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Ecological and nutritional significance of grass carp (*Ctenopharyngodon idella*): Implications for aquaculture and environmental management

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Abstract
The global aquaculture sector grows Grass carp (*Ctenopharyngodon idella*) as a freshwater species which grows rapidly, plant-based diet and used for different needs (protein source, weed control and sport fish) and economical contribution. Countries like Afghanistan, Myanmar and Vietnam mass culture grass crap for human food consumption and other countries like India, Bangladesh and Iran use as a weed control agent. Natural habitat deterioration has become an environmental concern because grass carp reproduce quickly without any regulatory mechanisms. Grass carp serve as one of the main food sources due to their high omega-3 fatty acids such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Humans can safely consume herbivorous fish like grass carp along with other tropic level species because these fishes have less negative effects on the environment during both their raising and consumption. The production of eco-friendly aquaculture feed by using organic waste and food waste leftover can advance sustainable aquaculture practices as well as decrease negative environmental impacts that occur in areas with invasive species. The present review article contemporary findings about grass carp nutritional aspects, ecological effects and its role in sustainable aquaculture systems and information about appropriate management strategies.

Keywords: *Ctenopharyngodon Idella*, grass carp, aquaculture, nutritional value, invasive species and aquatic vegetation control

Introduction

Primary importance for the global aquaculture sector relies on carp because these fishes ensure food security while freshwater fishes remain essential for marketplace demand. All four carp including *Ctenopharyngodon idella*, Catla catla, *Labeo rohita* (rohu) and *Cirrhinus mrigala* (mrigal) are widely grown because their swift growth and tolerant environmental conditions produce nutritious food. Fish populations serve as basic animal-protein food supplies to provide countries with necessary nutrition while creating local jobs and generating rural income. Sustainable aquaculture practices can be achieved through farming carps because they use economical feed sources that work well with other agricultural systems according to FAO (2020) [34].

The Grass carp (*Ctenopharyngodon idella*) serves various purposes as a valuable fish species because it originates from Pacific Far East waters as an herbivorous freshwater fish that offers significant ecological value as well as economic benefits and contributions to aquacultural practices (Shireman, 1983) [25]. As the solitary species of *Ctenopharyngodon* and a member of the Cyprinidae family with minnows and carps (Wildhaber *et al.*, 2023) [30] it distinguishes itself from all other *Ctenopharyngodon* genera. This fish species was used by Chinese aquaculture practices and the "Four Domestic Fish" for centuries in China until it became utilized globally for aquaculture goals and biological vegetation control (Cudmore *et al.*, 2004) [4]. The torpedo-shaped body of this fish meets its divergence to plant consumption while its broad head and barbless mouth promote its locomotive capabilities (Jones *et al.*, 2017) [13]. The capability of *Hydrilla verticillata* invasion management combined with its fast growth pattern was the key factor behind its United States introduction in 1963 (Weeks *et al.*, 2014) [29].

The China aquatic farming sector produced 5.76 million tons of *C. idella* in 2021 according to Xing *et al.* 2023 [32] which demonstrates their important position in global aquaculture of Cerastes species have initiated significant ecological disturbance across North America and Europe because they invaded both continents and displaced native ecosystem animals and reshaped environmental conditions (Cudmore *et al.*, 2017) [13].

A complete life cycle of *C. idella* contains four development phases including egg and larva and juvenile and adult phases that need ideal environmental factors for natural reproduction while aquaculture heavily depends on artificial hormone-stimulated reproduction according to Pullin and Kuo (2012) [19]. currently require a well-balanced diet containing proteins along with carbohydrates besides vitamins and minerals since dietary shortages have led to various health problems including weakened immunity metabolic issues and inferior flesh quality (Pyz and Kowalczyk, 2017; Yao *et al.*, 2024; Zhang *et al.*, 2022) [20, 39 33]. Strict biosecurity protocols and disease management strategies need to be established for grass carp aquaculture and vegetation control due to major obstacles created by GCRV and *Bothriocephalus acheilognathi* infections as well as bacterial and viral infections (Zhu *et al.*, 2023; Boonthai *et al.*, 2017) [33, 3]. The economic benefits of grass carp for large-scale aquaculture and weed control establish their fundamental role in global fisheries according to FAO (2009) [8]. Grass carp benefits demand operational strategies for their fullest application and ecological risk control to achieve sustainable fiscal development and environmental protection.

Description and Morphology

Grass carp is an elongated torpedo-shaped body, laterally compressed to facilitate movement through aquatic vegetation, making grass carp different from other human sources of content. The body has large dark-edged cycloid scales, usually 40 or 42 in number along the lateral line making it cross-hatched in appearance. The wild grass carp grows up to 60 cm in length and 100 cm and even exceeds these lengths of up to 150 cm and weighs more than 45 kg (Froese, 2010) [9]. The head is rounded, blunt, and scale less, with a narrow, short snout and a terminal mouth with no teeth or barbels. The mouth is oblique and has a firm, non-fleshy lips. The pharyngeal teeth are arranged in two rows with the following formulas 2,4-4,2 or 2,5-4,2 and have strongly ridged grinding surfaces, adapted for their herbivorous diet (Jones *et al.*, 2017) [13].

There is a short dorsal fin with 7 to 8 soft rays, the onset of which is slightly anterior to pelvic fins. There are 8 to 10 soft rays in the anal fin, closer to the tail as in many other cyprinids. The dorsal and anal fins do not have spines. Grass carp caudal fin is forked and helps in their swift motion (Froese, 2010) [9]. From its dorsal aspect grass carp display dark olive to brassy green coloration which progresses to silvery white or yellow tones in their sides and abdomen.

A change takes place where the initial pale color of their bodies transforms to darker hues beginning at their head. The study by Ding *et al.* (2017) [40] describes the fins of the species can be either clear or green-gray or present as dull silver. The breeding behavior of males produces tiny temporary tubercles that develop on their pectoral fins near the dorsal area and median margin at the start of that breeding season even though females only show slight roughness in the pectoral region. The development stages of grass carp start with the reproduction of eggs followed by a transition through larval stages and juvenile development ultimately resulting in adult maturity. Larvae start their existence in flowing river streams and then swim toward the river current. The natural habitat of grass carp needs particular hydrological factors for reproductive success because rising water levels and powerful current patterns are essential (Nikolsky, 1963; Cui *et al.*, 1992) [17, 6].

Life Cycle of Grass Carp

Egg reproduction is the initial life stage of grass carp which transforms into larval and juvenile development phases route to adult maturity. After hatching the new larvae start their lives in flowing river waters while drifting downstream. A successful reproduction as grass carp does best when water elevations rise in addition to strong water current patterns (Nikolsky, 1963; Cui *et al.*, 1992) [17, 6]. The eggs stay close to the surface until they hatch within a duration that is determined by water temperature (Shireman 1983) [25].

The newly hatched larvae reach a size of 5 to 6 millimeters in length. Grass carp acquire their first nutrition during the first days of life from their yolk sac. The fishes start feeding plankton only after their yolk sac becomes fully absorbed. The average duration of the larval phase lasts from 10 to 15 days as the creatures experience swift development of necessary components for upcoming feeding techniques and locomotor abilities. The fish develop their eating habits to focus on aquatic vegetation after finishing their larval phase and entering their juvenile stage. The fast growth of juvenile yellow croaker results in them attaining 20 to 25 centimeters of total length over their first year. The period from sexual maturity extends between 2 to 4 years of age where water temperature along with food availability acts as key environmental influences (Fu *et al.*, 2016) [10]. Aquaculture producers use artificial breeding approaches that combine luteinizing hormone-releasing hormone analogs or carp pituitary extract for hormone induction to maintain a continuous supply of fingerlings for commercial purposes (Pullin and Kuo 2012) [19]. The effective techniques find widespread use to defeat the natural spawning constraints in captivity. The optimal farming environment allows grass carp to grow into market size between 1-3 kilograms within one to two years according to FAO (2009) [8].

Nutritional Parameters

C. idella, a freshwater fish, fulfills human dietary requirements, as it provides large economic nutritional benefits particularly to those who do not have protein in their food. An edible portion of 100 grams contains 127 kcal of energy and 18.6 g protein with excellent quality; that is a nutritious form of lean animal protein. Although containing essential omega 3 fatty acids (0.2-0.5 g) for cardiovascular and neurological health, a low saturated fat is maintained. It provides 289 mg potassium, 210 mg phosphorus (including 29 mg calcium and 27 mg magnesium), less 0.7 mg iron, 0.8 mg zinc, 0.1 mg sodium, and 12.5 µg selenium. Grass carp provide some vitamin B12 (2.4 µg) and niacin (3.5 mg) which are important for metabolic processes and neurological activities. As a USDA Food Data Central food grain, the nutrients in each serving of grass carp enhance both the nation's food security program as well as human health outcomes.

A detailed nutritional profile assessment of *C. idella* exists in Ashraf *et al.* (2011) [36] which examines both wild types and farmed specimens. Research showed that the protein percentage in farmed grass carp reached 20.00±0.15% while the wild species only reached 19.46±0.24%. The lipid amounts in wild grass carp measured at 2.71±0.08% showed a marginally higher value than the lipid content in farmed grass carp which stood at 2.52±0.01%. Wild grass carp contained a slightly more moisture content (74.79±0.14%) than the farmed variety (74.30±0.07%). Scientific analysis of amino acids confirmed that farmed grass carp contained significantly elevated quantities of essential amino acids including phenylalanine, valine, arginine, lysine and tyrosine. The nutritional value of farmed grass carp exceeds that of wild grass carp because they provide crucial proteins along with vital nutrients in aquaculture operations (Tan, 1971) [35].

According to Cheng *et al.*, (2016) [37], specific nutritional measurements of farmed grass carp examined under two farming systems (grass-fed and feed-fed) showed varying muscle characteristics as well as nutritional attributes. The crude fat in ecological grass carp organically decreased although its moisture and ash composition and crude protein remained equivalent to feed-fed grass carp. Mineral concentrations in ecological grass carp reached noteworthy levels since phosphorus, and iron were significantly higher, and magnesium, manganese, and chromium presented very significant elevations. The detection of 17 amino acids showed essential amino acid contents were slightly higher while the Essential Amino Acid Index (EAAI) was slightly lower in ecological grass carp (6.85%) than in feed grass carp (6.27%). High concentrations of palmitic acid as well as arachidonic acid and linoleic acid emerged in 19 fatty acid types along with oleic acid, docosahexaenoic acid, and stearic acid between the two groups. The results showed that the total eicosapentaenoic acid + docosahexaenoic acid values reached 10.70% in feed-fed grass carp and 8.95% in ecological grass carp which demonstrated a material distinction. The nutritional value of ecological grass carp muscle rises from its better water-holding capacity lower fat levels and its more complete mineral content.

However, an analysis of *C. idella* by Golgolipour *et al.*, (2019) [38] after different cooking techniques including raw, poached, steamed, microwaved, pan-fried, and deep-fried methods showed substantial modifications in its nutritional component makeup. When food cooks the fish, fillets acquired increased amounts of protein, lipid and ash compared to their uncooked state. Total 3 fatty acids were minimally affected by different cooking methods until frying began when deep-frying reduced the content and pan-frying increased it. The fat content of n-6 fatty acids became higher in all samples after cooking than it was in uncooked fish. The sodium, potassium, magnesium, phosphorus and zinc content in mineral components reduced considerably after boiling the fillets. Readiness of fish through cooking procedures failed to impact vitamin D concentration but resulted in substantial reductions of vitamins A, B1 and B3 content. Both cooking enhancements of nutrients coincide with essential micronutrient losses typically indicated through vitamin and mineral reduction after cooking which becomes most pronounced through frying methods.

Economic Importance

C.idella has proven its economic importance in global aquaculture and aquatic weed management and is widely recognized as an economically important weed in Asian aquaculture. Being herbivorous and easily adapting to change, the species grew very fast to become a preferred species for large-scale farming, greatly contributing to food security and the local economy. In addition to being one of the most farmed freshwater fish species in the world, this fish also provides a relatively affordable and good quality protein source. Aquaculture production in China is a massive 5.76 million tons in 2021 with China remaining pivotal in aquaculture (Xing *et al.*, 2023) [32]. Its usefulness has been extended to biological control of aquatics weeds, an area where it provides an economical equation to mechanical or chemical control. At three to ten fish per acre, sterile grass carp (triploid, sterile fish) have been used to lower weed management costs to as low as $15 per acre ($100-$500 per acre herbicide or mechanical control) (Allen and Wattendorf, 1987) [1].

Grass carp have been a major part of the aquaculture sector in India, supporting millions of people for livelihood. Marketable sizes of 1-1.5 kg is reached within 8-10 months for cultured carps in weed-infested ponds surrounded with other carps and converted aquatic vegetation into high-quality protein (Laxmappa 2016) [15]. Even though it is not known exactly how much it was consumed, its presence in polyculture systems with Indian major carps implies growing consumer acceptance of fish in freshwater fish-consuming regions (Pipalova, 2006) [18]. Therefore, the development of value-added products fish patties and fish fingers has raised market value and consumer appeal by addressing the issues of intramuscular bones (Sehgal and Sehgal, 2002) [24].

The Indian carp market in 2021 is economically worth USD 14,824.9 million with an increase to USD 22,207.1 million by the year 2028. In 2021, the revenue of the grass carp segment accounted for 20.33% (Size, 2022) [27]. Limited specific consumption statistics, however, point to a major consumer base considering the contribution of this item in aquaculture. However the challenge by intramuscular bones has affected its marketability and consequently development of boneless or value-added products to attract customers (Sehgal and Sehgal, 2002) [24]

India is in a few regions where grass carp culture has been demonstrated to be taking place. Its efficiency in exploiting Potomogeton pectinatus was evidenced by the growth rate of 1.61-3.6 g/day in 62 days in Chilka Lake, Odisha (Routray and Routray, 1998) [22]. At Meghalaya, using *Azolla caroliniana* as feed, there was growth performance under organic conditions and the net profit was $0.12 per square meter (Majhi *et al.*, 2006) [16]. Composite fish culture trials in weed control and rapid growth were confirmed at the Central Inland Fisheries Research Institute in Kalyani, West Bengal (Sinha and Gupta, 1975) [26]. Studies conducted in Uttarakhand’s mid altitudinal regions (950-2000 m) showed that in polyculture with common carp; total production was increased by 37 percent with reduced feeding costs by having fresh Azolla incorporated (Bipin *et al.*, 2019) [41]. The Asian-Pacific Aquaculture 2019 conference was held at the Chennai Trade Center in Chennai from June 19-21, 2019, in which grass carp culture was highlighted. Bipin *et al.* (2019) [41] present research documentation that establishes mid-altitudinal polyculture systems operating within grass carp’s optimal environmental zone.

Environmental Impact

Human-driven population spreads of *C.idella* into regions beyond its natural habitat produce critical environmental changes that arise from its dietary habits and modified ecological zones. Unlike most aquatic organisms, grass carp eliminate their food source of aquatic plants through their massive dietary consumption rate. This capability results in the total disappearance of vegetation. The disappearance of plants negatively affects native fish and invertebrate species due to habitat degradation as well as loss of shelter spaces and breeding areas together with habitat simplification. Habitat quality suffers additional deterioration because vegetation clearing leads to greater water turbidity and the suspension of sediment (Greenfield 1973) [11]. Practicing aquatic plant consumption leads to the release of plant-produced excrement-containing nutrients which starts algal blooms and oxygen depletion and disrupts ecosystem balances within aquatic habitats thus affecting both plants and local animals (Robinson *et al.*, 2021) [21]. The competition between grass carp for resources reduces native fish populations most specifically those species that need weed-filled zones for eating, mating, or taking shelter. The modifications in species structure cause a cascade of ecological effects across different parts of the ecosystem (Wittmann *et al.*, 2014) [31]. The introduction of grass carp into North American and European territories has led to confirmed invasive species status which causes severe environmental disruption. Experts have confirmed that Great Lakes wetlands reproduce grass carp populations which leads to the destruction of native aquatic species (Cudmore *et al.*, 2017) [13]. Methods for controlling aquatic vegetation through grass carp need careful management of non-native species release because such actions create threats to biodiversity as well as ecosystem stability. Optimal vegetation control measures should be established through successful management techniques that prevent environmental harm (Greenfield 1973) [11].

The success of global freshwater aquaculture relies on grass carp because this fish has notable fast growth and herbivorous feeding habits alongside nutritious content. The grass carp displays environmental adaptability together with dual farming applications which foster agricultural food security and allow farmers to keep their rural operations. Grass carp functions both as an eco-maintaining control method and as a nutritious sustainable food source because of its vegetative structure and its mouthful of amino acids and vital micronutrients. The need for proper procedures stems from the environmental problems caused by this species when it establishes itself in unfamiliar ecosystems.

Conclusion

The worldwide aquaculture industry depends on grass carp as its essential species because it serves as both a nutritional food source and a rapidly growing aquaculture species that further controls the aquatic vegetation. The species advances dietary safety in developing nations by supplying citizens with top-quality protein meals. The deliberate introduction of grass carp into foreign environments creates significant ecological problems because it destroys habitats eliminates biodiversity and causes destructive effects on ecosystems. The control of underwater greens through carp seems promising but management systems must be established to stop their unwanted proliferation. The future sustainability of aquaculture requires resolving the conflict between the economic utilization of grass carp benefits and their ecological management practices.

Reference

1. Allen Jr SK, Wattendorf RJ. Triploid grass carp: Status and management implications. Fisheries. 1987;12(4):20-24.
2. Vishwakarma BK, Mohan D, Kala P, Pandey NN. Production potential of grass carp *Ctenopharyngodon idella* under different systems in mid hills of Uttarakhand. Asian-Pacific Aquaculture, 2019. Available from: https://www.was.org/Meeting/Program/PaperDetail/153579
3. Boonthai T, Herbst SJ, Whelan GE, Deuren VMG, Loch TP, Faisal M. The Asian fish tapeworm *Schyzocotyle acheilognathi* is widespread in baitfish retail stores in Michigan, USA. Parasites Vectors. 2017;10:1-10.
4. Cudmore BMNE, Mandrak NE. Biological synopsis of grass carp (*Ctenopharyngodon idella*). Can Manuscr Rep Fish Aquat Sci. 2004;2705(7):1-44.
5. Cudmore B, Jones LA, Mandrak NE, Dettmers JM, Chapman DC, Kolar CS, *et al*. Ecological risk assessment of grass carp *Ctenopharyngodon idella*. 2017.
6. Cui Y, Liu X, Wang S, Chen S. Growth and energy budget in young grass carp, *Ctenopharyngodon idella* Val., fed plant and animal diets. J Fish Biol. 1992;41(2):231-238.
7. Ding L. Grass carp, *Ctenopharyngodon idella*. In: Handbook of Nutrient Requirements of Finfish. CRC Press, 1991, p. 89-96.
8. FAO. *Ctenopharyngodon idellus*. In: Cultured Aquatic Species Fact Sheets. Rome: FAO, 2009.
9. Froese R. FishBase [Internet]. 2010. Available from: www.fishbase.org
10. Fu J, Shen Y, Xu X, Li J. Genetic parameter estimates for growth of grass carp, *Ctenopharyngodon idella*, at 10 and 18 months of age. Aquaculture. 2016;450:342-348.
11. Greenfield DW. An evaluation of the advisability of the release of the grass carp, *Ctenopharyngodon idella*, into the natural waters of the United States. Trans Ill State Acad Sci. 1973;66(1-2):47-53.
12. Han Q, Fan H, Peng J, Zhou L, Gan L. Ascorbic acid enhanced growth performance, oxidative status, and resistance to *Aeromonas hydrophila* in juvenile grass carp (*Ctenopharyngodon idella*). Aquac Int. 2020;28:15-30.
13. Jones LA, Mandrak NE, Cudmore BC. Updated (2003-2015) biological synopsis of grass carp (*Ctenopharyngodon idella*). Can Sci Advis Sec. 2017.
14. Kroboth PT, Chapman DC, Hrabik RA, Neely DA. Characteristics for the external identification of black carp from grass carp. J Fish Wildl Manag. 2019;10(2):304-313.
15. Laxmappa B. Weighing the risks of farming non-native fish species in India. Glob Aquac Advocate. 2016.
16. Majhi SK, Das A, Mandal BK. Growth performance and production of organically cultured grass carp *Ctenopharyngodon idella* (Val.) under mid-hill conditions of Meghalaya, NE India. Turk J Fish Aquat Sci. 2006;6(2):77-82.
17. Nikolsky GV. The Ecology of Fishes. London: Academic Press, 1963. 351 p.
18. Pipalova I. A review of grass carp use for aquatic weed control and its impact on water bodies. Aquat Ecosyst Health. 2006;9(2):110-122.
19. Pullin R, Kuo CM. Developments in the breeding of cultured fishes. In: Advances in Food-Producing Systems For Arid and Semiarid Lands Part B, 2012, p. 899-915.
20. Pyz-Łukasik R, Pecka KD. Fatty acid profile of fat of

grass carp, bighead carp, Siberian sturgeon, and Wels catfish. J Food Qual. 2017;2017:5718125.
21. Robinson KF, DuFour M, Jones M, Herbst S, Newcomb T, Boase J, *et al*. Using decision analysis to collaboratively respond to invasive species threats: A case study of Lake Erie grass carp (*Ctenopharyngodon idella*). J Great Lakes Res. 2021;47(1):108-119.
22. Routray P, Routray MD. Culture possibilities of grass carp, *Ctenopharyngodon idella*, Val., in pens of low saline brackishwater areas of Chilka Lake. J Aquac. 1998;1:13-17.
23. Santha CR, Grant WE, Neill WH, Strawn RK. Biological control of aquatic vegetation using grass carp: Simulation of alternative strategies. Ecol Model. 1991;59(3-4):229-245.
24. Sehgal HS, Sehgal GK. Aquacultural and socio-economic aspects of processing carps into value-added products. Bioresour Technol. 2002;82(3):291-293.
25. Shireman JV. Synopsis of biological data on the grass carp, *Ctenopharyngodon idella* (Cuvier & Valenciennes, 1844). FAO Fish Synop. 1983;(135).
26. Sinha VRP, Gupta MV. On the growth of grass carp, *Ctenopharyngodon idella* Val., in composite fish culture at Kalyani, West Bengal (India). Aquaculture. 1975;5(3):283-290.
27. Size PM. Share & trends analysis report by product and forecast to 2030, 2022.
28. Wang Y, Liu W, Li Z, Qiu B, Li J, Geng G, *et al*. Improvement and application of genetic resources of grass carp (*Ctenopharyngodon idella*). Reprod Breed. 2024;4(3):126-133.
29. Weeks EN, Hill JE. Grass Carp, the White Amur: *Ctenopharyngodon idella* Cuvier & Valenciennes. EDIS. 2014;2014(6).
30. Wildhaber ML, West BM, Ditter KK, Moore AP, Peterson AS. A review of grass carp and related species literature on diet, behavior, toxicology, and physiology. Fishes. 2023;8(11):547.
31. Wittmann ME, Jerde CL, Howeth JG, Maher SP, Deines AM, Jenkins JA, *et al*. Grass carp in the Great Lakes region: Establishment potential and ecological impact. Can J Fish Aquat Sci. 2014;71(7):992-999.
32. Xing Guo L, Hongye S, Zhaojun G, Guofeng C, Jie W, Hao Z. Environmental impact and development direction of grass carp, *Ctenopharyngodon idella*, aquaculture. J World Aquac Soc. 2023;54(5):1354-1366.
33. Zhu W, Qiao M, Hu M, Huo X, Zhang Y, Su J. Type II grass carp reovirus rapidly invades *Ctenopharyngodon idella* via nostril-olfactory system-brain axis, gill, and head skin. Viruses. 2023;15(7):1614.
34. Action SI. World fisheries and aquaculture. Rome: FAO, 2020. p. 1-244.
35. Tan YT. Proximate composition of freshwater fish grass carp, *Puntius gonionotus* and *Tilapia*. Hydrobiologia. 1971;37(2):361-366.
36. Ashraf M, Zafar A, Rauf A, Mehboob S, Qureshi NA. Nutritional values of wild and cultivated silver carp (*Hypophthalmichthys molitrix*) and grass carp (*Ctenopharyngodon idella*). Int J Agric Biol. 2011;13(2):210-214.
37. Cheng HH, Xie CX, Li DP, Xiao YH, Tian X, Chen J. Muscle nutrition and fish quality of grass carp (*Ctenopharyngodon idellus*) in ecological cultivation. J Fish China. 2016;40(7):1050-1059.
38. Golgolipour S, Khodanazary A, Ghanemi K. Effects of cooking methods on nutrients of grass carp (*Ctenopharyngodon idella*). Iran J Fish Sci. 2019;18(1):110-123.
39. Yao Y, Xu X, Liu Y. Large language model unlearning. Advances in Neural Information Processing Systems. 2024 Dec 16;37:105425-75.
40. Ding L, Spicer RA, Yang J, Xu Q, Cai F, Li S, *et al*. Quantifying the rise of the Himalaya orogen and implications for the South Asian monsoon. Geology. 2017 Mar 1;45(3):215-8.
41. Mehta BB, Coppo S, McGivney FD, Hamilton IJ, Chen Y, Jiang Y, *et al*. Magnetic resonance fingerprinting: A technical review. Magnetic resonance in medicine. 2019 Jan;81(1):25-46.