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Distribution and Economic Importance of Aquatic Macro Invertebrates: A Review

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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Review Article

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ABSTRACT

Aquatic macro-invertebrates are basic constituent of the aquatic food chain (serve as food for fish and other organisms), they aid in natural flow of energy as well as bio indicators of water quality. Others like snail are vectors of diseases- Schistosomiasis, Fascioliasis, Paragoniasis. Predatory insects and leeches damage fish eggs, fries and fingerlings. The distribution of aquatic macro-invertebrates are governed by good habitats, season of the year, physico-chemical parameters of water and sampling techniques. The factors playing a role in their distribution appears to have a role in dictating the survival and distribution of other aquatic organisms. The interplay of distribution, abundance and economic importance of aquatic macro invertebrates and other water organisms helps check population growth, survival of the fittest, and serve as targets for conservation initiatives. Therefore a combine effort of individuals and government is needed to provide, and ensure guidelines implementation to protect the aquatic system from pollution and degradation, and ensure maximum productivity.

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Keywords: Aquatic; macro-invertebrates; distribution; economic importance.

1. INTRODUCTION

The aquatic ecosystem comprises of fresh water bodies, marine water (salt) bodies, and those in between. Fresh water bodies includes ponds, streams, rivers, and lakes, and salt water bodies (seas and oceans). While estuaries and lagoons fall in between. These water bodies are made up of living and non living components interacting with each other for nutrients (nitrogen and phosphorus) and shelter [1].

Aquatic macro-invertebrates are small organisms visible to the naked eye and have no internal skeletal systems. They include insects, larvae, worms, snails, crayfish, clams, shrimps, mussels, leeches and water flies [2]. These can be found in a range of aquatic environments, such as small ponds, larger, sunny rivers, and swift-moving streams [3].

Aquatic macro-invertebrates play significant roles in the aquatic system. There role in the aquatic system is significant, ranging from being food to fish and other predators, to aiding natural energy and nutrients flow, and others playing a role in organism population dynamics, and maintaining pond health via saprophytic activity [4,5]. Macro-invertebrates further serve as bio-indicators of water quality by utilizing organic and detritus matter [6,7]. “It has been observed that caddish fly, mayfly, stone fly and dragon fly are sensitive to pollution and tends to be found in areas with good water quality while leeches and mosquitoes are pollution tolerant; meaning if found around a pond, there is chance that such a pond needs recycling” [8].

Other factors that determine the distribution of macro-invertebrates include availability of good habitat that provides for food, water, air, space and reproduction [9,10], in addition to physico-chemical parameters like dissolve oxygen (DO) and pH [11,12]. Sampling techniques is also known to determine macro-invertebrates assemblage in an aquatic system. However the number of individuals and variety of taxa captured may vary with times of the day [13].

The factors playing a role in their distribution appears to dictate the survival and distribution of other aquatic organisms, and due to their critical position in the food chain and aquatic health, it becomes apparent how their dynamics is correlated to economic importance, directly or indirectly. There’s paucity of information as regards the determinants dictating macro-invertebrates distribution dynamics, and such is what compelled a review aimed at highlighting the factors and the mechanisms by which such factors affect the distribution and economic importance of macro-invertebrates in the aquatic system.

2. FACTORS AFFECTING THE DISTRIBUTION OF AQUATIC MACRO-INVERTEBRATES

2.1 Good Habitat

“Good habitat that provided for food water, air, space and reproduction is a good factor affecting the distribution of aquatic macro-invertebrates” [10]. “Annelids like leeches are found in lakes, ponds mashes and streams. They are predaceous, feeding on worms, snails, fish eggs, aquatic insects and frogs. Others are scavengers and few suck blood” [14,15]. Six different habitats - catchment reservoirs, estuarine reservoirs, forest streams, rural streams, ponds and monsoon canals are reported by [16] as homes for diversity of freshwater mollusk. Gastropods have been shown to prefer these still and slow moving waters [12]. Estuarine waters are generally more turbid than the other listed habitats above, and the bivalves have been shown to prefer non-turbid waters [17]. Other than this niche specialization, exact population variation across these different habitats are yet to be reported, but it is speculated that such exists. Establishing such density and distribution dynamics for the respective habitats can go a long way in indicating the underlying driving factors.

“Habitats are varied and offer a wide range of substrates, but the complexity of these large structures represents an increased variety of micro-habitats that elevate local species diversity” [18]. “Larger substrates increase habitat heterogeneity by providing micro-habitat to support high density of mollusks” [19]. A survey of the macro-invertebrates in Fadama ponds of Anambra State of Nigeria revealed that 86% were arthropods [20]. This was consistent with the report of [21] who observed that “the phylum Arthropoda had the highest population among the phyla across stations when studying the variations of benthic composition in river Benue at Makurdi, Nigeria”. Apart from habitat heterogeneity, high algal production have been correlated with high invertebrates growth and abundance [22]. The overall availability of food and conducive environment for survival contributes in increasing population density of macro-invertebrates, and other aquatic life.

2.2 Season of the Year

This looks at the period and time at which a particular macro-invertebrate developed and flourish in an aquatic ecosystem. It is of advantage in deciding whether a particular macro-invertebrate or the specific aquatic ecosystem is going to be helpful or beneficial to other aquatic life e.g adult fish in the pond, or adversely affect the fish [23]. “Seasonal-related benthic fauna variation have been reported and the population of benthic fauna group during the dry season was higher compared to the wet season” [21]. This agreed with the finding of [24,25,26,6]. A good reason may be that during the dry season, quantity of water in rivers become reduced and clearer, the substrate get stabilized and the population of the benthic fauna increased. However, [27] stated that macro invertebrates diel activities can also differ among seasons, presenting activity peaks only in particular wet phases. Some aquatic organisms are vulnerable to disturbance and may affect their survival and completion of the life cycle [28]. In summary, the specific season of the year dictates water levels in aquatic ecosystems, and such will not only affect the biochemical composition, and habitat complexity, but it will by implication dictate macro-invertebrates activity and distribution.

2.3 Physicochemical and Hydrological Parameters

Physico-chemical parameters of a water body entails the physical and chemical factors affecting the survival, productivity, and bio-distribution of living organisms in the aquatic ecosystem. Hardness and pH are the most important factors that both directly and indirectly influence metabolic activities, and by implication, the growth and abundance of freshwater mollusks [29]. Other factors that play a critical role in modulating distribution of aquatic macro-invertebrates includes turbidity, seasonality, nutrient (macro and micro) concentration, and dissolved oxygen (DO). Both major and minor parameters contribute in detecting water quality. Aquatic macro-invertebrate assemblages have been reported to be primarily due to water quality rather than prevailing climatic conditions [30]. Macro-invertebrates have been shown to prefer clearer water than turbid water [31].

There’s varied sensitivity to DO levels across macro invertebrates taxa. A sudden and gradual depletion of DO can cause major shift in the distribution spectrum of aquatic organisms from intolerant species to population tolerant species [32]. Most macro invertebrates have been shown to tolerate all but very low DO levels (<10% saturation), with Mayflies showing the highest sensitivity to low oxygen conditions which was detrimental at DO levels <20% saturation [33].

Some macro-invertebrates could withstand a wide range of alkalinity of water bodies [12]. The faeces of earthworms are known to contain calcium, phosphorus, potassium and magnesium which helps to reduce alkalinity and acidity of water soil [5]. It was opined that pH, alkalinity, hardness were the important factors that significantly influenced the distribution of a number of aquatic mollusks in northern Nigeria, in addition to key nutrients like phosphate, phosphorus and sulphate [12].

Taking this contextually, physico-chemical parameters, depending on their concentration in a water body, and independent of hydrological factors, could affect the distribution and abundance of aquatic macro-invertebrates.

2.4 Sampling Techniques and Time of the Day

Some aquatic organisms are vulnerable to disturbance, and such may affect their survival and the completion of their life cycle [1]. The number and variety of macro invertebrates found have established connection with the sampling technique. Some studies have shown that the number of individual and variety of taxa captured may vary with time of the day [28]. Many species of macro invertebrates present diel changes in spatial distribution or activity which are essential part of the behavior dynamism of a community for which the sampling may not provide a complete picture [34]. Adequate sampling techniques have revealed activity cycle in macro invertebrate with some showing high abundance at night after sunset and before sun rise. Macro invertebrates surveys with different aims would require different sampling techniques [28]. Diel activity cycles are also associated with differential uses of the micro habitat along the day for macro invertebrates species [34] and assemblages [13].

The abundance and distribution of macro invertebrates also depends on the type of netting used. It was opined that dip-netting was more effective to sample macro invertebrates assemblages in different micro habitats while fyke nets were appropriate for nocturnal and swimming invertebrates [35]. However, the joint use of both sampling techniques would capture a good number of the representative macro fauna of a temporary pond than either one of its own [36,37,38].

3. ECONOMIC IMPORTANCE OF MACRO INVERTEBRATES TO AQUATIC SYSTEM

3.1 Constitute an Important Part of the Food Chain

A variety of natural fish food organisms found in a water body depend on the productivity of the water body. Some of the fish natural food organisms include phytoplankton, zooplankton, annelids, worms, insects and mollusk. The phytoplankton community in a water body serve as a base for the food chain and support commercial fisheries [39]. Insects forms part of the food chain and food web in a pond therefore providing food for fish and other aquatic organisms. High invertebrates growth and abundance in ponds have been associated with high algal production [22].

Aquatic invertebrates constitute an important part of the aquatic food chain; leeches serve as food for turtles, aquatic birds, snakes and crayfish [40], while earthworms serve as food for frogs, centipedes and small fishes [5]. Benthic organisms constitutes an important part of the aquatic food chain especially for fish. Many of them feed on algae and bacteria, which are on the lower end of the food chain [21]. Some shred and eat leaves, and others on organic matter that enters the water. Some of the zoobenthos that serve as essential food items for fish include nymph and eggs of insects like *Plecoptera* (*Isoptera* and *Odonata*) and adult insects like *Gammarus* of the order *Amphipoda* which are usually buried in the aquatic plants or under rocks [41]. High abundance of macro invertebrates that constitute part of aquatic food chain woulds serve as food for fish and other aquatic organisms. Since fish, as an affordable source of protein, plays a role in the economy and livelihood of a nation, it becomes apparent how, indirectly, the distribution and population of macro invertebrates in an aquatic system would boost this chain of food-economic efficiency.

3.2 Aid in Natural Flow of Energy

Living and non living components of an aquatic ecosystem are known to interact with one another for nutrients (nitrogen and phosphorus), and shelter [1]. Caddish flies are known to help breakdown dead and decaying matter thereby improving the biological cycle of the pond [42]. Coral reefs are known to accumulate from calcareous exoskeleton of marine invertebrates of the order *Scleractina* (Stony corals); these animals metabolize sugar and oxygen to obtain energy for their cell building processes, including secretion of exoskeleton, with water and carbon dioxide as by products [1]. Benthic fauna are indispensable organisms in aquatic community [21]. They play important functions such as mixing of sediments, mineralization, flux of oxygen in the sediment, cycling of organic matter, and monitoring of surface water quantity [43]. The abundance and critical position of the benthic macro invertebrates in the aquatic systems food chain enables them play a major role in the natural flow of energy and nutrients [21]. Furthermore, the physical movement and physiological activities of benthic macro invertebrates influences organic deposition in sediments, and re-mobilize sediment-bound pollutants and heavy metals, as well as community composition of microbes [44].

Benthic macro invertebrates like crustaceans, mollusks, insects are called ecosystems engineers, which execute multiple functional roles through bio-turbation that facilitates maintaining the freshwater as self sustaining and self stabilizing system.

3.3 Serve as Bio Indicators

The types and distribution of benthic fauna have been used widely as an indicator of water quality and ecological disturbance [6]. It has been observed that benthic macro invertebrates of running water are of value as long term indicators of water quality and provide signs of impending water pollution and habitat fragmentation [45]. Aquatic invertebrates have the ability to clean rivers as they utilize the organic and detritus matter [7]. Earthworms and nematodes are beneficial to water because they keep the soil moving as they eat, which is important to keep ponds and lakes healthy. On the other hand turpifex worms, when in high number, indicates organic pollution in water [5].

Bivalves were found in clear waters buried in sands [12], which indicates non-polluted water and oxygen-rich habitats, therefore are bio-indicators in inland waters [17]. Aquatic insects are an essential part of a balance water ecosystem, and the ones that are present can give vital information on pond health. Flies like caddish fly, mayfly, stone fly and dragon flies are sensitive to pollution, and tend to be found in areas with good water quality; while leeches and mosquitoes are pollution tolerant, meaning if found around a pond, there is need for recycling [8].

Macro invertebrates therefore are heterogeneous collection of various evolutionary taxa where their biotic and diversity indices are used to determine water quality and pollution changes in streams and rivers [21].

3.4 Serve as Predators, and Vectors of Diseases

Some of the benthic macro invertebrates proved detrimental to the young- and adult- stages of fish. Predatory insects cause a considerable damage to eggs, fries and fingerling stages of fish in the nursery and stocking ponds [23]. Water bug have armored bodies, a long, and very strong beak that is able to easily pierce other insects as well as fish, injecting toxic saliva resulting in prey immobilization [8]. Flatworms are predators of the pond, feeding on injured animals and fleas [5].

Aquatic macro invertebrates could also be vectors of diseases. Many species of leeches are predaceous, feeding on other worms, snails, fish eggs and aquatic insects [46]. Macro invertebrates are vectors of trematodes diseases of man and livestock. Gastropods like snails serve as intermediate host of Schistosomiasis, Fascioliasis and Paragoniasis [47]. Furthermore, the level of parasites infestation of fish is an eye opener to poor environmental condition and population of our aquatic system, serving as a risk factor for the emergence of diseases [48].

The population and biodiversity of aquatic macro invertebrates of predatory and health importance, can invariability affect the fish productivity and health of other aquatic organisms, and by extrapolation humans.

3.5 Macroinvertebrates and Forensic Investigations

The science of using insects and other arthropods in criminal investigations is known as forensic entomology [49]. Forensic entomology is critical to natural security. Insects and arthropods are present in carrion or a decomposing vertebrate body [50]. The postmortem index (PMI), the corpse's mobility, the manner and cause of death, and the association of suspects at the death scene can all be estimated using these insect colonisers [51]. Aquatic insects (macroinvertebrates) have been shown to have a role in forensic investigations. With the abundance of benthological knowledge relevant to medicolegal investigations into suspicious human fatalities, new directions for research and applications of aquatic ecological concepts and models have emerged [2].

4. CONCLUSION

The distribution and population dynamics of macro invertebrates in the aquatic ecosystem play some role in dictating the survival and distribution of other organisms. Aquatic macro invertebrates are basic constituents of the aquatic food chain as they serve as food for fish and other organisms, aid in natural flow of energy (mixing of sediments, mineralization and cycling of organic matter). In addition to being bio indicators of water quality, and vectors of diseases, They also serve as targets for conservation initiative. Predatory insects and leeches cause a lot of damage to eggs, fries and fingerlings stages of fish in nursery and stocking ponds. The distribution of aquatic macro invertebrates are governed by good habitats, season of the year, physico-chemical parameters of the water and sampling techniques. Since fish as an affordable source of protein, play a role the economy and livelihood of a nation, it becomes apparent how indirectly the distribution and population of aquatic macro invertebrates would boost this chain of food economy or deter it. It therefore implies that the interplay of factors driving distribution, and abundance of aquatic macro invertebrates could serve to check population growth and survival of the fittest of other aquatic organisms in water, and their associated economic importance. This calls for the attention of government to provide, and institute conservative guidelines to ensure the survival of economically important aquatic macro invertebrates in order to boost the overall aquatic productivity.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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