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Diversity of hemipterans in Sengunam pond, Perambalur, Tiruchirappalli, Tamil Nadu, India

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Abstract
Freshwater ecosystems are colonized by a diverse array of aquatic organisms and often contribute the bulk of regional freshwater biodiversity. Aquatic insects are abundant in most freshwater habitats and often exhibit high diversity and play an important role in ecosystem functioning by virtue of their abundance, taxonomic diversity and trophic significance, besides, water quality monitoring as reliable indicators. Ponds are an excellent habitat for biodiversity studies of freshwater insects. The present paper focuses on the diversity of hemipteran fauna in Sengunam pond, Perambalur, Tiruchirappalli, Tamil Nadu, India. The hemipteran insects recorded from Sengunam lake were *Aquarius* and *Limnogonus* (water striders), *Nepa* (water scorpion), *Ranatra* (water scorpion/water stick insect), *Hesperocorixa* and *Corixa* (water boatman), *Notonecta* (backswimmer), *Neoplea* and *Paraplea* (pygmy backswimmers), *Lethocerus* (giant water bug) and *Diplonychus* (water bug). Therefore, it is imperative to make continuous investigation, census and research activities on the taxonomy and diversity of aquatic insects, so that knowledge regarding this important group can be utilized by future researchers as baseline data for further research and conservation planning of both the aquatic insects and water bodies.

Keywords: Sengunam pond, hemipteran fauna, aquatic diversity

Introduction

Life without water is impossible because it sustains life in every possible form. Rivers, ponds, lakes and underground stores are the major sources of water. Functional parameters of an aquatic ecosystem attributes to the ecological significance resulting from the interactions between its physical, chemical and biological components. These interactions result in the creation of a variety of niches which are inhabited by various organisms thus providing a habitat for plants, animals and microorganisms in an ecosystem and determine the tropic dynamics of the aquatic body [1]. Fresh water ecosystems are colonized by a diverse array of aquatic organisms [2] and often contribute the bulk of regional freshwater biodiversity [3, 5]. The large water bodies have received much attention, while the small ones, especially the ponds remain neglected which serve as repositories to the local biodiversity [5]. There is growing evidence that ponds, despite their small size are rich in biodiversity [4] and often constitute biodiversity 'hot spots' within a region [5] and also show greater biotic and environmental amplitudes than rivers and lakes [6]. Ponds, as defined by Williams *et al.* [4], are lentic water bodies, temporary or permanent, including both natural and man-made water bodies. Despite their small size and unpredictable nature, these temporary water bodies are known to harbour novel, endemic, rare and/or threatened fauna [7, 8] and their resting stages, thus acting as "local natural reserves" or "hotspots" [9].

Insects are the most species rich and have successfully invaded virtually all aquatic habitats [10]. Aquatic insects live their life cycle in water bodies and are found in or on the surface of the waters [11]. All over the world about 45,000 species of insects are known to inhabit diverse freshwater ecosystems [12]. Aquatic insects are abundant in most freshwater habitats and often exhibit high diversity [13]. In aquatic food webs, they serve as food items for nearly the full range of vertebrate and invertebrate predators, and many function as predators themselves. Insects with their abundance and diversity dominate fresh water ecosystem as they are involved in nutrient recycling [14], since they belong to several specialized feeding groups *viz*., shredders, filter feeders, deposit collectors and predators [15]. They also form an important component of natural food web in aquatic ecosystem besides serving as reliable indicators of ecological characteristics of water [14]. The aquatic insects play an important role in ecosystem functioning by virtue of their abundance, taxonomic diversity and trophic significance. Aquatic insects are suited for use in Environmental Impact Assessment (EIA) and have a long tradition in water quality monitoring [16] as reliable indicators.

The high insect diversity of a pond is related to the high diversity in habitat characteristics, *viz*., hydroperiod, trophic structure and macrophyte diversity [17]. The biota of these habitats is adapted to such highly fluctuating conditions, by means of rapid life-cycles, production of resting eggs and diapause [18, 19]. Mukhopadhyay and Dewanji [20], Kiran *et al.* [21], Muthukumar *et al.* [22], Garg *et al.* [23] and Santhala *et al.* [24] have reported ponds as an excellent habitat for biodiversity studies, besides other studies on the diversity of freshwater insects [25, 36]. Further, studies on diversity of aquatic hemipteran bugs of Pocharam lake in Andhra Pradesh was

done by Deepa and Rao [37]. Therefore, the present paper focuses on the diversity of hemipteran fauna in Sengunam pond, Perambalur, Tiruchirappalli, Tamil Nadu, India.

Materials and Methods

Sengunam pond (11°16'05.0"N 78°54'33.9"E, 11°16'19.3"N 78°55'01.3"E) located in Sengunam village, 10km away from Perambalur, Tiruchirappalli, Tamil Nadu, India was taken as the study area. The pond is dense with floating and submerged vegetation with an area of 15 square hectares and an average depth of one metre. The study was taken from January 2016 to December 2016. Collection and habitat sampling of aquatic insects were done on a regular basis during the early hours of the day (6-9 a.m.) throughout the study period. The collected hemipteran fauna were then identified, categorized and recorded. The insects were identified on the basis of the external morphology and available keys [38-41].

Results

The hemipteran insects recorded from Sengunam lake are listed in Table 1. The aquatic insects were *Aquarius* and *Limnogonus* (water striders), *Nepa* (water scorpion), *Ranatra* (water scorpion/water stick insect), *Hesperocorixa* and *Corixa* (water boatman), *Notonecta* (backswimmer), *Neoplea* and *Paraplea* (pygmy backswimmers), *Lethocerus* (giant water bug) and *Diplonychus* (water bug) (Figure 1).

Discussion

India is one of the megabiodiversity countries in the world and occupies the ninth position in terms of freshwater biodiversity [42]. Science of aquatic entomology embraces different kinds of aquatic insects which comprises of a taxonomically diverse and ecologically important and interesting group of animals in lentic fresh water systems. One of the most fascinating characteristics of the aquatic insect population is their diverse pattern of aquatic habitat distribution coupled with their adaptability. The aquatic insects are sufficiently flexible to withstand severe and sometimes unpredictable environments. Aquatic insects exhibits the ability to use a wide variety of food resource, exploit and develop them into a variety of macro and micro feeders that operate from deep within the substrata to the top of the surface film. Besides these, they have been used as reliable bioindicators of aquatic pollution [43]. Aquatic insects help in determining the health status of a stream, pond, river or a lake. In addition to ecosystem function, aquatic insects are reliable indicators of human impact on freshwater ecosystem over a long period of time [44] and have proven themselves to be a vital tool for testing ecological paradigms [45]. Aquatic insects are probably best known for their ability to indicate about the water quality in a particular environment. If a sample of the aquatic insects in a particular place is analyzed, in term of the sensitive kinds versus tolerant kinds, one can get a good measure of the environmental health. Aquatic environments have a wide assemblage of insects, while polluted environments have only a few kinds of aquatic insects. This process is called biological monitoring. Therefore, the presence or absence of certain families of aquatic insects can indicate whether a particular water body is healthy or polluted [46].

Aquatic biodiversity is one of the most essential characteristics of aquatic ecosystem for maintaining its stability [47]. Aquatic ecosystems are under increasing pressure from various kinds of disturbances [48]. This situation threatens both aquatic living resources and human population [49]. Removal or loss of aquatic insects can cause negative effects in the ecosystem's stability and diversity. Biodiversity loss in freshwater ecosystems is an increasing phenomenon, mainly due to human activities [50]. The main causes are the habitat destruction and defragmentation, exotic species introduction and global climate change impacts [51].

Lentic environments, including lakes, ponds and various types of wetlands offer a broad array of aquatic habitats that have been exploited by a wide variety of insects [13]. Ponds are small shallow, natural or man-made water bodies defined as wetlands by the Ramsar Convention [9]. They play an important role in the conservation of aquatic biodiversity [5], despite their small size. Ponds are home for surface hunters and divers. One of the most fascinating characteristics of the aquatic insect population is their diverse pattern of distribution in habitats coupled with their adaptability. Aquatic insects spend their life cycle closely associated with water, either living beneath the surface or skimming along the top of the water [15]. The surface hunters are the common water striders and water skaters which are gregarious, and walk and run with great speed on water surface. The divers include the water boatman and water scorpions [52, 53].

Water striders, also known as "pond skaters", "water skippers" and "Jesus bugs" are 3-16mm in length, distributed worldwide, preferring the surface of temporary or permanent ponds and slow moving areas of streams and rivers. These bugs feed on small insects either living or dead on the water surface. They have fine water repellent hairs on the underside of the tarsal which allow them to walk on water's surface. The mid and the hind legs are used for locomotion; they are attached to large coxae connected to the sides of the thorax and are unfit for walking on land [54, 55].

The members of water scorpions are not scorpions, but possess two pairs of wings and grasping forelimbs that resemble a scorpion's pincers. Its length ranges from 15-46mm, cosmopolitan in distribution particularly in the warmer regions and are present in slow moving streams, ponds and similar bodies of water. It has a long respiratory siphon projecting out from its tail section that resembles a scorpion's stinging tail. They have a small head with large eyes that project to the side. This insect belongs to the sub-order Heteroptera, which includes insects with anterior wings that are stiffened to provide protective wing cases for the membranous posterior wings beneath [56].

Water stick insects are predatory members which take up a habitat of usually shallow water in weedy ponds. Their front legs are strong and are used to grasp prey. They breathe through a pair of long respiratory siphons extending from their tails which is often half the length of the insect. They eat tadpoles, small fish and other insects, which they pierce with their beak and inject saliva which both sedates and begins to digest their prey. They are active throughout winter as adults, except in extreme cold [30, 57, 58].

Water boatman is the largest group of aquatic true bugs which do not bite. These bugs have a worldwide distribution and are found common in ponds swimming in groups. Water boatman

feed mainly on algae and other plant material. They are small, slightly flattened and elongated bugs with dull mottled colouring. They have hairs on their two pairs of hind legs, and the hind legs are oar-shaped that allow them to paddle, as well as single-segment forelegs that are shaped like a scoop. They are similar in appearance to backswimmers, for which they are sometimes mistaken [59].

Backswimmers and pygmy backswimmers are aquatic bugs that often swim upside-down and are also known as "water bees" and "water wasps" whose size ranges from 5-15mm found in ponds, freshwater pools and slow moving streams. Most notably, backswimmers can be distinguished by the habit that gives them their name as they swim on their backs. While resting at the surface, body is typically tilted with the head downward. Similar in appearance to the water boatman, the backswimmer can be distinguished by wings that are lighter in colour than legs and lack of scoop-shaped forelegs. Another striking feature that sets them apart from water boatman is that they are carnivorous hunters, with prey and eating habits very similar to those of the giant water bug. These back swimmers often prey on other aquatic insects and sometimes on small vertebrates. On the other hand, pygmy backswimmer ranges from 1.9-2.3mm in length dwelling on vascular aquatic plants in standing water. They are poor swimmers who prefer to walk through thick submerged vegetation and prey on microcrustaceans, mosquito larvae and invertebrates [60]. They are invertebrate predators that can play a major role in shaping the structure and the abundance of zooplankton population in several freshwater environments [61-63]. They are mainly associated to the littoral areas with macrophytes, although they can also inhabit the limnetic zone, as their distribution pattern depends on both biotic and abiotic factors [64-68]. They normally explore the water surface, although they are also able to dive to at least 0.5m [69]. They usually attack prey by grabbing them with their fore and mid legs, piercing them with the rostrum, and injecting digestive enzymes before sucking the inner content [70]. They have a broad diet that includes several aquatic organisms, *viz.*, rotifers, crustaceans, mosquito larvae, tadpoles and aquatic insects [62, 67, 71-76]. Furthermore, they often feed on terrestrial organisms trapped on the water surface that become vulnerable to predation, such as bees, ants and mosquitoes, besides, their ability and preference to feed on zooplankton and insect larvae have been observed [61-63].

Water bug/giant water bug, also known as the "electric light bug", "toe-biter", and the "fish killer/giant fish killer" is the largest true bug, with adults reaching lengths of more than two inches. Its habitat involves ponds, shallow margins of lakes and rivers with submerged vegetation and detritus. The water bug is cosmopolitan in distribution and is most diverse in the tropics. Due to its flat, brown, oval-shaped body, it often gets mistaken for a beetle or a cockroach. These bugs have a length of 13-75mm and are predators that consume a wide range of prey including other aquatic insects, tadpoles and crustaceans, fish, salamanders and other amphibians. The giant water bug has a short, pointed rostrum underneath its head that it uses to pierce its prey and injects toxin that both paralyzes its victims and causes its insides to liquefy. The bug then sucks the liquefied guts through its rostrum like a straw. Using this method, the giant water bug is able to capture and eat animals up to fifty times its own size [77-84]. Giant water bugs of the genus *Lethocerus* are traditionally used as human food in Southeast Asia. The family Belostomatidae also shares several characters with the definition of "living fossils" since similar representations of these bugs are already known as fossil documentations from the Upper Triassic of Virginia (North America) since 210 million years ago [85].

The study of the aquatic insect population has assumed importance in the context of population to water bodies and the potentialities of many aquatic bugs in controlling mosquito population. Many aquatic hemipterans have been considered as effective predators of mosquito larvae [86-89]. Jenkins [90] published a list of 220 species of invertebrate predators, of which only a few can be manipulated as biological controls. Of those, few were aquatic heteropterans (Notonectidae, Belostomatidae, Nepidae and Naucoridae) and semiaquatic heteropterans (Veliidae and Gerridae), which inhabit rice fields and marshes, which are ecologically important mosquito predators [87, 88]. Aquatic hemipterans like water bugs of Superfamily Nepoidea which includes Belostomatidae and Nepidae families, predators of mosquito larvae [91, 92] prefer stagnant or slow flowing waters, with a consistent presence of aquatic and semiaquatic vegetation [93-97] have an intermediate place in the food chain, apart from being eaten, are often important predators too [98]. Therefore, it is imperative to make continuous investigation, census and research activities on the taxonomy and diversity of aquatic insects, so that knowledge regarding this important group can be utilized by future researchers as baseline data for further research and conservation planning of both the aquatic insects and water bodies.

Table 1: Taxonomic classification of aquatic hemipterans recorded from Sengunam pond

Insect	Kingdom	Phylum	Class	Order	Suborder	Infraorder	Superfamily	Family	Subfamily
Aquarius	Animalia	Arthropoda	Insecta	Hemiptera	Heteroptera	Gerromorpha	Gerroidea	Gerridae	Gerrinae
Limnogonus	Animalia	Arthropoda	Insecta	Hemiptera	Heteroptera	Gerromorpha	Gerroidea	Gerridae	Gerrinae
Nepa	Animalia	Arthropoda	Insecta	Hemiptera	Heteroptera	Nepomorpha	Nepoidea	Nepidae	Nepinae
Ranatra	Animalia	Arthropoda	Insecta	Hemiptera	Heteroptera	Nepomorpha	Nepoidea	Nepidae	Ranatrinae
Hesperocorixa	Animalia	Arthropoda	Insecta	Hemiptera	Heteroptera	Nepomorpha	Nepoidea	Corixidae	Corixinae
Corixa	Animalia	Arthropoda	Insecta	Hemiptera	Heteroptera	Nepomorpha	Nepoidea	Corixidae	Corixinae
Notonecta	Animalia	Arthropoda	Insecta	Hemiptera	Heteroptera	Nepomorpha	Notonectoidea	Notonectidae	Notonectinae
Neoplea	Animalia	Arthropoda	Insecta	Hemiptera	Heteroptera	Nepomorpha	Notonectoidea	Pleidae	Pleinae
Paraplea	Animalia	Arthropoda	Insecta	Hemiptera	Heteroptera	Nepomorpha	Notonectoidea	Pleidae	Pleinae
Lethocerus	Animalia	Arthropoda	Insecta	Hemiptera	Heteroptera	Nepomorpha	Nepoidea	Belostomatidae	Belostomatinae
Diplonychus	Animalia	Arthropoda	Insecta	Hemiptera	Heteroptera	Nepomorpha	Nepoidea	Belostomatidae	Belostomatinae

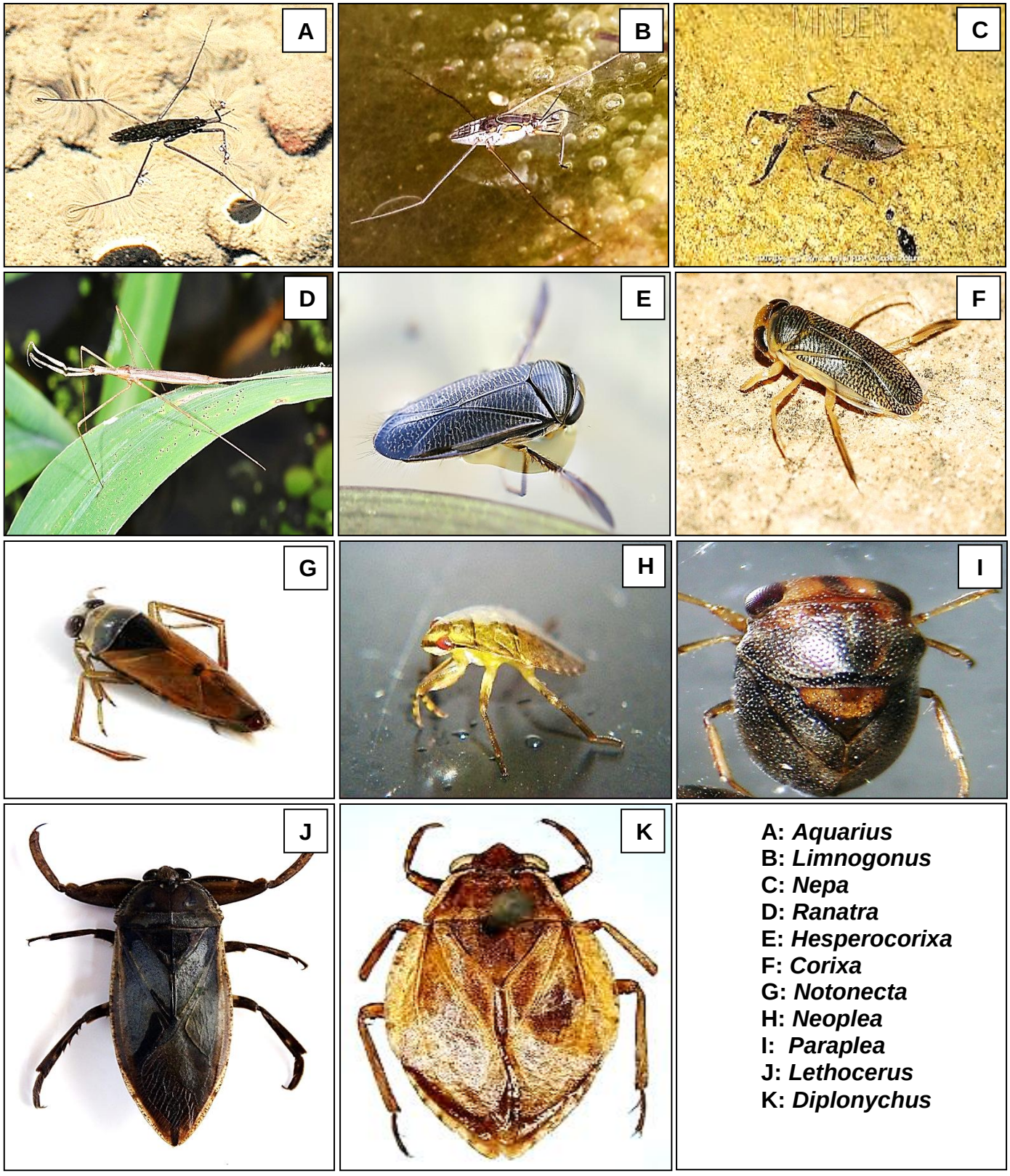

Fig 1: Aquatic hemipterans recorded from Sengunam pond

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