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Review Article

Scientific Potential of Fish Species Used as Medicine by Indigenous and Non-Indigenous Groups of North East India: A Review with Supporting Research-Based Studies

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ABSTRACT

Background: Northeast India is rich in biodiversity, sustaining abundant aquatic fauna. The Indigenous and non-indigenous groups rely on their surrounding biosphere for food and medicines; they use numerous ichthyofauna in their environment to treat diseases. This review aims to compare the use of fish species in therapeutic practices by Indigenous and non-indigenous groups of Northeast India, and assess their scientific potential through available literature, moreover the review, highlights the fish resource management practices by these groups. **Materials and Methods:** Accessible literature from authentic sources like Scopus, Web of Science and Google Scholar etc., has been used to write this review. 53 articles were initially collected, but 38 articles were included based on pertinence to our study. **Conclusion:** This review recorded around 48 fish species with medicinal properties utilised by different communities in the states to cure diseases like anaemia, wounds, respiratory issues, and so forth. Out of 24 families, the Cyprinidae family appears to be highly utilised by numerous groups. The Bodo's of Assam leads in fish therapy, with approximately 41%, whereas tribes of Tripura utilise ichthyotherapy to a lesser extent compared to other groups of North East India. This study disclosed notable therapeutic compounds reported from fish, like docosahexaenoic acid, eicosapentaenoic acid and anticancer peptides. Furthermore, indigenous practices of conservation and sustainable utilization of fish resources have also been documented. More on-site research and documentation, scientific experiments to validate the medicinal properties of fish, their risk assessment, and effective conservation measures are the pressing need.

Keywords: Cyprinidae, Ichthyofauna, Northeast India, Therapeutic compounds.

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INTRODUCTION

The lush green vegetation covering the plateaus and hills of Northeast India and the different forms of water bodies such as the river system, lakes, beels/wetlands and swamps harbour a vast array of unique flora and fauna that gives it a distinct identity among the biodiversity hotspots of the world.[1] Latitudes 21°50'N to 29°34'N, and longitudes 85°34'E to 97°50'E, surrounds northeastern India.[2] Northeast India is a homeland for different ethnic groups, primarily hill tribes of mongoloid descent. The 2011 census reveals that 427 distinct tribal groups reside in the northeastern region of India.[3] Plants and animals have always been a part of the diverse cultures, religious practices, and native traditional knowledge of the residing ethnic groups.[4] The indigenous knowledge of medicinal practices has been instrumental in the primary health sector of ethnic groups residing in remote places. Approximately 80% of people worldwide depend upon traditional medicine derived from plants, animals, and their byproducts for the treatment of various diseases, as per the World Health Organisation (WHO).[5] Many variables, including affordability, accessibility, and cultural norms, could be the cause of most people's primary reliance on traditional remedies. Traditional medicine as defined by the World Health Organisation (WHO), encompasses the entirety of knowledge, expertise and customs rooted in indigenous theories, beliefs and experiences across diverse cultures.[6] Furthermore, both the Unani and Ayurvedic medical systems contain information on medications obtained from animals.[5] Ethnoichthyology a part of ethnozoology encompasses the traditional beliefs, food, medicinal value of fish and fish products, and its scientific validation.[4] The sustainable use of fish has been an important part of the residing tribe's diet, medicine, religious practices, and source of income, since time immemorial. There is ample evidence of how plentiful

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nutrients, whether protein, fatty acids, etc., are obtained from different parts of fish species, and their product.[7] There are over 267 different species of fish classified under 114 genera, 38 families, and 10 orders within the total ichthyofaunal diversity of northeast India.[1]

It is evident that, among all of the protein sources, fish is the most economical. In addition to its nutritional value, the native tribes of northeastern India employ fresh or preserved fish as medicine to treat a wide range of diseases, including asthma, heart disease, kala-azar, anaemia, malaria, smallpox, night blindness, rheumatoid arthritis, improved vision, tuberculosis, kidney stones, etc. Fish is used as medicine in raw form or preparing it with other foods, such as bamboo shoots, or applied topically to the affected region.[4,5,7-9] Different research papers suggest the importance of polyunsaturated fatty acids found in fishes, especially of omega-3 family. They exhibit several vital properties that can enhance the overall human health in terms of physiology and have been contributing towards decreased vulnerability to cancer and heart disease.[10] Even fermented fish such as 'Hukoti' is employed to treat diseases such as malaria; also, it acts as a painkiller.[11] An ethnic group's use of an exclusive system of medicine grants them special recognition that is crucial for the conservation and management of biological assets. Their rituals and religious practices tend to be in balance with nature, providing them enough time to restore.[7] This knowledge could be the foundation for creating novel medications to treat a range of illnesses.[4] This study aims to provide a comparative and scientific review of fish species used as traditional medicine by different Indigenous and non-indigenous groups of Northeast India recorded so far, also it throws light on the fish resource management practices by these groups This study and its analysis have implications for future experimental validation of the medicinal properties of fish species that may lead to the development of pharmaceuticals. Additionally, it marks the importance of risk assessments and their conservation, and sustainable management.

A comparative study of fish used as medicine by ethnic and non-ethnic groups of North East India

Two distinct studies were conducted among the Bodo tribes of Kokrajhar district that used fish with medicinal properties to treat a range of diseases. Among both the studies, the method used by Basumatary *et al.*, (2023) is more relevant as it statistically (Use value and Relative frequency of citation) signifies the prevalence and popularity of fish species as medicine among the tribes. But from both studies it can be observed that the Bodo tribes preferably use fishes belonging to the family Channidae and Cyprinidae, indicating their relative importance as ethnomedicine among them.[4,12] Another survey conducted among the Karbi inhabitants of Karbi anglong district revealed 4 species of fish from the family Cyprinidae and 1 species from the family Angullidae-were used for their medicinal properties. Moreover, a research further reported that the Karbi tribes in Diphu, Karbi Anglong, Assam used 16 species of fish from 12 families out of which 3 belong to the family Channidae and the remaining 9 species of fish belong to individual families, namely, Cyprinidae, Anabantidae, Heteropneustidae, Bagridae, Mastacembelidae, Synbranchidae, Clariidae, Belonidae, and Osphronemidae to treat 30 different diseases. Statistical analysis reveals, that fish species belonging to Cyprinidae family are mostly used as ethnomedicine among the Karbi group.[5,7] In another research study, the Indigenous and non-indigenous people of the Pobitora Wildlife Sanctuary, Morigaon, Assam, particularly those in the Nath and Karbi communities, use 8 different species of fish, classified into 7 families, Cyprinidae, Chacidae, Anabantidae, Synbranchidae, Channidae, Belonidae, and Notopteridae, to treat several diseases.[3] Similarly, the communities, namely, Chutiya, Ahom, Kalita, and Koch Rajbangsi residing in adjacent areas of Gibbon Wildlife Sanctuary, Assam, use 7 species of fish that are classified under 6 distinct families to restore health from 8 different symptoms and diseases.[13] The findings in another study, further indicate that Mising tribes of Dhemaji district, Assam, use 4 species of fish for therapeutic purposes, classified under 4 different families, to be specific, they belong to Cyprinidae, Anguillidae, Siluridae, and Gobiidae.[14] The Tangsa and Wancho tribes of Eastern Arunachal Pradesh employ 4 species of fish to cure a wide range of ailments. The Tangsa tribe uses 4 species of fish from Synbranchidae, Mastacembelidae, Cyprinidae, and Clariidae families; in contrast, the Wancho tribe uses only a single species of fish from the Mastacembelidae family.[15] Another field study shows that the tribes of Khowai district of Tripura utilise 2 fish species categorised in two families namely, Synbranchidae and Channidae to treat certain ailments.[16] Furthermore, it was observed that in the Bishnupur district of Manipur, 21 species of fish categorised under 11 families and 18 genera are used as traditional medicine to cure disease conditions and diseases by the different ethnic communities.[17] Fish is extensively used as medicine, by the Meitei communities, in Manipur, 7 types of ornamental fish species were used as folklore medicine belong to the family, Channidae, Cobitidae, Clariidae, Anguillidae, Synbranchidae and 2 species from Cyprinidae to treat a wide range of diseases such as anaemia, asthma, stomach ulcer, etc.[18] A list of different uses of many fish fauna by the ethnic communities of Northeast India in treating various ailments has been mentioned in Table 1.

The ethnomedicinal use of 2 fish species belonging to Cyprinidae, and Channidae has been observed to be most prevalent among all the ethnic tribes and people of other communities recorded so far. Moreover, if we compare further, fish species belonging to Cyprinidae family is most commonly utilized as ethnomedicine to treat a range of diseases among all the tribes recorded so far, indicating its relative ethnomedicinal importance among the ethnic and non-ethnic groups. Fish contains different vital properties, and functional elements that contribute to its

ethnomedicinal value, thereby helps preventing many diseases/ailments (Figure 1).

Scientific evidence that supports the uses of different fish species and their products as medicine

Validation of traditional knowledge plays a crucial role in the scientific management of diseases in the modern medical system; therefore, several research studies have provided scientific facts through experiments and analysis that are depicted henceforth.

The essential fatty acid docosahexaenoic acid (DHA) extracted from *Channa striatus* has been proven to be a nutraceutical with therapeutic benefits. Eicosapentaenoic acid and docosahexaenoic acid extracted from fish and fish oil have proven to be beneficial in improving many symptoms of skin disorders; moreover, they also aid in regulating prostaglandin metabolism. This study corresponds with the use of *Channa striatus* by Bodos to treat gastritis as proper prostaglandin metabolism can prevent gastritis and aid in wound healing.[4,19] An investigation of the *Monopterus albus* body and head oil reveals that significant concentration of docosahexaenoic acid (DHA) and arachidonic acid (AA). Supplements marketed for infants often contain docosahexaenoic acid and arachidonic acid. Therefore, *Monopterus* species have the potential to be used as a natural source of DHA and AA.[20] *Clarias batrachus* and *Heteropneustes fossilis* both contain significant amounts of monounsaturated fatty acid and polyunsaturated fatty acid and have sufficient amounts of Vitamin A and D.[21] A study reveals that the deficiency of Vitamin A slows down the process of wound healing by slowing down new collagen synthesis and its cross-linking. While its intake through diet can fasten the process of wound healing.[22] These findings provide a scientific perception of the use of *Heteropneustes fossilis* and *Clarias batrachus* by Bodos and Karbis and *Channa striatus* by Bodo as an ethno remedy for wound healing.[4,23] It is evident from research that the consumption of fish or fish oil, as it contains EPA and DHA in certain amounts, enhances fibrinolytic activity, which could be considerably beneficial in treating cardiovascular diseases. Clinical trials suggest that with the increase in intake of omega-3 fatty acid (EPA and DHA) rich foods, found in fish, such as *Anguilla* species, *Wallago aatu*, there is a reduction in the formation of Thromboxane A2 (TXA2), Leukotriene B4 (LTB4), IL-1, IL-6, Tumour Necrosis Factor (TNF), and C-reactive protein, which are linked to many diseases such as diabetes, obesity, cancer, autoimmune diseases, rheumatoid arthritis, and asthma.[24-26] These studies are in line with the number of remedies used by ethnic groups of Northeast India to treat several ailments. For example, *Anguilla bengalensis* is used to treat Rheumatoid arthritis by the Karbis while *Channa gachua* is used to treat the same by Bodos of Assam. Furthermore, *Wallago aatu* is used by Mising tribe to treat Asthmic trouble. In a recent study, 3 anti-cancer peptides were isolated from *Clarius magur* that possessed the potential to restrict the proliferation of cancer cells by causing apoptosis of cancer cells thus leading to their death.[27]

Fish resource management and conservation by Indigenous and non-indigenous groups

Different ethnic and non-ethnic groups have different management practices, and their own set of rules and regulations to safeguard their resources. The traditional fish management practices of Karbis are in harmony with nature. Their fishing period, tools, fishing nets, fish catching practices only by a particular group of people and its distribution to the entire village has aided in eliminating certain unsustainable, unethical and illegal practices such as over-exploitation, poisoning the water bodies by synthetic chemicals that are detrimental to the aquatic life. Their concept of not fishing during the spawning season, allows the aquatic life to revitalize. These practices and rituals are pivotal in the conservation and sustainable use of medicinally important fish.[7] However, due to the influence of technology and modern medications, traditional knowledge most of which is passed through word of mouth is gradually diminishing.[5] Some of the fish species with medicinal properties are already classified under concerning conservation status, the *Tor putitora* species is already enlisted in the endangered category, while *Osteobrama belangeri, Bagarius bagarius, Anguilla bengalensis* are categorised under near threatened.[6] The ethno ichthyological knowledge and efforts of indigenous tribes are significant in the protection and conservation of fish species. Additionally, awareness campaigns should be organized to make the Indigenous tribes more aware of the red-list species, so that they can further contribute to the protection, conservation and sustainable use of these species in their area.[3]

However, the increasing use of pesticides is a major concern for aquatic life.[28] Toxic chemicals from point and non-point sources contaminate surface water and sediments in streams, rivers, and lakes. Fat-soluble contaminants accumulate in the fatty tissues of fish through bioaccumulation, leading to potential health risks from consuming contaminated fish. These risks include carcinogenic (e.g., DDT, heptachlor) and non-carcinogenic contaminants (e.g., methyl mercury). Although these are in low concentrations in aquatic environments, fish concentrate them through bioaccumulation and biomagnification. Consumption of fish is a major exposure route for these contaminants.[29] Fish from polluted areas can carry heavy metals and pesticides.[30] High mercury levels might counteract the benefits of omega-3 fatty acids in fish. Eels effectively accumulate mercury due to their carnivorous diet, leading to both biomagnification and bioaccumulation. Mercury exposure, in certain populations (pregnant women, children), should be managed by avoiding species high in mercury (e.g., swordfish, shark).[31,32] Contaminants in fish can be transferred to humans, posing health risks, so developing methods to monitor these chemical and microbial contaminants before consumption is essential.[30]

Table 1: List of fish fauna used to treat a wide range of diseases by ethnic communities of Northeast India.[3-7,13-16,33-35]

Scientific name	Family	Local name	Part used	Disease/Ailments	Tribe/State
Amblypharyngodon mola	Cyprinidae	Nune	Head	Cooked head is eaten for the improvement of eyesight.	Karbis of Assam.
		Moaya	Flesh, Head	Boiled fish used to increase blood cells and stomach pain.	Bodos of Assam.
		Moa	Whole fish	Used to treat pain, pox, asthma etc.	Nearby tribes of Gibbon Assam.
				Helps to cure premenstrual pain.	Nearby tribes of Pobitora Assam
Anguilla bengalensis	Anguillidae	Nujung	Fats	Used to cure rheumatoidArthritis.	Karbis of Assam.
		Nangdor	Head	Used against piles.	Bodos of Assam.
Bangana dero	Cyprinidae	Nusem	Bile juice	Used to cure stomach ache.	Karbis of Assam.
Labeo pangusia	Cyprinidae	Nutun	Whole fish	Used as health tonic.	Karbis of Assam.
		Nyahnyal	Whole fish	Used as energy booster.	Tangsas of Arunachal Pradesh.
Puntius sp.	Cyprinidae	Ok-puthi	Head	Cooked head is used to improve memory power.	Karbis of Assam.
			Whole fish	Used as blood purifier too.	Karbis of Assam.
Anabas testudineus	Anabantidae	Kaowi	Whole fish	Used against jaundice, cold and fever.	Bodos of Assam.
		Kaoi mas	Whole fish	Used against menstrual cramps.	Karbis of Assam.
			Whole fish	Used in the treatment of Dysmenorrhoea	Nearby tribes of Pobitora Assam.
Badis badis	Badidae	Dusumwi	Flesh, Head	Used to treat postpartum respiratory issues.	Bodos of Assam.
Channa gachua	Channidae	Nasrai	Head	Used against several problems including arthritis, joint pain, low lactation etc.	Bodos of Assam.
		Cheng mas	Whole fish	Boiled fish eaten to cure abdominal pain.	Nearby areas of Pobitora Assam.
		Ok langso	Whole fish	Used in the treatment of abdominal pain and offered in religious function "Chojun".	Karbis of Assam.
Channa marulius	Channidae	Na sal	Flesh, Head	Used to improve haemoglobin in blood	Bodos of Assam
Channa punctata	Channidae	Na gwri	Flesh, Head	Used to reduce cold, fever and in the treatment of kidney stone.	Bodos of Assam.
		Ok-meklot	Eyes	Used to remove corn.	Karbis of Assam.
		Lati	Head	Used as sex stimulant.	Tribes of Tripura.
		Goroi mas	Whole fish	Used to treat tuberculosis.	Nearby tribes of Pobitora Wildlife Sanctuary.
Channa stewartii	Channidae	Changeli mas	Whole body	Used in the treatment of diseases like pain, diabetes, high pressure etc.	Nearby tribes of Gibbon wildlife sanctuary, Assam.
Channa striata	Channidae	Sol	Head	Used in the treatment of several diseases like cold, fever, wound and as a blood purifier.	Bodos of Assam.
			Caudal fin	Soup of herbs with caudal fin used to treat typhoid, gastritis.	

Scientific name	Family	Local name	Part used	Disease/Ailments	Tribe/State
Monopterus cuchia	Synbranchidae	Kunchirui	Whole fish or blood	Used raw fish to treat kala azar.	Karbis of Assam.
		Pawshai	Raw blood	Used as blood purifier of human body.	Tangsa tribe of Arunachal Pradesh.
		Kaicha	Blood	Blood used in hair massage to prevent hair loss.	Tribes of Tripura.
		Cushia	Flesh and blood	Used against premenstrual cramp.	Tribes of Gibbon and pobitora.
		Cuchia	Flesh, blood	Used against anaemia.	Bodos of Assam.
Trichogaster fasciata	Osphronemidae	Bengshi	Head, flesh	Used in the treatment of jaundice, cold and fever.	Bodos of Assam.
Labeo rohita	Cyprinidae	Rhou	Head, Flesh	Used as food to develop brain.	Bodos of Assam.
		Ngui	Stomach, gut	Used in the treatment of stomach ache and digestive issues.	Nyishi tribe of Arunachal Pradesh.
		Rou mas	Gall bladder or bile	Used to treat gastric ulcers and adenocarcinoma.	Nearby tribes of Gibbon, Assam.
Clarias magur	Clariidae	Magur	Flesh	Taken with medicinal herbs to treat anaemia to improve haemoglobin level.	Bodos of Assam.
Heteropneustes fossilis	Heteropneustidae	Singi	Flesh	Used in the treatment of anaemia.	Bodos of Assam.
		Singki	Whole body	Used against anaemia.	Karbis of Assam.
		Singhi mas	Whole fish	Cooked with spices and used to treat wound and pain.	Nearby tribes of Gibbon, Assam.
Wallago attu	Siluridae	Barali	Skin	Used to treat scars on skin and dry skin problem.	Bodos of Assam.
		Seketa	Head	Used as liver tonic to improve liver function.	Karbis of Assam.
		Borali	Air bladder	Used in the treatment of asthmatic trouble.	Misings of Assam.
Labeo gonius	Cyprinidae	Kuri	Whole fish	Used to treat allergic reactions.	Misings of Assam.
		Kursa	Flesh, Head	Used against allergy.	Bodos of Assam.
Chanda nama	Ambassidae	Chandanga	Whole fish	Used during illness to improve health condition.	Bodos of Assam.
Nandus nandus	Nandidae	Tota	Flesh, Head	Used in the treatment of cold and fever.	Bodos of Assam.
Botia dario	Botiidae	Balabatia	Flesh, Head	Used against cold, fever and anaemia.	Bodos of Assam.
Lepidocephalichthys guntea	Cobitidae	Balabatia	Whole fish	Cooked with medicinal plant and used against different ulcers.	Bodos of Assam.
Glossogobius giuris	Gobiidae	Namutra	Flesh, Head	Used to prevent night bed-wetting in children.	Bodos of Assam.
		Patimutura	Flesh	Used against the disease of bed wetting.	Missing of Assam.
Rasbora sp.	Cyprinidae	Maoya	Flesh,Head	Used as a medicine of eyesight and brain development.	Bodos of Assam.
Chitala chitala	Notopterida	Chital	Scales	Dried, grinded scales are used to remove dandruff in children.	Bodos of Assam.

Scientific name	Family	Local name	Part used	Disease/Ailments	Tribe/State
Chaca chaca	Chacidae	Kurkuri mas	Flesh	Dried and grinded fish powder is used orally with water to treat asthma.	Nearby tribes of Gibbon sanctuary.
			Flesh	Used against polio.	Tribes of Pobitora.
			Whole fish	Used against polio.	Karbis of Assam.
			Whole fish	Fish is dried and boiled with water and spices to treat polio.	Missing of Assam.
Xenentodon cancila	Belonidae	Kokila mas	Whole fish	Cooked fish is eaten to treat joint pain and swelling.	Nearby tribes of Pobitora sanctuary.
		Kokil mas	Spine and bone Joint pain, Swelling	To pick out clotted blood Spine and bone used to pick out dead erythrocytes.	Karbis of Assam.
		Kongkila mas	Head, Snout, whole fish	Used to pick out dead erythrocytes and also used against headache.	Karbis of Assam.
Mastacembelus armatus	Mastacembelidae	Ok-turding	Whole fish	Used to get relief from pain	Karbis of Assam.
		Ngahpuh	Whole fish	After consumption of this fish, the person's saliva is used against cuts, burns, wounds and boils etc.	Wancho tribe of Arunachal Pradesh.
			Raw blood	Used as an energy booster in case of low blood count.	Wancho tribe of Arunachal Pradesh.
		Ngahchim	Whole fish	Chopped pieces applied as an ointment to get relief from body pain.	Tangsa tribe of Arunachal Pradesh.
				Cooked fish used against malaria, blood pressure and child birth delaying issue.	
			Body mucus	Fresh body mucus is used against any disease.	Tangsa tribe of Arunachal Pradesh.
			Raw blood	Used as an energy booster in case of low blood count.	Wancho tribe of Arunachal Pradesh.
Bagarius bagarius	Sisoridae	Nguri	Fins and Bones	Bones and fins are burnt into ash and applied on skin to get relief from body burns and the ash is also taken with water to cure stomach pain.	Galo tribe of Arunachal Pradesh.
Notopterus notopterus	Notopteridae	Kandhuli mas	Whole fish	Used to cure abdominal and delivery pain.	Nearby tribes of Pobitora sanctuary.
				Cooked fish is taken as a medicine for abdominal and delivery pain.	Karbis of Assam.
Semiplotus sp.	Cyprinidae	Ngui	Stomach	Smoked stomach is taken to cure stomach ache.	Nyishi tribe of Arunachal Pradesh.
Amblyceps sp.	Amblycipitidae	Ngui	Bones	Fish bones are burnt into ash and applied on the skin to treat burns or other wounds.	Galo tribe of Arunachal Pradesh.
Psilorhynchus balitora	Psilorhynchidae	Ngokangui (Nyishi), Nyokapagra (Galo)	Whole body	Smoked fish is used to treat diarrhoea.	Nyishi and Galo tribe of Arunachal Pradesh.

Scientific name	Family	Local name	Part used	Disease/Ailments	Tribe/State
Anguilla sp.	Anguillidae	Eel	Blood	Used to treat weakness.	Missing of Assam.
		Ngub	Body mucus	Used to cure burns Galo and Nyishi tribe of Arunachal Pradesh.	Galo and Nyishi tribe of Arunachal Pradesh.
Trichogaster lalius	Osphronemidae	Bengshi	Whole fish	Used in the treatment of Typhoid.	Bodos of Assam.
Clarias batrachus	Clariidae	Magur	Whole fish	Used against smallpox and to overcome weakness.	Karbis of Assam.
				Used against body aches and wound healing.	Nearby tribes of Gibbon sanctuary.
		Ngahpak	Whole fish	Used to boost energy.	Tangsa tribe of Arunachal Pradesh.
Danio rerio	Cyprinidae	Nijou	Whole fish	Used in the treatment of anaemia.	Bodos of Assam.
Puntius sarana	Cyprinidae	Pitikri	Flesh	Used to improve eyesight.	Bodos of Assam.
Puntius sophore	Cyprinidae	Pitikri	Alimentary canal, bile	Used as pain reliever.	Bodos of Assam.
Parambassis ranga	Ambassidae	Chandanga	Whole fish	Used in the treatment of cold and fever.	Bodos of Assam.
Parambassis lala	Ambassidae	Chandanga	Whole fish	Boiled cooked fish used to get relief from illness.	Bodos of Assam.
Mystus sp.	Bagridae	Tengara	Whole fish	Used in the treatment of smallpox.	Karbis of Assam.
Mystus carcio	Bagridae	Tengwna	Flesh	Used to strengthen the body after illness.	Bodos of Assam.
Mystus tengara	Bagridae	Tengwna	Flesh	Cooked with herbs and eaten to regain strength.	Bodos of Assam.
Macrognathus aral	Mastacembelidae	Turi	Flesh	Used to treat mild fever.	Bodos of Assam.
Macrognathus pancalus	Mastacembelidae	Na thuri	Head	The species is believed to have anti-cancer properties and is used against cellulitis caused by growing nails.	Bodos of Assam.
Leiodon cutcutia	Tetraodontidae	Na tepa	Whole fish	Fish paste is used to treat skin wounds and roasted fish is also used against gastritis.	Bodos of Assam.

MATERIALS AND METHODS

This review documents, the scientific potential of fish species used as medicine by different In digenous and non-in digenous groups of Northeast India further it aims to identify gaps, mark the need for scientific assessments to verify this Indigenous knowledge and recognize the necessity of conservation strategies for protecting this potential resource. Therefore, original and review articles in English language were thoroughly searched in authentic online sources such as Scopus, Web of Science, Pubmed, Google Scholar, etc. Keywords such as 'ethnozoology', 'ethnoichthyology', 'traditional medicine', etc., were used to find relevant papers. Initially, 53 articles were collected. Ethnozoological articles that did not have any information on fish species and articles whose abstracts were only accessible were excluded due to lack of required data. 38 articles among 53 articles contained the necessary information. The articles used to write this review were published from 2001 to 2024 except the one published in 1980.

RESULTS AND DISCUSSION

Fish species belonging to different families that are used for their medicinal properties are depicted in the graph of Figure 2. The result reveals a total of 48 species of fish, belonging to 24 families that are being used as medicine by different tribes in Northeast India. Among the 24 families, Cyprinidae is the predominant one, and 11 species belonging to this family are used by the different groups to cure an array of ailments. Cyprinidae is followed by the family Channidae, 5 species of which are believed to have therapeutic value by the communities of Assam, Arunachal Pradesh, Tripura, etc. The least utilised families are Anabantidae, Badidae, Synbrachidae, Heteropneustidae, Siluridae, Nandidae,

Botiidae, Cobitidae, Gobiidae, Chacidae, Belonidae, Sisoridae, Amblycipitidae, Psilorhynchidae, and Tetraodontidae. Further, the percentage of different tribes that use fish as medicine is depicted by Figure 3. The Bodo community represents the highest usage with a total of 41%. Further 21% of species used by the Karbi tribe is second highest among all other groups assessed. Furthermore, Nyishi and Galo tribes use least number of fish species as folk medicine. Our findings disclose that the topmost and most commonly used fish species as medicine by different groups of Northeast India belong to the family Cyprinidae, and the second most is Channidae. Our findings are similar to that found in Zootherapeutics study done in Bangladesh, most of the fish species with medicinal value were recorded from the family Cyprinidae followed by Channidae. Furthermore, fish species from 2 other families viz. Hemiramphidae (*Hemiramphus* sp) and Synodontidae (*Harpodon neherius*) are documented to have medicinal values which were not recorded from North east India as it has no marine or coastal areas. Although the same fish species were used for different symptoms and diseases, some species belonging to Cyprinidae were used in Bangladesh and

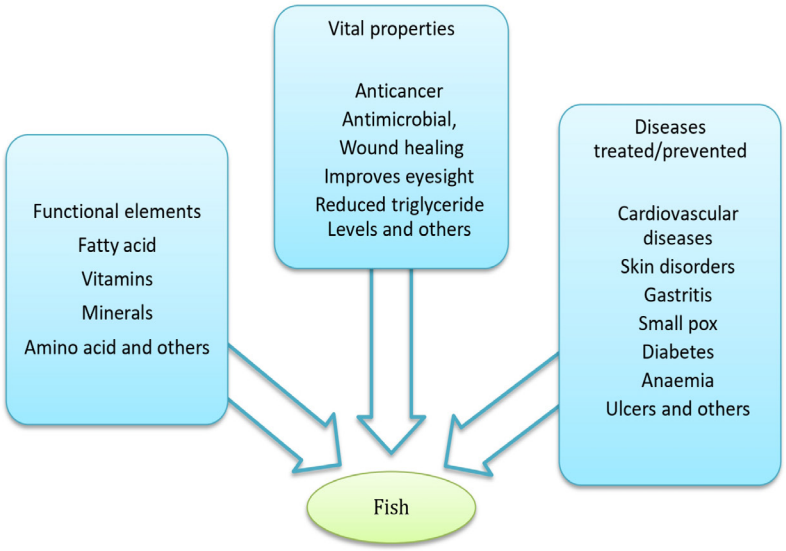

Figure 1: Graphical presentation of medicinal fish representing vital properties, functional elements it contains and diseases it can prevent and cure.[8,10,23,33]

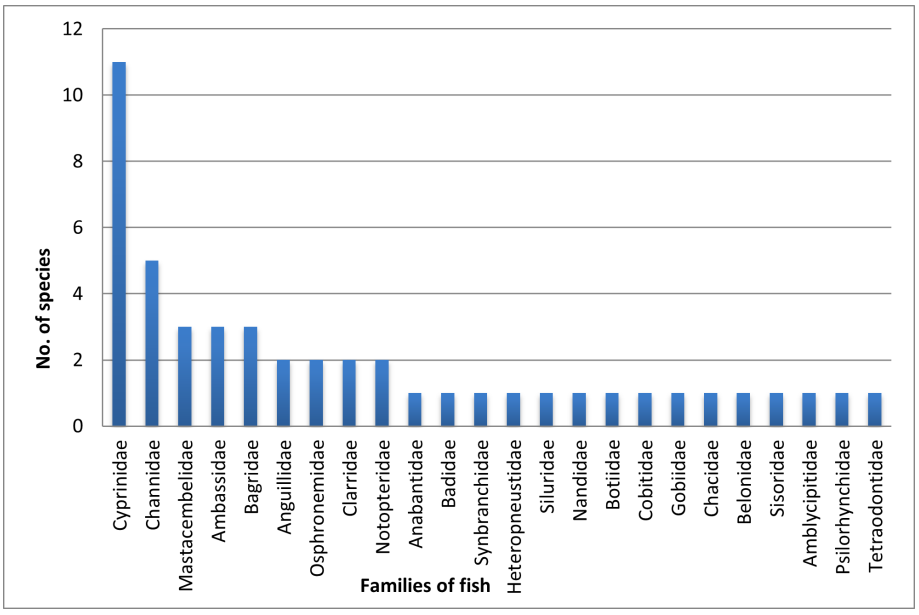

Figure 2: Number of species belonging to different families that are used as medicine by tribes of Northeast India.[3-7,13-16,33-35]

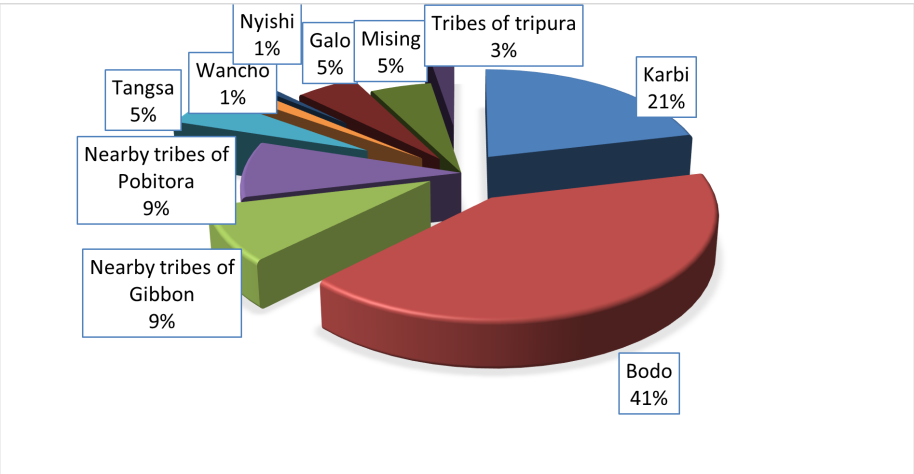

Figure 3: Percentage of fish species used by different tribes of North East India.[3-7,13-16,33-35]

Northeast India for common causes such as improving eyesight, boosting energy, enhancing memory, relief from cold etc.[36] The study of ethno-medicinal uses of fish in Kashmir Valley is also in line with our study, as their data reveals fish species belonging to Cyprinidae were mostly use for therapeutic purpose.[37] Such wide utilization of fish species belonging to Cyprinidae can be accounted for the presence of fresh water habitat found in these areas. On the contrary, an ethno zoological study in Kerala reports the highest use of fish species belonging to Actinopterygii.[38] More documentation on ethnomedicinal use of fish species is the pressing need for further research. Additionally, validation of this traditional knowledge is essential, which can be further done through biochemical studies on the documented fish species. Integration of ethnomedicine and modern science, may lead to new discoveries in the field of medicine.

CONCLUSION

Northeast India, a hub of natural resources, traditional wisdom, and diverse ethnic communities has been a source of vital information on native traditional medicine and its innumerable benefits from time immemorial. Their reliance on traditional medicine is based on various factors like religious customs, accessibility, affordability, etc. Varieties of fish are not only used as sources of protein, but they also exhibit disease-curing properties. They are orally consumed or topically applied in different forms. This knowledge is traditionally and verbally passed from one generation to the next in a family among the Indigenous and non-indigenous groups, and thus simply relying on it seemed to be difficult for many people around the world. But today there are proven scientific benefits, and experiments that have validated this traditional knowledge to some extent, furthermore, this knowledge has also laid the foundation stone for creating modern medicines from certain compounds extracted from fish. Different species of fish and fish products contain eicosapentanoic acid and docosahexaenoic acid, anti-cancer peptides which contribute to their disease-curing properties. In this review paper, we have incorporated as many documented fish species that have been used as medicine by the ethnic tribes of Northeast India. Our review study has collected and analysed information on 48 fish species categorised into 24 families. Our findings disclose that the most commonly used fish species as medicine by different groups belong to the family Cyprinidae, and the second most belongs to the Channidae. Furthermore, our results reveal that the Indigenous and non-indigenous people of Assam are mostly dependent on ichthyofauna to cure health conditions, followed by Arunachal Pradesh and then Tripura. As evident, the Bodo tribe among all groups has shown the highest utilisation (41%) of fish as medicine which essentially signifies their greater dependency on traditional medicine, especially fish fauna, which may be due to various aspects, while it is least employed by the Nyishi and Wancho tribes (1% each) of North East India and some reasons for such a trend may include their increased reliance on other sources of traditional medicine. Additionally, ethnic and non-ethnic groups have inculcated sustainable and ethical fish management practices that are in harmony with their environment.

The socio-cultural aspect of fish species can be sustainably exploited for producing potential medicines to treat a wide range of diseases, this would also aid in conservation. But there is still a void of documentation on the medicinal uses of ichthyofaunal species in some states of Northeast India, which implies conducting more on-site research. The mode of administration and dose are important parameters to be recorded alongside the fish species used as medicine. Although there has been some supporting evidence for its scientific implication in treating certain diseases, more experiments with detailed assessments and efficacy are the pressing need to promote the medicinal value of these fish species. Comprehensive risk assessments of consuming fish from a particular environmental site also contribute to its validity. To prevent over-exploitation of red-list fish species laws and regulations can be amended. In addition, incorporating a sense of awareness and judicious use of the red-listed fish species

among the Indigenous and non-indigenous groups can aid in the conservation of such fish species.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

DHA: Docosahexaenoic acid; **AA:** Arachidonic acid; **EPA:** Eicosapentanoic acid; **IL-1:** Interleukin-1; **IL-6:** Interleukin-6.

AUTHORS CONTRIBUTIONS

All the authors have extensively contributed to the process of writing this review paper. The concept, design, clinical studies, and final drafting of the manuscript have been done by Tinnu Sonar, while the article screening, data acquisition, data analysis and interpretation and reviewing have been done by Preronaa Gogoi. Literature search, manuscript preparation and reviewing have been carried out by Bibha Shah. Further literature search, manuscript editing and reviewing has been done by Neha Kumari Prasad.

SUMMARY

The present review provides a comprehensive record of ethnomedicinal fish species utilized by Indigenous and non-indigenous groups of Northeast India. Also, it sheds light on the scientific assessment of some ethnomedicinal fish species and sustainable fish management practised by these tribes. Our findings reveal that a total of 48 species of fish belonging to 24 families are being used as traditional medicine by the people of Northeast India. The highest number of ethnomedicinal fish species has been recorded from the family Cyprinidae. Furthermore, scientific studies have disclosed the presence of therapeutic compounds such as docosahexaenoic acid (DHA), Eicosapentanoic acid (EPA) and anti-cancer peptides in the fish species used as medicine by different groups of Northeast India. Consumption of EPA and DHA can help reduce the formation of TNF, and C-reactive proteins which are associated with diseases such as diabetes, autoimmune diseases, cardiovascular diseases etc. Therefore, these studies have provided a scientific background to the potential of using ethnomedicinal fish species to treat various diseases. However, more field surveys, documentation and scientific assessment are equally essential for the further development of pharmaceuticals from these ethnomedicinal fish species.

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