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Original Paper

Freshwater shellfish, *Pila globosa*: a review on its ecological and economical importance, nutritive and ethno-medicinal values

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Abstract

The freshwater Indian apple snail, *Pila globosa* (Swainson, 1822), is well adapted to the equatorial and tropical regions of the planet, where there are periods of heavy rain that are followed by dry spells. It is the most important biotic component of the ecosystem and a dominating member of its communities, making it crucial for the health of the ecosystem. It has a significant economic importance in the international trade market. The flesh of *P. globosa* is used in aquaculture and as a human protein supplement because of its high protein and low fat content, along with essential fatty acids. The shell of *P. globosa* is a good source of minerals, especially calcium. *P. globosa* has been employed in traditional medicinal practices to treat diseases like high blood pressure, heart disease, asthma, rickets, rheumatoid arthritis, osteoporosis, calcium metabolism, bleeding piles, constipation, diarrhoea, smallpox, syphilis, dizziness, anxiety, nervousness, urticaria, night blindness, and conjunctivitis. It is also used to regulate body temperature, to speed up wound healing, to treat circulatory issues, to revive virility and vitality, to treat weakness, and for vision improvement. *P. globosa* has antimicrobial, anti-inflammatory, anti-oxidative, anti-cancer, and immune boosting properties, and it can be a benefit to mankind. This review provides an overview of the ecological and economic importance, nutritional and ethno-medicinal values of the snail *P. globosa*.

Key words: ecological importance, economic importance, ethno-medicinal importance, nutritional importance, *Pila globosa*.

Introduction

The binomial nomenclature for the freshwater snail *Pila globosa* was given by William John Swainson in the year 1822. The *P. globosa* is known as the "apple snail" because it has a huge, globular shell and can reach the size of an apple. In the animal kingdom, *P. globosa* belongs to the phylum Mollusca, class Gastropoda and family Ampullariidae.

P. globosa is widely distributed geographically. The snails are extremely well adapted to the equatorial and tropical regions of the planet, where there are periods of heavy rain that are followed by dry spells (Subba Rao, Dey 1989). They are found in the Oriental (India, Sri Lanka, Pakistan, Myanmar, Thailand, Nepal, Malaysia, the Philippines, Vietnam, Indonesia, etc.) and Ethiopian (Africa, Madagascar, and Arabia) regions. In India, it occurs in the states of Maharashtra, Uttarakhand, Uttar Pradesh, Madhya Pradesh, West Bengal, Jharkhand, Bihar, Odisha, Assam, Meghalaya, and Kerala. It frequently occurs in rivers, pools, ponds, tanks, streams, lakes, marshes, rice fields, ditches, irrigation canals, wetlands, and brackish water with low salinity (Jahan et al. 2001; Nath et al. 2008). Normally, it favours clear, shallow waters. This review article aims to discuss the ecological and economical significance, nutritional, and ethno-medicinal values of the snail *P. globosa*.

Ecological importance

The Indian apple snail, *P. globosa* is a key species in freshwater and grassland ecosystems (Panda et al. 2022). Freshwater snails are food for numerous animals and hence, they play a significant role in the aquatic ecosystem food chain (Thorps, Covich 2009).

By operating as a biofilter, which is necessary for the preservation of biodiversity, the snails play a critical ecological role in maintaining healthy aquatic ecosystems (Jahan et al. 2001). They clean water because they consume algae, dead plant matter, and other organic detritus. Since they are voracious eaters of aquatic plants, they are useful in reducing aquatic vegetation that frequently clogs canals. They are helpful in the management of aquatic weeds. For instance, in the state of Kerala in southern India, *P. globosa* serves as a highly effective biological control agent for the aquatic weed *Salvinia molesta*, which poses a severe threat to agriculture, particularly paddy farming (Thomas

1975). They are also excellent ecological indicators of water pollution. *P. globosa* is a reliable contamination biomarker and biomonitor of water pollution to assess the health of the aquatic ecosystems (Singh, Agarwal 1979; Sahib, Rao 1988; Johnson 1990; Sivaramakrishna et al. 1991; Rajyalakshmi et al. 1996; David et al. 2003; Bhattacharya et al. 2016).

The snail *P. globosa* may play a crucial role in the transmission of infectious trematodes such as echinostome and amphistome cercariae, *Cercaria andhraensis, Cercaria pigmentata, Artyfechinostomum sufratyfese, Diplodiscus* spp., *Xiphidocercaria* spp., and others, under certain conditions (Anjaneyulu 1967; Murty 1970). It also acts as an intermediate host for microorganisms such as *Pichia kudriavzevii, Pseudomonas* spp., *Aeromonas* spp., and *Escherichia* spp. (Ajesh, Sreejith 2014; Kathade et al. 2020).

Economic importance

P. globosa is one of the most commercially valued and abundant gastropod. International commerce in apple snails is a significant part of global trade. Due to the significant rise in consumption of snails over the past few years, nations like Italy and France have recently expressed interest in snail farming (Elmislie 1982). The demand for the delicious, high-protein snail meat is rising everywhere. Shellfisheries are a solution to the global food shortage crisis, since they provide low-income individuals with a readily accessible supply of affordable animal protein (Prabhakar, Roy 2009). Due to the presence of shrimp farms in south-east Bangladesh, *P. globosa* trading is a major industry in that region (Kabir et al. 2004). Freshwater shellfisheries are significant cottage industries in Bihar's Mehsi town in the Champaran district (Datta Munshi, Chowdhary 1988). According to CARE International, 5929.95 tonnes shell is used annually for lime production, fish culture and poultry feed and yearly harvest of *P. globosa* from natural habitats is 365 849 metric tonnes in Bangladesh (http: www.careinternational.org.uk).

The leftover shell fragments are used in the preparation of mosaic tiles. The shell of *P. globosa* can be employed as a precursor for nanocrystalline hydroxyapatite, which suggests that its shell can be used to manufacture ceramic products that are both environmentally friendly and economically feasible (Nayak, Misra 2019). Due to its high calcium carbonate concentration, snail shell is used to make slaked lime in the lime industry (Nath et al. 2008; Shathi, Rahman 2022). The shell can be used for bioremediation, pharmaceutical uses, and the fabrication of electrical apparatus (Parveen et al. 2020). Powdered snail shell is an ingredient of fertilizer. In order to prepare chicken feed, shell grit and dust are used (Banerjee, Satish 1988; Datta Munshi, Chaudhary 1988). The collection of different types of snail shells is the delightful hobby of millions of people all over the globe. The shells of snails are bright, colorful, incredibly attractive, and intricately sculpted. These shells are embellished and used for a variety of purposes, including as wall decorations, show pieces, wall pieces, and making spoons, glasses, knives, gouges, spindles, hammers, anvils, cups, trays, key chains, buttons, bangles, bracelets, necklaces, weights for fishing nets, and cameo carving (Iheke, Nwankwo 2016).

It was proposed that the stomach juices of the snail *P. globosa* could be used during the preparation of somatic chromosomes of ferns *Ampelopetris prolifera* and *Adiantum capillus* for cytological research (Niranjan, Roy 1982; Kumud, Minakshi 1994). They serve as good examples of gastropod anatomy in the laboratory. *P. globosa* snails are popular house aquarium pets because of their attractive, mysterious look, size, and beautiful colour (Perera, Walls 1996). The majority of pet stores in the United States of America sell them as pets.

Nutritional importance

P. globosa is regarded as the cheapest source of nutrients for indigenous people and poor rural residents. In areas where there is a food problem, eating these snails is an intriguing choice. In these situations, eating the snails has two advantages: it promotes snail collection and adds protein to the diet of farmers, particularly in developing nations. *Pila* is a crucial source of food for a protein-rich diet in poor nations like Thailand, Mexico, Bangladesh, Nepal, Taiwan, and Sri Lanka because of their nutritional values and their high protein content (Prabhakar, Roy 2009; Chutia, Pegu 2017). The 29 different ethnic tribes in Bangladesh eat *P. globosa* flesh (Saha 1998). In African communities, *Pila* snails are a highly relished delicacy and recognised as "Congo meat" (Fagbuaro et al. 2006; Meyer Rochow 2009). Indians also consume P. globosa (Thomas 1975). The snail *P. globosa* is the most popular gastropod species consumed by primarily tribal, low-income, and middle-class people in Bihar, the Sundarban region of West Bengal, and other regions of India. In a number of marketplaces in Bihar, Jharkhand, Bengal, Arunachal Pradesh, and Mizoram, apple snail *P. globosa* is often sold. Snails are collected from the wild and then taken to markets to be sold. *P. globosa* is known locally as Genri in Bihar, Samuk in West Bengal, and Ghongha in Maithili. Due to the high $CaCO_3$ content, i.e., 3.04 mg of calcium per gram of snail shell powder (Baby et al. 2010), it is regarded as one of the best natural sources of calcium (Wilkins, Lee 2002; Nath et al. 2008).

Aquaculture systems also make use of apple snails. The practice of rearing snails for food is known as heliciculture. Various aquatic animals are known to eat species including *P. globosa, Bellamya bengalensis*, and *Lamellidens marginalis* (Subba Rao, Dey 1989). In south-west Bangladesh, brackish water prawn (*Penaeus monodon*) and freshwater prawn (*Macrobrachium rosenbergii*) farming heavily utilizes the biomass from *P. globosa* as a food source (Baby et al. 2010; Nahid et al. 2013). *Pila* meat is used as an additional

food source for local catfish (*Clarias batrachus*) and exotic fish (*Clarias gariepinus*) culture (Banglapedia 2022). Additionally, it serves as a good alternative food source for domesticated ducks, chickens, pigs, and frogs that are bred for human consumption. In Bangladesh, shrimp farmers have long fed their shrimp using the meat of *P. globosa*.

Snail meat is a superior source of protein next to that found in fish and prawns. Both the foot and hepatopancreas of *P. globosa* have edible value (Panda et al. 2021). Snail meat contains a special sterol and a vital fatty acid (Ning et al. 1994). This means that regardless of the total lipid content, this food can be used for patient nutrition (Saldanha, 2001). Many studies have confirmed that *P. globosa* meat is consumed as food because of its high protein and low fat content (Krishnamoorthy 1968; Mahata 2002; Misra et al. 2002; Prabhakar, Roy 2009).

By determining the amount of protein, carbohydrates, and lipids present in the species' bodily tissue, its nutritional value can be determined (Padidela, Thummala 2015). The flesh of *P. globosa* has a low fat content (0.725%), a high protein level (8.27%), and a carbohydrate content of 2.90% (Baby et al. 2010). The mineral composition content in shell in mg per 100 g is calcium (721.44), iron (60.56), phosphorus (1360.23), sodium (200.67), and potassium (60.55). Oil extracted from *P. globosa* has a higher refractive index (1.21), iodine value (50.28), unsaponifiable matter (1.55%), and saponification value (194.63) (Nargis et al. 2011). The fatty acid composition of oleic, lauric, and palmitic acids in *P. globosa* is 20.37%, 14.30%, and 18.52%, respectively. The protein content in *P. globosa* is high (21.47%) and the fat content is low (1.80%). The flesh of *P. globosa*a is reported to contain 2.37% carbohydrate (Nargis et al. 2012). The snail *P. globosa* contains protein (33.81%), fat (1.80%), a high level of calcium (304.427), phosphorus (133.356), iron (99.147), sodium (43.485), and potassium (31.889) in mg per 100 g. It also contains saturated fatty acids (48 – 60%) and essential fatty acids (21 to 33%), which bear special nutritional importance (Misra et al. 2002). *P. globosa* is a good source of protein (10.67%) and is low in fat content (0.06%) (Dutta Singh 2019). Analysis of the biochemical profile of *P. globosa* in the pre-monsoon, monsoon, and post-monsoon seasons showed a moderate protein level and a low lipid level (Ranjani et al. 2017). The epiphragm of *P. globosa* is rich in protein (17 to 23% dry weight) and low in carbohydrate (0.4 to 2.0% dry weight) (Meenakshi 1964). As a useful alternate source of protein, snails have an essential amino acid index of 0.84 and energy content between 4.745 and 5.594 Kcal per g dry weight (Sing 1991; Bombeo-Tuburan et al. 1995).

Ethno-medicinal importance

The snail *P. globosa* has been used in traditional medicinal practices. The inhabitants of rural areas think that snail food has some special healing properties. They are used as medication to treat a variety of illnesses, including high blood pressure, heart disease, anxiety, dizziness, and nervousness, as well as to regulate high temperatures in the body and to treat circulatory issues. *P. globosa* controls digestive ailments, including constipation, dysentery and diarrhea. In India, males have the habit of chewing beeda for digestive purposes, and snail shell lime is one of the combinations in beetle leaf "beeda paan" (Panda, Misra, 2007).

In Tamilnadu state, *P. globosa* snails are used in the preparation of "Nathai parpam," which is used as medicine in the Siddha form of medical practice to cure bleeding piles, fistula, burning sensation of the anus, enlargement of the spleen, diabetes and tuberculosis (Rengasundari et al. 2017). Water from cleaned and briefly submerged eviscerated snails can be used as an eye drop to treat conjunctivitis. Its use for night blindness, along with raw turmeric and tobacco, has been documented (Bodding 2001). The people of Santhal Pargana district of Jharkhand State use *P. globosa* for various eye diseases (Bodding 2001). It also aids in vision improvement.

Bone diseases like rickets, osteoporosis, and calcium metabolism are treated with snail extract. Rural residents also utilise a soup made from snail flesh to cure rheumatoid arthritis, to reduce joint swelling, and to speed wound healing. The chemical constituent (stigmasta-4,22-dien-3-beta-ol) found in *P. globosa* binds effectively with the human calcitonin receptor ectodomain, which is highly expressed in the osteoclasts of bones and hence very important in the treatment of bone disorders (Pandiarajan et al. 2022). An extract of *P. globosa* inhibits differentiation of osteoclasts by blocking NFκB and NFATC1 signaling pathways, indicating that it can be used in osteolytic bone diseases (Pandiarajan et al. 2019).

The meat of *Pila* is traditionally used in African concoctions because of its medicinal benefits, particularly in cases of labour pain and to avoid blood loss during birth (Cooper, Knowler 1991). Pregnant women have a high intake of snail haemolymph (Adeyeye 1996). It has therapeutic power to treat a variety of skin conditions, including urticaria, sometimes known as hives. Nagaland tribes use snails to cure asthma (Jamir, Lal 2005). Eating snail flesh helps to revive virility and vitality (Oyenuga 1968). The Saharia people of Rajasthan are reported to treat weakness with *Pila* shells in traditional medicine (Mahawar, Jaroli 2007). It is also used to supplement deficiencies in vitamins and minerals because it is a great source of minerals and vitamins (Mahata 2002). They are a rich source of trace and minor components that are required for human growth and development. The Chakhesang tribe of Nagaland state uses snails to treat anaemia due to their high iron content (Kakati, Doulo 2002).

The presence of diverse functional groups such as alkyl, alkyne, aldehyde, amide, ketone, benzene ring, and carboxylic acid and thirteen bioactive components such as

cholesterol, gamma-ergostenol, eicosane, *n*-hexadecanoic acid, 6-octadecenoic acid, and cholecalcif in *P. globosa* has been reported (Pandiarajan et al. 2022). There are few studies regarding the antioxidant activity of *Pila* species (such as Pandiarajan et al. 2022), which described free radical scavenging activity against 2,2-diphenyl-1-picrylhydrazyl and hydrogen peroxide in *P. globosa*; Marimuthu et al. (2017) and Khalil et al. (2019) reported antioxidant activity in *Pila virens* and *Pila maculata*, respectively. *Pila* species have natural immunity against disease-causing microorganisms, such as *Staphylococcus, Streptococcus*, and *Penicillium* species (Hamzat 2003). Bacterial ailments like whooping cough can be treated with the snail (Cobbinah 1993). The flesh of *P. globosa* is also used to treat small pox due to its anti-viral activity. The meat of small snails is cooked in mustard oil and smeared on the sore to cure syphilis on the neck and chest (Bodding 2001). It is an important source to derive bioactive compounds that exhibit antimicrobial, anti-inflammatory, anti-oxidative, anti-cancer, and immune-boosting properties (Benkendorff et al. 2011).

Discussion

The freshwater snail *P. globosa* plays a critical ecological role in maintaining healthy freshwater aquatic ecosystems. It has significant economic importance in the international trade market. It is an easily available source of low-priced animal protein for people of middle and lower incomes. It has been employed in traditional medicinal practices to treat various ailments, and it can be a benefit to mankind.

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