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Review: The potential of *wader* fish (*Puntius* spp.) as a source of food, medicine, and traditional use

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Abstract. *Zen HM, Nurcahyo FD, 'Azizah HPN, Nurwulandari M, Naim DMd, Setyawan AD. 2024. Review: The potential of wader* fish *(Puntius* spp.*) as a source of food, medicine, and traditional use. Asian J Trop Biotechnol 21: 75-88.* Freshwater ecosystems rich in biodiversity are often inhabited by *wader* fish (*Puntius* spp.: Cyprinidae). *Wader* fish are omnivores, consuming various plankton and aquatic insects, and are typically found in river streams with relatively clear water and pH around 6.0-6.5. Its adaptive habitats, including rivers, lakes, and ponds, and widespread distribution from India to Southeast Asia make them critical elements in freshwater ecosystem sustainability. This study aims to maintain the availability of nutritious food, preserve traditional knowledge in medicine, and safeguard the population of *wader* fish for future generations. Morphological analysis is crucial for understanding *wader* fish's characteristics and phylogenetic relationships, with *wader* fish exhibiting diverse morphological traits, including unique body colors and structures. In Indonesia, *Puntius* consists of 33 species, classified into three subgenera: *Puntius, Poropuntius, and Barbodes.* Besides providing significant economic value, *wader* fish also play a crucial role in preventing community malnutrition. They are an essential protein source and offer various health benefits. The morphology of *wader* fish includes a compact body shape, flat head, and various colors and patterns on its body. As a nutritious food source, *wader* fish are rich in protein, fats, vitamins, and minerals that benefit humans. Additionally, the potential uses of *wader* fish in medicine are diverse, including antioxidant, antibacterial, anti-inflammatory, immunity, and liver health benefits. For further research, exploring the specific mechanisms by which bioactive compounds in *wader* fish, such as antimicrobial properties and antioxidant effects, contribute to human health is recommended. Understanding these mechanisms and effects can offer deeper insights into the potential therapeutic applications of *wader* fish in traditional and modern medicine.

Keywords: Food, medicine, potential, traditional use, *wader*

INTRODUCTION

Freshwater ecosystems host the most extensive diversity of ecosystems but face significant threats (Roesma et al. 2016). *Wader* fish (*Puntius* spp.), a term for small fish in the family Cyprinidae, are freshwater fish classified in the *Puntius* spp. (Yang et al. 2015). Migration in fish is influenced by fitness and habitat landscape (Prasetyo and Retnoaji 2020). *Wader* fish shoal and migrate to areas with ample food sources (Sumiarsih and Eddiwan 2018). As omnivores, they consume plankton, algae, aquatic insects, and larvae. *Wader* fish are typically found in slow-flowing rivers with a pH of 6.0-6.5 (Pratami et al. 2018). Their adaptive habitat extends to lakes (Chavan and Kumbhar 2020), rivers, rice fields, irrigation channels, and fish ponds (Desrita et al. 2018). For breeding, they need clear water, moderate currents, and good oxygenation (Hertika et al. 2021). Murky waters hinder respiration, reproduction, and growth (Kjelland et al. 2015). The size and condition of the fish are crucial for reproduction rates (Kant et al. 2016). They are widely distributed in India and Southeast Asia (Patel et al. 2020).

In Indonesia, *wader* fish can be found on various islands, such as Java, Sumatra, Kalimantan, and Sulawesi (Yustian and Zulkifli 2022). The distribution of fish is greatly influenced by environmental factors, including biotic, abiotic, technological, and human activities (Putri et al. 2021). A water body's biotic and abiotic factors can also impact the structure and density of fish (Miranda and Miqueleiz 2021). Additionally, physical and chemical aspects estimate the stages of oogenesis and reproduction (Susatyo et al. 2022). The diversity of fish species in a water region affects sustainability and conservation efforts (Su et al. 2021). Hematology can be used as an indicator of fish health with measurements of erythrocytes, leukocytes, hemoglobin concentration, hematocrit, and micronucleus tests (Arfiati et al. 2020), demonstrating responses to changes related to water quality, nutrition, and disease (Fazio 2019). *Wader* fish have promising economic value (Kumar et al. 2021a) and also have a major component in tropical fish trade (Gupta et al. 2018), contributing to high protein intake (Setiyoko et al. 2022). Nutritionally, these fish are a source of protein, carbohydrates, and essential

micronutrients to help prevent malnutrition in communities (Hossain et al. 2018).

Morphological analysis is conducted to understand the phylogenetic relationship from evolutionary aspects such as morphological, behavioral, and ecological characteristics (Matsuura 2015), including fish performance, morphometrics, and meristics (Rahayu and Nugroho 2014). Knowledge of the morphology and characteristics of *wader* fish is crucial for sustainable management (Prajapati et al. 2022). *Wader* fish has great potential as a highly nutritious food source and valuable traditional medicinal ingredients; it provides a high supply of animal protein in food sources that play an important role in the health of the human body (Pratiwi et al. 2017). Regular consumption of *wader* fish can prevent various diseases and fulfill essential nutritional needs for growth and development (Fiqriani et al. 2023). Apart from being a food source, *wader* fish also plays a role in medicine with bioactive compounds that have long been used to treat various diseases and health problems. Its benefits in medicine can be in the form of external treatment, such as on open wounds, and internal treatment, such as relieving inflammation in the joints. Even though *wader* fish is a food ingredient, it is part of local culture and traditions in some regions. For example, in some traditional ceremonies or festivals, *waders* are used as a symbol of fertility or good luck. Although not fully recognized scientifically, using *wader* fish in traditional medicine is important to cultural heritage and local knowledge. Preserving traditional knowledge in medicine, such as using *wader* fish, is crucial as it not only provides effective treatments but also preserves the cultural identity of communities.

Understanding the benefits of *wader* fish is not only important for maintaining the availability of nutritious food but also important for preserving traditional knowledge in medicine. If understood more deeply, the nutritional content of *wader* fish will result in significant benefits in the development of *wader* fish utilization. It can positively impact the protection of *wader* fish populations by promoting the sustainable utilization of resources; this will ensure their availability for future generations while supporting growth in the health and economic sectors.

DISTRIBUTION AND HABITAT OF *Puntius* spp.

According to the 2013 Marine Life Census, there are over 23,000 species worldwide, with approximately 12% being fish species (2,760-3,000 species) (Darmanto 2019). Indonesia has approximately 1,248 freshwater species, constituting about 9% of the total freshwater species worldwide (Kristanto et al. 2014). *Puntius* spp. is a native species that used to be abundant in rivers, streams, ponds, and floodplains in South and Southeast Asian countries (Arunkumar et al. 2017). According to Roesma et al. (2018), The generic name *Puntius* spp. was introduced by Hamilton in 1822. Later, several synonym names like *Barbonymus*, *Barbus*, *Barbodes*, *Systomus*, *Capoeta*, and *Hypsibarbus* were used by researchers as generic names, although these have not been widely accepted. *Puntius* spp. is commonly known as the silver barb or spotted barb and is one of the most important commercial fish for food and freshwater aquariums. It has the most significant number of species among the Cyprinidae family and inhabits various freshwater environments. *Barbus* is typically used in Europe, while *Puntius* is used in Asia, especially in India, where *Puntius* spp. has a high abundance and variety of species that, according to Hamilton, are very commonly found (Kapuri et al. 2020). These fish play a significant role in their native habitats, contributing to biodiversity and serving as important species in local ecosystems and fisheries. The widespread presence and ecological importance of *Puntius* spp. species underscore the need for conservation efforts to preserve their populations amidst environmental changes and anthropogenic pressures. In addition, its cultural and economic value in many local communities, where it is a highly nutritious fish that commands a high price, further underscores the importance of prioritizing the conservation and sustainable management of this species over other species that may not provide similar ecological or socioeconomic benefits (Munandar and Eurika 2016). *Puntius* spp. is known as a freshwater fish with high economic potential, and its abundant availability in nature is also one of the reasons why *Puntius* spp. should be prioritized over other fish species (Azzahra et al. 2024).

In Indonesia, the genus *Puntius* consists of 33 species distributed across various aquatic regions. Based on their scale structures, the genus *Puntius* is further classified into three main subgenera: *Puntius*, *Poropuntius*, and *Barbodes* (Haryono 2006). According to Damayanti et al. (2022), observations of the morphological characteristics of *wader* fish in Sempor Reservoir, Central Java, Indonesia revealed that the exact species could not be identified using the fish identification guide by Kottelat et al. (1993). This challenge arises due to the similarities in morphological traits among several species, including *Puntius anchisporus* (Vaillant, 1902), *Puntius microps* (Günther, 1868), and *Puntius parrah* (Day, 1865). Key characteristics for, *P. anchisporus* has a yellowish body, a Standard Length (SL) of 45 mm, dorsal fin formula D.II.10, and 5½ transverse body scales. *P. microps* is dark-colored, with an SL of 79 mm, 21-23 lateral line scales, dorsal fin formula D.I.8, and distinctive circular projections on its scales. Meanwhile, *P. parrah* is silvery-black, with an SL of 65-70 mm, 25 lateral line scales, and a dorsal fin formula of D.III.8. All three share an abdominal fin formula of V.I.8, but differences in lateral line scales and dorsal fin structure serve as the primary distinguishing traits.

Their habitats include natural lakes, flooded marshes, and rivers unaffected by strong currents and sedimentation. *Wader* fish prefers calm water habitats overflowing water. They are usually found on the riverbed, in floodplain areas, and occasionally in reservoirs (Apriliani et al. 2018). The preference for such habitats highlights the adaptability and ecological significance of *wader* fish in maintaining the biodiversity of freshwater ecosystems. These fish are commonly found in ponds, reservoirs, and rivers with clear water (Firmansyah et al. 2015). Although they have an adaptive habitat, *wader* fish require relatively cool

temperatures, clear water, moderate currents, and adequate oxygen for their reproductive processes. Vegetation also affects water quality, providing a more stable zone for *wader* fish to live and reproduce. Changes in environmental conditions related to water quality, including temperature, pH, and oxygen content, due to pollution or habitat destruction can affect their well-being and survival. The blood profiles of *wader* fish also indicate water quality changes (Hertika et al. 2021). *Wader* fish is one of the freshwater fishes that is gaining popularity as a fishery commodity in Indonesia (Apriliani et al. 2018). Its ability to adapt well makes it widespread in various freshwater habitats, where it plays an important role in maintaining ecosystem balance by controlling populations of other organisms and becoming a food source in the food chain.

SPECIES DESCRIPTION/MORPHOLOGY OF *WADER* FISH (*Puntius* spp.)

Body

The body size and shape of *wader* fish (*Puntius* spp.) can vary depending on the species. Generally, they possess small to medium-sized bodies with a slender appearance and a well-proportioned head. The shape and size of their fins, including the caudal, dorsal, pelvic, and pectoral fins, also vary depending on the species and their environment. *Wader* fish typically have compact bodies with dorsolaterally flattened heads. Their bodies are covered in regularly shaped cycloid scales, providing additional protection and enhancing their aquatic capabilities, with a distinctive black and pearlescent coloration. A line of curved ribs runs along their sides, with approximately 22-23 scales (Damayanti et al. 2022). Common features of the *wader* fish include circuli on scales that do not curve backward (Damayanti et al. 2022). These fish have elongated slender bodies with small dorsal and anal fins. They are relatively small, typically ranging from 5 to 10 cm. The length and weight of the fish vary according to gender, gonad maturity level, season, and even time of day (feeding). This variability in size and weight indicates the adaptability and resilience of *wader* fish in diverse environmental conditions. Morphological characteristics of *wader* fish can also be seen from the mosaic structure of their scales (Lubis et al. 2021). *Wader* fish has various species with different physical characteristics commonly observed in size (Utomo et al. 2023).

Mouth

Their mouths are positioned subterminally and can be protracted. Each corner of the mouth has a pair of barbels, and their operculum is pearlescent. Their mouths are at the snout's tip, facing upwards, reflecting their surface feeding habits (Ardiansyah et al. 2024). This mouth positioning is well-adapted for their feeding strategy, which involves capturing prey from the water surface. The shape of the mouth of the *wader* fish can also vary depending on the species and its diet. Generally, the shape of the *wader*'s mouth can be classified into several types: terminal, superior, and inferior. The terminal mouth shape of a *wader* fish is a mouth located at the tip of the head and facing forward (Budiantoro et al. 2024). This mouth shape is often found in predatory *wader* fish species actively pursuing prey, such as *wader* fish that feed on insects or small fish. The terminal mouth allows the fish to capture and swallow prey quickly. At the same time, *wader* fish with a superior mouth has a mouth located at the top of the head and slightly jutting upwards. This mouth shape is often found in *wader* fish that forage for food on the water's surface, such as plankton or small invertebrates. The superior mouth of some *wader* fish allows them to filter food from the water's surface effectively. In contrast, species with an inferior mouth have mouths located at the bottom of their heads, jutting downward. This mouth shape is typically found in species that forage for food on the substrate, such as detritus or bottom-dwelling invertebrates. The inferior mouth enables these *wader* fish to gather food from the bottom substrate efficiently. Overall, the subterminal mouth shape in *wader* fish reflects adaptations to their specific diet and environment (Setyaningrum et al. 2020).

Fins

The fins of *wader* fish (*Puntius* spp.) are also important parts of their morphology. Fins on *wader* fish have different fin structures and size variations depending on the species and habitat environment of the *wader* fish. Some species of *wader* fish may have longer or shorter fins, some have thicker or thinner fins, and some have fins with different numbers or shapes within the species. Their dorsal fins are tall and erect, providing good maneuverability when swimming. These strong dorsal fins help *wader* fish adapt to various aquatic environments, from fast-flowing rivers to calm marshes. The fins of *wader* fish also adapt to the type of habitat they live in, such as rivers, lakes or swamps. For example, when *wader* fish live in fast-flowing rivers, they tend to have longer and stronger fins to help them better navigate the strong currents. *Wader* fishes that live in lakes with calm currents or slower-flowing waters tend to have shorter fins that are wider fish in size, allowing them to move efficiently in calm water. *Wader* fish also have pectoral and ventral fins on their bodies, which maintain balance and provide direction while swimming; it can be classified into species with weak backbones, no repeating backbones, simple dorsal fins, and strong dorsal fins (Plamoottil et al. 2016). These adaptations in fin structure enable *wader* fish to thrive in diverse aquatic habitats, enhancing their survival and reproductive success. Figure 1 illustrates the general body structure and distinctive features of the *wader* fish, including its compact body shape, coloration, and fin variations.

Color and pattern

One characteristic of *wader* fish (*Puntius* spp.) is their body color and pattern, ranging from color combinations (red, orange, yellow, black) to vertical lines and spots. The colors on the bodies of *wader* fish play a role in their adaptation to the surrounding environment, such as

foraging, camouflaging from predators, and attracting mates during mating seasons. Morphonologically, *wader* fish. has a black spot at the base of the tail (Fakhrurrozi et al. 2016). Their scales are pearlescent with black spots on the back; *wader* fish has color with attractive patterns (Roesma and Chornelia 2014). The colors and patterns of *wader* fish are pretty varied; color variations can be found in a single species, and color variations can be found depending on age, sex, environmental conditions, and genetic factors. The body color of *wader* fish is often influenced by environmental factors such as lighting, water depth, substrate type, and vegetation. It is known that *wader* fish that live in darker waters or have dark substrates tend to have a darker or neutral body color that serves to disguise and avoid predators. It is inversely proportional to *wader* fish that live in bright waters or with bright substrates and tend to have brighter or striking body colors to attract mates or outwit prey. In addition to environmental factors, some species of *wader* fish also have differences in color due to the role of genetics and natural selection that occurs in the environment. The body color of *wader* fish serves various ecological functions, including communication, sex identification, and adaptation to survive in their environment. Besides having body colors that may be pretty striking, *wader* fish also often have unique and complex patterns. Patterns can include stripes, spots, or other patterns found throughout their bodies. This patterning on the body of *wader* fish itself may serve as an evolutionary adjustment that aids *wader* fish in camouflage or same-sex recognition. These vibrant colors and patterns serve ecological functions and make *wader* fish popular for ornamental aquariums.

Eye

The eyes of *wader* fish (*Puntius* spp.) are relatively large, allowing for good vision even in murky water, facilitating the detection of prey and predators. In ecological processes, *wader* fish assist in controlling organism populations in water and serve as a food source for other predators in the food chain, as they feed on plankton and small insects. Additionally, *wader* fish is also a primary food source for the catfish (*Kryptopterus limpok*) Bleeker, 1852) from the Cyprinidae family (Adiyanda and Yusfiati 2014). When infected, *wader* fish tend to be difficult to identify solely based on their external morphology (Patra et al. 2016). This highlights the importance of regular health monitoring and effective disease management practices in aquaculture to ensure the sustainability of *wader* fish populations.

Figure 1. *Wader* fish (*Puntius* spp.). Source: Masykuri (2015)

Generally, female *Puntius* spp. possess a larger abdomen size than male fish (Sentosa and Djumanto 2010). The variation in abdomen size is associated with its role, since female *wader* fish hold many eggs for reproduction, leading to a bigger abdomen. At the same time, male *wader* fish possess a more slender midsection. An adult male *wader* fish has a body length of about 7-9 cm, whereas an adult female *wader* fish measures approximately 8-10 cm (Raharjeng et al. 2022).

FOOD SOURCE OF *WADER* FISH (*Puntius* spp.)

Food primarily serves as a provider of about 40 types of nutrients, including carbohydrates, proteins, fats, vitamins, minerals, and water, needed as a source of energy for growth, tissue maintenance, and metabolic regulation according to gender, age, physical activity, and body weight (Sibuea 2021). One of the food sources that can provide many nutrients for humans is fish. Fish are rich in chemical compositions such as protein, fats (especially polyunsaturated fatty acids), vitamins (including vitamin A, vitamin B2, vitamin B6, and others), minerals (such as iron, calcium, iodine, potassium, and other minerals), and carbohydrates. In many parts of the world, fish are considered a good source of nutrition (Fitri et al. 2022). Fish consumption is significant in regions with limited access to other protein sources, making *wader* fish (*Puntius* spp.) a valuable component of local diets.

One type of fish commonly consumed in Indonesia is *wader* fish. Some previous studies have shown that *wader* fish plays a significant role as a food source and an important source of micronutrients in preventing malnutrition, vitamin deficiency, and mineral deficiency in rural areas, especially for vulnerable groups such as women and impoverished children (Hasan et al. 2018). Small fish like those from the *wader* fish species contain various vitamins and minerals important for embryonic growth, bone formation, muscle and tooth formation, brain and nerve development, intelligence in children, and milk production in breastfeeding mothers (Borah 2019). These nutritional benefits underscore the importance of promoting *wader* fish as a dietary staple in communities facing nutritional challenges.

Nutritional composition of *Puntius* spp.

The proximate composition analysis of *wader* fish (*Puntius* spp.) conducted by Mahanty et al. (2014) indicates that the fish is rich in protein (exact amount unspecified) and minerals. Amino acid profiles reveal a high level of the essential amino acid histidine (22.94±0.01%). Despite its low-fat content (5%), the fatty acid profile shows that the fish is abundant in unsaturated fatty acids, with oleic acid being the most prominent (28.63±0.02%), and it contains significant amounts of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Mineral profiles indicate that calcium is the most abundant macro mineral (9,748.2±23.96 mg kg^{-1}), followed by potassium (2,283.7±12.75 mg kg^{-1}) and sodium (1,610±22.34 mg kg^{-1}). The fish is also rich in micro minerals such as iron

(115.0±8.81 mg kg^{-1}), zinc (51.1±10.15 mg kg^{-1}), and manganese (11.2±2.09 mg kg^{-1}). Vitamin profiles demonstrate that the fish is rich in all fat-soluble vitamins (A, D, E, and K), with vitamin E being the most abundant (30,685.8 µg kg^{-1}). With this comprehensive nutritional profile, *wader* fish shows potential as a highly nutritious food component.

The current review highlights the significant nutritional benefits of *wader* fish (Table 1), which includes high protein content, essential vitamins, and omega fatty acids. However, several research gaps and future directions remain to be explored. First, while general nutritional information is available, detailed quantitative profiling is lacking across various fish populations and environmental conditions. Future studies should investigate how factors such as habitat, diet, and seasonal changes impact the nutritional composition of *wader* fish. Additionally, although some research suggests potential health benefits such as anti-inflammatory and antioxidant properties, clinical evidence supporting these claims is limited. Long-term human studies are necessary to validate the therapeutic effects of consuming *wader* fish particularly about heart health, inflammation, and immune function.

Moreover, further research is needed to understand how different processing methods (such as drying, freezing, and fermenting) affect the nutritional and bioactive components of *wader* fish. This would not only have implications for the food industry but could also improve the shelf life of fish products. The potential for *wader* fish to be incorporated into functional food products, such as protein supplements or omega-3-enriched items, also warrants investigation. Research should optimize product formulations to maintain the fish's health benefits while appealing to consumers. Finally, with growing interest in the nutritional use of fish, research into sustainable harvesting practices for *wader* fish is essential. This will help prevent overfishing and ensure the long-term availability of the species without disrupting local ecosystems.

Table 1. Nutritional composition of *wader* fish (*Puntius* spp.)

Nutritional component	Average content	Unit	Reference
Protein	21.50	%/100 g	Sarjubala et al. (2018)
Fat	2.70	%/100 g	Sarjubala et al. (2018)
Calcium (Ca)	190	mg/100 g	Musa (2009)
Phosphorus (P)	150	mg/100 g	Mahanty et al. (2014)
Iron (Fe)	5.5	mg/100 g	Sarjubala et al. (2018)
Vitamin A	750	IU/100g	Mahanty et al. (2014)
Vitamin D	20	µg/100g	Mahanty et al. (2014)
Omega-3 (EPA+DHA)	0.75	g/100g	Mustafa et al. (2015)
Omega 6	0.10	g/100g	Mustafa et al. (2015)
Carbohydrates	1.55	%/100 g	Musa (2009)
Moisture content	75.60	%/100 g	Musa (2009)

Carbohydrates

Carbohydrates are the primary energy source for the human body, providing 4 calories (kilojoules) of food energy per gram (Fitri and Fitriana 2020). They serve many crucial functions, such as supplying energy to the brain and nerves, regulating metabolism, and serving as the main energy source for the body. Carbohydrates are highly essential at every stage of life, especially during childhood when there is a high demand for energy for play and brain development. Inadequate carbohydrate consumption has been linked to an increased risk of stunting by up to 1.7 times (Azmy and Mundiastuti 2018). Stunting, characterized by impaired growth and development, can have long-term detrimental effects on a child's health, cognitive abilities, and overall quality of life.

Research by Mohanta et al. (2007, 2009) on the impact of the varying carbohydrate content on the growth and nutrient utilization of *wader* fish (silver barb) has shown consistent results. The first study (2007) revealed that an optimal carbohydrate content of around 260 g/kg leads to good growth and nutrient utilization, with the best performance achieved by the group with this carbohydrate level (D-2). Additionally, body protein concentration, Protein Productive Value (PPV), and Energy Productive Value (EPV) were also higher in this group. The second study (2009) reinforced these findings by showing that fish given carbohydrate content between 260 g/kg and 340 g/kg, particularly in groups R and D-5, exhibited better weight gain, feed intake, and Feed Conversion Ratio (FCR). This research also noted an increase in body protein and lipid levels with increased carbohydrates and a protein-sparing effect of carbohydrates, allowing for a reduction in protein content without reducing growth performance. Overall, these two studies demonstrate that the optimal carbohydrate content for *wader* fish ranges from 260 g/kg to 340 g/kg, which supports optimal growth and efficient nutrient utilization.

Protein and amino acids

The human body requires approximately 45-46 grams of protein daily (Andhikawati et al. 2021). *Wader* fish (*Puntius* spp.) is rich in high-quality protein containing essential amino acids needed for human health. High levels of protein, fats, and ash are recorded in *wader* fish (Sarjubala et al. 2018). According to Mahanty et al. (2014), *wader* fish. has a composition with crude protein levels of 16.2±0.14%, high crude fat levels, and ash content reaching 5.36±0.12%. This protein contains both essential and non-essential amino acids. Essential amino acids are crucial for various biochemical processes in the body. Still, the body cannot synthesize them independently, so they must be obtained from additional nutritional intake (Rahayu et al. 2019). The amino acid profile shows that histidine is dominant (22.93±0.01%), while tryptophan is 1.69±0.005 mg kg^{-1}. Glycine is the dominant non-essential amino acid (10.39±0.07%), essential for skin tissue regeneration. This fish protein is rich in essential amino acids needed for human nutrition. High-protein foods are believed to have a greater satiating effect than high-carbohydrate or high-fat foods (Cuenca-Sánchez et al. 2015). Although *wader* fish

has high protein content, in fish storage, attention must be paid to temperature and storage time because, according to Mazrouh (2015), significant protein content decreases during frozen storage at -50°C for 20 days in the muscles of frozen fish *Labeo rohita* (Hamilton, 1822). In *wader* fish, protein content decreases due to denaturation and loss of gelatin caused by long-term frozen storage, as well as proteolysis caused by psychotropic microbial growth. Thus, proper storage and handling are crucial to preserving the nutritional quality of *wader* fish.

Proteins are essential for body growth and tissue repair. Animal protein is the best for human growth and development because its composition is similar to human protein. This protein is beneficial as fuel for the body and provides essential amino acids needed for building tissues (Islamiati et al. 2024). The protein content in *wader* fish is relatively high, with an excellent amino acid profile. This high protein content makes *wader* fish a valuable food source for supporting muscle growth and repair in humans and other animals. This indicates that *wader* fish can be one of the choices for animal protein sources that we can consume.

Fat and fatty acids

Consumption of fats in foods in moderate amounts is important for human health because it provides the body with essential Fatty Acids (FAs) and fat-soluble vitamins and regulates satiety and energy balance (Pepino et al. 2014). These fish contain beneficial fats, including omega-3 and omega-6 fatty acids. According to Mustafa et al. (2015), *wader* fish (*Puntius* spp.) contains a total lipid of 10.2% in the head and 8.7% in the body. There are 21 types of fatty acids, with the head containing 64.52% Saturated Fatty Acids (SFA), 25.76% monounsaturated fatty acids (MUFA), and 8.72% Polyunsaturated Fatty Acids (PUFA). The body contains 34.84% SFA, 23.97% MUFA, and 40.99% PUFA. The omega-3 content is 4.28% in the head and 17.86% in the body, while omega-6 is 4.43% in the head and 23.12% in the body, with an omega-3/omega-6 ratio between 0.35 to 1.50. *Wader* fish is an important source of beneficial omega-3 and omega-6 fatty acids for health. According to Majumdar et al. (2017), *wader* fish belongs to the 'semi-fatty' fish group (lipid content usually ranges from 2-5% in seasonal farming). Variations in lipid content may be associated with raw fish lipid content. Increased protein and product lipid content is caused by reduced water content. These fatty acids are crucial for cardiovascular health and cognitive function.

Proteins are essential for body growth, tissue repair, and numerous metabolic functions. *Wader* fish is a rich source of protein, boasting a well-balanced amino acid profile. This makes it a precious food for supporting muscle growth and repair in humans and other animals. The proteins in *wader* fish are also crucial for various metabolic processes, including the production of enzymes that catalyze biochemical reactions and the synthesis of hormones that regulate physiological activities. Additionally, proteins play a vital role in maintaining and repairing cellular structures and ensuring the proper functioning of the immune system. Specifically, proteins and mitochondrial DNA interact with TLR9 and FPR receptors, activating the NLRP3 inflammasome, which triggers inflammatory signaling pathways and recruits immune cells to respond to infection and tissue damage (Faas and De Vos 2020). Regular consumption of *wader* fish can significantly contribute to meeting daily protein requirements, thereby supporting overall health and well-being.

Vitamins

Vitamins are organic compounds that play a very important role in cell growth and function, as well as in maintaining the health and metabolism of the body to remain optimal (Ramandha and Muhsin 2023). The human body requires vitamins to function optimally, but most vitamins cannot be naturally produced, at least not in sufficient quantities to meet our daily needs (Ofoedu et al. 2021). When the body cannot meet the amount of vitamins, then vitamins must be supplied from food (Zhang et al. 2018). *Wader* fish (*Puntius* spp.) is a fish rich in vitamins, including vitamins A, D, E, and K. Vitamin E (30,685.8 µg kg^{-1}) is one of the most abundant (Mahanty et al. 2014). Vitamin E, as a potent antioxidant, protects cell membranes from oxidative damage, prevents cell lysis and hemolysis, and reduces the risk of neonatal hyperbilirubinemia; these functions are supported by the regeneration of oxidized vitamin E with the help of vitamin C (Sareharto and Wijayahadi 2016). These vitamins are essential in immune function, bone health, and skin integrity.

Wader fish is rich in vitamins and minerals for maintaining various bodily functions and overall health. Vitamins such as A, D, and B-complex are vital for various bodily functions, including vision, bone health, and energy metabolism (El Bahgy et al. 2021). Vitamin A is crucial for maintaining healthy vision and immune function, while vitamin D is essential for calcium absorption and bone health. B-complex vitamins are important for energy metabolism and neurological function. In addition to vitamins, *wader* fish is a good source of minerals; the mineral content includes calcium, phosphorus, and iron. Calcium and phosphorus are necessary for maintaining strong and healthy bones and teeth, while iron is vital for oxygen transport in the blood and overall vitality. The presence of these minerals in *wader* fish contributes to the maintenance of bone strength, efficient oxygen transport, and the prevention of anemia. Regular consumption of *wader* fish can help meet daily vitamin and mineral requirements, supporting overall health and preventing deficiencies.

Minerals

Macro minerals, also known as major minerals, are minerals required in large amounts by the human body. They are an important part of the body's biological structure and play a role in various metabolic and almost all body processes (Ali 2023). The five major minerals in the human body include calcium, phosphorus, potassium, sodium, and magnesium. In addition, there are trace elements such as iodine, sulfur, zinc, iron, chlorine, cobalt, copper, manganese, molybdenum, and selenium that have specific biochemical functions in the body (Godswill et al. 2020). Fish are rich in essential minerals, including iron,

calcium, zinc, potassium, and magnesium. According to Sarojnalini and Devi (2014), Eleven essential mineral elements were found to be abundant in *wader* fish (*Puntius* spp.) with varying levels of iron, calcium, zinc, potassium, and magnesium within specific ranges, such as iron from 152.17 to 320.39 mg/100g, calcium from 902.06 to 1356.02 mg/100g, zinc from 91.07 to 138.14 mg/100g, potassium from 193.25 to 261.56 mg/100g, and magnesium from 225.06 to 229.10 mg/100g. The important function of Fe in the body includes its role as a heme component. Iron deficiency can inhibit the body's ability to bind and transport oxygen (Tasik 2022). Calcium serves as the primary messenger in all physiological functions within the body (Ahmad 2021). Humans and animals require zinc for various physiological functions, including growth, immune system, and reproductive processes (Candra 2018). Magnesium is significant in various metabolic processes, including carbohydrate, lipid, and protein metabolism, and in ATP synthesis in mitochondria (Mahardhika et al. 2019). Its role is maintaining tissue health and body functions and maintaining acid-base balance within the body (Kartika et al. 2019). Therefore, consuming *wader* fish can contribute to meeting the body's daily mineral requirements and promoting overall health.

These detailed analyses show that *wader* fish is a vital component of aquatic ecosystems and a valuable source of human nutrition. Including *wader* fish in the diet can significantly contribute to the nutritional needs of various population groups, especially in rural and underdeveloped areas where access to diverse food sources may be limited. The nutritional profile of *wader* fish indicates its potential as a valuable food source. Its high protein content, essential fatty acids, and rich vitamin and mineral composition make it an excellent choice for a balanced diet. Regular consumption of *wader* fish can support muscle growth, cardiovascular health, and overall well-being. This nutritional richness and its ecological role underscores the importance of conserving *wader* fish populations and promoting their sustainable use in aquaculture.

TRADITIONAL USE OF *WADER* FISH (*Puntius* spp.)

According to Altaf et al. (2020), *wader* fish (*Puntius* spp.) has been traditionally recognized for its various health benefits. These include its role in regulating blood sugar levels, maintaining chemical balance in the body, increasing hemoglobin, regulating blood balance, reducing joint pain, improving sexual function, and repairing the central nervous system. In addition to its nutritional value, *wader* fish holds significant cultural importance among various indigenous communities. Ethnozoological studies reveal that these communities rely on *wader* fish as a dietary staple and medicinal resource, citing its purported benefits in traditional healing practices for ailments such as joint pain and inflammation (Grenz 2020). Furthermore, intriguingly, several tribes have woven myths and beliefs around the *wader* fish, attributing mystical properties to its consumption. For instance, among the indigenous tribes of South Asia, a belief exists that consuming *wader* fish can bring luck and prosperity. In contrast, others regard it as a symbol of resilience and adaptability in their folklore (Schuetz-Miller 2022). Indigenous people in South Punjab, Pakistan, have traditionally used freshwater fish like *wader* fish (*Puntius* spp.) to alleviate joint pain. This practice often involves cooking the fish with traditional herbs known for their anti-inflammatory properties, such as turmeric and ginger, which are believed to enhance its medicinal benefits, as Iqbal et al. (2023) reported.

Wader fish is typically not consumed in its raw form. Instead, it undergoes various culinary techniques to enhance its flavor, texture, and palatability. These techniques, such as boiling, frying, and roasting, significantly alter the taste and texture and affect its nutritional composition (Hananiah and Rahim 2022). Each cooking method has a distinct effect on the nutritional profile of *wader* fish. For instance, boiling may lead to some loss of water-soluble vitamins and minerals, while frying could result in increased fat content due to oil absorption. On the other hand, roasting may preserve more nutrients than other methods, depending on factors such as cooking temperature and duration. Choosing the right cooking technique is crucial as it can optimize the digestibility of the food while minimizing nutrient loss (Goswami and Manna 2019). This indicates that the use of *wader* fish in traditional medicine has the potential to provide effective solutions to specific health problems and is an integral part of local medical practices in various regions.

Due to its high micronutrient content, the Bangladesh community often utilizes *wader* fish for market sale. Recent market surveys have shown that the price of *wader* fish typically ranges from 100 to 150 Bangladeshi Taka/kg or equivalent to 1.18-1.77 USD/kg, depending on the season and local demand (Islam et al. 2022). Micronutrients are necessary components that humans and other living things need in different amounts at different times to coordinate various physiological processes necessary for maintaining health. Micronutrient requirements for human nutrition are typically less than 100 milligrams per day, whereas daily requirements for macronutrients are measured in grams (Godswill et al. 2020). Although the required amounts are relatively small, micronutrients are crucial in maintaining human health and bodily balance. Furthermore, traditional knowledge highlights the crucial importance of micronutrients in supporting complex brain functions. For instance, zinc is essential in metalloprotein synthesis and receptor binding, calcium contributes to signal transduction and membrane potential, and magnesium and zinc are involved in neurotransmission (Maggini et al. 2021).

Deficiency or imbalance of micronutrients, such as zinc, calcium, or magnesium, can disrupt brain function and potentially lead to various health issues, including neurological disorders. Mineral deficiencies, such as zinc, calcium, or magnesium, can profoundly affect brain function and overall health. These minerals are crucial in neurotransmitter synthesis, nerve signal transmission, and maintaining neuronal health. Zinc deficiency, for instance, has been linked to impaired cognitive function and emotional stability. Calcium is essential for

neurotransmitter release and nerve cell communication; its deficiency can lead to muscle cramps, seizures, and impaired memory. Magnesium deficiency affects synaptic function and neuroplasticity, potentially contributing to mood disorders like anxiety and depression. Without adequate levels of these minerals, the brain's ability to function optimally is compromised, potentially leading to neurological disorders such as Alzheimer's disease, Parkinson's disease, or multiple sclerosis. Thus, maintaining a balanced intake of essential minerals through diet or supplementation is crucial for supporting brain health and preventing neurological issues.

Local communities have long recognized the value of micronutrients for their traditional medicinal uses. Foods rich in zinc, calcium, and magnesium—such as certain freshwater species like *wader* fish support brain health and overall well-being. These fish are not only a dietary staple but also hold cultural significance, with traditional practices passed down through generations. To conserve these species and ensure their continued utilization, local communities often implement traditional conservation measures, such as regulating fishing seasons, promoting sustainable harvesting techniques, and advocating for the preservation of aquatic habitats. By safeguarding these practices, communities help maintain the availability of micronutrient-rich foods and contribute to the ecological balance of their environments (Dawson et al. 2021).

APPLICATION OF *WADER* FISH (*Puntius* spp.) AS MEDICINE

Fish is an inexpensive and readily available source of animal protein for human consumption, making it a primary choice in a balanced diet, alongside shrimp for antibiotics (Ghosh et al. 2021) and microalgae as a major source of nutrition, including protein, fat, vitamins, minerals, and color in aquatic animal diets (Sheikhzadeh et al. 2024). Research has shown that fish is rich in Essential Amino Acids (EAAs) and Polyunsaturated Fatty Acids (PUFAs) that play a vital role in the maintenance and development of fetuses, neonates, and infant brain development (Maulu et al. 2021). Furthermore, the presence of docosahexaenoic acid (DHA) in fish, which is a major component of many cells, especially brain nerve cells and retina cells, plays a crucial role in fetal brain development, motor skills, lipid metabolism, and cognitive function (Mohanty et al. 2016). Among the various types of consumed fish, the *wader* (*Puntius* spp.) is a small freshwater fish species commonly found in Southeast Asian waters. Its main habitats include ponds, rivers, and flowing water, making it easily accessible and important in providing nutrition. This fish belongs to the Cyprinidae family (Tiwari et al. 2021). It is considered a daily consumption choice by local communities (Sari and Dewi 2017) due to its abundant availability and delicious taste. In terms of diet and health, consuming *wader* fish can benefit from meeting daily nutritional needs and supporting overall body development and health.

Wader fish (*Puntius* spp.) has been widely applied and studied in medicine. The content found in *wader* fish has been proven to have the ability to combat harmful pathogens in the human body. These pathogens can cause diseases or infections (Purbomartono et al. 2022). However, in-depth research on using *wader* fish in traditional medicine is still relatively rare. Herbal treatments are used for more than just treating diseases; this includes boosting the immune system, reducing stress, promoting growth, and enhancing disease resistance (Hodar et al. 2021). Antigen recognition is the immune system's primary function, a sophisticated network of cell connections. Viruses and bacteria that are still alive or inactive are examples of antigens. Passive immunity and active immunity are the two kinds of immunity that exist (Mulya et al. 2023). Herbal treatments are considered much safer than conventional allopathic drugs and have far fewer side effects (Modak and Chattoraj 2015). It is because herbal remedies have minimal side effects, and some often argue that herbal medicines are more effective in curing various diseases, ranging from mild to severe illnesses (Kamaluddin 2016). Nutrition experts have shown that *wader* fish has a higher calorie, protein, and fat content than snapper fish, making it an attractive choice in a healthy diet. Additionally, the high content of healthy fats and omega-3 in *wader* fish is also considered effective in reducing high cholesterol levels in the human body (Fitriana and Setiawan 2023).

Omega-3 fatty acids are essential for the brain's growth, operation, and aging since they are in many physiological processes linked to neurogenesis, neurotransmission, and neuroinflammation. Omega-3 fatty acid deficiencies in the diet have been linked to a higher chance of developing mental conditions in humans, such as autism, attention-deficit/ hyperactivity disorder, bipolar disorder, schizophrenia, dementia, and depression (Lange 2020). The omega-3 fatty acids in *wader* fish significantly benefit human health. Some of its benefits include lowering blood pressure and blood lipid levels, reducing the risk of myocardial infarction, and improving the function of the human immune system and brain health. Additionally, it has been documented that omega-3 fatty acids play an important role in protecting the body from various mental disorders and the risk of cancer (Sedyaaw et al. 2024). In addition to being rich in omega-3, *wader* fish is also abundant in omega-6. According to Mustafa et al. (2015), *wader* fish is an important source of beneficial omega-3 and omega-6 fatty acids for health. Omega-6 is a polyunsaturated fatty acid essential for human health, with various benefits such as supporting growth and development, maintaining healthy skin and hair, and strengthening the immune system. Furthermore, omega-6 plays a role in optimal brain function by supporting communication between nerve cells, which is crucial for cognition and mood. A balanced intake of omega-6 can also help reduce the risk of heart disease by lowering LDL cholesterol levels and increasing HDL cholesterol levels, as well as helping to reduce inflammation and pain in people with arthritis (Balić et al. 2020). However, it is important to maintain a balance between omega-6 and omega-3 intake to avoid the risk of excessive inflammation and chronic diseases.

Table 2. Medicinal and health benefits of *wader* fish (*Puntius* spp.)

Medical use	Details	References
Antimicrobial	Mucus extract shows potential in inhibiting biofilm matrix structures and exhibits antibacterial activity against *E. coli*, *P. aeruginosa*, *B. subtilis*, and *S. aureus.*	(Patel et al. 2020)
Antioxidant	Contains high antioxidant activity, which helps in protecting cells from oxidative damage.	(Sarjubala et al. 2018)
Anti-inflammatory	Rich in omega-3 fatty acids, which reduce inflammation by suppressing the production of pro-inflammatory molecules such as eicosanoids and cytokines.	(Poggioli et al. 2023)
Immune system support	Omega-3 and omega-6 fatty acids, and high-quality protein and essential vitamins (A, D, E, K); support immune function.	(Mahanty et al. 2014)
Liver health	Enhances liver function by regulating typical liver enzymes (SGPT, SGOT, ALP, ACP) and supports detoxification processes.	(Kumar et al. 2021b)
Joint pain relief	Traditionally used to alleviate joint pain and inflammation, it is often combined with herbs like turmeric and ginger.	(Altaf et al. 2020)
Heart health	Omega-3 and omega-6 fatty acids in the fish help lower blood pressure and reduce the risk of heart disease.	(Sedyaaw et al. 2024)
Cognitive function	The high levels of omega-3 fatty acids contribute to improving cognitive function and brain health.	(Sedyaaw et al. 2024)
Cancer prevention	Omega-3 fatty acids have been documented to reduce the risk of certain cancers and protect the body from mental disorders.	(Sedyaaw et al. 2024)
Wound healing	Traditionally used for external wound healing and herbal treatments to enhance medicinal benefits.	(Altaf et al. 2020)

Antioxidant

Based on Table 2, antioxidants play a critical role in maintaining health by protecting cells from oxidative damage and supporting essential bodily functions (Huang et al. 2019). *Puntius* spp. or *wader* fish, is also recognized for its rich mineral content, including magnesium, potassium, and calcium, as well as its high antioxidant activity. This suggests that consuming *wader* fish offers not only high-quality protein but also significant benefits in terms of mineral intake, antioxidant support, and monounsaturated fatty acids, all of which may contribute positively to overall human health (Sarjubala et al. 2018). Research conducted by Bora and Chutia (2023) shows that the addition of Fermented Bamboo Shoot (FBS) extract in processed fish products can function to improve the immune system, help heart problems, reduce cholesterol levels, and reduce the risk of cancer. Apart from benefits for humans, *wader* fish also have benefits for providing animal feed. Based on research conducted by Subandiyono et al. (2018), feeding *wader* fish with feed mixed with pineapple extract can increase feed efficiency (FUE), Protein Efficiency Ratio (PER), weight and length growth (RGR and RGR-L) by up to 218.06%. Furthermore, adding curcumin extract, which has benefits as an antioxidant, anti-inflammatory, antimicrobial, anticancer, and nerve protector, into fish feed can also improve fish health and nutrition (Alagawany et al. 2021).

Antioxidants, especially those derived from natural sources, have been a major focus for preventing lipid peroxidation and protecting biomolecules from damage caused by free radicals. It has been proven that proteins and peptides derived from food have significant bioactive or physiological properties. In addition to providing essential nutrition, many peptides produced from plant or animal proteins, both in vitro and in vivo, have important regulatory roles in the human body (Majumdar et al. 2016). Colorimetric methods are commonly used to evaluate antioxidant activity in *wader* fish. These methods include testing Hydroxyl Radical Scavenging Activity (HRSA), DPPH radical scavenging, inhibition of Angiotensin-1 Converting Enzyme (ACE), and inhibition of lipid peroxidation (Chen et al. 2022). Additionally, lipids found in fish contain many Polyunsaturated Fatty Acid (PUFA) groups, making them highly susceptible to oxidation (Goswami et al. 2013). The lipids found in fish contain many Polyunsaturated Fatty Acids (PUFAs), such as omega-3 and omega-6. These fatty acids have double bonds that easily react with oxygen in the air, causing lipid oxidation. This oxidation process can change in the fish's taste, aroma, and color and decrease its nutritional quality and freshness. Moreover, lipid oxidation can also produce harmful compounds such as free radicals and aldehydes, which can damage body cells and increase the risk of chronic diseases such as cancer and heart disease. Therefore, due to the high content of PUFAs in fish lipids, they are susceptible to oxidation and need to be properly preserved to maintain their nutritional quality and freshness (Nayak et al. 2018).

Antibacterial

Antibacterial or antibiotics are compounds that can either stop or completely eradicate bacterial development. Infections that pose a risk to human health could be brought on by these microorganisms (Hoffman 2020).

Mucus extract from *wader* fish (*Puntius* spp.) has been shown to have the potential to inhibit biofilm matrix structures and exhibit antibacterial activity against several common pathogens, such as *Escherichia coli*, *Pseudomonas aeruginosa*, and *Bacillus subtilis*, with observed additive effects on *Staphylococcus aureus* (Patel et al. 2020). The strong antimicrobial quality of this extract is crucial for probiotic bacteria in combating pathogenic microorganisms (Haider et al. 2021), especially those related to gastrointestinal infections, such as *Salmonella typhi*, *S. aureus*, and *E. coli*. Sometimes, these microorganisms become foodborne pathogens that potentially infect humans with gastroenteritis. Probiotics produce several antimicrobial compounds, including conjugated bile salts, lactic acid, hydrogen peroxide, and other organic acids, which support their antimicrobial activity (Ngasotter et al. 2021). Thus, this research provides important insights into the potential application of mucus extract from *wader* fish in controlling the growth and spread of pathogenic microorganisms in natural environments or biological systems. The histological structure of the *wader*'s intestinal lining consists of the muscular tunica, serosal tunica, mucosal tunica, and submucosal tunica, which generally function for healthy digestion, nutrient absorption, and protection against infection (Nita and Retnoaji 2022).

Based on research conducted by Mahmud et al. (2019), *wader* fish powder enriched with macro and micronutrients, especially protein, has been proven safe for consumption for a minimum of three months, based on biochemical content evaluation, sensory quality, and microbiological characteristics. Analysis of the biochemical composition of *wader* fish body (male and female) indicates the presence of lipids, proteins, ash, and carbohydrates. Furthermore, several important minerals, such as iron, zinc, copper, manganese, magnesium, calcium, phosphorus, potassium, and some amino acids, are also present in the body of these fish. Although male *wader* fish have higher protein (21.50%), fat (2.70%), ash (1.90%), and carbohydrate (1.55%) content, female *wader* fish have higher water content (75.60%), as well as higher concentrations of manganese and iron minerals, in line with findings reported by Musa (2009). This research provides a deeper understanding of the nutritional composition of *wader* fish in terms of gender, which can serve as an important basis for developing quality food products beneficial to human health.

Anti-inflammatory

The inflammatory response is a complex, multi-phase process involving a series of mediator signals and various cell types working in concert. This adaptive reaction can be triggered by dangerous signals such as tissue damage or microbial invasion, activating various inflammatory pathways (Meng et al. 2021). The primary goal of this response is to eliminate the initial cause of cell injury, clear out necrotic cells and tissues damaged from the original insult and the inflammatory process, and establish a repair process. Inflammation is intricately linked to cancer and plays a critical role in the growth, progression, and spread of tumors. Numerous studies have established that chronic inflammation can suppress the immune system, thus hindering its ability to fight off cancer cells effectively. This suppression extends to the response to chemotherapeutic treatments, reducing their efficacy and making cancer cells more resistant to such therapies (Zappavigna et al. 2020). Furthermore, chronic inflammation creates a microenvironment conducive to cancer development by promoting tumor growth, facilitating angiogenesis (the formation of new blood vessels that supply the tumor with nutrients and oxygen), and enabling metastasis (the spread of cancer cells to other parts of the body).

Wader fish (*Puntius* spp.) is rich in omega-3 fatty acids, such as EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid). Omega-3 has strong anti-inflammatory properties and can reduce inflammation by suppressing the production of molecules and substances that promote inflammation, such as eicosanoids and cytokines (Poggioli et al. 2023). Eicosanoids are diverse bioactive lipid mediators from Polyunsaturated Fatty Acids (PUFAs) with 20 carbon atoms. These molecules are crucial in various physiological and pathological processes, including inflammation, immunity, and homeostasis. Eicosanoids are produced through the enzymatic oxidation of PUFAs, primarily arachidonic acid, via three major pathways: the cytochrome P450 (cytP450) pathway, the lipoxygenase (LOX) pathway, and the cyclooxygenase (COX) pathway (Calder 2016).

Immunity and liver health

The immune system plays a critical role in protecting the body against pathogens and in the initiation and management of cancer. While the adaptive immune system's immunosurveillance can effectively prevent or limit cancer development, the innate immune system and inflammation often play dual roles in carcinogenesis and the progression of early-stage cancer (Galasso et al. 2024). The liver is the most important organ in maintaining the body's defense against various organic and inorganic toxic substances. Changes in typical liver enzyme activities, such as SGPT, SGOT, ALP, and ACP, are often used as strong markers for liver diseases (Kumar et al. 2021b). Meanwhile, the immune system's capacity to effectively recognize specific pathogens and develop immunological memory is called adaptive immunity or specific immunity. According to Shaalan et al. (2016), the use of nanoparticles in the medical field has been discovered, including drug and gene delivery, immunization, and diagnostics. The complex interaction between genes, proteins, cytokines, and cells forms the body's response when interacting with antibodies and antigens (Awad and Awaad 2017). The respiratory burst activity, which occurs when phagocytes produce Reactive Oxygen Species (ROS), is an important part of the innate immune response and antioxidants. This ROS production burst is a crucial defense mechanism in the body's immune system, contributing to the overall ability of the body to fight infections effectively (Yogeshwari et al. 2015).

Wader fish has several nutritional components that can enhance and maintain the immune system and overall health, including various vitamins. *Wader* fish is rich in vitamins such as A, D, E, and K (Mahanty et al. 2014). These vitamins play a crucial role in maintaining immune function and consuming foods rich in mineral fibers such as zinc and selenium is also important, as it boosts the immune system. Sarojnalini and Devi (2014) state that *wader* fish is abundant in eleven essential mineral elements. Moreover, *wader* fish is a good source of high-quality protein containing essential amino acids essential for human health (Sarjubala et al. 2018). Protein from fish sources is necessary for building and repairing immune cells. According to Mustafa et al. (2015), *wader* fish is a valuable source of beneficial omega-3 and omega-6 fatty acids for health. Omega-3 from fish helps reduce inflammation and protect cells from damage. This nutritional balance, along with the intake of complex carbohydrates and vitamin A supporting skin and mucous membrane health, is crucial for strengthening the immune system.

CONCLUDING REMARKS

Puntius spp., or *wader* fish, is a highly affordable and nutrient-rich source of animal protein in Southeast Asia. It is rich in essential amino acids and Polyunsaturated Fatty Acids (PUFAs) like omega-3 and omega-6, crucial for cardiovascular and cognitive health. In addition, this fish is a valuable source of vitamins and minerals such as iron, zinc, magnesium, and calcium, which collectively support brain development and immune function and reduce the risk of heart disease. The traditional use of *wader* fish in medicine is supported by the antimicrobial properties of its mucus, which are effective against pathogens like *E. coli* and *S. aureus*. This not only highlights its nutritional value but also its significance in the cultural heritage of Southeast Asia. However, while *wader* fish has shown great promise in these areas, significant gaps in current research must be addressed. The specific mechanisms by which bioactive compounds in this fish contribute to human health, particularly its antimicrobial, antioxidant, and anti-inflammatory properties, are not yet fully understood. Longitudinal studies are necessary to explore the long-term health outcomes associated with regular consumption of *wader* fish, including its effects on cardiovascular health, cognitive function, and immune response. Additionally, research into the environmental sustainability of increasing *wader* fish cultivation would help assess its viability as a long-term food and medicinal resource. Future research should aim to provide more detailed quantitative data on the fish's nutritional composition and examine its medicinal potential in modern health care. Addressing these gaps will provide a more comprehensive understanding of *wader* fish and ensure its continued role in promoting human health while preserving cultural practices. Therefore, while *wader* fish remains a staple in the daily diet of local communities, its full potential can only be realized through further scientific inquiry.

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REFERENCES

Adiyanda R, Yusfiati Y. 2014. Analisis isi lambung ikan lais janggut (*Kryptopterus limpok*, Bleeker 1852) di Sungai Tapung Hilir Propinsi Riau. JOM FMIPA 1 (2): 511-524. [Indonesian]

Ahmad FFR. 2021. Konsentrasi Kalsium Serum dengan Fungsi Paru Penderita Penyakit Paru Obstruksi Kronik (PPOK). CV. Azka Pustaka, Pasaman Barat. DOI: 10.33221/jikm.v9i01.488. [Indonesian]

Alagawany M, Farag MR, Abdelnour SA, Dawood MAO, Elnesr SS, Dhama K. 2021. Curcumin and its different forms: A review on fish nutrition. Aquaculture 532: 736030. DOI: 10.1016/j.aquaculture.2020.736030.

Ali AAH. 2023. Overview of the vital roles of macro minerals in the human body. J Trace Elem Min 4: 100076. DOI: 10.1016/j.jtemin.2023.100076.

Altaf M, Abbasi AM, Umair M, Amjad MS, Irshad K, Khan AM. 2020. The use of fish and herptiles in traditional folk therapies in three districts of Chenab riverine area in Punjab, Pakistan. J Ethnobiol Ethnomed 16: 38. DOI: 10.1186/s13002-020-00379-z.

Andhikawati A, Junianto J, Permana R, Oktavia Y. 2021. Komposisi gizi ikan terhadap kesehatan tubuh manusia. Marinade 4 (2): 76-84. DOI: 10.31629/marinade.v4i02.3871. [Indonesian]

Apriliani R, Basuki F, Nugroho RA. 2018. Pengaruh pemberian recombinant Growth Hormone (rGH) dengan dosis berbeda pada pakan buatan terhadap pertumbuhan dan kelulushidupan benih ikan tawes (*Puntius* spp.). Sains Akuakultur Tropis: Indones J Trop Aquac 2 (1): 49-58. DOI: 10.14710/sat.v2i1.2561. [Indonesian]

Ardiansyah A, Setiawan A, Rohmah MF, Khasanah MLN, Kharomah S, Sari YC, Fardhani I. 2024. Keanekaragaman ikan dan tumbuhan air tawar di Sumber Gentong, Kecamatan Pakis, Kabupaten Malang. Biota: Jurnal Ilmiah Ilmu-Ilmu Hayati 9 (2): 172-182. DOI: 10.24002/biota.v9i2.6649. [Indonesian]

Arfiati D, Hertika AMS, Lukito DA, Puspitasari AW. 2020. Haematology profile in silver barb (*Barbonymus gonionotus*) caught from Jagir River, Surabaya City, East Java, Indonesia. IOP Conf Ser: Earth Environ Sci 416 (1): 012008. DOI: 10.1088/1755-1315/416/1/012008.

Arunkumar AA, Sivaraman T, Manimekalan A. 2017. Species diversity and habitat inventory of *Puntius* spp. from various water bodies of South India. J Pharm Sci Res 9 (10): 1775-1784.

Awad E, Awaad A. 2017. Role of medicinal plants on growth performance and immune status in fish. Fish Shellfish Immunol 67 (1): 40-54. DOI: 10.1016/j.fsi.2017.05.034.

Azmy U, Mundiastuti L. 2018. Konsumsi zat gizi pada balita stunting dan non-stunting di Kabupaten Bangkalan. Amerta Nutr 2 (3): 292-298. DOI: 10.2473/amnt.v2i3.2018.292-298. [Indonesian]

Azzahra ZF, Soegianto VR, Albarra MZ, Puspitasari KL, Anggita BA, Ambarwati ED, Arisman AF, Rahma KDA, Akbar S, Anggraini DD. 2024. Sosialisasi inovasi pembuatan kerupuk ikan wader sebagai upaya pengembangan produk komoditas perikanan. Jurnal Akademik Pengabdian Masyarakat 2 (5): 14-21. DOI: 10.61722/japm.v2i5.2361. [Indonesian]

Balić A, Vlašić D, Žužul K, Marinović B, Bukvić Mokos Z. 2020. Omega-3 versus omega-6 polyunsaturated fatty acids in the prevention and treatment of inflammatory skin diseases. Intl J Mol Sci 21 (3): 741. DOI: 10.3390/ijms21030741.

Bora G, Chutia SJ. 2023. The notion of pickling fish using Fermented Bamboo Shoot (FBS) extracts. Chron Aquat Sci 1 (4): 36-47.

Borah BC. 2019. Small indigenous freshwater fish species in nutrition of ethnic population of North East India. Acta Sci Nutr Health 3 (7): 158-167.

Budiantoro A, Sari LR, Suwartiningsih N. 2024. The fish diversity in Code River, Bantul Regency, Yogyakarta special region. AIP Conf Proc 3001 (1): 030022. DOI: 10.1063/5.0189449.

Calder PC. 2016. Eicosanoids. Essays Biochem 64 (3): 423-441. DOI: 10.1042/EBC20190083.

Candra A. 2018. Suplementasi seng untuk pencegahan penyakit infeksi. J Nutr Health 6 (1): 31-36. DOI: 10.14710/jnh.6.1.2018.31-36. [Indonesian]

Chavan S, Kumbhar A. 2020. Breeding ecology of river tern (*Sterna aurantia*) at Ujjani-Bhigwan reservoir bird sanctuary near Pune-Solapur Highway, India. Asian J Conserv Biol 9 (2): 1-10.

Chen J, Jayachandran M, Bai W, Xu B. 2022. A critical review on the health benefits of fish consumption and its bioactive constituents. Food Chem 369: 130874. DOI: 10.1016/j.foodchem.2021.130874.

Cuenca-Sánchez M, Navas-Carrillo D, Orenes-Piñero E. 2015. Controversies surrounding high-protein diet intake: Satiating effect and kidney and bone health. Adv Nutr 6 (3): 260-266. DOI: 10.3945/an.114.007716.

Damayanti P, Bhagawati D, Setyaningrum N. 2022. Identifikasi dan kekerabatan fenotipe ikan familia Cyprinidae asal Waduk Sempor, Jawa Tengah. Ekotonia: Jurnal Penelitian Biologi, Botani, Zoologi dan Mikrobiologi 7 (1): 1-14. DOI: 10.33019/ekotonia.v7i1.3138. [Indonesian]

Darmanto H. 2019. Pengenalan spesies ikan berdasarkan kontur otolith menggunakan convolutional neural network. Joined J 2 (1): 41-59. DOI: 10.31331/joined.v2i1.847. [Indonesian]

Dawson N, Coolsaet B, Sterling E et al. 2021. The role of Indigenous peoples and local communities in effective and equitable conservation. Ecol Soc 26 (3): 19. DOI: 10.5751/ES-12625-260319.

Desrita D, Muhtadi A, Tamba IS, Ariyanti J, Sibagariang RD. 2018. Community structure of nekton in the upstream of Wampu Watershed, North Sumatra, Indonesia. Biodiversitas 19 (4): 1366-1374. DOI: 10.13057/biodiv/d190424.

El Bahgy HE, Elabd H, Elkorashey RM. 2021. Heavy metals bioaccumulation in marine cultured fish and its probabilistic health hazard. Environ Sci Pollut Res 28 (1): 41431-41438. DOI: 10.1007/s11356-021-13645-8.

Faas MM, De Vos P. 2020. Mitochondrial function in immune cells in health and disease. Biochim Biophys Acta-Mol Basis Dis 1866 (10): 165845. DOI: 10.1016/j.bbadis.2020.165845.

Fakhrurrozi Y, Kurniawan A, Kurniawan A. 2016. Pengembangan potensi ikan cempedik di Belitung Timur: Suatu pendekatan biologis dan etnobiologi. Script Biol 3 (4). DOI: 10.20884/1.sb.2016.3.4.49. [Indonesian]

Fazio F. 2019. Fish hematology analysis as an important tool of aquaculture: A review. Aquaculture 500: 237-242. DOI: 10.1016/j.aquaculture.2018.10.030.

Fiqriani RA, Halang B, Mahrudin M. 2023. Pengembangan bahan ajar berbentuk e-booklet keanekaragaman Famili Cyprinidae sebagai bahan pengayaan konsep Animalia di SMA. JUPEIS: Jurnal Pendidikan dan Ilmu Sosial 2 (1): 14-28. DOI: 10.57218/jupeis.Vol2.Iss1.410. [Indonesian]

Firmansyah MA, Werdiningsih I, Purwanto P. 2015. Perbedaan daya makan ikan wader pari (*Rasbora argyrotaenia*), ikan wader bintik dua (*Puntius binotatus*), dan ikan kepala timah (*Aplocheilus panchax*) sebagai predator jentik nyamuk *Aedes* sp. Sanitasi: Jurnal Kesehatan Lingkungan 6 (4): 151-156. DOI: 10.29238/sanitasi.v6i4.837. [Indonesian]

Fitri AS, Fitriana YAN. 2020. Analisis senyawa kimia pada karbohidrat. Sainteks 17 (1): 45-52. DOI: 10.30595/sainteks.v17i1.8536. [Indonesian]

Fitri N, Chan SXY, Che Lah NH et al. 2022. A comprehensive review on the processing of dried fish and the associated chemical and nutritional changes. Foods 11 (19): 2938. DOI: 10.3390/foods11192938.

Fitriana NHI, Setiawan RF. 2023. Analisis nilai tambah dan strategi pengembangan usaha keripik wader pada Usaha Mikro, Kecil, dan Menengah (UMKM) di Kecamatan Wonorejo Kota Surabaya. Berkala Ilmiah AGRIDEVINA 12 (2): 77-87. DOI: 10.33005/agridevina.v12i2.4311. [Indonesian]

Galasso L, Cerrito L, Maccauro V, Termite F, Ainora ME, Gasbarrini A, Zocco MA. 2024. Hepatocellular carcinoma and the multifaceted relationship with its microenvironment: Attacking the hepatocellular carcinoma defensive fortress. Cancers 16 (10): 1837. DOI: 10.3390/cancers16101837.

Ghosh AK, Panda SK, Luyten W. 2021. Anti-vibrio and immune-enhancing activity of medicinal plants in shrimp: A comprehensive review. Fish Shellfish Immunol 117: 192-210. DOI: 10.1016/j.fsi.2021.08.006.

Godswill AG, Somtochukwu IV, Ikechukwu AO, Kate EC. 2020. Health benefits of micronutrients (vitamins and minerals) and their associated deficiency diseases: A systematic review. Intl J Food Sci 3 (1): 1-32. DOI: 10.47604/ijf.1024.

Goswami P, Mandal P, Jha P, Misra T, Barat S. 2013. Antioxidant activities of different spices on the lipid oxidation of cooked and uncooked fillet of two fish species belonging to the genus *Puntius*. J Agric Sci Technol 15 (4): 737-746.

Goswami S, Manna K. 2019. Nutritional analysis and overall diet quality of fresh and processed (Sun-dried and fermented) *Puntius sophore*. Curr Res Nutr Food Sci 7 (2): 360-368. DOI: 10.12944/CRNFSJ.7.2.06.

Grenz JB. 2020. Healing the Land by Reclaiming an Indigenous Ecology: A Journey Exploring the Application of the Indigenous Worldview to Invasion Biology and Ecology. [Doctoral dissertation]. University of British Columbia, Vancouver. DOI: 10.14288/1.0394715.

Gupta D, Dwivedi AK, Tripathi M. 2018. Taxonomic validation of five fish species of subfamily Barbinae from the Ganga River system of northern India using traditional and truss analyses. PLoS ONE 13 (10): e0206031. DOI: 10.1371/journal.pone.0206031.

Haider MN, Bhattacharjee S, Shikha FH, Hossain I. 2021. Bacterial count and proximate composition of an Indian sub-continental freshwater barb, punti (*Puntius sophore*) and a gangetic catfish, gulsha (*Mystus cavasius*) during drying-up process. J Aquat Food Prod Technol 30 (4): 474-483. DOI: 10.1080/10498850.2021.1896613.

Hananiah N, Rahim AA. 2022. The application of hurdle technology in extending the shelf life and improving the quality of fermented freshwater fish (Pekasam): A review. Malays J Sci Health Technol 8 (1): 44-54. DOI: 10.33102/mjosht.v8i1.240.

Haryono H. 2006. Studi morfometri ikan wader goa (*Puntius microps* Gunther, 1868) yang unik dan dilindungi Undang-Undang. Berkala Penelitian Hayati 12 (1): 51-55. DOI: 10.23869/bphjbr.12.1.20069. [Indonesian]

Hasan T, Hossain MF, Mamun M, Alam MJ, Salam MA, Rafiquzzaman SM. 2018. Reproductive biology of *Puntius sophore* in Bangladesh. Fishes 3 (2): 22. DOI: 10.3390/fishes3020022.

Hertika AMS, Arfiati D, Lusiana ED, Putra RBDS, Wasti DRN. 2021. Health evaluation of *wader* fish (*Puntius* spp.) caught from Brantas River, Malang City, Indonesia. IOP Conf Ser: Earth Environ Sci 934 (1): 012059. DOI: 10.1088/1755-1315/934/1/012059.

Hodar AR, Vasava R, Mahavadiya D, Joshi N, Nandaniya V, Solanki H. 2021. Herbs and herbal medicines: A prominent source for sustainable aquaculture. J Exp Zool India 24 (1): 719-732.

Hoffman PS. 2020. Antibacterial Discovery: 21st Century Challenges. Antibiotics 9 (5): 213. DOI: 10.3390/antibiotics9050213.

Hossain M, Pramanik M, Uddin N, Hossen M, Nawer F, Khatun D. Ahamed F. 2018. Life-history traits of pool barb *Puntius sophore* (Cyprinidae) in different Ecosystems of Bangladesh. Indian J Geo-Mar Sci 47 (07): 1446-1454. DOI: 10.31629/marinade.v4i02.3871.

Huang Q, Liu H, Suzuki K, Ma S, Liu C. 2019. Linking what we eat to our mood: A review of diet, dietary antioxidants, and depression. Antioxidants 8 (9): 376. DOI: 10.3390/antiox8090376.

Iqbal KJ, Umair M, Altaf M, Hussain T, Ahmad RM, Abdeen SMZU, Pieroni A, Abbasi AM, Ali S, Ashraf S, Amjad N, Khan AM, Bussmann RW. 2023. Cross-cultural diversity analysis: Traditional knowledge and uses of freshwater fish species by indigenous peoples of Southern Punjab, Pakistan. J Ethnobiol Ethnomed 19: 4. DOI: 10.1186/s13002-022-00573-1.

Islam MR, Baten MA, Newaz A. 2022. Sensory and physico-chemical quality evaluation of traditional, improved and commercially dried *Puntius sophore*. Intl J Anim Resour 2 (1): 52-61.

Islamiati U, Anggi V, Insani NN. 2024. Edukasi pemanfaatan makanan sumber protein terhadap tumbuh kembang anak di Desa Sejahtera. Jurnal Pengabdian Kepada Masyarakat Nusantara 5 (1): 588-592. DOI: 10.55338/jpkmn.v5i1.2681. [Indonesian]

Kamaluddin MT. 2016. Obat herbal berkhasiat, keamanan perlu dimonitor. J Indones Med Assoc 66 (10): 461-464. [Indonesian]

Kant KR, Gupta K, Langer S. 2016. Fecundity in fish *Puntius sophore* and relationship of fecundity with fish length, fish weight and ovary weight from Jammu water bodies J and K (India). Intl J Fish Aquac Sci 6: 99-110.

Kapuri R, Sinha AK, De P, Bhakat S. 2020. Diversity of *Puntius* spp. (Cyprinidae: Cypriniformes) collected from Banshlai River, Birbhum, West Bengal, India. Intl J Fish Aquat Stud 8 (2): 34-41.

Kartika AGD, Pratiwi WSW, Indriawati N, Jayanthi OW. 2019. Analisis kadar magnesium dan kalium pada garam rich minerals. Rekayasa 12 (1): 1-4. DOI: 10.21107/rekayasa.v12i1.5094. [Indonesian]

Kjelland ME, Woodley CM, Swannack TM, Smith DL. 2015. A review of the potential effects of suspended sediment on fishes: potential dredging-related physiological, behavioral, and transgenerational implications. Environ Syst Decis 35 (3): 334-350. DOI: 10.1007/s10669-015-9557-2.

Kottelat M, Whitten AJ, Nurani KS, Soetikno W. 1993. Freshwater Fishes of Western Indonesia and Sulawesi. Periplus Editions Ltd, Hong Kong.

Kristanto AH, Gustiano R, Sugama K. 2014. Pembenihan Ikan Air Tawar Asli di Perairan Indonesia. AMaFRaD Press, Jakarta. [Indonesian]

Kumar J, Datta SN, Tewari G, Hassan SS, Dubey S. 2021a. Population dynamics of *Puntius sophore* (Hamilton, 1822) of river Sutlej in Punjab (India). Environ Biol 42 (6): 1505-1511. DOI: 10.22438/jeb/42/6/MRN-1654.

Kumar S, Moniruzzaman M, Chakraborty A, Sarbajna A, Chakraborty SB. 2021b. Crosstalk between heat shock proteins, NRF2, NF-κB and different endogenous antioxidants during lead-induced hepatotoxicity in *Puntius ticto*. Aquat Toxicol 233: 105771. DOI: 10.1016/j.aquatox.2021.105771.

Lange KW. 2020. Omega-3 fatty acids and mental health. Glob Health J 4 (1): 18-30. DOI: 10.1016/j.glohj.2020.01.004.

Lubis K, Sudibyo M, Siregar EH, Laili N. 2021. Short Communication: Morphological study of the scales of *Barbodes* cf. *binotatus* (Cyprinidae) from Toba Lake, Indonesia by using Scanning Electron Microscopy-Energy Dispersive Spectroscopy (SEM-EDS). Biodiversitas 22: 3821-3828. DOI: 10.13057/biodiv/d220927.

Maggini S, Óvári V, Ferreres GI, Pueyo AMG. 2021. Beneficios de la suplementación con micronutrientes sobre el estado nutricional, el metabolismo energético y el bienestar subjetivo. Nutr Hosp 38 (2): 3-8. DOI: 10.20960/nh.03788.

Mahanty A, Ganguly S, Verma A, Sahoo S, Mitra P, Paria P, Mohanty BP. 2014. Nutrient profile of small indigenous fish *Puntius sophore*: proximate composition, amino acid, fatty acid and micronutrient profiles. Natl Acad Sci Lett 37: 39-44. DOI: 10.1007/s40009-013-0186-3.

Mahardhika DNK, Samsuria IK, KSL EKE. 2019. Perbedaan kadar magnesium dan klorida pre dan post hemodialisis. Jurnal Kedokteran Diponegoro 8 (1): 588-595. DOI: 10.14710/dmj.v8i1.23463. [Indonesian]

Mahmud N, Al-Fuad S, Satya SI, Mamun AAl, Ahmed S, Karim A, Islam M, Ferdaus J, Islam S, Sakib N, Yeasmin J. 2019. Development and biochemical composition assessment of fish powders from Bangladeshi Indigenous fish species and shelf-life characteristics evaluation during 90 days of room temperature (27°C-30°C) storage. Food Nutr Sci 10 (08): 963-984. DOI: 10.4236/fns.2019.108069.

Majumdar RK, Roy D, Bejjanki S, Bhaskar N. 2016. Chemical and microbial properties of shidal, a traditional fermented fish of Northeast India. J Food Sci Technol 53 (1): 401-410. DOI: 10.1007/s13197-015-1944-7.

Majumdar RK, Roy D, Shitole S, Bhaskar N. 2017. Scientific evaluation of Shidal technology-An age old traditional practice of fish preservation of Northeast India. J Tradit Folk Pract 5 (1): 193-196. DOI: 10.25173/jtfp.2017.5.1.61.

Masykuri MF. 2025. Keanekaragaman morfologi Ikan Wader (Famili Cyprinidae) di Kabupaten Bantul, Daerah Istimewa Yogyakarta. [Thesis]. Universitas Sebelas Maret. [Indonesian]

Matsuura K. 2015. Taxonomy and systematics of tetraodontiform fishes: A review focusing primarily on progress in the period from 1980 to 2014. Ichthyol Res 62: 72-113. DOI: 10.1007/s10228-014-0444-5.

Maulu S, Nawanzi K, Abdel-Tawwab M, Khalil HS. 2021. Fish nutritional value as an approach to children's nutrition. Front Nutr 8: 780844. DOI: 10.3389/fnut.2021.780844.

Mazrouh MM. 2015. Effects of freezing storage on the biochemical composition in muscles of *Saurida undosquamis* (Richardson, 1848) comparing with imported frozen. Intl J Fish Aquat Stud 3 (2): 295-299.

Meng T, Xiao D, Muhammed A, Deng J, Chen L, He J. 2021. Anti-Inflammatory action and mechanisms of resveratrol. Molecules 26 (1): 229. DOI: 10.3390/molecules26010229.

Miranda R, Miqueleiz I. 2021. Ecology and conservation of freshwater fishes biodiversity: Weneed more knowledge to develop conservation strategies. Water 13 (14): 1929. DOI: 10.3390/w13141929.

Modak BK, Chattoraj P. 2015. Study on treatment of fin rot in cultured *Puntius sophore* (Ham.) using extract of neem (*Azadirachta indica*) leaves. J Environ Sociobiol 1 (1): 29-33.

Mohanta KN, Mohanty SN, Jena AJ. 2007. Protein-sparing effect of carbohydrate in silver barb, *Puntius gonionotus* fry. Aquac Nutr 13 (4): 311-317. DOI: 10.1111/j.1365-2095.2007.00482.x.

Mohanta KN, Mohanty SN, Jena J, Sahu NP, Patro B. 2009. Carbohydrate level in the diet of silver barb, *Puntius gonionotus* (Bleeker) fingerlings: Effect on growth, nutrient utilization and whole body composition. Aquac Res 40 (8): 927-937. DOI: 10.1111/j.1365-2109.2009.02186.x.

Mohanty BP, Ganguly S, Mahanty A et al. 2016. DHA and EPA content and fatty acid profile of 39 food fishes from India. BioMed Res Intl 2016: 4027437. DOI: 10.1155/2016/4027437.

Mulya W, Mulyana W, Sari IP, Yuliana L. 2023. Meningkatkan sistem kekebalan tubuh terhadap infeksi saluran pernapasan melalui vaksinasi. Eunoia 2 (1): 79-83. [Indonesian]

Munandar K, Eurika N. 2016. Keanekaragaman ikan yang bernilai ekonomi dan kandungan logam berat Pb dan Cd pada ikan sapu-sapu di Sungai Bedadung Jember. Proc Biol Educ Conf 13 (1): 717-722. [Indonesian]

Musa A. 2009. Nutritional quality components of Indigenous freshwater fish species, *Puntius stigma* in Bangladesh. Bangladesh J Sci Ind Res 44 (3): 367-370. DOI: 10.3329/bjsir.v44i3.4412.

Mustafa T, Naser MN, Murshed S, Farhana Z, Akter M, Ali L. 2015. Fatty acid composition of three small indigenous fishes of Bangladesh. Bangladesh J Zool 43 (1): 85-93. DOI: 10.3329/bjz.v43i1.26141.

Nayak M, Saha A, Pradhan A, Samanta M, Mohanty TK, Giri SS. 2018. Influence of dietary lipid levels on growth, nutrient utilization, tissue fatty acid composition and desaturase gene expression in silver barb (*Puntius gonionotous*) fingerlings. Comp Biochem Physiol B Biochem Mol Biol 226: 18-25. DOI: 10.1016/j.cbpb.2018.08.005.

Ngasotter S, Waikhom D, Sharma S, Meitei MM, Mangang YA, Irungbam SK, Bhuneshwar, Devi MS, Singh AS. 2021. Characteristics and mechanism of potential probiotics with special reference to lactic acid bacteria from traditional fermented fish products: A review. J Exp Biol Agric Sci 9 (3): 263-275. DOI: 10.18006/2021.9(3).263.275.

Nita JAF, Retnoaji B. 2022. The effect of chlorpyrifos insecticide on the histological structure of *wader pari* fish intestine (*Rasbora lateristriata* Bleeker, 1854). Jurnal Pengelolaan Sumberdaya Alam dan Lingkungan 12 (1): 1-11. DOI: 10.29244/jpsl.12.1.1-11.

Ofoedu CE, Iwouno JO, Ofoedu EO et al. 2021. Revisiting food-sourced vitamins for consumer diet and health needs: A perspective review, from vitamin classification, metabolic functions, absorption, utilization, to balancing nutritional requirements. PeerJ 9: e11940. DOI: 10.7717/peerj.11940.

Patel M, Ashraf MS, Siddiqui AJ, Ashraf SA, Sachidanandan M, Snoussi M, Adnan M, Hadi S. 2020. Profiling and role of bioactive molecules from *Puntius sophore* (freshwater/brackish fish) skin mucus with its potent antibacterial, antiadhesion, and antibiofilm activities. Biomolecules 10 (6): 920. DOI: 10.3390/biom10060920.

Patra A, Sarker S, Banerjee S, Adikesavalu H, Biswas D, Abraham TJ. 2016. Rapid detection of *Flavobacterium columnare* infection in fish by species-specific polymerase chain reaction. J Aquac Res Dev 7: 445. DOI: 10.4172/2155-9546.1000445.

Pepino MY, Kuda O, Samovski D, Abumrad NA. 2014. Structure-function of CD36 and importance of fatty acid signal transduction in fat metabolism. Ann Rev Nutr 34: 281-303. DOI: 10.1146/annurev-nutr-071812-161220.

Plamoottil M. 2016. *Puntius euspilurus*, a new fish species (Cypriniformes: Cyprinidae) from Kerala, India. Intl J Res Stud Biosci 4 (9): 1-6. DOI: 10.20431/2349-0365.0409001.

Poggioli R, Hirani K, Jogani VG, Ricordi C. 2023. Modulation of inflammation and immunity by omega-3 fatty acids: A possible role for prevention and to halt disease progression in autoimmune, viral, and age-related disorders. Eur Rev Med Pharmacol Sci 27 (15): 7380-7400. DOI: 10.26355/eurrev_202308_33310.

Prajapati PS, Ahirwal SK, Singh J, Chakraborty SK, Jaiswar AK, Sreekanth GB. 2022. Biometric analysis of white sardine *Escualosa thoracata* (Valenciennes, 1847) from Goa Coast, India. Indian J Fish 69 (3): 150-154. DOI: 10.21077/ijf.2022.69.3.121378-18.

Prasetyo A, Retnoaji B. 2020. Migration biomodelling of *wader pari* fish (*Rasbora lateristriata* Bleeker, 1854) toward varied current direction and substrate type. AIP Conf Proc 2260 (1): 030005. DOI: 10.1063/5.0015701.

Pratami VA, Yulia, Setyono P, Sunarto. 2018. Zonasi, keanekaragaman dan pola migrasi ikan di Sungai Keyang, Kabupaten Ponorogo, Jawa Timur. Jurnal Ilmu Lingkungan 16 (1): 78-85. DOI: 10.14710/jil.16.1.78-85. [Indonesian]

Pratiwi AI, Husni A, Budhiyanti SA, Aji BR. 2017. Quality of cultured *wader* pari during storage at different temperature. Jurnal Pengolahan Hasil Perikanan Indonesia 20 (1): 123-130. DOI: 10.17844/jphpi.v20i1.16499. [Indonesian]

Purbomartono C, Husin A, Bagasnabila IS, Zularini FGD, Susiyani AT, Purwaningsih EP, Purnomo P. 2022. Efektivitas dan potensi herbal untuk peningkatan pertumbuhan benih lele dumbo (*Clarias gariepinus*). Sainteks 19 (2): 219-229. DOI: 10.30595/sainteks.v19i2.14903. [Indonesian]

Putri SS, Arya IW, Andriani ASPR. 2021. Morphometric character of *Puntius binotatus* (Pisces: Cyprinidae) fish as the Sungi River Conservation Base of Tabanan Regency Bali. Asian J Appl Res Community Dev Empower 5 (2): 1-4. DOI: 10.29165/ajarcde.v5i2.65.

Raharjeng ARP, Sani LPA, Harahap JO, Blatama D, Pratama SF, Adaninggar A, Saragih SG. 2022. Pengaruh chlorpyrifos terhadap perkembangan embrio ikan wader pari. Berkala Ilmiah Biologi 13 (2): 21-31. DOI: 10.22146/bib.v13i2.4766. [Indonesian]

Rahayu AD, Nugroho D. 2014. Pendekatan fenetik taksonomi dalam identifikasi kekerabatan dan pengelompokkan ikan Genus *Tor* di Indonesia. Bioedukasi 7 (1): 60-64. DOI: 10.20961/bioedukasi-uns.v7i1.2844. [Indonesian]

Rahayu DRUS, Piranti AS, Sihwaningrum I. 2019. Diversivikasi hasil olahan ikan lele di Desa Kaliwangi Kecamatan Purwojati Kabupaten Banyumas. Dinamika Journal: Pengabdian Masyarakat 1 (1): 54-61. DOI: 10.20884/1.dj.2019.1.1.602. [Indonesian]

Ramandha MEP, Muhsin LB. 2023. Analisis uji pemisahan Parasetamol dan Vitamin C pada sediaan tablet Farmasi menggunakan uji pemisahan Kromatografi Lapis Tipis. Jurnal Ilmu Kesehatan dan Farmasi 11 (1): 16-19. DOI: 10.51673/jikf.v11i1.1664. [Indonesian]

Roesma DI, Chornelia A, Mursyid A, Kamsi M. 2016. Fish diversity of the Batang Toru River System, south Tapanuli, North Sumatra. Biodiversitas 17: 628-634 DOI: 10.13057/biodiv/d170235.

Roesma DI, Chornelia A. 2014. Geographic variation of morphological characters in *Puntius lateristriga* (Valenciennes, 1842) from Sumatra and the adjacent island. Asian Conf Life Sci Sustain Off Proc 39 (1): 27-29.

Roesma DI, Tjong DH, Munir W, Aidil DR. 2018. New record species of *Puntius* (Pisces: Cyprinidae) from West Sumatra based on Cytochrome Oxidase I Gene. Intl J Adv Sci Eng Inf Technol 8 (1): 250-256. DOI: 10.18517/ijaseit.8.1.4170.

Sareharto TP, Wijayahadi N. 2016. Kadar vitamin E rendah sebagai faktor risiko peningkatan bilirubin serum pada neonatus. Sari Pediatri 11 (5): 355-362. DOI: 10.14238/sp11.5.2010.355-62. [Indonesian]

Sari MP, Dewi R. 2017. Pengaruh penambahan ikan wader pari (*Rasbora lateristriata*) terhadap sifat organoleptik kerupuk. Asuhan Kebidanan Ibu Hamil 5 (9): 57-67. [Indonesian]

Sarjubala W, Shantosh M, Romharsha H, Sarojnalini C. 2018. Nutritional properties of some freshwater fish species of Manipur, India. J Coldwater Fish 1 (1): 48-53.

Sarojnalini C, Devi WS. 2014. Antioxidant properties and nutritive values of raw and cooked pool barb (*Puntius sophore*) of Eastern Himalayas. Intl J Nutr Food Eng 8 (1): 8-12.

Schuetz-Miller MK. 2022. Tricksters unmasked. J Southwest 64 (1): 1-99. DOI: 10.1353/jsw.2022.0002.

Sedyaaw P, Koli JM, Sadawarte RK, Sawant SS, Vishwasrao VV. 2024. A review on nutritional benefits of fish on human health. Futur Trends Agric Eng Food Sci 3 (15): 98-107. DOI: 10.58532/V3BCAG15P1CH8.

Sentosa AA, Djumanto. 2010. Habitat pemijahan ikan wader pari (*Rasbora lateristriata*). Jurnal Ikhtiologi Indonesia 10 (1): 55-63. [Indonesian]

Setiyoko A, Nurdiarti RP, Nastain M. 2022. Diversifikasi produk olahan ikan wader dan manajemen usaha berbasis marketing online di BUMDes Margosari, Kulon Progo. Agrokreatif: Jurnal Ilmiah Pengabdian kepada Masyarakat 8 (1): 67-76. DOI: 10.29244/agrokreatif.8.1.67-76. [Indonesian]

Setyaningrum N, Sugiharto S, Susatyo, P. 2020. Komposisi dan status guild komunitas ikan di Waduk Sempor, Jawa Tengah. Depik 9 (3): 411-420. DOI: 10.13170/depik.9.3.15094. [Indonesian]

Shaalan M, Saleh M, El-Mahdy M, El-Matbouli M. 2016. Recent progress in applications of nanoparticles in fish medicine: A review. Nanomedicine 12 (3): 701-710. DOI: 10.1016/j.nano.2015.11.005.

Sheikhzadeh N, Soltani M, Heidarieh M, Ghorbani M. 2024. Role of dietary microalgae on fish health and fillet quality: Recent insights and future prospects. Fishes 9 (1): 26. DOI: 10.3390/fishes9010026.

Sibuea P. 2021. Kajian manfaat makanan fungsional di saat pandemi COVID-19. Jurnal Riset Teknologi Pangan dan Hasil Pertanian (RETIPA) 2 (1): 83-92. DOI: 10.54367/retipa.v2i1.1483. [Indonesian]

Su G, Maxime L, Jun X, Sheng T, Sebastian V, Sebastian B. 2021. Human impact on global freshwater fish biodiversity. Science 371 (1): 835-838. DOI: 10.1126/science.abd33.

Subandiyono, Hastuti S, Nugroho RA. 2018. Feed utilization efficiency and growth of Java barb (*Puntius javanicus*) fed on dietary pineapple extract. AACL Bioflux 11 (2): 309-318.

Sumiarsih E, Eddiwan K. 2018. Otolith growth pattern of *Puntius schwanenfeldii* from the Koto Panjang Reservoir, Regency of Kampar, Riau, Indonesia. Intl J Aquac Fish Sci 4 (2): 013-017. DOI: 10.17352/2455-8400.000037.

Susatyo P, Lestari W, Sugiharto S, Chasanah T. 2022. Reproductive aspects of javaen barb fish, *Systomus orphoides* in the initial domestication program. Biodiversitas 23 (3): 1511-1519. DOI: 10.13057/biodiv/d230340.

Tasik WF. 2022. Pengaruh suplementasi mineral seng Zn dalam pakan berbasis tepung darah terhadap gambaran darah ikan kerapu bebek *Cromileptes altivelis*. Jurnal Vokasi Ilmu-Ilmu Perikanan 2 (2): 65-70. DOI: 10.35726/jvip.v2i2.744. [Indonesian]

Tiwari M, Barooah MS, Sharma P, Bordoloi PL, Hussain IA, Ahmed AM. 2021. Physico–chemical characteristics of fish flour prepared from locally available small indigenous fish species of Assam. J Food Process Preserv 45 (9): e15704. DOI: 10.1111/jfpp.15704.

Utomo BSB, Taufik I, Kusmini II. 2023. Morphometric and genetic characterization of dominant fish species in Progo River, Yogyakarta, Indonesia. Sci World J 2023 (11): 7197251. DOI: 10.1155/2023/7197251.

Yang L, Sado T, Hirt MV et al. 2015. Phylogeny and polyploidy: resolving the classification of cyprinine fishes (Teleostei: Cypriniformes). Mol Phylogenet Evol 85: 97-116. DOI: 10.1016/j.ympev.2015.01.014.

Yogeshwari G, Jagruthi C, Anbazahan SM, Mari LSS, Selvanathan J, Arockiaraj J, Dhayanithi NB, Ajithkumar TT, Balasundaram C, Ramasamy H. 2015. Herbal supplementation diet on immune response in *Labeo rohita* against *Aphanomyces invadans*. Aquaculture 437: 351-359. DOI: 10.1016/j.aquaculture.2014.12.024.

Yustian I, Zulkifli H. 2022. Aquaculture ponds provide non-breeding habitat for shorebirds in Banyuasin Peninsula, South Sumatra, Indonesia. Wader Stud 129 (1): 31-38. DOI: 10.18194/ws.00265.

Zappavigna S, Cossu AM, Grimaldi A, Bocchetti M, Ferraro GA, Nicoletti GF, Filosa R, Caraglia M. 2020. Anti-inflammatory drugs as anticancer agents. Intl J Mol Sci 21 (7): 2605. DOI: 10.3390/ijms21072605.

Zhang Y, Zhou WE, Yan JQ, Liu M, Zhou Y, Shen X, Li GH. 2018. A review of the extraction and determination methods of thirteen essential vitamins to the human body: An update from 2010. Molecules 23 (6): 1484. DOI: 10.3390/molecules23061484.