA)2021; Fellow, Freshwater Biological Association of Nigeria (FFBAN) 2024; and Fellow Association for Animal and Environmental Biology 2024; Member, Fisheries Society of Nigeria, Nigeria Association for Aquatic Sciences, Nigeria Conservation

Society, Nigeria Ecological society, Freshwater Biological Association of Nigeria, Biosafety Society of Nigeria, Science Teachers Association of Nigeria, New Zealand Freshwater Science Society NZFSS and the American Freshwater Society. He has supervised 6 PhDs; 24 Masters to graduation and currently supervising 4 PhD and 10 MSc students. He has written 4 Chapters in books, 55 Journal articles and was external examiner to; Federal University of Kashere Gombe, Federal University of Technology Minna, Modibbo Adama University Yola (Fisheries & Hydrobiology, Aquatic Entomology and Toxicity) etc. He has served as Member of several NUC Resource Verification and Accreditation teams among others. He has won several research grants both at local and international levels; including TETFund Institutional Based Research, National Research Fund, Rufford Foundation, International Dragonfly Research Fund Germany, Africa Finance Corporation, etc.

Areas of ongoing research include; Freshwater Biodiversity, Aquatic pollution and Toxicity, Stream process, Macroinvertebrates, Aquatic food web, Land use activities and Aquaponics Development project. Prof. Danladi M. Umar has travelled widely around the globe.

Professor Umar is happily married and blessed with 8 children. His hobbies are; traveling, mountain climbing, swimming and playing golf.

Professor Danladi Mohammed Umar holds the traditional titles of; Wakilin Ilimin Kalshingi and Dan Lawan Malan Inna.

INAUGURAL LECTURES OF GOMBE STATE UNIVERSITY

LECTURE SERIES	NAME	TITLE	DATE
1st	Prof. Ibrahim Waziri Abubakar	Western Healthcare System in Northern Nigeria: An outline of its Foundation and Development	27th January, 2022
2nd	Prof. Oluwasanumi Adedimeji Adepoju	The Infrangible Nature of Knowledge: The need for Researchers to be Multipotentialities	15th December ,2022
3rd	Prof. Mahmoud Umar	Public Sector Reforms in Nigeria: The Imperatives of New Public Governance Model	25th May, 2023
4th	Prof. Adewale Olukayode Ogunrinade	Aladura and the Perpetuation of Indigenous Christianity Among the Yoruba	13th July, 2023
5th	Prof. Rasheed Abdulganiy	Academicizing the Hadith: Comprehensive Exploration of Prophetic Guidance in Addressing Human Multi-Dimensional Challenges	26th September, 2023
6th	Prof. Halima Mohammed Abba	Green Solutions for a Sustainable Future	7th March, 2024
7th	Prof. Mohammed M. Manga	A Privileged Nomadic Microbial Warrior: Battles in Health and Medical Education	23rd April,2024
8th	Professor Bulus Wayar	Demographically Undetermined, Territorially Boundless, Linguistically Attritional: The Lifeline of Fulfulde in Africa	28th May, 2024
9th	Professor Seydou Hankouraou	Physics, Health and Sustainable Development	25th June, 2024

10th	Professor Danladi Adamu Bojude	Championing Community Oncology: Saving Lives, Empowering Communities	30th July, 2024
11th	Professor Kennedy Poloma Yoriyo	The Lady Mosquito Which Underdeveloped and Kept Africans in A Poverty Vicious Circle	27th August, 2024
12th	Professor Sani Adamu	Toxicology Versus Nutrition; Pro-Oxidants Versus Antioxidants; Each, A Coin with Two Sides: Which One Is the Killer?	26th November, 2024
13th	Professor Lazarus Mbaya	The Intractable Environmental Challenges in the Jewel State: Perspectives of a Geomorphologist	17th December, 2024
14th	Professor Iliya Jalo	The Dilemma of a Neonatologist in Low Resource Setting: Using Improvised Technologies to Enhance Newborn Survival	28th January, 2025
15th	Professor Danladi Mohammed Umar	The Role of Freshwater Ecology in Water Security and Human Wellbeing	25th February 2025