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Impact of Water Hyacinth (*Eichhornia crassipes*) Infestation on Water Quality and Growth of a Benthic Mollusc *Pachymelania aurita* Müller (Gastropoda: Melaniidae): Experimental Evaluation

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ABSTRACT

Background: Bio-invasion has been considered as a significant component of global change and one of the major causes of species extinction and great economic loses. Invasive species like water hyacinth are of interest to ecologists, biological conservationists and natural resources managers due to their rapid spread, threat to biodiversity and damage to ecosystems.
Objectives: In this study, the impacts of water hyacinth infestation on water quality and growth of benthic gastropods, *Pachymelania* species under experimental conditions were studied for six months by a fortnightly data collection and analyses.
Methods: Five different experimental setups with varying degrees of water hyacinth stand and cover were used to establish probable impact on water quality and growth of the animals.
Results: Low dissolved oxygen and significantly higher alkalinity values were observed in experiment five which had the highest water hyacinth stand. The results recorded for adults and juveniles indicated that the animals were affected by the density of water hyacinth stand. In adults, average length and body weight were highest in experiment 2, while the lowest values were recorded in the control experiment. Juveniles recorded the highest overall average length and body weight in experiment 3, while the lowest values were recorded in the control experiment and experiment 3 respectively. Condition factor, K was highest in experiment 2 and lowest in experiments 4 and 5.
Conclusion: This study shows that floating macrophytes are inimical to the growth and development of gastropods when present in large expanse and pose a lot of challenges to artisanal fishery.

Keywords: Water hyacinth, Water quality, gastropods, Artisanal fishing, socio-economic impact

INTRODUCTION

Bio-invasion has been considered as a significant component of global change and one of the major causes of species extinction and great economic lost (Cook, 1990; Ayalew *et al*., 2012). Invasive species are of interest to ecologists, biological conservationists and natural resources managers due to their rapid spread, threat to biodiversity and damage to ecosystems (Mironga, 2003; Marshall and Brendonck, 2003). Some may alter the hydrology and physico-chemical properties of water, nutrient cycling and the general ecological balance in the aquatic ecosystem (Mack *et al.* 2000). Water hyacinth (*Eichhornia crassipes*) is the most deleterious of all invasive plant species in tropical countries and has been regarded as the most 'notorious' weed in the world (Greenfield *et al*., 2007; Rands *et al*., 2010).

By the beginning of the 20th century water hyacinth has invaded aquatic systems in almost every country of the world. The first surge of the weed in Nigeria was observed in September, 1984 along the Badagry Creek in Lagos State where the weed formed a thick 'mat' over the surface of the water (Sharma and Edem, 1988). By 1990, the weed has spread through the entire Nigerian coast line in the creeks and lagoons. Inland water bodies such as Rivers Niger, Benue, Benin, and Kaduna were affected. The spread of water hyacinth in the country is perceived as a major environmental problem (Uwadiae *et al*., 2011). This is especially so in the south where many rivers and channels are blocked by dense growth of the weed which impede navigation, block access by artisanal fishermen to fishing grounds and lower primary productivity of aquatic systems (Uwadiae *et al*., 2011).

Water hyacinth is a perennial, herbaceous monocotyledon member of the pickerelweed family (Pontederiaceae). It is usually found as a free-floating aquatic macrophyte that derives its nutrients from the water column (Brendock, 2003). Mature specimens have long feathery roots that can be over 2 m in length. However in shallow waters individuals can root themselves into sediment and individual plants can even be found fully rooted on bank sides. The matured plants possessed above the ground density of about 14 plants/m^2 and biomass of more than 1494 g (Rommens *et al*., 2003). Water hyacinth grows fast from seeds and from shoots that break off and grow into new plants. The number of plant doubles every 5 to 15 days, so in a single season, 25 plants can multiply up to 2 million. It commonly forms dense, interlocking mats due to its rapid reproductive rate and complex root structure (Mironga, 2003; Rakotoarisoa *et al*., 2005). Water hyacinth reproduces both sexually and asexually. Ten to 100 % of existing seeds are found to germinate within six months, with dry conditions promoting germination (Wilson *et al*., 2005). Nutrients and temperature are considered the strongest determinants for water hyacinth growth and reproduction (Lu *et al*., 2007; Wilson *et al.* 2007). Salinity constraints generally limit water hyacinth establishment in coastal areas and within estuaries (Mangas-Ramirez and Elias-Gutierrez, 2004).

Water hyacinth has become a nuisance to fisheries, navigation, water intake to hydropower plants, irrigation and recreation in many tropical and subtropical aquatic systems and it restricts photosynthesis in other aquatic plants through increased sedimentation and by shading the water column, leading to deoxygenation with a detrimental impact on aquatic organisms, especially invertebrates (Uwadiae, *et al*., 2011). The survival of the plant is encouraged in water bodies where nutrient levels are high due to agricultural runoff, deforestation, and insufficient wastewater treatment. Its success as an invader is attributed to its ability to outcompete native vegetation and phytoplankton for light. Its proliferation is exacerbated by water contamination from industrial effluent, fertilizer run-off and raw sewage. These wastes encourage the growth of water hyacinth which impacts negatively on the water quality and impedes the growth of benthic organisms.

The benthic gastropod filter feeder *Pachymelania* spp is a common species in Nigerian Coastal waters and occurs along the West African coast from Senegal to Angola, and constitute an important source of protein for inhabitants of villages along the coastline, notably in the Nigerian Niger Delta. The species is gathered and consumed and also sold in markets. The juveniles of these species constitute an important component of the staple of snail-eating fish. *Pachymelania* spp lives in sandy-mud sediment in the open lagoons and avoids areas with a strong current. They live in water depths of up to 5 m. It is a euryhaline species inhabiting areas of salinity variation between 0 and 27 ‰ and prefers the upper region of the infra-litoral. The weak teeth and the fringed mantle border further attest to the fact that it is a filter feeder, which means that a larger percentage of their food comes from microalgae.

The species has received a lot of research attention due to its economic importance. Uwadiae *et al*. (2009) established the ecological requirements and natural food components of one of the species, *Pachymelania aurita*. However, a major gap in the research efforts on these species is on its survival outside its natural environment and the need to establish the possible impact of the ubiquitous water hyacinth on the animals. Therefore, this present study was aimed to assess the impact of water hyacinth on the physico-chemistry of water and growth of edible benthic gastropod (*Pachymelania* species) in experimental conditions to establish its impact on the animals for a better understanding of the socio-economic implications for artisanal fishing.

MATERIALS AND METHODS

Collection of materials for experimental set-up

Water

A large quantity of water from the Lagos Lagoon was collected using plastic buckets and the required quantity transferred to experimental tanks

Specimens of water hyacinth

Water hyacinth used for the study was collected from the Lagos Lagoon at the University of Lagos Lagoon Front. Specimens were collected in wide-open mouth big bowls with water from the habitat and taken to the laboratory where the collected specimens were placed in a holding glass tank containing water from their habitat for one week, to establish their level of survival in an artificial space different from their natural habitat. Care was taken to ensure that no *Pachmelania* spp was attached to the collected specimens.

Sediment

Sediment from the Lagos Lagoon was collected using van Veen grab. Specimens of gastropod in sediment collected for the experiment were carefully handpicked and removed.

Specimen of *Pachymelania* species

Specimens of *Pachymelania* species used for this investigation were collected from the Lagos Lagoon, south-west Nigeria, using a van Veen grab. Several hauls were emptied into a wide-open plastic bowl after retrieval from the water and specimens were stored in plastic containers with water from the habitat and taken to the laboratory.

Laboratory procedure

Preparation of Sediment

In the laboratory, sediment collected from the habitat was sundried and the quantity (1746 g x 10 x2) required for the experiment was weighed and kept.

Measurement of length and weight of specimens

Length of specimens was measured using a calibrated ruler. The ruler was placed side by side with the specimen to be measured and length taken against the ruler and recorded in mm. Specimens of animals whose length have been taken were weighed with an electronic scale of 0.001g sensitivity. Before weighing, the animals were drained on a fine sieve, air-dried for 10 minutes on absorbent paper and exposed to air until liquid is no longer visible. Length and weight of specimens were taken before the animals were introduced into the experimental tanks, and fortnightly for twenty weeks.

Condition factor of experimental species (K):

The condition factor is the state of the general well-being of a fish been studied in relation to size, and is denoted by the equation;

$$K = 100W/L^3$$

where, K = condition factor; L = standard length; W = weight. This formula was used to assess condition factor of specimens in this experiment. According to Lagler (1956), the value of K is not constant for individuals, species or populations but is subject to wide variations for organisms. In natural conditions, the K-factor should be equal to 1, while < 1 and >1 indicate below and above-average conditions respectively.

Selection of specimens and categorization into age groups

Specimens of *Pachymelania* species were identified using the identification keys of Edmunds (1978). According to Egonmwan (2007), specimens of *Pachymelania* species between 0 and 33 mm may be categorized as juveniles (Plate 1) while those above 44 mm may be categorized as adults (Plate 2). In the laboratory, 400 specimens comprising 200 adults and juveniles respectively were selected based on good health.

Experimental design and setup

A summary of the characteristics of the different experimental setups is shown in Table 1. Five different treatments were formulated in this experiment (Table 1). All factors considered in the formulation of the treatments were the same for each treatment except the presence and quantity of water

Plate 1: Juveniles of *Pachymelania aurita*

Plate 2: Adults of *Pachymelania aurita*

hyacinth. Ten (two replicated for each treatment) different plastic tanks of 1 x 0.7 x 0.4 m in size were used for the experiment. Eight of the tanks (Experiments 2 – 5) contained different quantities of water hyacinth, while treatment 1 which is the control had no stand of water hyacinth.

After placing the tanks on a platform in an open space to allow enough sunlight and atmospheric influence, 1746 g of sediment from the habitat was added to each tank, followed by 30 L of water. The water and sediment were left for 24 h to allow for settling. Water hyacinth stands were introduced in the tanks and left for another 24 h to allow for further settling, after which specimens of *Pachymelania* species were then introduced into the tanks. Measurement of weight, length and analysis of environmental characteristics were carried out forthnightly for six months. Loss of water from the tanks due to evaporation was minimized as much as possible by adding water from the habitat up to the initial water level.

Statistical analysis

One-Way analysis of variance (ANOVA) was used to compare the variations in lengths and weights of specimens in the experimental tanks. When significant variations are detected, a *post hoc test* using Tukey's Honestly Significantly Different (HSD) was performed to determine the locations of significant differences. The relationships between biotic and environmental parameters were determined using Spearman rank correlations. All statistical analyses were performed with Statistical Package for the Social Sciences (SPSS) 10 and Excel 2003; 2007 for Windows.

RESULTS

Environmental conditions in experimental tanks

During the period of the experiment there were great variations in the values recorded for these parameters (Fig. 1). The highest level (12.00 mg/L) of dissolved oxygen in experimental tanks was recorded in tanks 1 and 3 in the sixteenth week of study, while the least value (0.10 mg/L) was observed in tank 5 in the tenth week. Values of BOD_5 ranged between 0.10 mg/L observed in tank 5 in week 5 and 10.00 mg/L recorded in tank 4 week 8. The highest value (140.00 mg/L) of alkalinity occurred in tank 5 in week 3, while the least value (0.50 mg/L) was recorded in tank 1, week 5. The lowest value of nitrate 0.00 mg/L was observed in different tanks and weeks including tank 1 in week 5 to week 8, tank 2 ; week 2 and tank 5; week 7 while the highest value (27.02mg/l) was in tank 3; week 7 and week 8. Generally nitrate concentrations were higher in tank 3 than in tank 2 and tank 5. The highest value (12.50mg/l) of phosphate was recorded in tank 2, weeks 7 and 8 while the lowest (0.00mg/l) was recorded in tank 1, week 2.

Growth pattern of adults *Pachymelania* species

Summaries of values of growth parameters recorded are presented in Table 2. The results recorded for adults indicate that adult were affected by the density of water hyacinth stands. Overall average length (38.77 mm) and body weight (3.74 g) were

Table 1. Summary of characteristics of the different experimental setups

	Experiment 1 (Control)	**Experiment 2**	**Experiment 3**	**Experiment 4**	**Experiment 5**
Quantity of water (Litres)	30	30	30	30	30
Weight of sediment (g)	1746	1746	1746	1746	1746
Number of water hyacinth stands	None	10	20	30	40
Number of specimens of P. aurita	40: 20 adults and 20 juveniles	40: 20 adults and 20 juveniles	40: 20 adults and 20 juveniles	40: 20 adults and 20 juveniles	40: 20 adults and 20 juveniles
Initial mean length for adults (mm)	37.9	38.15	39.1	38.70	39.31
Initial mean weight for adults (g)	3.51	3.66	3.41	3.25	3.56
Initial mean length for juveniles (mm)	24.85	25.2	25.05	26.05	25.55
Initial mean weight for juveniles (g)	0.91	0.86	0.88	0.96	0.93
Mean Phosphate (PO_4) (mg/L)	0.3	0.3	0.3	0.3	0.3
Mean Nitrate (NO_3)(mg/L)	6.09	6.09	6.09	6.09	6.09
Mean Dissolved oxygen (DO)(mg/L)	8.3	8.3	8.3	8.3	8.3
Mean Alkalinity (mg/L)	7.6	7.6	7.6	7.6	7.6
Mean Biochemical Oxygen Demand (BOD_5) (mg/L)	0.1	0.1	0.1	0.1	0.1

highest in experiment 2, while the lowest values (37.76 mm; 3.37 g) were recorded in the control experiment. Average values recorded in other experiments were; 38.6 mm and 3.47 g in experiment 3, 38.44 mm and 3.31 g in experiment 4, 38.7 mm and 3.47 g in experiment 5.

Patterns of growth observed in length and body weight in all the experiments varied greatly (Figs. 2 - 7). In experiment 1, adults showed an appreciable increase in length between weeks 2 (37.9 mm) and 10 (38.05 mm), after which the length remained constant. Weight of adults however showed an appreciable decline from 3.49 g observed in week 2 to 3.07 g in week 20. The experimental condition in experiment 2 appears to favour the overall growth of the animal. An appreciable increase in length and weight of both adults was observed throughout the experimental period. The 38.15 mm length recorded for the adult in week 2, increased to 39.12 mm in week 20, while weight increased from 3.59 g in week 2 to 3.96 g in week 20.

In experiment 3, adults did not show any appreciable change in length and weight. In experiment 4, the length of adults remained constant, while there was a consistent decrease in weight in adults. Weight in adults decreased from 3.34 g in week 2 to 3.13 g in week 20. The pattern of variations in length and weight observed in experiment 4 were similar to those observed in experiment 5.

Growth pattern of juveniles *Pachymelania* species

Specimens of juveniles recorded highest overall average length (27.5 mm) and body weight (1.18 g) in experiment 3, while the lowest values (25.63 mm; 0.97 g) were recorded in the control experiment and experiment 3 respectively. Average weight values recorded in other experiments were; 1.03 g, 1.12 g, and 1g in experiments 1, 2 and 5 respectively, while those of length were; 26.56 mm, 26.26 mm and 26.43 mm in experiments 2, 4 and 5.

Variations in length and body weight of juveniles in all the experiments varied greatly (Figs. 8 - 13). In experiment 1, the length of juveniles increased progressively (from 24.85 mm in week 2 to 26.07 mm week 20) throughout the period of the experiment. This trend was also recorded in weight of the specimens which increased from 0.91 g in week 2 to 1.02 g. In experiment 2, appreciable increase in length and weight of juveniles was observed throughout the experimental period. The animals increased progressively in length from 25.2 mm in week 2 to 25.71 mm in week 20, while increase from 0.86 g in week 2 to 1.07 g in week 20 was observed for the weight.

In experiment 3, length of juveniles increased from 25.05 mm in week 2 to 28.38 mm in week 20, while the weight progressed from 0.88 g in week 2 to 1.39 g in week 20. In experiment 4, length of juveniles remained constant, while the weight decreased consistently throughout the period of experiment. The trend observed in experiment 4 was similar to the pattern observed in experiment 5, although in 5, consistent reduction in length was observed in both juveniles and adults.

Condition factor (K)

Figures 14 and 15 depict variations in K of adult and juvenile specimens respectively used for this study. For adult specimens, K decreased from 0.006 recorded in week 4 to 0.0006 observed in week 20 in the control, progressed from 0.006 observed in week 4 to 0.007 in week 20 in experiment 2 and remained constant at 0.006 in experiment 3. In experiment 4, K fluctuated between 0.005 and 0.006, while in experiment 5 there was a decline from 0.006 observed in week 4 to 0.005 in week 20.

In the juvenile specimens, K increased from 0.006 recorded in week 4 to 0.008 observed in week 8, but decreased subsequently to 0.005 in week 20 in the control while there was a progressive increased from 0.005 recorded in week 4 to 0.006 in week 20. Condition factor for juvenile specimens remained constant in the four months of study and latter increased to 0.006 in week 20. Experiments 4 recorded consistent decrease from 0.006 observed in week 4 to 0.006 in week 20.

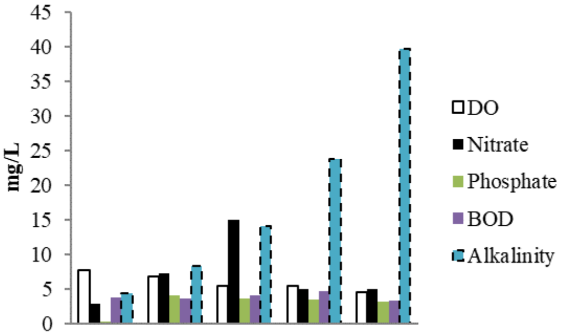

Fig. 1. Variations in water quality parameters of experimental setups

Table 2. Summary of length and weight values recorded for adults and juveniles during the experiment

	Length (nm)														
	Experiment 1(Control)			Experiment 2			Experiment 3			Experiment 4			Experiment 5		
	Min	Max	Mean±SE	Min	Max	Mean±SE	Min	Max	Mean±SE	Min	Max	Mean±SE	Min	Max	Mean±SE
Adult	33.00	49.00	41.00±11.31	33.50	43.00	38.25±6.72	33.00	44.00	38.50±7.78	30.50	43.50	37.00±9.19	30.50	43.50	37.00±9.19
Juveniles	16.50	32.00	24.25±10.96	15.00	32.50	23.75±12.37	21.00	40.00	30.50±13.44	21.50	31.00	26.25±6.72	21.00	31.00	26.00±7.07
	Weight (g)														
	Experiment 1(Control)			Experiment 2			Experiment 3			Experiment 4			Experiment 5		
	Min	Max	Mean±SE	Min	Max	Mean±SE	Min	Max	Mean±SE	Min	Max	Mean±SE	Min	Max	Mean±SE
Adult	0.81	4.86	2.84±2.86	1.33	5.03	3.18±2.62	1.42	4.60	3.01±2.25	1.30	4.82	3.06±2.49	1.10	5.03	3.07±2.78
Juveniles	0.22	3.80	2.01±2.53	0.25	3.93	2.09±2.60	0.47	3.89	2.18±2.42	0.52	1.37	0.95±0.60	0.50	3.01	1.76±1.77

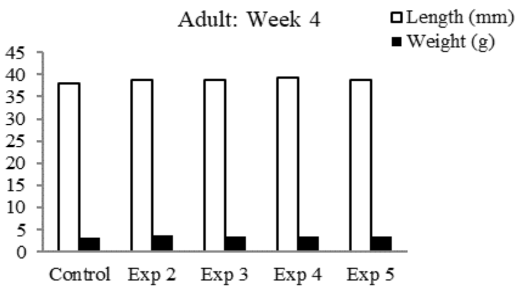

Fig. 2. Variations in weight and length of adult specimens in week 4

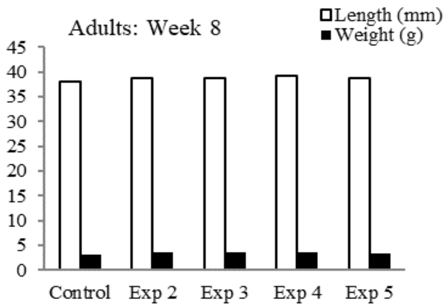

Fig. 3. Variations in weight and length of adult specimens in week 8

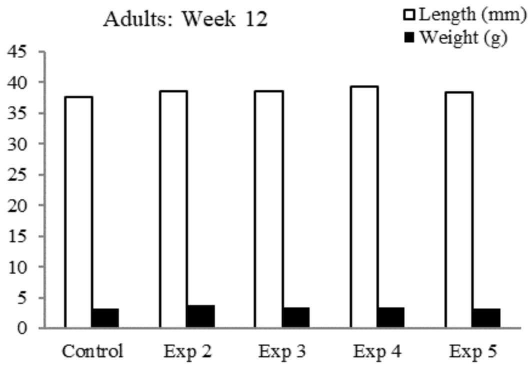

Fig.4. Variations in weight and length of adult specimens in week 12

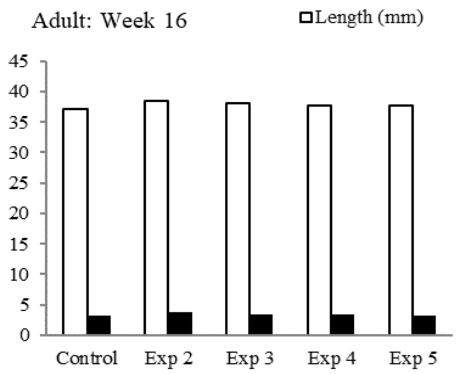

Fig.5. Variations in weight and length of adult specimens in week 16

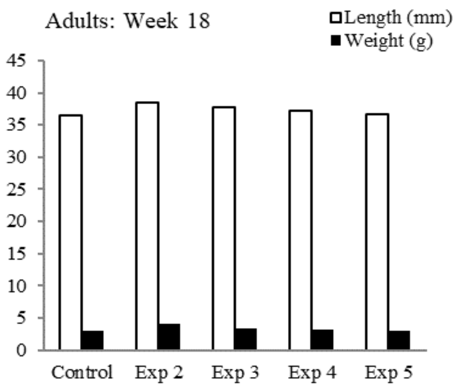

Fig.6. Variations in weight and length of adult specimens in week 18

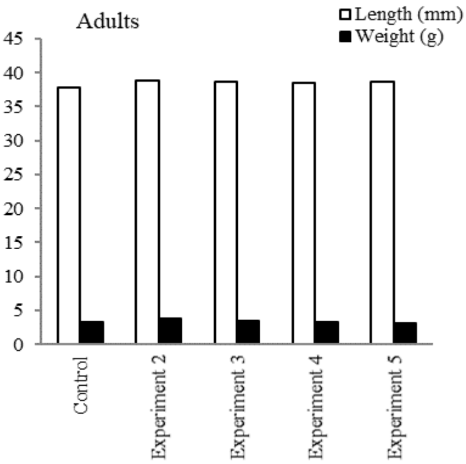

Fig.7. Overall mean values for adult specimens

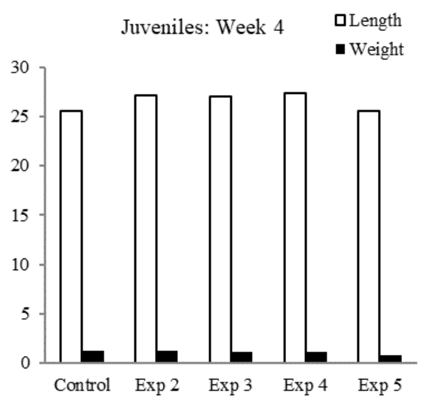

Fig.8. Variations in weight and length of juvenile specimens in week 4

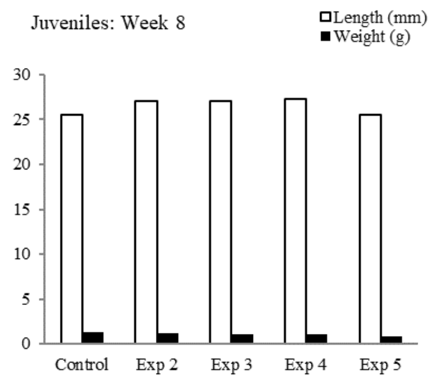

Fig.9. Variations in weight and length of juvenile specimens in week 8

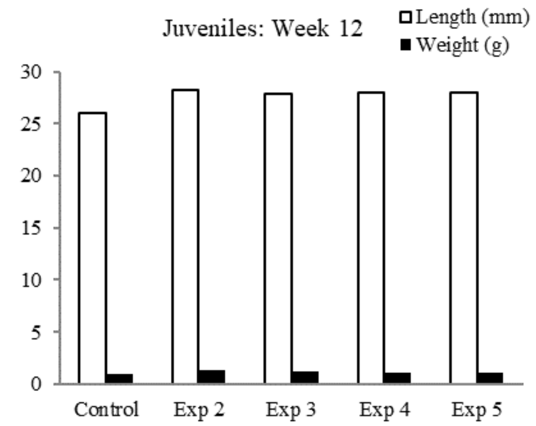

Fig10. Variations in weight and length of juvenile specimens in week 12

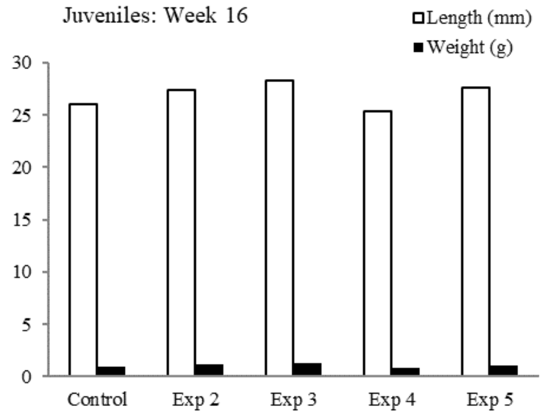

Fig11.Variations in weight and length of juvenile specimens in week 16

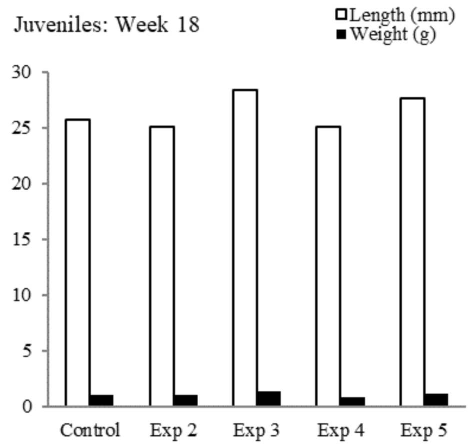

Fig.12. Variations in weight and length of juvenile specimens in week 18

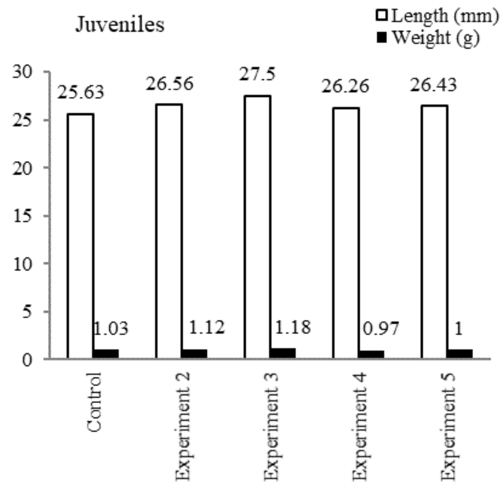

Fig.13. Overall mean values for juvenile specimens

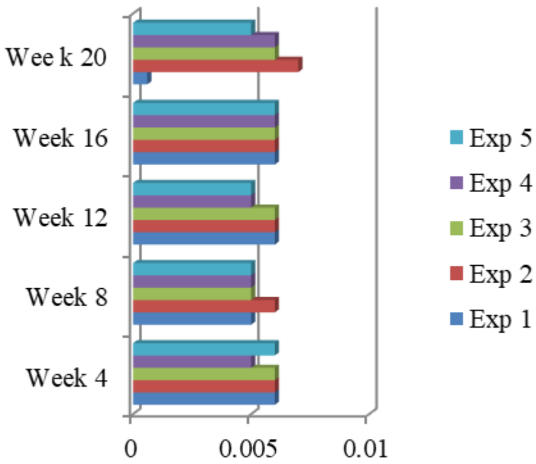

Fig.14. Variation in condition factor of adult specimens

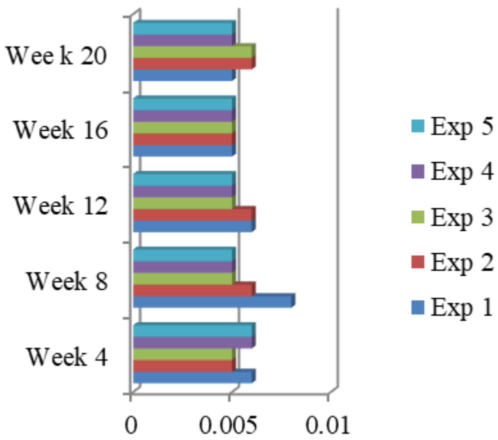

Fig.15. Variation in condition factor of juvenile specimens

DISCUSSION

Effects of water hyacinth on water quality and growth of *Pachymelania* species

In previous researches on water hyacinth's effects on water quality, the most commonly documented effects are lower phytoplankton productivity and dissolved oxygen concentrations beneath mats (Masifwa *et al*., 2001; Uwadiae *et al*., 2011). Other water quality effects include higher sedimentation rates within the plant's complex root structure and higher evapo-transpiration rates from water hyacinth leaves when compared to evaporation rates from open water (Firehun *et al.,* 2014). Photosynthesis is limited beneath water hyacinth mats, and the plant itself does not release oxygen into the water as do phytoplankton and submerged vegetation (Brendock, 2003), resulting in decreased dissolved oxygen concentration. The extent of dissolved oxygen reduction is dependent on the capacity of the water hyacinth mat to prevent light infiltration into the water column. In this study, experiment 5 which had the highest water hyacinth stands recorded the lowest concentration of DO. This observation corroborates the findings of earlier studies which reported that water hyacinth was associated with significantly lower concentrations of dissolved oxygen (Uwadiae *et al*., 2011) when compared to *Hydrilla verticillata* and *Sagittaria lancifolia L.* (Troutman *et al*., 2007).

The number of water hyacinth stands in experimental tanks (Table 1) affected water quality and growth of specimens. According to Marshall and Brendonck (2003), the percent cover, or mat size, of water hyacinth that causes notable decreases in dissolved oxygen varies with the system. The average water hyacinth plant absorbed 2.36 mg of ammonium, 1.13 mg of nitrate, and 0.39 mg of phosphate per kilogram of water hyacinth (wet weight) each hour, therefore, it has the potential to significantly reduce nutrient concentrations in a water body depending on the extent of cover and density (Brendock *et al*., 2003; Meerhoff *et al*., 2003). The values of phosphate recorded in the various experiments (Fig. 1) attests to this assertion. Phosphate values varied inversely with the number and cover of water hyacinth stands in experimental tanks. Rommens *et al.* 2003; Burrows, 2005) found that littoral sites with water hyacinth in Lake Chivero, Zimbabwe, had significantly less ammonium, nitrate, and dissolved oxygen than limnetic sites or than littoral sites without water hyacinth.

The length, body weight and condition factor of specimens used in this study were also affected by the water hyacinth canopy. This may due to the fact that, biological respiration increases with increasing plant density and could lead to anaerobic conditions beneath water hyacinth mats, this may be responsible for the poor growth and development recorded for the animals. *Pachymelania* spp., are majorly filter feeders, they depend on a mixture of benthic microalgae and phytoplankton as their food source. Since free-floating plants can monopolize light and absorb nutrients from the water column, preventing phytoplankton from obtaining sufficient resources for photosynthesis (Brendock, 2003; Greenfield *et al*., 2007), it limits the quantity of food available to the benthos. Furthermore, water hyacinth can entrap phytoplankton and detritus thereby making their distribution and spread difficult. In overall, water hyacinth seems to limit the productivity of phytoplankton and other microalgae thereby reducing the amount of food available to these gastropods.

It is important to note that aquatic vegetation provide ideal habitat for macroinvertebrate colonization (Uwadiae, *et al*., 2011). The structure provided by the roots and leaves create complex habitat for macroinvertebrates, especially for epiphytic macroinvertebrates like snails, arachnids and amphipods. Several studies have documented a positive correlation between epiphytic macroinvertebrate densities and the surface area of floating aquatic vegetation, including water hyacinth (Brendock, 2003). Within its native range, water hyacinth is an important substrate for invertebrate colonization (Brendock, 2003). However, the presence of mats of floating macrophyte in large proportion is inimical to the aquatic ecosystem as demonstrated in this study.

Socio-economic effects of water hyacinth

There are many socio-economic impacts associated with water hyacinth infestation. Although, there are some beneficial impacts, the negative impacts are far-reaching when examined on long-term ecological and social-economic scales. The costs of preventing, managing and eradicating the plant pose great challenges to the local fishing folks (Martinez *et al*., 2007). Water hyacinth invasion into aquatic systems presents a lot of problems for many human uses. The most direct impacts are to boating access, navigability, recreation, and to pipe systems for aquaculture, industry, and municipal water supply. Access to fishing grounds and fish catchability are also affected (Rommens *et al*., 2003). Furthermore, evapotranspiration from water hyacinth can exceed open-water evaporation rates by a factor of ten in some areas (Masifwa *et al*., 2001). This can be a serious concern in water-limited areas and small water bodies. Water hyacinth can greatly affect a fishery if it induces changes in fish community composition, or if the catchability of harvested species is changed (Meerhoff *et al*., 2003).

This study has demonstrated the impact of water hyacinth infestation on the growth and condition factor of gastropods which constitute a major component of fish harvested from coastal water bodies in Nigeria. The implication of this is that a lot of efforts are needed to harvest the quantity of the gastropod that will meet the markets need of these peasants. In Lake Victoria, fish catch rates decreased because water hyacinth mats blocked access to fishing grounds, delayed access to markets, and increased fishing costs (effort and materials) (Navarro and Phiri, 2000; Rommens, 2003; Wondie, 2013; Villamagna and Murphy, 2010). Mats may also block breeding, nursery, and feeding grounds for economically important species. The socio-economic impacts of water hyacinth will also vary with the uses of the water body. An infestation will likely have a greater socio-economic impact when the water body supports several human uses. For a system that is primarily used as a water source, impacts could be measured in terms of changes to water quality. While it is inherently difficult to assign a value to the loss of water quality, a surrogate estimate can be used. In this example, any change in the cost of water treatment could be considered a substitute economic value.

It is also important to recognize that biological impacts and socio-economic impacts may not be immediately realized. Instead damages may increase over time or as a result of synergistic biological or economic interactions. For example, reduced dissolved oxygen may occur as a result of dense water hyacinth mats, but it is the risk of fish kills that would likely draw socio-economic attention. Accounting for all of the impacts is inherently challenging; however, in a world where the invasive species are rapidly increasing, we should begin to prioritize management efforts. The economic cost of controlling water hyacinth infestations is a function of the rate of removal, cost of labor, cost of equipment, and the frequency of operation. Each of these factors will vary based on the extent of the infestation and the type of control used.

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