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FEATURE ARTICLE

# Rice fields : an ecosystem rich in biodiversity

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Rice fields have been in existence since the beginning of organized agriculture. Since then a rich biodiversity has become associated with rice fields. Rice fields constitute man-made ecosystems. Due to their long existence, the vast extent of land they occupy in the humid tropics, the array of ecological habitats they encompass and the different phases they pass through during a cultivation cycle, rice fields have become unique ecosystems. It is an ecosystem that sustains not only the people whose staple diet is rice but also a diverse assemblage of plants and animals that have made rice fields their niche. Rice fields are dynamic and rapidly changing ecosystems. The varied agronomic practices conducted on rice fields and the series of growth stages the rice crop passes through during a short passage of time, have made rice fields a haven for a vast array of plant and animal life. To these life forms the rice fields offer shelter, food, breeding and nesting grounds. The rice fields also offer temporary refuge to those animals that are not permanent inhabitants but visit this ecosystem for a variety of purposes.

Rice cultivation in Sri Lanka goes back to the Indo-Aryan immigration dating back to more than 2500 years. Currently about 12% of our land area amounting to *ca.* 750,000 ha are under rice cultivation. Rice fields could be considered as agronomically managed temporary wetland ecosystems, which sustain a diversity of life forms. A survey conducted in rice fields in Bathalagoda, in the Kurunegala District during the late 1990's documented an overall faunal diversity of 495 invertebrate species belonging to 10 phyla, and 103 vertebrate species belonging to five classes, under 53 families. The arthropods constituted the major group of terrestrial invertebrates (82%) dominated by insects followed by spiders. The flora consisted of 82 species of macrophytes comprising grasses, broad leafed weeds and pterydophytes.

The rice agro-ecosystems of the world are categorized into five major types: (i) Irrigated rice fields (ii) Rain-fed rice fields, (iii) Deep water rice fields, (iv) Upland rice fields and (v) Tidal water rice fields. This categorization is based on water regimes, drainage, temperature, soil type, topography and location. Irrigated rice fields in tropical Asia are the source of 1/3 of the world's rice. Several features characterize the rice field agro-ecosystem. It is a man made ecosystem, developed mostly from converted marshes and is therefore, not a natural ecosystem. They sustain a monoculture of rice crop, *Oryza sativa,* for most part of the year. The fields are flooded and drained and subjected to a variety of agronomic practices necessary for the management of the rice crop. The rice fields remain extremely stable on the long term but only relatively stable on the short term during a single cultivation cycle. The rice ecosystem thus encompasses a variety of habitats that are ephemeral and undergo rapid changes.

A variety of studies including food web interactions, economics of insect pest damage, predator and parasitoid biology, ecology and impact of inputs in to the ecosystem have highlighted the rich biodiversity of rice field fauna and flora. The areas most researched are under high yielding rice varieties and varieties resistant to diseases and insect pest damage. A complex and rich web of general and specialist predators and parasitoids live in or on the rice plant, rice weeds. Water and soil keep most of the rice pests in check.

Rice fields have unique characteristics that make them ideal grounds for diverse biological organisms. The agronomic practices required for the cultivation of the rice crop to a greater extent determine the ecological characteristics of the rice fields.

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In addition, the different growth stages of the rice plant from seedling to harvest create micro-climatic conditions, offering a variety of habitats and niches conducive to a variety of life forms. The inhabitants that colonize the rice fields arrive in several waves, the early arrivals (ie. microscopic primary producers, saprophytes etc.) set the stage for those that follow. Built into this cycle of events are inputs made into this ecosystem by farmers to ensure a good harvest. Practices such as ploughing the field prior to planting, flooding and draining the field, adding basal fertilizer before planting and at critical growth stages, application of pesticides, weedicides, manual weeding and abandoning the fields after harvest to fallow are an integral part of rice cultivation. These practices have variable effects on the population dynamics of the rice field fauna and flora.

The necessity to have an aquatic phase during the seed germination and seedling stages of the rice plant through a rain fed or an irrigation system ensures the flooding of the rice fields. The flooded rice fields are an ideal habitat for a variety of aquatic invertebrate communities comprising neuston, zooplankton, nekton, periphyton, and benthos. As many as over 170 species of these organisms belonging to nine phyla have been recorded from rice fields in the Kurunegala District of Sri Lanka. Aquatic vertebrates such as freshwater fish and amphibians colonize the fields during the aquatic phase for breeding, and these in turn attract numerous species of predatory birds (ie., kingfishers, herons, egrets) and reptiles such as water snakes (Figure 1) and monitor lizards. The muddy bottom of the flooded rice fields harbours a variety of organisms. These include protozoans, annelid and nematode worms, and arthoropods. The rice field waters have become the home of several mosquito species, some of which are disease vectors. The aquatic snails too play the role of intermediate host to certain diseases causing organisms. Furthermore, the diversity of fauna and flora inhabiting the rice field waters and soil play an important role in enriching the ecosystem and helping in the recycling of nutrients.

The seedling stage of the rice plant is followed by tillering, booting and flowering stages. These vegetative and reproductive growth stages attract a variety of phytophagous insects and promote the growth of weeds. The arthropod community in rice fields command special attention due to their abundance and diversity. Further, arthropods play a variety of roles both harmful and beneficial to the rice crop. As pests of the rice plant, over 40 species of insects have been recorded from rice fields in Sri Lanka. They cause varying types of damages to the rice plant in varying degrees. The rice leaf feeders, sap feeders, stem borers and gall formers are members of the rice insect pest community. The natural enemies of insects comprising over 90 species of predators and nearly 30 species of parasitoids ensure a natural balance between the different groups of organisms. They also play a beneficial role by reducing rice pest damage.

The predatory arthropods are dominated by the rich spider community that comprise of three distinct guilds occupying specific microhabitats in the rice fields. The regular orb weavers spin a neat orb web in the canopy of rice plants and rice weeds from where they prey upon rice pests and other insects (Figure 2). The minute irregular space -web spinners spin their webs at the base of rice plants, across cracks and crevices in the ground. The latter type of microhabitat becomes more numerous later in the cultivation cycle during the fallow period due to the presence of cattle whose hoof imprints provide such openings. The cursorial hunting spiders spin no web but ambush prey while hiding among the foliage.

The growth of weeds in the rice field proper and the surrounding bunds adds another dimension to this ecosystem that is dominated by the monocrop. Weeds, graminaceous and broad leafed abound the rice fields and provide a refuge to the rice pests and natural enemies as they move from the rice plant to the weeds. A total of

**Figure 1:** *Amphiesma stolata* (Buff-striped Keelback)

**Figure 2:** Aranaeid spider, *Argiope* spp.

89 species of such weeds in 21 plant families have been recorded from our studies and these show a specific distribution pattern within the rice fields, in relation to the temporal and spatial hydrology. They are subjected to a variety of weed control practices such as weedicide use, slashing, clear weeding and even burning after harvest.

The water is drained off during the grain ripening stage, which requires dry field conditions. This results in a short semi-flooded phase, followed by a dry phase that continues into harvest and fallow. Rice fields become attractive to a variety of grain feeding animals that includes insects such as the well known paddy bug whose feeding results in partially filled or empty grains inflicting steady losses to the harvest. About this time an influx of vertebrate fauna different in composition to those found during the aquatic phase enrich the rice fields. They come in search of food, to nest and to breed. These include grain feeding birds (parakeets, munias) and mammals (rats, mice etc.) and predatory reptiles and mammals (cobra, rat snake, Russell's viper, fishing cat etc.). Not only the rice field proper and bunds but the land adjoining paddy fields that may be cultivated or may have become thickets or are contiguous with the marshes are used by these visiting vertebrates. These habitats serve as ecotones providing a variety of food resources and shelter to a range of vertebrates.

Modern agronomic practices used in rice cultivation affect rice field biota in different ways. Biocides and agrochemicals adversely affect the terrestrial arthropod natural enemies, aquatic insects and benthic oligocheates. Field preparation by tractor results in the death of insectivorous aestivating amphibians which are natural enemies of pests and other insects. Intense slashing of the weed cover on bunds have detrimental effects on bees, parasitoids, the predatory spiders and insects. Since rice fields harbour an abundance of natural enemies that prevent significant insect problems, over- reliance on insecticide use could upset this natural balance. Conservation and maintenance of the rice field biodiversity would promote the development of effective trophic linkages which can ameliorate pest damage and soil fertility problems. The presence of arthropod natural enemies can be enhanced by manipulation of weed communities through partial slashing of weed cover on bunds. Leaving the rice stubble and the weed cover intact after harvest further enriches the fallow vegetation which is a refuge to the fauna that previously depended on the rice plant. The non rice habitats in the vicinity and periphery of rice fields sustain a reservoir of natural enemies during successive cultivation cycles and therefore command special attention.

Rice cultivation has been the pride of Asian societies, and plays a significant role in their cultural heritage. The old saying that the rice farmer is fit to be a king after washing the mud indicates the place that the rice farmer had in ancient society. The past glory that rice farming had has disappeared due to commercialization of rice cultivation, leading to numerous impacts on the rice field ecosystem and the ancient agronomic practices. Furthermore, popularization of high yielding rice varieties has led to the loss of a number of traditional rice varieties in Sri Lanka. The supposedly low social standard and poor income associated with rice farming have driven youth out of villages into cities in search of jobs. Consequently, rice cultivation and management of rice fields rich in biodiversity rest in the hands of a few. Future sustenance of the rice farmer and this unique agro-ecosystem, together with its rich biodiversity and cultural practices, could only be achieved through committed state patronage.