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IMPACT OF OVER CULTIVATION OF MAKHANA, *EURYALE FEROX* SALISB.

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Abstract: *Euryale ferox* Salisb. is commercially very important plant as it possesses spiritual significance, potent medicinal properties and enhances socio-economical condition of the locality. In India, this plant is grown annually at large scale in 9 districts of North Bihar namely Madhubani, Darbhanga, Katihar, Sitamarhi, Purnea, Kishanganj, Araria, Saharsa and Supaul. However, its cultivation was started in 1998 in neighbouring district Maldah specifically in Harishchandrapur - II Block of Tal area by bringing seeds from Darbangha, Bihar on experimental basis with assistance of the State Government of West Bengal. By 2001, it spread from Harishchandrapur - II Block to Harishchandrapur - I Block followed by Chanchal - II Block in Tal area to Gajol Block in Barind area and to Diara area by 2012. The exponential spread of plant and adoption of cultivation practice in Maldah district has altered the actual agricultural practice of the district and creating ecological imbalances in water bodies resulted in loss of aquatic biodiversity and may lead to health hazard of the associated personnel though the popped makhana is on high pricing and demand. Thus, this article deals with different kinds of impacts and mitigation measures for restoration of water bodies, aquatic biodiversity and welfare of associated manpower for their better livelihood.

Keywords: Biodiversity loss, Health hazards, Impacts, Makhana, Mitigation measures.

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INTRODUCTION

Makhana/Pool Makhana, Fox nut/Gorgon nut are common names of *Euryale ferox* Salisb. is commercially very important plant as it possesses spiritual significance, potent medicinal/ economic properties and enhances socio-economical condition of the locality as the same is known as one of the best cash crop grown in aquatic ecosystem. The aquatic ecosystem is more or less related with healthy wetlands.

Wetlands are among one of the most productive and biologically rich ecosystem (Chatrath, 1992; Gopal, 1995) and or may be treated as 'Biological Supermarket' of the extensive food-chain and food-web in tropical countries as compared to

tropical savannahs. They host a vast and varied repository of biodiversity, rich in fish, mammals, birds, amphibians, reptiles and other plant and animals species (Ashok, 2016; Verma and Prakash, 2021). However, the wetlands of Maldah district are under threats based on physio-graphical features, human pressure including uncontrolled malpractice of cultivation of cash crops, aqua-culture, etc. All these anthropogenic activities have not only created serious biodiversity threats but also resulted in such precious repositories and ecosystems in endangered condition (Bhattacharya *et al.*, 2000; Prakash and Verma, 2022).

Euryale ferox Salisb. belongs to the family Nymphaeaceae and order Nymphaeales (Salisbury, 1805). The plant is hydrophytic, grow in enriched soil preferably in still water up to 5 meters deep (Huxley,1992; Bown, 1995). This is only extant species in the genus *Euryale* and is close relative of genus *Victoria*. In wild, it is a perennial plant but for getting better produce, it is being cultivated every year. This plant is native to Eastern Asia (Bangladesh, China, India, Japan, Korea and Myanmar) and Southern Asia. In India, it is cultivated in the wetlands of Bihar, Assam and West Bengal (mainly Tal region of Malda district), Tripura, Manipur and Kashmir. In Bihar it is found in 9 districts namely Madhubani, Darbhanga, Katihar, Sitamarhi, Purnea, Kishanganj, Araria, Saharsa and Supaul (local name Makhana) and Loktak lake, Manipur (local name Thangzing) to Korea and Japan, as well as parts of Eastern Russia. The plant is frequently cultivated for food in China and India (Facciola, 1990). In China, the plant is known for its cultivation since 3,000 years back (Howes, 1948). In India, *Euryale* is normally cultivated in ponds, wetlands, etc. and alone State of Bihar produces and fulfils almost 80 percent of all Makhana requirements in the country. During survey, out of >50 water bodies, it was found growing in 12 water bodies of Maldah district located in Tal and Barind areas (Fig. 1 and Table 1).

Historically, 'Malda' or 'Maldah' name of the district suggests that it is full of 'dahas' meaning 'lakes' or 'water bodies' and is even today there are 562 water bodies comprising 467 natural and 95 man-made (Khatun and Anwaruzzaman, 2012). The main reason to have these water bodies in the district is possibly due to physio-graphically low lying areas in which water of 7 flowing rivers *i.e.* Ganga, Phulhar, Mahananda, Kalindari, Pagla, Tangon and Punrabhava passes through most part of the territorial region trapped and thus developed the water bodies/wetlands and functioning as one of the richest bio-diversity reserves.

Unfortunately these 'gifts of nature' often called as 'lungs and kidneys of nature' are facing threats *viz.* natural threats (possibly due to global warming, depletion of water level, changes in flow pattern of rivers, etc.) and anthropogenic threats (cultivation of cash crops, aqua/pisci-culture, water pollution by various activities including surface runoff enriched with different kinds of contaminants from sewers, domestic and agricultural waste water particularly inorganic manure/pesticides/herbicides/insecticides, etc.).

In this process one of the promising practice of cultivation of *Euryale ferox* (commonly called as 'makhana' in hindi, asamia and bengali, 'jewar' in punjabi, 'juwar' in kashmiri, 'kunta-padma' in oriya and 'fox nut' or 'gorgon' in english) started in the district with assistance of State Government specifically in Harishchandrapur - II Block of Tal area during 1998 by bringing seeds from Darbangha located in neighboring State Bihar which further spread upto Harishchandrapur - I Block from Chanchal - II Block in Tal area to Gajol Block in Barind area (Gupta and Kumar, 2006).

The economic importance and uses of this plant in domestic and medicinal purposes is so high that it is spreading very fast in the district and if its cultivation may continue in same way, then it may threat to loss of aquatic biodiversity due to non-penetration of solar light to the bottom, deplete water level by evaporation due to broad size leaves, deteriorate quality of water, climate change, etc. Thus, this paper deals taxonomic enumeration along with its uses, distribution, physico-chemical characteristics of water bodies, assessment of different threats caused due to cultivation of *Euryale ferox* Salisb. and mitigation measures for their restoration and conservation.

MATERIALS AND METHODS

Maldah is a district, located in between 24°40'20" to 25°32'08" N lat. and 87°45'50" to 88°28'10" E long. and covering 3,733 sq.km land area classified into Tal, Diara and Barind, encompass by Bihar and Uttar Dinajpur at North, Murshidabad at South, Bangladesh at east and Jharkhand and Bihar at West. It shares 165.5 km international border with Bangladesh and is also known as gateway of North Bengal. Out of 7 rivers passing through district have been naturally shifted their courses to several kilometers from its actual, resulted to which they have been curved out numerous ox-bow-lakes and cut-off channels mostly in Tal region by siltation and hence, quite a few remnants of tal (lake) are still visible. Other than tal (jhil or lake) and natural rivers, beels, pond, etc. are also existing in the district and are being used for various purposes like drinking, irrigation, cleaning/washing, bathing and become primary source of livelihood for cultivation of cash crops, aqua/pisci-culture, etc.

In whole Maldah district, >50 water bodies (*i.e.* rivers, jhil, beel, pond, etc.) were inventoried for phytoplanktonic forms and while doing so, 12 water bodies located at different locations in Tal areas namely Damua Pond, Adhsoi Beel, Ashidoab Beel, Hazartakia Beel and Janipukur Beel in Harishchandrapur - I Block, Meethna Beel and Manna Beel in Harishchandrapur - II Block, Bochamari Beel and Singera Beel in Chanchal - II Block and in Barind areas namely Singer Beel, Kuchla Beel and Hatia Beel in Gajol Block were found under cultivation of *Euryale ferox* Salisb. depicted in Fig. 1.

The primary data was collected from published books, reports, media, interacting with local inhabitants, Government officials, etc. and secondary data was generated by personal observation and assessment made for some of the physico-chemical parameters. The atmospheric and water temperature was measured by mercury thermometer graduated up to 110 °C and hydrogen-ion-concentration (pH) was recorded by high quality BDH pH paper strip. The colour and odor was assessed as per APHA (1998). Taxonomically species was described with its uses, water body and block-wise percentage of cultivation was evaluated, impacts of ecological factors and suggested feasible mitigation measures for their restoration.

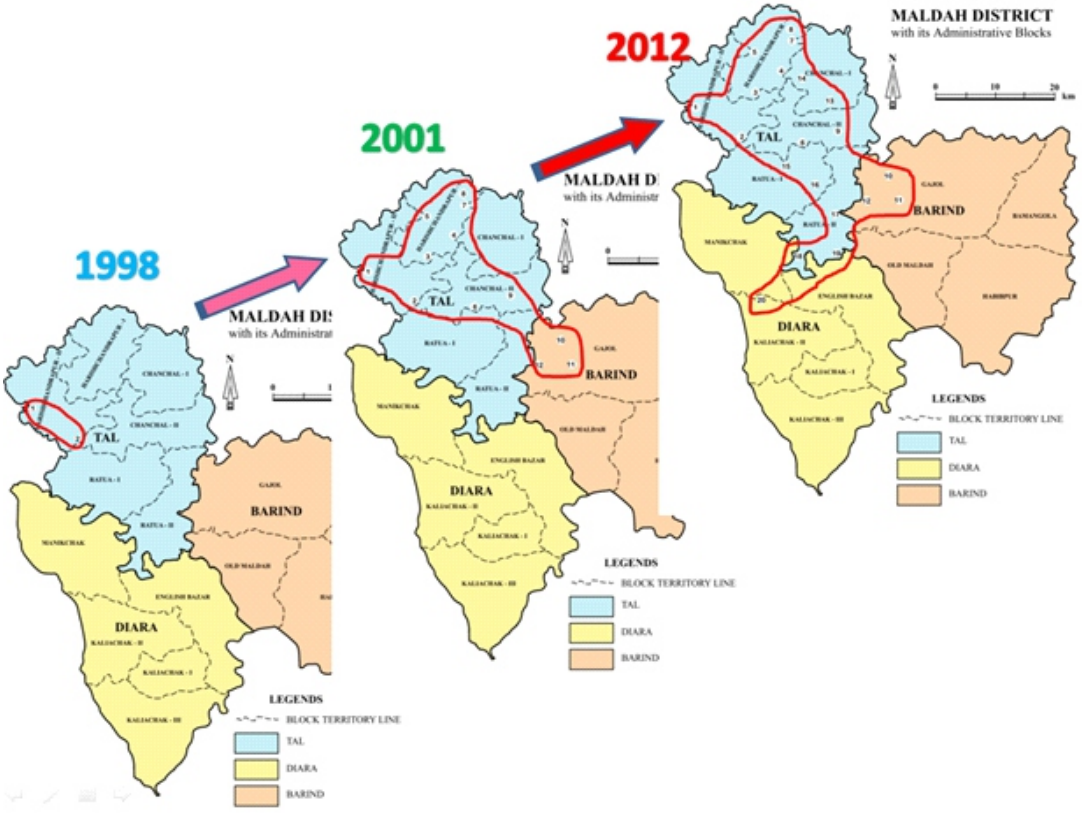

Fig. 1: Cultivation of Makhana in Maldah District, India.

RESULTS AND DISCUSSION

Physico-chemical characteristics of water and percentage cultivation of *Euryale ferox* Salisb. in 12 water bodies are depicted in Table 1. The atmospheric and water temperature ranged from 29 to 36 °C and 28 to 34 °C respectively while pH ranged from 6.0 to 7.5. The colour of the water was found blackish in most of the water bodies possibly due to lack of phototrophic micro flora and rotting of plant parts followed by greenish due to presence of phytoplanktonic algal forms and muddy possibly due to anthropogenic activities. The odor of the water was recorded as foul, rotten, fishy, grassy and odorless in different water bodies depending upon the effect of the spread of large leaves of the plant and decaying of dead cells by the microbial activities including aquatic fungi. Depending upon size of the water bodies and spread of *E. ferox* Salisb., 100% cultivation was recorded in Ashidoab Beel (Uttar Harshchandrapur) followed by 90% in Janipukur Beel (Serpur) and Singer Beel (Korchadanga) and 80% in Damua pond (Konar) depicted in Photo 1 and Beels of Hazartakia (Pirajpur), Manna (Bhaluka) and Kuchla (Eklakhi).

Table 1. Physico-chemical characteristics and percentage occurrence of *Euryale ferox* Salisb. (Makhana) in different water bodies of Maldah District

S. No.	Name of Water Bodies	Village	Block	Physico-chemical Characteristics					Covered area by Makhana in Water Bodies (in %)	Area-wise Cultivation (in %)
				Temperature (in °C)		pH	Colour	Odor		
				Atmos.	Water					
1.	Damua Pond	Konar	Harishchandrapur - I	29	28	6.5	B	FO	80	
2.	Adhsoi Beel	Pachla, Pirajpur	Harishchandrapur - I	36	34	6.0	B	FO	70	
3.	Ashidoab Beel	Uttar Harishchandrapur	Harishchandrapur - I	30	29	6.8	B	R	100	84
4.	Hazartakia Beel	Pirajpur	Harishchandrapur - I	34	32	7.0	B	R	80	
5.	Janipukur Beel	Serpur	Harishchandrapur - I	35	34	6.0	B	F	90	
6.	Meethna Beel	Talsur	Harishchandrapur - II	33	32	7.0	G	FO	70	75
7.	Manna Beel	Bhaluka	Harishchandrapur - II	33	32	7.5	B	FO	80	
8.	Bochamari Beel	Bowaliya	Chanchal - II	33	32	7.0	G	F	60	45
9.	Singera Beel	Ganga Devi	Chanchal - II	30	28	6.5	M	GR	30	
10.	Singer Beel	Korchdanga	Gajol	34	33	6.5	B	R	90	70
11.	Kuchla Beel	Eklakhi	Gajol	31	29	7.0	B	FO	80	
12.	Hatia Beel	Hatia	Gajol	34	32	7.0	M	OL	40	

Atmos. = Atmospheric, B = Blackish, G = Greenish, M = Muddy, FO = Foul, R = Rotten, F = Fishy, GR = Grassy, OL = Odorless

The plant is very huge (4 to 5 feet across) like other water lily, grows from a short rhizome in water and may extend up to 5 meter depth, produces a rosette of leaves covered with spine on either side and float on surface of water. Stem stout, root rhizomatous, petiole and peduncle are long, leaves having quilted texture, large (30-120 cm in diameter varies due to water level and concentration of nutrients and other factors) and round at times slightly elliptical, deeply veined, flat leaves with a leaf stalk attached at the centre of the lower surface. Dorsal side of leaves is green and ventral side is purplish with dichotomously branched ribs, corrugated prickly spines found all over the plant (Photo 2). New leaves are highly polymorphic, different in appearance from mature leaves due to varying ornamentation (Photo 3). The stems, leaves and flowers are covered with sharp prickles and remain floating on water surface (Photo 16). Older leaves remain partly submerged. Flower is of two types:

1). **Cleistogamous:** Flower does not bloom completely nor comes out much above the water surface (Photo 4, 5, 17). The flower is prickly, length ranged from 5.0 to 7.0 cm and circumference 5.0 to 6.0 cm in dia. Fertilization takes place by self pollination.

2). **Chasmogamous***:* Cup-shaped flower comes out from water partly or completely (Photo 6), bloom fully during early morning, ranged from 5.0 to 7.0 cm in length and 3.5 to 5.0 cm in dia. Flowers are purple to deep violet with an outer row of white petals. Sepal four, triangular ovate, 1.0 to 1.3 cm, green and shining outside and bears strong spines. Petals more than dozen, shining violet, blue or

Photo 1. *Euryale ferox* Salisb. commonly known as 'makhana' in natural habitat in Damua Pond, Konar, Harishchandrapur - I along with other aqautic macrophytes and siltation, 2. Dorsal and ventral view of leaves, 3. Young and mature leaves with Cleistogamous flower, 4. Bloomed Cleistogamous flower, 5. L.S. of Cleistogamous flower, 6. Bloomed Chasmogamous flower, 7. Ripen fruit with young seeds, 8. Young seed covered with spongy mucilaginous aril, 9. Imature seed withous aril, 10. Mature seed and 11. Popped makhana.

Photo 12. Harvesting of mature fruits and floating seeds while croping, 13. Elimination of plants from water body on maturity, 14. Collection of seeds from bottom, 15. Sowing seedlings, 16. Developing plants, 17. Formation of flower and fruit, 18. Nearly mature fruit, 19. L.S. of fruit for showing arrangements of developing seeds, 20. Seeds with spongy mucilaginous aril, 21. Drying of collected seeds, 22. Grading of seeds, 23. Pre-popping roasting, 24. Final popping, 25. Crusing by hand to separate rind from popped makhana, 26. Sieving for eliminating rind and unwanted items, 27. Eliminating rind/unwanted item on conveyer belt in industry, 28. Packing in gunny bag for transportation for different purposes.

fading white (Photo 6), oblong-lanceolate, 1.0 cm. Androecium and gynoecium after the whorl of petals are indefinite, ovary inferior and multi-locular (7 to 16 loculed) in which seeds developed (Photo 19). After cross pollination in 2 to 3 days, flower sinks under water and fruit formation take place. Fruit is covered with dense strong spines (Photo 7, 18), 5.0 to 7.0 cm in dia. (equivalent to a small orange) and when ripe become soft and pulpy (Hedrick, 1972).

A mature plant bears on an average 15 to 20 fruits and each fruit bears approximately 30 to 50 seeds (Gupta and Kumar, 2006) while Facciola (1990) and Uphof (1959) reported 8 to 15 seeds. Seeds are of pea size (0.7 to 1.3 cm in dia.) with hard seed coat, yellowish-brownish green in young, covered with mucilaginous spongy golden arils (Photo 7, 8, 20) which help them to float on surface of water for 2 to 3 days after dehiscence and rest on bottom of water bodies after rotting as well as release of air from aril and become deep dark brown-black after maturation (Photo 9, 10, 21). Mature seeds are sub-orbital with smooth undulated surface all around. About 450 to 1,000 seeds are produced by a single healthy plant and tender seeds are edible raw. The mature fruits and floating seeds are collected even during cultivation (Photo 12) and after elimination of fully mature plant (Photo 13) skilled divers/labourer collects mature seeds from bottom (Photo 14) and then cleaned, dried in open sky (Photo 21), graded, fried, popped (Photo 22, 23, 24 respectively) and processed to get white shining popped makhana (Photo 11, 25). Further, to eliminate unwanted items including rind (if any) from the popped makhana manually sieved and/or segregated on conveyer belts in industry (Photo 26, 27), packed in gunny bags (Photo 28) for transportation and are being used for various purposes including ethno-botanical uses (Duke and Ayensu,1985).

Makhana is used as main source of starch similarly as arrowroot (Howes, 1948; Facciola, 1990) and is pious, light and nutritious food developed mainly under water, enriched with potent properties. Since ancient time for treatment of aliments in ayurvedic as well as traditional Chinese system of treatment (GOI, 1990) makhana is used in preparation of medicines. It not only controls the premature and involuntary ejaculation but also increases the sperm counts and improves impotency (Bown, 1995, WHO, 1998).

Ecological Stresses

It is true that cultivation of makhana is spreading in the district very fast but the question remains why one should worry so much. This crop cultivation takes place under such an ecological condition which is naturally very rich in bio-diversity (Mishra, 1998). Water bodies of Maldah district are in general used for pisciculture, irrigation, drinking, washing, etc. The livelihood of the district mainly depend up on pisciculture and agricultural practice of variety of paddy which have been further strengthened with the financial assistance of the State Government to grow more and more *Euryale ferox* Salisb. However, during the study, it has also been experienced that the water bodies in which makhana has been cultivated shown sign of adverse effect on the ecology of natural aquatic ecosystem. This may be possibly due to:

i. Each part of the plant is armed with spines which make survival of other aquatic lives difficult.

ii. Dense and large canopy coverage of prickly leaves and parts of the plants does not allow to pass solar light to greater extent or to different water zones and or layer may further adversely affect the occurrence of primary producers like nektons, phytoplankton, etc. on which the primary, secondary and tertiary consumers depends. Besides, it may cause competition for nutrients and space for same or different other species of flora and fauna.

iii. Depth of water in no case should be below 0.6 m during May-June and above 1.5 m during October-November so that it may act as an interface between terrestrial and aquatic ecosystems with plenty of aquatic plants to supply plenty of humus to keep the land fertile for future cultivation/ cropping.

iv. The large size of leaves and its spread/canopy cover to a wider space may also cause high rate of evapo-transpiration resulting to decrease in

water level and to get the desired production of makhana, the cultivators replenish water bodies to normal water level from other extraneous sources.

v. To get better produce farmers are using excessive amount of insecticides/ pesticides of endosulfan group and enrich water by using urea and mixture of NPK 30:20:10 as well as vitamins (Ankavite-L, Miracle and Heera 303) which kills caterpillar, fishes, molluscs, birds, reptiles and aquatic lives (Mishra, 1998).

vi. Filth and dumps/heaps of the harvested plants year after year within or along the water bodies may cause decomposition of the same and contribute to lower level of dissolved oxygen in shallow water as well as resulted to siltation and minimize the area may adversely affect on the density and diversity of aquatic ecosystem.

Besides, other anthropogenic interferences are also one of the causes of threatening to such water bodies are as follows:

i. Cultivation of makhana in other water bodies are mushrooming very fast.

ii. Wetlands are being used for agricultural purposes after reclamation.

iii. Draining out of water and encroachment for construction of railway, roads, bus stand, human settlement, industries and other developmental infrastructures.

iv. Encroachment in water bodies by real estate promoters/developers and slum dwellers.

v. Dumping of solid wastes and garbage from municipality as well as industries.

vi. Pollution from untreated domestic sewage, industrial effluent and surface runoff from agricultural fields especially insecticides, pesticides, herbicides, fungicides, rodenticides, inorganic manure, etc.

Consequently, the aquatic food-chain may disrupt enormously and affect the food-web resulting loss of biodiversity. Hence, to sustain all living organisms along with dependant population and to retain good quality of water, conservation of water bodies after restoration is essential to maintain the equilibrium in aquatic ecosystem of the district.

Restoration of water bodies

The natural water bodies in which the *Euryale ferox* Salisb., makhana is being grown for years may be restored by the following suggestions are as follows :

i. Cultivation practice should be carried out either on rotation basis or restricted to the limited time period as per issued permits.

ii. Technology should be developed for seeding at a regular distance for sparse occurrence and de-planting mechanically.

iii. Technology should also be developed to minimize siltation in water bodies by utilizing harvested/de-planted plants for manufacturing of bio-gas, bio-fertilizers and other purposes instead of dumping within and around the water bodies.

iv. De-siltation programme should be launched by the farmers at regular intervals.

v. Aqua/pisci-culture should be encouraged in order to healthy survival of wetlands.

vi. Cultivators should be aware properly to opt aqua/pisci-culture practice for their livelihood a better option than cultivation of makhana.

vii. Stringent law should be enforced for banning all types of alteration of wetland, dumping of solid and liquid wastes.

viii. Draining out of water from them should be prohibited and regular monitoring systems should be developed.

ix. Local people including students of educational institutions should be encouraged to preserve this wealth in its original form.

x. People from the riparian villages should/may be sensitized regarding

beneficial role of wetland and harmful effect if converted into another use, etc.

xi. An appropriate forum for resolving the conflict on wetland issues has to be set up.

xii. Relevant ministries and administrations should to allocate sufficient funds towards the conservation of these ecosystems.

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REFERENCES

1. **APHA** (1998). Standard Methods for the Analysis of Water and Wastewater. American Public Health Association, Washington, D.C.
2. **Ashok K.V.** (2016). The Sarus Crane Pair: Made for Each Other. *International Journal on Biological Sciences*. 7(2): 87-89.
3. **Bhattacharya S., Mukherjee K. and Garg J.K.** (2000). Wetlands of West Bengal, IWMED, Kolkata.
4. **Bown D.** (1995). Encyclopaedia of Herbs and their Uses. Dorling Kindersley, London.
5. **Chatrath K.J.S.** (1992). Wetlands of India, Ashish Publishing House, New Delhi.
6. **Duke J.A. and Ayensu E.S.** (1985). Medicinal Plants of China. Reference Publications Inc.
7. **Facciola S.** (1990). Cornucopia - A Source Book of Edible Plants. Kampong Publications.
8. **GOI** (1990). Wetlands of India - A Directory. Ministry of Environment and Forest, Govt. of India New Delhi.
9. **Gopal B.** (1995). Hand Book of Wetland Management, Prepared and Produced by WWF, New Delhi.
10. **Gupta P. and Kumar S.** (2006). Maldah jila ke jalaashyo mein makhana ka parishthiki addhayan eum upyogita. *Vanaspati Vaani*,. 15:24-26.
11. **Hedrick U.P.** (1972). Sturtevant's Edible Plants of the World Dover Publications.
12. **Howes F.N.** (1948). Nuts-Their Production and Everyday Uses. 1st Edition, Faber & Faber, London.
13. **Huxley A.** (1992). The New RHS Dictionary of Gardening. Mac Millan Press.
14. **Khatun J. and Anwaruzzaman A.K.M.** (2012). Gorgon Cultivation - A Serious Threat to Wetland Bio-diversity. *Golden Research Thoughts*. 2(3) :1-9.
15. **Mishra R.L.** (1998). Gorgon Plant: An Aquatic Ornamental. *Journal of Horticulture*. Jan.-Mar. : 20-21.
16. **Prakash S. and Verma A.K.** (2022). Anthropogenic activities and Biodiversity threats. *International Journal of Biological Innovations*. 4(1): 94-103. https:// doi.org/ 10.46505/IJBI.2022.4110.
17. **Salisbury R.A.** (1805). Description of the Natural order of Nymphaeceae. *Annals of Botany*. II:73-74.
18. **Uphof J.C.T.** (1959). Dictionary of Economic Plants. Weinheim.
19. **Verma A.K. and Prakash S.** (2021). Nesting Behaviour and Current threats to the Indian Sarus Crane around Alwara Lake of District Kaushambi (U.P.), India. *International Journal of Biological Innovations*. 3(1): 127-133. https://doi.org/10.46505/IJBI.2021.3111.
20. **WHO** (1998). Medicinal Plants in the Republic of Korea. World Health Organization, Manila.