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PREFACE

In the ever-evolving tapestry of scientific inquiry, the field of Animal Science stands as a cornerstone, where the intricacies of the animal kingdom are explored, understood, and celebrated. As we embark on this journey through the pages of "Research and Reviews in Animal Science," we are poised to delve into a realm where curiosity meets discovery, where questions find their answers, and where the pulse of innovation beats vibrantly.

This compendium represents not just a collection of scholarly works, but a testament to the collective efforts of passionate researchers, scholars, and practitioners who dedicate their intellect and expertise to unraveling the mysteries that surround the diverse species with which we share our planet. Within these pages, readers will encounter a rich tapestry of studies, analyses, and insights that span the breadth and depth of Animal Science.

From the intricacies of animal behavior to the dynamics of livestock production systems, from the exploration of nutritional needs to the pursuit of sustainable practices, the topics encapsulated within this volume are as diverse as the creatures they seek to understand. Each chapter represents a thread in the fabric of knowledge, woven together to form a comprehensive mosaic of understanding.

As we navigate the terrain of contemporary research and review in Animal Science, it is imperative to acknowledge the tireless efforts of the contributors whose dedication fuels the advancement of our understanding. Their commitment to excellence, coupled with their relentless pursuit of truth, serves as a guiding light illuminating the path toward scientific enlightenment.

Moreover, in an era marked by unprecedented global challenges, the insights contained within these pages hold profound implications for the well-being of both animals and humans alike. Whether addressing issues of animal welfare, public health, or environmental sustainability, the research delineated herein serves as a catalyst for positive change, inspiring action and advocacy in pursuit of a more harmonious coexistence with the natural world.

As we embark on this intellectual odyssey, I extend my deepest gratitude to the authors, editors, and reviewers whose contributions have shaped this volume into a beacon of knowledge and discovery. May the insights contained within these pages spark curiosity, provoke contemplation, and inspire a renewed commitment to the pursuit of truth.

Editors

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Research and Reviews in Animal Science Volume IV
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THE IMPACT OF MEDICINAL PLANTS ON FISH IMMUNITY

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Abstract:

Aquaculture is the fastest growing food industry which has enormous growth potential. Globally these days, Infectious infections, primarily caused by bacteria, fungus, viruses, and parasites are one of the leading causes of aquaculture's limitations and result in significant financial losses. The frequency of disease outbreaks rises in direct proportion to increased intense aquaculture. Despite the fact that synthetic chemicals and antibiotics have several negative impacts on both human health and the environment, they are commonly utilized to treat these disorders. Researchers are searching for an antibiotic substitute in this context that would be both environmentally benign and financially viable for fish growers. Since ancient times, people have used natural goods such as medicinal plants to treat a variety of illnesses in humans. Potential bioactivities are known to be caused by a wide variety of active substances. The use of medicinal plants in aquaculture has thus generated a lot of attention in an effort to improve immune function, prevent fish infections and provide safe, environmentally acceptable alternatives to chemical and antibiotic substances. There may be benefits to using medicinal herbs in aquaculture as risk-free and natural alternatives to antibiotics.

Keywords: Fish, Disease, Immune Response, Immunostimulant, Medicinal Plants

Introduction:

Aquaculture plays a critical role in global food production (FAO, 2021). Freshwater aquaculture is a prominent sector of the aquaculture business. This industry has grown significantly over the last ten years and is predicted to continue rising as a result of the growing need for cost-effective animal protein worldwide (Dev, A. K. *et al.,* 2024). The output of farmed fish worldwide hit an all-time high of 114.5 million tonnes in 2018, along

with the production of 32.4 million tonnes of aquatic algae, 26000 tonnes of ornamental seashells, and 82.1 million tonnes of fish. The production of catch fisheries worldwide reached a record 96.4 million tonnes in 2018, increasing 5.4% from the average of the three years earlier. 12.5% of the total production from capture fisheries globally came from catches in inland water (FAO, 2020). However, the use of intensive and semi-intensive aquaculture production methods increased the frequency of disease outbreaks, which led to a partial or complete loss of fish production (M.G. Bondad-Reantaso *et al.,* 2005). Moreover, a number of variables, such as temperature, handling, overcrowding, poor water quality and inadequate feeding can form a state of stress and leading to immunosuppression in fishes, which increases their vulnerability to infectious diseases (Awad, E. and Awaad, A., 2017). Numerous investigations have shown that the primary causes of aquaculture diseases include fungus, viruses, bacteria, and parasites (Dev, A. K. *et al.,* 2024). Fish diseases can be broadly divided into two categories: infectious diseases and non-infectious disorders. The main source of infectious diseases are disease-causing organisms found in the surroundings or transferred by other fish. Non-infectious diseases, on the other hand, are rarely treatable with drugs and are typically brought on by environmental factors, dietary inadequacies, or genetic abnormalities (Sanil, 2020). An organism's immune system defends it against illness by identifying and eliminating of pathogens and preventing tumor growth. (Magnadottir, B., 2015).

Global awareness of the negative effects of antibiotics has led to a movement in consumer preference toward natural products (Citrasu, 2010). Herbs include a wide variety of active ingredients including flavonoids, alkaloids and polysaccharides. In order to improve fish immune response against bacterial, fungal, viral and parasitic diseases, the herbal compound extracts work as immunostimulants. These include lysozyme, complement, antiprotease, meloperoxidase, reactive oxygen species, reactive nitrogen species, phagocytosis, respiratory burst activity, nitric oxide, total hemocytes, glutathione peroxidase and phenoloxidase (Hai, 2015). Over the last few decades, medicinal herbs used in aquaculture have drawn more attention (Wang *et al.,* 2017). The most promising alternative source for managing different diseases in aquaculture is traditional medicinal herbs. Additionally, the immunostimulants improve growth and raise the survival rates of stressed fish, among other effects (Arulvasu *et al.,* 2013). Moreover, different plant parts such as leaf, flower and rhizome in forms of crude, extract and active ingredient are used to modulate specific biological functions of fishes (Tadese *et al.* 2021). Therefore, adding

functional supplements such as plants may enhance feed utilization and growth which can enhance the efficiency of aquaculture resources (Reverter *et al.,* 2021).

Medicinal plants

A. Aloe vera (*Aloe barbadensis)*:

Aloe vera is a member of the Aloaceae family and is used as a traditional medicinal plant (Assis *et al.,* 2020). About 99–99.5% of the plant's leaves are made up of water along with the remaining solid components (about 0.5–1%) making up 75% of the active ingredient. These solid constituents include enzymes, minerals, water and fat soluble vitamins, simple and complex polysaccharides, organic acids and phenolic compounds. The plant has been linked to a wide range of pharmacological activities including immune system stimulant, antiviral, antibacterial, antifungal, anti-inflammatory and anti-radioactive qualities (Mehrabi *et al.,* 2020). Fish (Labeo rohita) were fed diets supplemented with AVP (aloe vera powder) at 0% (T0), 1% (T1), 2% (T2), and 3% (T3) respectively, at a rate of 2% of their total fish biomass each day. The highest NWG, SGR and protein content over control, together with superior feed conversion ratio and protein efficiency ratio, were achieved at the 3% AVP inclusion level, yielding 48.19, 21.37, and 24.59% of the best outcomes (Kaur *et al.,* 2020).

B. Ginger (*Zingiber officinale*):

Ginger is a member of the Zingiberaceae family (Bharathi *et al.,* 2021). It is thought that ginger has a wide range of preventative and therapeutic uses. According to Swain *et al.* (2018), ginger is useful as an immunomodulatory agent in fish and animals, can reduce disease-related losses in aquaculture. The portion of it that can be used medicinally are its underground rhizomes (Ajeel *et al.,* 2013). Zingiberene is the primary component of ginger (Zingiber officinale), a herbaceous perennial plant that also has a combination of zingerone, shogaols, gingerols and sesquiterpenoids (Hodar *et al.,* 2021). When administered in conjunction with oxytetracyclin, ginger (10 g/kg diet) helps reduce oxidative stress and immunosuppression in rainbow trout (Zargar *et al*, 2020). In striped catfish, Pangasianodon hypophthalmus, 10 g/kg of included ginger powder diet demonstrated a stronger growth response in terms of increased weight gain and specific growth rate (Swain *et al.,* 2018).

C. Neem (*Azadirachta indica*):

Neem is a member of the Meliaceae family. Aquaculture directly uses neem, sometimes referred to as an Indian herbal remedy, for its leaves, bark and fruit extracts. Anti-inflammatory, anti-ulcer, antipyretic, anti-malarial, antibacterial, antifungal and antiviral qualities have all been linked to neem (Bharathi *et al.,* 2021). It has over twenty-five components such as salannin and vepol, which have been shown to have a larger effect on fish resistance to viruses, fungi and parasites (Hodar *et al.,* 2021). Significant hypoglycemic, hypolipidemic, hepatoprotective, anti-fertility and hypotensive properties were observed in a water soluble extract of *A. indica* leaves (Mousa *et al.,* 2008). Neem leaf aqueous extract has been used to combat fish fry predators like dragonfly larvae and fish parasites on fish farms. Neem extract is typically thought to be lowly hazardous to aquatic species that is not its intended target (Onivosa *et al.,* 2017). Even after a brief exposure (24 hours), neem leaf extracts (1.035 g/l) had an impact on the hematological, ionoregulatory, biochemical and enzymatic parameters of Cirrihinus mrigala (Saravanan *et al.,* 2011). In place of antibiotics, a 150 mg/L extract from the *Azadirachta indica* (neem) plant was utilized to treat bacterial infections in Oreochromis mossambicus (Thanigaivel *et al.* 2015, Kuebutornye *et al.,* 2020).

D. Turmeric (*Curcuma longa*):

Curcuma longa or turmeric belongs to the Zingiberaceae family (Ayoub *et al.,* 2019). Curcuma longa rhizomes are the source of turmeric (Koca *et al.,* 2020). The health benefits of curcumin and its derivatives for animals include antibacterial, antioxidant, anti-inflammatory, appetite-inducing, immunomodulatory and gastro-protective properties (Alagawany *et al.,* 2021). Labeo rohita was fed Curcuma longa for 60 days, there was an increase in lysozyme activity, superoxide anion generation and serum bactericidal activity (Sahu *et al.,* 2008). The hematological parameters of the common carp (*Cyprinus carpio*) could be significantly improved by dietary supplementation of curcumin (100 mg/kg diet) (Yonar, 2018, Alagawany *et al.,* 2021). The fish Clarias batrachus suffered considerable hemorrhage and metabolic damage as a result of exposure to fenvalerate. However, fish haematological and biochemical levels significantly returned to normal after receiving oral turmeric rhizome extract administered daily via stomach intubation technique at a dose of 100 mg/Kg body weight each day for 15 days (Kumari *et al.,* 2020).

List of medicinal plants used as immunostimulant

Medicinal plant	**Common name**	**Properties**	**References**
Aloe vera	Aloe	Anti-inflammatory, anti-viral, antibacterial, antifungal, anti-radioactive and immuno-stimulant	Mehrabi *et al.,* 2020
Allium sativum	Garlic	Growth promoter, Antimicrobial, Antiviral, Antioxidant, and Antiparasitic	Valenzuela-Gutiérrez, R. *et al.,* 2021
Azadirachta indica	Neem	Anti- inflammatory, anti – ulcer, antipyretic, anti – malarial, antibacterial, antifungal and antiviral	Bharathi *et al.,* 2021
Citerus sinesis	orange	Antimicrobial and antifungal	Acar *et al.,* 2015
Cinnamomum verum	Cinnamon	Enhance antioxidant and digestive enzymes, activities, high survival against *A. hydrophila*	Abdel-Tawwab *et al.* (2018a)
Curcuma longa	Haldi	Antimicrobial, antioxidant, anti-inflammatory, appetite-increasing, immunomodulatory and gastro-protective, hypoglycemic, hypolipidemic, hepatoprotective, anti-fertility and hypotensive activities	Johannah *et al.,* 2018, Alagawany *et al.,* 2021.
Glycyrrhiza glabra Linn.	Mulethi	Growth promoter	Kumar *et al.,* 2007
Ocimum gratissimum	Clove	Increase intestinal villi length, absorption area, reduce cholesterol and glucose level, increase protein, antioxidant and survival against *Listeria monocytogenes*	Abdel-Tawwab *et al.* (2018b)

Trigonella foenum-graecum)	Fenugreek	Increase haemolytic complement, peroxidase, antiprotease activity, enhance cellular and humoral immune parameters	Guardiola *et al.* (2018)
Trachyspermum ammi	Ajwain	Improve growth performance and lysozyme activity	Ali *et al.* (2017)
Zingiber officinalis	Ginger	Deworming substance, anti-inflammatory, anti-oxidative, immunomodulatory	Swain *et al.,* 2018

Benefits of medicinal plants for fish health

A. Antibacterial agents:

The active ingredients in herbal remedies with antibacterial properties have the potential to lyse cell walls, prevent the creation of proteins and DNA, suppress enzyme secretions and disrupt the quorum sensing route signaling process (Citarasu, 2010). Gram positive and Gram negative bacteria are both effectively combatted by herb extracts' strong antibacterial properties. An alternate antibacterial treatment for tilapia ectoparasites and the bacterial pathogen *A. hydrophila* was Indian almond extract. The extract of aloe vera has been shown to have antimicrobial properties. It was discovered that the antibacterial properties of cinnamon were antagonistic to the *A. hydrophila* infection in Nile tilapia. Fish sick with Vibrio were treated with *Zingiber officinale*.

B. Antiviral agents:

Infectious hematopoietic necrosis virus, infectious pancreatic necrosis virus, hirame rhabdovirus, yellowtail ascites virus, striped jack neurological necrosis virus and iridovirus are the main viruses that cause significant mortality rates in fish aquaculture. Inhibiting or blocking the transcription of the virus can minimize its replication within the host cell and improve non-specific immunity through the use of herbal active substances. Therefore, rather than using the traditional approach of altering viral proteins, attempts to regulate viral components through herbal plants to stimulate or manipulate innate immune

response by targeting those cellular ingredients needed for viral replication are crucial (Tadese *et al.,* 2021).

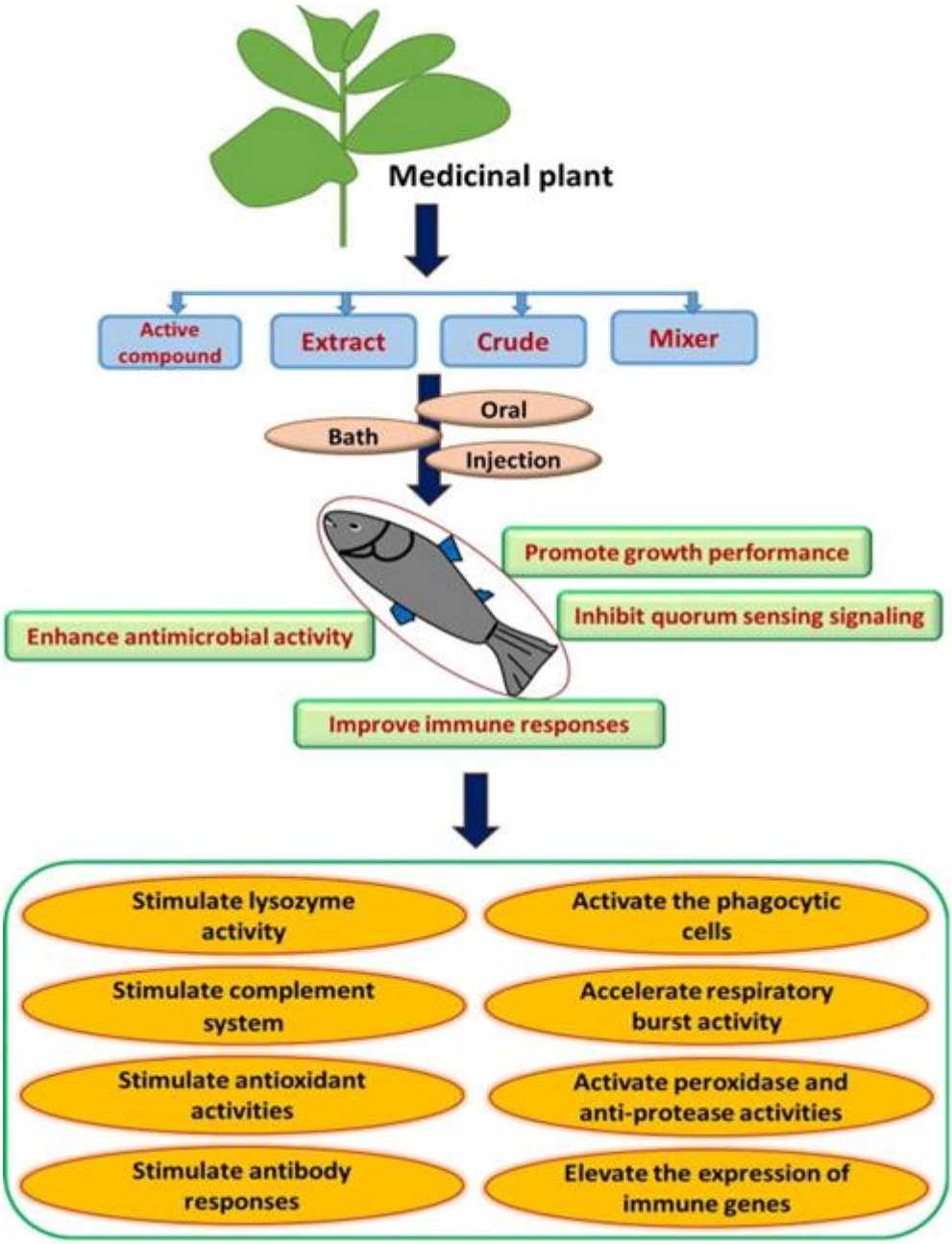
C. Growth promoters:

Herbal products reduced osmotic stress and greatly enhanced growth and efficiency. It has been established that medicinal herbs stimulate growth. First off, they improve the digestive enzymes of aquatic creatures, increasing their rates of development and survival. The transcription rate is aided by the herbal growth promoters. According to Citarasu (2010), this process causes an increase in RNA and total amino acid content as well as an increase in the amount of proteins produced by the cells. Herbs carry out their primary function in feeding as a flavor, which affects eating habits, the release of digestive juices and the overall amount of feed consumed. Additionally, olfactory feed ingredients promote growth by acting as feeding enhancers, causing fish to consume more feed than usual (Syahidah *et al.,* 2015). When freshwater prawns were fed diets supplemented with herbs, their muscle, sodium and potassium levels, and vitamin C and E levels in the hepatopancreas all rose (Hai., 2015). For instance, in one study, *Channa punctatus* were given experimental feed containing ginger twice a day for 60 days at a body weight of 5%. Because the meal containing ginger contains carbs, vitamins, carotenoids, minerals, tannin, fiber, alkaloids, flavoids and saponin, the maximum mean increase in final weight after feeding is 174.92g. This is in contrast to the diet containing no ginger (Pandit *et al.,* 2020).

D. Immunostimulants:

An immunostimulant is a chemical, drug, stressor or action that enhances the defense mechanisms or immune response, thus rendering the animal more resistant to diseases. (Citarasu, 2010). The thymus, spleen and kidneys are the main target organs of medicinal plants which mainly promote the maturation and development of animal immune organs. In addition, medicinal plants can directly promote antibody production and participate in the specific immune response. Many medicinal plants can promote the production of cytokines that mediate specific/non-specific immunity, including interleukin, interferon and tumour necrosis factor. Medicinal plants display more biological activity than single compound because of their richness in secondary metabolites, such as essential oils, saponins, phenolics, tannins, alkaloids, polypeptides and polysaccharides (Tadese *et al.* 2021). Phagocytic activity is a primitive defense mechanism and an important

characteristic of the fish immune system. Herbal medicine extracts can enhance phagocytosis in various fish species (Kuebutornye *et al.,* 2020)



The impact of medicinal plants on fish immunity (Gupta, N. *et al.,* 2021)

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VIEWPOINT OF SPEECH AND LANGUAGE DISORDERS IN PEOPLE WITH PARKINSON'S DISEASE

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Abstract:

Parkinson's disease (PD) is the second most common neurodegenerative disorder. Cardinal features include resting tremor, rigidity, bradykinesia, and postural instability. These symptoms may give rise to a variety of secondary impairments such as altered gait, reduced aerobic capacity, incoordination, imbalance, dysphagia, and falls. Rehabilitation professionals play a very important role in the rehabilitation of people with Parkinson's disease, particularly in the management of motor symptoms, speech impairment, and prevention of secondary complications. The most common speech problem associated with PD is Hypokinetic Dysarthria affecting the respiratory, phonatory, and articulatory systems responsible for speech production and swallowing. Phonatory defects include reduced loudness, vocal tremors, reduced pitch and loudness ranges. Articulatory errors commonly observed are imprecise consonant articulation. Limited pitch and loudness inflections, abnormal rate of speech, slurred speech, imprecise consonant articulation, errors in prosody, and disfluent speech adversely affect the speech intelligibility of persons with PD. Persons with PD display difficulties in both verbal and non-verbal language. Language impairment includes difficulty in word retrieval, lexical errors, poor syntactic structures, and pragmatic errors.

Keywords: Parkinson's Disease, Rehabilitation, Speech Disorders, Language Disorders

Introduction:

Parkinson's disease (PD) is a complex and progressive disorder characterized by various motor and non-motor symptoms.[1] Cardinal motor features include rest tremor,

rigidity, bradykinesia, postural instability and an altered walking pattern, including freezing of gait.[2,3]The onset of the cardinal motor symptoms arises from the loss of dopaminergic neurons of the substantia nigra pars compacta, leading to depletion of dopamine in the striatum. Therefore, the inhibitory influence from the basal ganglia to other brain regions that are involved in the control and execution of voluntary movement becomes exaggerated, which may account for bradykinesia and rigidity.[4] On the other hand, balance impairment could be caused by dysfunctions in the non-dopaminergic system, as it is often resistant to dopamine.[5] The cardinal motor symptoms may give rise to a variety of secondary impairments such as altered gait (e.g., reduced walking speed, stride length, cadence and level of independence in walking), reduced aerobic capacity and falls.[6]Other main clinical features includes tremor, impaired balance, lack of coordination, expressionless face, dysphasia, urinary problems and constipation. Some people with Parkinson's may experience changes in their cognitive function, including problems with memory, attention, and the ability to plan and accomplish tasks. Symptoms usually begin gradually and worsen over time. As the disease progresses, people may have difficulty walking and talking. They may also have mental and behavioral changes, sleep problems, depression, memory difficulties, and fatigue. Over time, as the disease progresses, some people may develop dementia and be diagnosed with Parkinson's dementia, a type of Lewy body dementia. People with Parkinson's dementia may have severe memory and thinking problems that affect daily living. These secondary impairments, together with worsening of the motor symptoms as the disease progresses, may trigger a vicious cycle of further decline in physical activity level, activity and participation. Although most people with Parkinson's first develop the disease after age 60, about 5% to 10% experience onset before the age of 50. Early-onset forms of Parkinson's are often, but not always, inherited, and some forms have been linked to specific alterations in genes.

Parkinson's disease (PD) is the second most common neurodegenerative disorder. Although, dopaminergic drugs are the mainstay for improving PD symptoms, there are still few effective disease-modifying therapies. Rehabilitation professionals play a very important role in the rehabilitation of people with PD, particularly in relation to the management of motor symptoms, speech impairment and prevention of secondary complications. With the increasing prevalence of PD and the rapid transition to an aging society, more emphasis needs to be placed on rehabilitation that could slow the disease progression combined with pharmacological therapy. Several rehabilitation programs have

been attempted in relation to motor function, swallowing difficulty, and speech disorders; however, the overall level of evidence is still limited.[7]

Content:

The most common speech problem associated with PD is Hypokinetic Dysarthria, although hyperkinetic dysarthria or mixed dysarthria may not be unseen. Bradykinesia, rigidity, and stooped posture in the presence of limited facial expressions sometimes creates communication barriers for persons with PD. The observable speech characteristics result from the disease's progression, the severity of the problem, the type of therapeutic intervention, and compensatory mechanisms applied. The respiratory, phonatory, and articulatory systems responsible for speech production and swallowing are affected due to hypokinesia and bradykinesia of the muscles involved.

Persons with PD frequently present with the failure to control respiration for speech which affects the articulation of speech sounds and results in observable errors of prosody. They may often have reduced tidal air volume, inspiratory air volume, and reduced phonation duration due to restricted chest and abdominal wall movements. Left untreated, it may lead to upper airway obstruction, obstructive sleep apnoea, and aspiration pneumonia[8].

Phonatory defects are one of the initial indicators of the disease, mainly characterized by reduced loudness, vocal tremors, and reduced pitch and loudness ranges. Reduced levels of subglottal air pressure, rigidity in the vocal fold movements, increased perturbations of amplitude and frequency are commonly seen in such persons. Vocal fold bowing as well as incomplete vocal fold closure during phonation in the laryngeal mechanism[9] may emerge as observable harsh or breathy voice quality.

Articulatory errors are a common phenomenon in PD. The restricted range of movements of active articulators of the oral peripheral mechanism and the tremors in lips, mandible, and tongue lead to imprecise articulation of vowels and consonants. Both imprecise consonant articulation and decreased voice quality have higher degree of severity in Late Onset Parkinson's Disease in comparison to Early Onset Parkinson's Disease which may be attributed to widespread brain atrophy[10].

Limited pitch and loudness inflections, abnormal rate of speech, slurred speech, imprecise consonant articulation, errors in prosody, and disfluent speech adversely affect the speech intelligibility of persons with PD. Moreover, nonverbal communication is also

affected due to fixed facial expressions, restricted arm movements, and limited animations during conversations.

It is common to experience language difficulties leading to poor working memory, limited attention span, and impaired cognitive and executive functions in persons with PD. They display poorer language abilities such as difficulties in word retrieval, lexical errors, and poor syntactic structures than their non-PD counterparts. Pragmatic errors such as initiating, maintaining, turn taking in conversations, and syntactic errors such as limited grammatical complexities in expressive language are frequently impaired in PD. There are substantial correlations between the degree of overall pragmatic impairment and mental status, motor severity, and disease duration[11]. Hence, pharmacological intervention, physical and occupational therapy, speech and language therapy, and yoga therapy are important aspects of rehabilitation to improve the quality of life of persons with PD.

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ENHANCING FISHING SUCCESS THROUGH THE USE OF ARTIFICIAL BAIT AND FEEDING TECHNIQUES

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Abstract:

Enhancing our understanding of the foraging behaviour of fish is crucial for advancing research on longline fishing, particularly with bait innovation. The chapter enlightens with the general mechanisms of long lining, baits used and factors related to bait fishing. The chemical compounds that trigger food search behaviour vary among species, and incorporating specific feeding attractants into manufactured baits could enhance species selectivity. Furthermore, the distinct properties of chemical stimuli and odours serve to improve longline efficiency through the creation of long-lasting baits. The appearance and physical characteristics such as size, shape, texture and strength in manufactured baits can enhance catch efficiency. The use of artificial bait is to be increased to conserve the live bait resources and to retain the sustainability of ecosystems. However, the use of low cost raw materials is to be evaluated to ensure the feasibility of the technology.

Keywords: Artificial Bait, Long Line, Fish, Species, Attractants

Introduction:

Long lines are utilized for capturing large fishes that possess high economic value. To catch these fishes, bait fishes are considered an essential tool. However, in recent times, there has been an increase in the use of gears and crafts, leading to the over exploitation of economically valuable fisheries. Unfortunately, this has resulted in a decline in bait fisheries as they are excessively targeted for catching other fishes. It is crucial to address this issue and conserve bait fisheries as they play a significant role in the ecosystem.

To replace live bait, feed technology that utilizes artificial bait derived from fish and byproduct waste can be employed. The use of feed attractants in fish bait is essential for

inducing a feeding response in fish. Fish are naturally attracted to scents and flavours that resemble their usual prey or food sources. By incorporating feed attractants into the bait, anglers can replicate these natural food sources, triggering a feeding response in fish and enticing them to take the bait. Commonly used feed attractants include fish oils, amino acids, and natural extracts derived from bait fish and other aquatic organisms. Moreover, feed attractants can help disguise any unnatural odours or flavours in the bait, making it more appealing to fish. By incorporating feed attractants, long line fishermen can effectively counteract these undesirable odours and enhance the overall appeal of the bait to fish.

Long lining

Long lining is a fishing technique that has the potential to significantly boost economic development in various countries and regions. This method is specifically designed to target larger and deeper swimming fish species, which are highly valued in international markets. However, to fully benefit from this potential, it is essential to handle the fish with care and maintain high-quality standards throughout the entire process of catching, processing, and exporting. While the initial costs for local operators to establish a longlining operation may be substantial, the potential profits are equally significant.

One of the primary advantages of long lining is its ability to enhance the quality of food resources available to the population. Moreover, it can help alleviate fishing pressure on reef and lagoon stocks that are often over exploited. By promoting sustainable and responsible fishing practices, particularly in horizontal tuna long lining, fishermen can play a crucial role in the conservation of marine resources. All fishermen must act as responsible stewards of the resources they rely on.

To effectively utilize long lining, fishermen must have a good understanding of the target species, as well as the bycatch and incidental catch species. This involves studying their behaviour patterns and using appropriate bait. Additionally, knowledge of suitable knots and splices for assembling gear components, as well as the proper use of ropes and lines for fishing operations and boat handling, is essential. Long lining can pose risks if not carried out safely and professionally, so it is crucial to take necessary precautions and be well-prepared.

Impact of fishing on bait fish resources

Fisheries targeting bait fishes are carried out separately by individual fishing boats, with the majority of the catch being utilized for pole and line as well as longline fishing. There are two primary techniques employed for capturing bait fishes: encircling seine nets and dip nets. Encircling nets are predominantly utilized for capturing sprats, whereas dip nets are employed for other species that inhabit deeper regions, often close to coral reefs. The selection of bait fish species is determined by their availability. Various cues, which vary among species, are used to identify schools of fish. Pelagic shoaling species, like sprats and juvenile fusiliers, can be located by observing ripples on the sea surface. Fishermen rely on their understanding of the presence of specific coral species and the associated bait fish to ascertain the location of most other baitfish species. Good to the clear water, they can assess the species and quantity of fish before deploying the net. Encircling nets are used by surrounding the identified bait fish shoal and subsequently hauling them onboard. In the past, split coconut leaves tied to ropes were utilized as scare lines to enhance the effectiveness of encircling nets in the northern islands. However, the use of scare lines has significantly declined due to the availability of superior snorkelling aids that enable fishermen to swim alongside the shoals. The overfishing conducted by mechanized vessels is progressively escalating, underscoring the need to safeguard live bait resources and minimal wastage.

The extant live bait fishing methods are appropriate for the scale of operation and new interventions in the plan shouldn't greatly disrupt these fishing practices The new management scheme should not contribute to the downfall fisheries. Appropriate monitoring mechanisms need to be put in place. Management interventions when designed and enforced carefully will enhance the sustainability of the resources. If live bait wastage can be reduced, then the live bait requirements of the fleet are decreased, which will tend to mitigate to some degree live bait over-exploitation. Gentle live bait handling, efficient use of live bait during chumming operation and improved design of live bait tanks onboard etc. will improve the live bait use efficiency. The live bait fishes are also caught occasionally for domestic consumption though at a very small scale, especially during monsoon months when offshore fishing is affected due to squally weather or monsoon.

Exploring the uses of artificial bait from fish and byproduct disposal

The Fishing communities may easily afford and easily obtain biodegradable waste materials that occur naturally and locally for use in making the majority of fishing gear and storage units. The gear used in traditional fishing methods is also easily manufactured by fishermen without the assistance of outside parties, as there aren't many technicalities or pieces of machinery involved in its construction. These age-old techniques are the most environmentally benign and sustainable means of capturing fish, making them the ideal means of preserving the inherent biodiversity.

Factors affecting the bait efficiency

The species composition, size and structure of fish caught during fishing are influenced by various factors such as gear configuration, bait size, hook design, light sticks, soak time, and the number of hooks per basket in the longline fishery (Ontomwa *et al.* 2024). Globally, commercial and recreational fishers have long utilized a wide range of creatures, both aquatic and terrestrial in origin, as bait. Matsuzaki, M. (1943) and Otter, E. C. (1898) mentioned that today's baits are the outcome of a long-term selection process. The efficiency of fish bait depends on the attractants and stimulants incorporated in it. Harada, K. (1989) observed that research on attractants or stimulants for fish and shellfish has made remarkable strides in the last several decades. A variety of shrimp species are utilized as bait in both commercial and recreational fishing, regardless of the kind of prey, within the class of animals known as crustaceans. On the other hand, recreational fishers in certain areas utilize sea roaches only for a small number of specific species. Preferences vary greatly between target species and between commercial and recreational fishing, even within the same taxonomic group. Different species within the same taxonomic group exhibit a significant variation in their preferences, both in terms of target species and between commercial and leisure fishing.

Motivation for feeding and the behaviour of searching for food is influenced by internal factors such as hunger state and life history, as well as external factors including, season, day and night, temperature and current. Deploying baited longlines during sunrise or sunset, during moderate tides, across current, and in regions or times of low prey abundance can enhance the effectiveness of catching fish.

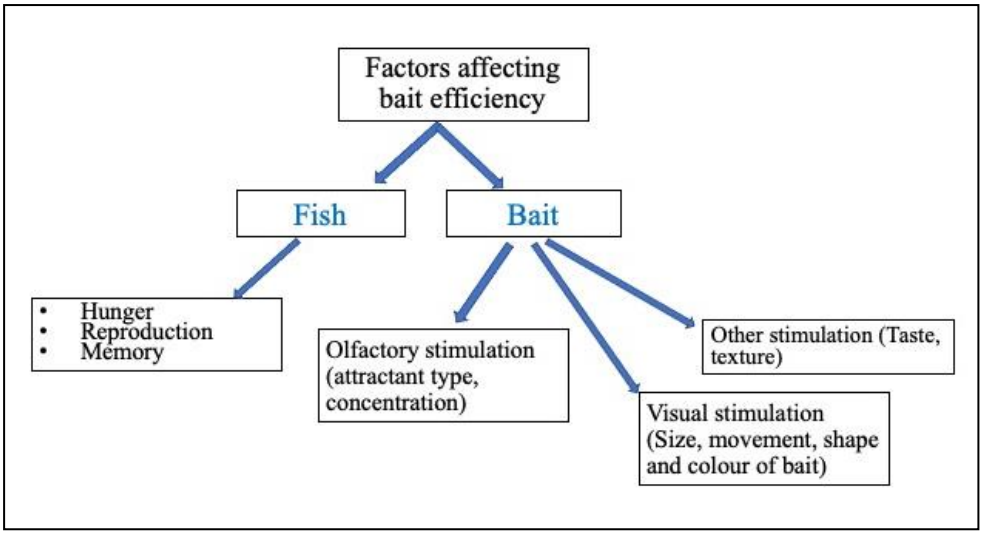

Figure 1: Factors affecting the efficiency of bait

Species specificity

Experiments conducted in commercial long lining and anecdotal evidence from fishermen have demonstrated the species-specific effects of baits. Squid is the most effective bait for cod and hake (*Merluccius* sp.), while mackerel appears to be more effective for haddock (Martin and McCracken 1954). Pol *et al.* (2008). There is significant potential in using baits or extract mixtures to attract specific target species based on odour. These characteristics of feeding attractants should serve as the foundation for the development of species-selective bait-fishing methods.

The specificity of bait varies with the following factors,

a) Size of bait (Ingolfsson *et al.,* 2017)
b) Texture
c) Taste

Composition of bait

The feeding behaviour in fish is triggered by low-molecular weight substances that are highly soluble in water, such as amino acids, peptides, prostaglandins, bile acids, and steroids (Carr and Derby 1986; Hara 1992; Kasumyan and Doving 2003; Hara 2011). Fatty acid composition, volatile compounds and hydrocarbons affect the preferability of baits (Ozyurt *et al.* 2023). Among these, amino acids are the most significant group, with short-chain neutral amino acids being the major stimulating agents (Hara 1992, 2011; Marui and Caprio 1992; Kasumyan and Doving 2003). These substances can act individually or in

combination to play a crucial role in stimulating feeding (Hara 2011) and fish have a remarkable ability to differentiate between different amino acids (Friedrich 2006). Betaine, a feeding stimulant, can be found in various prey species and is known to attract several fish species such as salmonids and sturgeons (Yamashita *et al.* 2006) while nucleosides and their derivatives enhance feed intake in certain flatfish species (Raubenhaimer *et al.* 2010). Furthermore, fatty acid oxidation products and their derivatives have the potential to stimulate feeding even at low concentrations (Jobling 2004).

Attractants and stimulants

Since the objective of bait in fishing gear is to attract fish from a distance, the main component of bait is an "attractant" that triggers the food search behaviour of fish. These stimulating compounds are primarily amino acids like alanine, cysteine, serine, glutamine, glycine, and proline, which can act individually or in combination are discussed in (Kasumyan, 1997; Raubenheimer *et al.* 2010). The source of attractants for alternative baits can be either natural resources (surplus and waste products) or their hydrolyzed extracts and synthetic stimulating compounds specifically targeted for species-specific capture. Protein hydrolysates from shrimp and blue mussels, obtained from industrial waste, have been observed to be potential attractants for cod. However, capelin attractant was not effective enough to stimulate cod and cannot be used in making alternative baits (Siikavuopio *et al.* 2017). Another important component of bait is a binder, which provides texture and consistency to the bait. Its major role is to ensure the controlled release of attractants over a long period, mimicking natural bait. Typically, when the bait is placed in water, there is a high initial release rate that decreases rapidly, followed by a nearly constant release rate in the later period. The prolonged release of attractants is believed to increase the catchment of cod (Lokkeborg, 1990). However, the binder alone is not sufficient to provide shape and strength to the bait, especially in long line fishing. It requires support or reinforcement, which has been achieved through various techniques such as the use of bait bags and fibre matrix, surface hard gel coating of baits, and high temperature-pressure extrusion or extrusion through fibre mesh tubes (Lokkeborg *et al.,* 2014). Numerous efforts have been made to develop alternative baits, and many of them are patented, providing limited information about the composition and technology of bait development. Norbait DA, a Norwegian company, produces baits from fish wastes and offal using alginate as a binder or gel.

Environmental and social concern

The use of artificial baits will help to reduce the negative impacts caused by the utilisation of fish and other organisms as baits. The ecological significance of live bait fishes in the atoll system is much beyond sustainability. Some of the live bait fishing practices hamper corals while driving the fish out of the coral crevices. Coral destruction and other physical disturbance of the reef should be discouraged. Live bait fishing should have a very minimal impact on the ecosystem and the environment. Fishing activities that have an impact need to be regulated. Efforts should be made to reduce bycatch in the live bait fishery including juveniles of reef fishes. The fishing gear and baits were also found to attract mammals, sharks, sea birds etc. that are also considered bycatch. Enforcement of Fisheries Management regulatory mechanisms can mitigate the problems greatly.

Role of fishermen

Fishers need to be regarded as partners in the protection of the fishery resources to enhance the acceptance of control measures. There is a need for the awareness of the public on the necessity for the protection of live bait habitat and reduction of wastage. Awareness generation on management and conservation should be integrated into the regular work programme of the Department of Fisheries for the reduction of negative impacts on the ecosystem and physical environment.

Conclusion:

Feed technology plays a crucial role in the fishing industry, specifically in the area of harvesting healthy fish from the environment. Unlike its name suggests, feed technology is not involved in the production of fish instead focuses on ensuring sustainable fisheries by avoiding environmental hazards and preventing overfishing of bait fish. Gears such as long lines, troll and line, pole and lines etc. are used in an eco-friendly manner to support sustainable fishing practices. In conclusion, fish attractants serve as a valuable asset in the angler's toolkit for optimizing fishing outcomes. When used thoughtfully and alongside effective baiting methods, they can contribute to a memorable fishing experience. By embracing these techniques, fishermen can reap the advantages of using organic bait while reducing their impact on the environment and promoting the long-term well-being and endurance of aquatic ecosystems.

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COCOONED IN HISTORY: REFLECTING ON ASSAM'S SERICULTURE INDUSTRY

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Abstract:

The sericulture industry in Assam, India, represents a significant aspect of the state's cultural heritage and economic landscape. This book chapter explores the historical roots, current status, and future prospects of sericulture in Assam. It delves into the rich tradition of silk production, including the cultivation of Muga, Eri, and Mulberry silks, each cherished for its unique qualities and aesthetic appeal. Despite facing challenges such as competition from imported textiles and outdated manufacturing processes, the sericulture industry in Assam continues to thrive, offering valuable employment opportunities and empowering marginalized communities. The book chapter highlights the importance of sericulture for rural development and economic empowerment, emphasizing its low gestation period, high returns, and eco-friendly nature. Looking ahead, the book chapter discusses opportunities for growth and innovation in the sericulture industry, including leveraging technological advancements, investing in research and development, and expanding market reach. Ultimately, the book chapter concludes that sericulture holds great promise for Assam's socio-economic development, preserving its cultural heritage while driving sustainable growth and prosperity in the region.

Keywords: Assam, Sericulture, Rural Economy

Introduction:

Nestled in the northeastern part of India, Assam is a serene state adorned with breath-taking natural beauty, including verdant hills, expansive plains, and mighty waterways. Renowned for its vibrant fairs and festivals, Assam is a haven for biodiversity, housing rare and near-extinct wildlife within its lush landscapes. As part of a global

biodiversity hotspot, Assam boasts an array of endangered species, such as the Golden Langur, Hoolock Gibbon, and Clouded Leopard, among others. Blessed with abundant rainfall, ranging between 178 and 305 cm annually, concentrated from June to September, Assam's fertile alluvial plains provide an ideal environment for agriculture, including the cultivation of rice and the production of world-famous tea. Additionally, Assam is rich in mineral and oil resources, contributing to its economic prosperity.

Sericulture, an ancient tradition in Assam, holds a special place in the state's cultural heritage. Assam takes pride in its traditional production of Muga, Eri, and Mulberry silks, with Muga silk being particularly emblematic. Endemic to the region, Muga culture thrives in various districts, making Assam the largest producer of Muga silk globally. Eri silk, another prized variety, is cultivated across the state, while Mulberry silk production remains concentrated in specific districts. Although Oak Tasar silk is produced on a limited scale in certain regions, Assam's emphasis lies on the production of Muga and Eri silks, renowned for their quality and uniqueness. This chapter explores the historical significance, current status, and future prospects of the sericulture industry in Assam, highlighting its integral role in the state's cultural and economic landscape.

Sericulture industry of India:

Sericulture stands as a comprehensive agro-based cottage industry, encompassing various activities such as the cultivation of host plants and the rearing of silkworms to produce cocoons for raw silk production. India holds the esteemed position of being the second largest producer of silk globally. To foster the growth of sericulture, the Government of India has allocated ₹2161.68 crores over three years (2017-2020) to its Central Sector Scheme ‘Silk Samagra’.

India's silk industry boasts a unique distinction, being the sole producer of all five commercially known silks. The country's total raw silk production reached 34,903 MT during the 2021-22 period, reflecting its robust contribution to the global silk market. In terms of exports, India garnered earnings of Rs. 1848.96 crores during the same period, underscoring its significance in international trade. Moreover, the silk industry plays a vital role in employment generation, with approximately 8.8 million individuals employed in various facets of sericulture across the country during the 2021-22 period. This highlights the industry's socio-economic impact, providing livelihood opportunities to a significant portion of the population.

Historical roots of sericulture in Assam:

The roots of sericulture in Assam stretch back to ancient times, as evidenced by references in historical texts and archaeological findings. The Ahom kings played a pivotal role in nurturing and promoting the art of silk production, recognizing its economic significance for the region. Assam's favorable climate and abundant vegetation provided an ideal environment for sericulture to thrive. Historical texts like the 'Ramayana' and Kautilya's 'Arthasastra' mention silk cultivation in ancient Assam. Kautilya's 'Arthasastra' even details the production of Dukula, a type of silk fabric, which had three varieties: Vangaka, Paundraka, and Suvarnakudya, identified today as Paat silk, Eri silk, and Muga silk respectively. The ancient text "Kalika Purana" also documents the use of silk in ancient Kamrup's religious ceremonies. Some historians suggest that knowledge of sericulture may have been introduced to Assam by the Bodo people migrating from China around 3000-2000 BC. Moreover, a silk trade route, the south-western silk-road, passing through Myanmar and Assam, connected China to Turkmenistan, further facilitating the exchange of silk. The sericulture industry in Assam encompasses both mulberry (Pat) and non-mulberry (Eri, Muga, and oak Tasar) sericulture. The Tibeto-Burman people introduced sericulture practices from China to Assam. The Muga culture, often hailed as the 'pride of Assam,' is believed to have originated in the sub-Himalayan region of Northeast India. Initially confined to the Ahom community in upper Assam, Muga silk production later expanded. Sualkuchi emerged as a prominent silk weaving village, earning the moniker "Manchester of the East" or "Manchester of Assam" due to its prolific silk production. Despite its rich heritage and cultural significance, challenges persist in sustaining the sericulture industry in Assam. Efforts to revitalize silk production and preserve traditional weaving techniques remain ongoing, ensuring that Assam's legacy as a silk-producing hub endures for generations to come.

The present landscape:

In Assam, sericulture stands as a cornerstone of the state's economy, offering sustenance to numerous families, especially in rural areas. This industry encompasses a diverse array of activities, ranging from mulberry cultivation and silkworm rearing to silk weaving and marketing. Assam's reputation for producing exceptional silk varieties, including Muga, Eri, and Pat silk, is upheld with pride, each type cherished for its unique attributes and aesthetic appeal. Government initiatives play a pivotal role in supporting the

sericulture sector, aiming to boost silk production, improve silk quality, and empower silk farmers and weavers. Programs such as the Chief Minister's Samagra Gramya Unnayan Yojana (CMSGUY) and the Assam Silk Outreach Mission have been pivotal in providing financial aid, training opportunities, and infrastructure development to stakeholders within the sericulture industry.

Cultivation of three distinct silk worm varieties contributes to the vibrant tapestry of the state's sericulture:

Muga silk:

Muga silk, renowned for its radiant golden hue and exclusivity to Assam, holds a revered status. Thriving in Assam's unique climate, Muga Silk worms, scientifically known as "Anthera Assam," are cultivated across various districts of the Brahmaputra valley. With approximately 2625 hectares of land dedicated to its production, Muga Silk production sustains around 30,000 households in Assam. Research and extension activities undertaken by institutions like the Assam Agricultural University in Jorhat and the Central Silk Board of India further propel the growth of the Muga Silk industry.

Eri silk:

Eri silk, deeply rooted in Assam's traditions, involves silkworms feeding on castor leaves. Unlike Muga Silk, the cocoon of Eri Silk cannot be reeled and requires spinning. Eri Silk production spans all districts of Assam, with nearly 2993 hectares of land dedicated to cultivating food plants for Eri Silk worms. The state hosts 21 Eri Silk spinning training centers and a Sup Silk Mill in Jagiroad, engaging around 1.28 lakh families in Eri Silk rearing and production.

Mulberry silk:

Mulberry silk, another significant component of Assam's sericulture landscape, engages approximately 40,000 families in its production. Cultivation of food plants for Mulberry Silk worms covers around 2300 hectares of land, primarily in Upper Assam districts like Lakhimpur, Sibsagar, Dibrugarh, and Jorhat. The State Sericulture Department's systematic Seed Organisation Programme and establishment of a Cold Storage plant in Kamrup District underscore efforts to enhance Mulberry Silk production.

Sualkuchi, affectionately termed the "Manchester of the East," serves as Assam's focal point for silk weaving. Renowned for its production of exquisite fabrics of Muga Silk, Mulberry Silk, and Oak Tassar Silk, Sualkuchi remains an emblem of Assam's rich

sericulture heritage. The introduction of Oak Tassar Silk has led to the establishment of Tassar Centers in hill districts like Karbi Anglong and North Cachar, harnessing the abundance of Oak trees in the region for silk production.

Challenges and opportunities:

The sericulture industry in Assam faces various challenges that hinder its growth and competitiveness. These challenges include:

1. Imports of low-priced textiles: The influx of inexpensive textiles from other countries poses a threat to the market for Assamese silk products, leading to increased competition and price pressures.
2. Use of old silk manufacturing processes: Outdated technology and traditional manufacturing methods may result in inefficiencies and lower quality products compared to modern production techniques.
3. Use of poor quality seeds and less productive silkworm breeds: The use of inferior quality seeds and breeds can lead to lower silk yields and inferior product quality, impacting the profitability of sericulture operations.
4. Poor supply chain management and increased import of silk from China: Inadequate supply chain management practices and reliance on imported silk from countries like China can disrupt local silk production and undermine the competitiveness of Assamese silk products.

In addition to these challenges, the sericulture industry in Assam also faces natural challenges such as inconsistent weather patterns, pest attacks, and diseases that affect silkworm rearing and mulberry cultivation. Limited access to credit, outdated technology, and inadequate market linkages further compounds the difficulties faced by silk farmers and weavers. However, amidst these challenges, there are opportunities for the sericulture industry in Assam to thrive. The growing demand for sustainable and eco-friendly textiles presents a unique opportunity for Assamese silk, known for its organic production methods and natural sheen. Additionally, the emergence of e-commerce platforms and global trade networks offers avenues for expanding the market reach of Assam's silk products beyond national borders. By addressing the challenges and leveraging these opportunities, the sericulture industry in Assam can unlock its full potential and contribute significantly to the state's economic development.

Importance and future prospects:

The sericulture industry in Assam offers significant benefits and opportunities for rural development and economic empowerment. Here are some key points highlighting its importance:

- Value addition in villages: A substantial portion (57%) of the final product's gross value in the silk fabric industry flows back to cocoon growers, contributing to rural income generation and livelihood improvement.
- Low gestation, low investment, high returns: Mulberry cultivation for silkworm rearing requires relatively low investment and offers quick returns, with mulberry plants supporting silkworm rearing for 15-20 years.
- High employment potential: Sericulture provides gainful employment to millions of people every year, with one person employed throughout the year for producing every 3.07 kg of silk used in handlooms.
- Women-friendly occupation: Over 60% of those employed in the sericulture industry are women, as sericulture activities are effectively managed by them, from host plant garden management to post-cocoon activities like silk reeling and weaving.
- Ideal for weaker sections of society: Sericulture can be practiced with low land holdings, making it an ideal occupation for weaker sections of society. Its low gestation period and high returns further contribute to its suitability for rural communities.
- Eco-friendly activity: Mulberry cultivation contributes to soil conservation and provides green cover, while waste from silkworm rearing can be recycled as inputs. Sericulture is also labor-intensive and does not involve smoke-emitting machinery.

Looking ahead, the sericulture industry in Assam holds great promise. By embracing technological advancements, investing in research and development, and focusing on skill development and capacity building, Assam can further enhance silk production efficiency, improve quality standards, and expand market reach. Leveraging its rich cultural heritage and artisanal skills, Assam can emerge as a global leader in sustainable silk production and ethical fashion, driving socio-economic growth and prosperity in the region.

Conclusion:

The sericulture industry in Assam stands as a testament to the state's rich cultural heritage and economic potential. Rooted in ancient traditions and supported by favorable climatic conditions, sericulture has been a cornerstone of Assam's identity for centuries. Despite facing challenges such as competition from imported textiles and outdated manufacturing processes, the industry continues to thrive, offering valuable employment opportunities, particularly in rural areas, and empowering marginalized communities. The future of sericulture in Assam looks promising, with opportunities for growth and innovation. By leveraging technological advancements, investing in research and development, and enhancing market linkages, Assam can further strengthen its position as a global leader in sustainable silk production. Moreover, initiatives aimed at skill development and capacity building can empower local communities and artisans, ensuring the industry's long-term sustainability and contributing to the state's socio-economic development. As Assam continues its journey towards prosperity, the sericulture industry will remain a vital component of its economic landscape, preserving its cultural heritage and fostering sustainable growth for future generations to come.

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AMBERGRIS: SPERM WHALE'S VOMIT

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Introduction:

Ambergris is a highly prized commodity used in perfumery; a waxy substance generated in the intestines of sperm whales. It is taken straight out of the whale and discovered drifting in the sea or washing up on land. Ambergris deposits can occasionally be spotted floating on the ocean's surface or washing up on beaches all over the world. Ambergris is frequently referred to as the "floating gold" and the "treasure of the sea" due to its high market value.

History

The drug has been present in fossilised evidence dating back 1.75 million years, indicating that humans have probably been consuming it for more than a millennium. It has been referred to as floating gold and the treasure of the sea. For years, its origins were a mystery, leading to a number of theories being put forth, such as the use of big bird droppings or solidified sea foam. However, on rare occasions, these sections enter the whale's intestines and fuse together. Over several years, they grow inside the whale to produce a solid mass of ambergris.

Formation

Sperm whales consume vast amounts of cephalopods, including squids, which enter their stomachs and trigger a chain of biological processes that result in the formation of "ambergris," which shields the whales' internal organs from the prickly beaks and pens of the cephalopods. Once ambergris gets large in their stomach, sperm whales either vomit or excrete it to prevent intestinal blockage.

Characteristic of ambergris

Grainy fragments of shell and beak can be found in ambergris lumps, which range in colour from grey to dark brown. The lightest forms are seen in shades of grey or pure

white. When ambergris masses are exposed to the water and air for extended periods of time, oxidation occurs and the mass changes colour. Grey to brown are the shades between black and white. The smell of ambergris is one of its most distinctive features. There have been reports that it smelled strongly of faeces when it was taken out of the whale. However, once the mass dries out, the aroma is supposed to become more pleasant. It's commonly described as musky at this point. In fact, Herman Melville mentioned this peculiar odour in his book Moby Dick. He described how a dead whale's foul stench "stole a faint stream of perfume" from it.

Ambergris

Applications of ambergris

Ambergris is used to extract ambrein, an odourless alcohol that prolongs the fragrance of perfumes. For centuries, ambergris has been classed by colour by perfumers, with pure white variants producing the best fragrances. Ambrein has since been supplanted by synthetic compounds in all save the most expensive perfumes due to their affordability and ease of access. But because of its unique characteristics, ambergris has been valued for generations. It is most well-known for being used as a fixative for premium perfumes in the perfume business. In certain civilizations, it has also been used as an aphrodisiac, herbal medicine, and for medical purposes. The fact that ambergris emits pheromones, making it a real aphrodisiac, has increased the product's mystique. Additionally, ambergris has been utilised to improve wine and culinary flavours. It has also been added as an unusual flavouring to upscale cocktails, specialty cakes and boutique chocolate in recent years.in addition, known by its ancient Arabic name, anbar, it was utilised as incense, an aphrodisiac, and a medication to treat a variety of illnesses, including those affecting the heart, brain, and senses.

Sperm whale

Pods, or groups of approximately 15 to 20, are the typical form in which these cetaceans are found in temperate and tropical waters worldwide; solitary males, on the other hand, may stray into colder climates. Sperm whales can live up to 62 years, reaching sexual maturity at 7 to 13 years old and physical maturity at 25 to 45 years old. Their main source of food is cephalopods, such as the enormous squid. Of the toothed whales, the sperm whale has undergone the greatest evolutionary modification. One-third of the body's length and, it is believed, more than one-third of its weight are made up of the head. There are typically 36 to 50 big conical teeth in the lower jaw and a variable number of non-erupting vestigial teeth in the upper jaw. The spermaceti organ, also known as the case by whalers, is located in the intricately formed upper lip and nose of the head. Spermaceti and sperm oil were taken from this fluid for lubrication and illumination purposes. Sperm whales are the only animals with spermaceti organs. It can reach through 40% of the whale's length and has a capacity of up to 2,000 litres (530 gallons).

Sperm Whale

Hunting of sperm whales

Sperm whales were heavily hunted in the middle of the 19th and 20th centuries in order to obtain ambergris, oil, and other important goods. International restrictions on whale hunting were sparked by the massive population losses caused by large-scale hunting. Sperm whales are classified as "Endangered" by the IUCN. According to a 2022 study by Whitehead & Shin, there are around 850,000 sperm whales in the world, a 57% decrease in 310 years due to extensive whaling in the 1840s and 1960s. "Whales are currently protected worldwide, but they may still be in danger in the future," Richard states."Some nations are still pushing for the reintroduction of whaling as a population control and management strategy." Ambergris sales and collecting are subject to different laws in different countries.

Conservation of Sperm Whales

Since the Sperm Whale is protected under Schedule II of the Wildlife (Protection) Act, 1972, it is forbidden in India to exchange, possess, sell, or otherwise deal in ambergris. Sperm whales are protected globally under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix I. However, because ambergris is regarded as a naturally ejected waste product and is allowed to trade in many nations, it is not covered by the CITES regulations. Nonetheless, the domestic laws of the United States, Australia, and India forbid its ownership and commerce.

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ECO-PATHOLOGICAL INSIGHTS INTO CESTODE PARASITES: A COMPREHENSIVE REVIEW

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Abstract:

Fish represents a vital dietary staple, providing essential nutrition for human consumption. However, fish are susceptible to infections caused by a diverse group of pathogens known as parasites. Among these parasites, cestodes, commonly referred to as tapeworms, are prevalent in fish populations. Cestodes belong to the phylum Platyhelminthes and the class Cestoda, encompassing approximately 5000 species that parasitize various vertebrates, including humans. The life cycle of cestode parasites is intricate, typically involving three hosts. Understanding this complex life cycle is paramount for comprehending the interplay of intrinsic and extrinsic factors impacting fish populations. Research in this field sheds light on the dynamics of parasitic infections in fish, which have been escalating steadily over the years. Factors such as climate change, pollution, and human activities have contributed significantly to this rise. Numerous studies have focused on identifying new species of cestode parasites and elucidating their detrimental effects on fish growth and health. Parasitism remains a prevalent phenomenon across ecosystems, and researchers strive to grasp its implications for fish populations and stream ecology. By gaining insight into the ecological role of parasitic infections, researchers can better discern changes within fish populations and their broader environmental context.

Keywords: Fish, Cestode Parasites, Host

Introduction:

Fish is a rich source of minerals like magnesium zinc, iodine, iron and potassium. Parasites are omnipresent and they are mainly surviving in their host species. Numerous parasites with diverse life cycles that are categorized in various ways can be found growing on fish. Some of these parasites must pass through a number of intermediate hosts before they may reach a host, whereas many of them are transferred directly between ultimate hosts. Parasitic animals have evolved from free-living ancestors. Current evolutionary theory suggests that this is most likely to have occurred when individuals, pre-adapted for some other purpose, gained a selective advantage over other conspecifics by initial close association with and subsequent exploitation of a larger host organism (Poulin, 1998). Parasite life cycles can be maintained and developed in optimal conditions found in aquatic environments. The study of the occurrence of parasites in a particular fish species can give clues about the feeding ecology of the fish, and consequently about the food-web transmission of the parasites (Costa *et al.,* 2018). Marine environment is complex and provides extremely diverse habitat for a host and their parasites. Every host population within a habitat therefore acquires a characteristics array of parasites and these parasites communities in their turn can also characterize the habitat (Dogiel *et al.,* 1962) and this concept forms the basis of modern ecological parasitology which deals with distribution and abundance of parasites in time and space (Kennedy, 1975).

The community structure of parasites is shaped by a number of ecological parameters, including temperature, depth range, host behavior, and food. They exhibit a complex life cycle with three hosts. Copepods are the primary host, followed by fish as the intermediate host and humans as the final host. Parasitic infections occur when parasites and hosts are present in the same place at the same time. The presence of infective parasite stages may also cause hosts to undergo changes in behavior. In fish infection mechanisms is depend on environmental factors and the tissue of the host. Parasites diminish the dietary level of the host. Parasites decrease the growth of fish, making the host more susceptible to pathogens and affecting productivity. Analysis of host-parasite associations accordingly shows that animals with comparable food habitats tend to have similar kinds of parasites and that related hosts tend to have related parasites (Cameron, 1964).

Cestode infection is foodborne or by ingestion by the host. All cestodes parasites shows three stages- eggs, larvae, and adults. Adult cestode parasites reside in the intestine

of the final host species of fish. A cestode infection occurs when an adult tapeworm excretes feces into the environment, which is subsequently eaten by an intermediate host. Larvae develop from eggs, enter the circulation and accumulate in the muscle and other organs.

Effects of parasites on fish health:

Parasites are ubiquitous in aquatic environments and can significantly impact the health and well-being of fish populations. These organisms, ranging from protozoa to helminths, establish various relationships with their fish hosts, leading to a range of effects that can affect individual fish, populations, and even entire ecosystems.

Firstly, parasites can directly compromise the health of individual fish. They can cause tissue damage through their attachment mechanisms or by feeding on host tissues, leading to lesions, inflammation, and impaired organ function. For example, ectoparasites like the fish louse (Argulus) and the anchor worm (Lernaea) attach themselves to the skin and gills of fish, causing irritation, secondary infections, and sometimes even death if left untreated. Endoparasites such as nematodes, trematodes, and cestodes infect various organs like the intestines, liver, and kidneys, disrupting their normal function and leading to symptoms like reduced growth, lethargy, and organ failure.

Moreover, parasites can weaken fish by draining their energy reserves. Many parasites rely on their hosts for nutrition, either by feeding directly on host tissues or by absorbing nutrients from their surroundings. This can lead to reduced food intake efficiency and increased metabolic demands on the host, ultimately resulting in decreased growth rates and compromised immune function. In aquaculture settings, where fish are reared intensively, parasitic infections can lead to significant economic losses due to reduced productivity and increased mortality rates.

In addition to direct physiological effects, parasitic infections can also alter fish behavior and ecological interactions. For example, some parasites manipulate the behavior of their hosts to enhance their own transmission. For instance, certain trematode parasites alter the behavior of their fish hosts, causing them to exhibit erratic swimming patterns that make them more susceptible to predation by their next host in the parasite's life cycle. This phenomenon, known as parasite-induced behavioral manipulation, can have cascading effects on predator-prey dynamics and ecosystem stability.

Furthermore, parasitic infections can weaken fish populations and make them more vulnerable to other stressors, such as pollution, habitat degradation, and climate change. Weakened individuals are less able to cope with environmental challenges and are more susceptible to secondary infections, leading to population declines and increased mortality rates. In extreme cases, parasitic outbreaks can result in mass mortalities, disrupting ecosystem dynamics and affecting other organisms that depend on fish as a food source.

To mitigate the effects of parasites on fish health, various strategies can be employed. These include regular monitoring and surveillance for parasite presence, implementation of biosecurity measures to prevent parasite introduction and spread, use of chemical treatments and therapeutics to control parasite populations, and promotion of good husbandry practices to enhance fish immunity and resilience. Additionally, research into the ecology and life cycles of fish parasites can help improve our understanding of their impacts and inform more effective management strategies.

Parasites exert diverse effects on fish health, ranging from direct tissue damage and energy depletion to behavioral manipulation and population-level impacts. Understanding these effects is crucial for the sustainable management of fish populations and the conservation of aquatic ecosystems. By implementing appropriate monitoring, prevention, and control measures, we can minimize the negative impacts of parasites and ensure the health and resilience of fish populations in both natural and aquaculture environments.

Infection accompanying changes in behavior of fish:

Infectious diseases can profoundly influence the behavior of fish, leading to alterations that range from subtle shifts in activity patterns to dramatic changes in social interactions. Understanding these infection-induced behavioral changes is crucial for comprehending the ecology and dynamics of aquatic ecosystems. Here, we explore the mechanisms and ecological implications of how infections affect fish behavior.

One of the most intriguing phenomena in this context is parasite-induced behavioral manipulation. Parasites, such as trematodes, protozoa, and nematodes, have evolved intricate strategies to manipulate the behavior of their fish hosts, often to enhance their own transmission. For instance, the trematode *Diplostomum spathaceum* alters the behavior of infected fish, causing them to exhibit increased shoaling behavior and reduced vigilance, which can make them more susceptible to predation by birds, the parasite's definitive hosts.

These alterations in fish behavior are often mediated by direct effects on the central nervous system. Parasites release neuroactive compounds or interfere with neurotransmitter pathways, leading to changes in sensory perception, motor coordination, or decision-making processes. For example, the trematode *Euhaplorchis californiensis* infects killifish, altering their behavior by affecting serotonin levels in the brain, resulting in increased susceptibility to predation by birds.

In addition to parasite-induced behavioral manipulation, infections can also lead to more general changes in fish behavior due to physiological stress or discomfort. For instance, bacterial or viral infections can cause inflammation, pain, or metabolic disturbances, leading to reduced activity levels, altered feeding behavior, or increased aggression. These behavioral changes may reflect an attempt by infected fish to conserve energy, allocate resources towards immune defenses, or minimize the risk of further injury or predation.

The consequences of infection-induced behavioral changes in fish extend beyond individual fitness to impact ecosystem dynamics. Alterations in the behavior of key predator or prey species can propagate through food webs, affecting the abundance and distribution of other organisms. For example, increased predation on infected prey may influence the composition of predator communities or alter the foraging behavior of top predators, leading to cascading effects on lower trophic levels.

Furthermore, infection-induced changes in fish behavior can have economic implications for fisheries and aquaculture industries. Disease outbreaks can lead to reduced growth rates, increased mortality, or decreased reproductive success in infected fish populations, resulting in economic losses for commercial fisheries or aquaculture operations. Moreover, behavioral changes associated with infection may impact the effectiveness of management strategies, such as stock enhancement or habitat restoration efforts.

To mitigate the effects of infection-induced behavioral changes in fish, integrated approaches that consider both ecological and physiological factors are essential. This may involve monitoring the prevalence and distribution of infectious diseases in wild fish populations, implementing biosecurity measures to prevent the introduction and spread of pathogens in aquaculture facilities, and developing targeted treatments or vaccines to control disease outbreaks. Additionally, maintaining habitat quality and biodiversity may

enhance the resilience of fish populations to infectious diseases by promoting natural immune defenses and reducing stressors that exacerbate infection-induced behavioral changes.

Infections can profoundly influence the behavior of fish, with implications for individual fitness, ecosystem dynamics, and human activities. By elucidating the mechanisms and ecological consequences of infection-induced behavioral changes, we can better understand the complex interactions between pathogens, hosts, and the environment, and develop more effective strategies for managing and conserving fish populations in the face of infectious diseases.

Change foraging behaviour of fish:

Infectious diseases have been shown to alter the foraging behavior of fish, often as a consequence of physiological stress, discomfort, or pathogen-induced changes in neurological function. For instance, research has demonstrated that fish infected with parasites or pathogens may exhibit reduced activity levels and altered feeding behavior. This can manifest as decreased exploration of the environment, reduced pursuit of prey, or changes in the types of food items consumed.

One study by Sopinka *et al.* (2014) found that fish infected with the parasite *Diplostomum pseudospathaceum* exhibited reduced foraging activity compared to uninfected individuals. The researchers observed that infected fish spent less time actively searching for prey and showed a preference for less energetically demanding feeding strategies. This altered foraging behavior was attributed to the physiological stress caused by the parasite infection, which may have affected the fish's energy budget and metabolic rate.

Similarly, bacterial and viral infections can also influence fish foraging behavior. For example, a study by Ellis *et al.* (2017) showed that fish infected with viral pathogens exhibited decreased feeding rates and altered food preference compared to healthy individuals. The researchers suggested that the presence of the virus may have induced changes in the fish's sensory perception or appetite regulation, leading to alterations in foraging behavior.

In addition to direct effects on feeding behavior, infectious diseases can also impact other aspects of fish ecology that indirectly influence foraging. For instance, parasitic infections can affect fish growth rates, energy reserves, and reproductive success, all of

which can influence foraging behavior and food acquisition strategies. Moreover, changes in predator-prey dynamics resulting from infection-induced alterations in behavior can also affect the availability and distribution of food resources in aquatic ecosystems.

Overall, infection-induced changes in foraging behavior can have important implications for the health and ecology of fish populations. Understanding the mechanisms underlying these behavioral alterations is essential for predicting the impacts of infectious diseases on fish communities and ecosystem dynamics.

Effects on humans:

Infectious diseases affecting fish can have consequential impacts on humans, both directly and indirectly, through various pathways such as food safety, economic losses, and public health concerns.

Firstly, infectious diseases in fish can pose a threat to human health through the consumption of contaminated seafood. Fish that are infected with parasites, bacteria, or viruses may harbor pathogens that can cause foodborne illnesses in humans. For example, certain fish parasites, such as Anisakis spp. and Diphyllobothrium spp., can infect humans upon consumption of raw or undercooked fish, leading to symptoms ranging from gastrointestinal discomfort to more severe complications like anisakiasis and diphyllobothriasis (Audicana & Kennedy, 2008; Scholz et al., 2019). Bacterial pathogens like Vibrio spp., Salmonella spp., and Listeria monocytogenes can also contaminate fish and seafood products, causing foodborne illnesses such as vibriosis, salmonellosis, and listeriosis (Baker-Austin et al., 2013; CDC, 2020; EFSA, 2021).

Moreover, infectious diseases in fish can have significant economic implications for human populations, particularly those dependent on fisheries and aquaculture for food security and livelihoods. Disease outbreaks in aquaculture facilities can lead to mass mortalities, reduced productivity, and financial losses for fish farmers and associated industries (Munang'andu et al., 2012; Stentiford et al., 2017). In wild fisheries, declines in fish populations due to infectious diseases can impact the availability and affordability of fish products, affecting local economies and food supply chains (Harvell et al., 2019).

Additionally, infectious diseases in fish can indirectly affect human health and well-being by disrupting ecosystem services and ecological balance. For example, declines in fish populations due to disease outbreaks can disrupt food webs and alter nutrient cycling in aquatic ecosystems, potentially leading to cascading effects on water quality, biodiversity,

and ecosystem stability (Lafferty et al., 2015; Johnson et al., 2020). These changes may, in turn, impact human communities reliant on ecosystem services provided by healthy aquatic environments, such as clean water, recreational opportunities, and cultural traditions (Costanza et al., 2014).

In summary, infectious diseases affecting fish can have multifaceted impacts on human health, livelihoods, and ecosystems. Understanding the linkages between fish health, human well-being, and ecosystem health is essential for developing integrated approaches to disease management and conservation that promote the sustainable use of aquatic resources and protect human populations from the risks associated with infectious diseases in fish.

Conclusion:

From the above data collected from different research papers, it is found that there is an immense diversity of cestode parasites in fish; they affect fish behavior and cause severe damage to their tissues. As the climatic conditions are favorable for the parasite, its population is increasing rapidly. This increase is mainly due to climate change, pollution, and several anthropogenic activities. This has affected the lives of fish. Aquatic habitats provide the epitome of conditions for the evolution of the parasite life cycle. The conclusion reached was that, within a given geographic area, a specific species group could be dominant in one host and dominating, influent, or accessory in another host. Various contributing elements, including habit, habitat, food, and other physiological parameters, could be responsible for this. It is estimated that there are numerous species of fish parasites which are still unknown and many species are new to science.

So, it is suggested that molecular level of study is necessary to description of unknown species, understanding the life cycle and interaction of these organisms with their hosts is often key to understanding the dynamics of ecosystems generally. To bring the knowledge of India's cestode fauna up to par with current understanding, contemporary molecular technologies should be used in systematic research.

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CHEMOTHERAPY IN AQUACULTURE

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A short history of chemotherapy

Because of his contributions to immunology and chemotherapy, German scientist Paul Ehrlich is regarded as the founding father of chemotherapy. However, the development of chemotherapy as a cancer treatment began during World War II when it was found that American naval troops exposed to mustard gas had altered bone marrow cells. Later studies discovered that a substance known as nitrogen mustard was effective in treating lymphoma. The development of medicines that destroyed cancer cells that were developing quickly began at this point.

Shortly after, a Boston researcher demonstrated that a substance connected to folic acid caused leukaemia remissions in young patients. The substance known as "aminopterin" was the forerunner of methotrexate, a medication used frequently to treat cancer. Since then, scientists have found a wide range of medications that inhibit several processes involved in cell division and proliferation. The finding that cancer treatments worked far better in combinations was a big breakthrough. Combinational chemotherapy proved effective in treating a considerable percentage of lymphomas by the late 1960s. Treatments have been increasingly focused in recent years in an effort to reduce side effects and increase effectiveness, and research in this area is ongoing. Additionally, over time, medications to lessen and manage adverse effects have made substantial advancements.

Definition of chemotherapy

The application of chemicals to treat illness, particularly cytotoxic and other drug-treated cancer. Any substance that eliminates bacteria or stops their growth is an antimicrobial agent (AMA). Chemotherapy is the general term for chemical drugs used to treat a microbial infection. It includes antibiotics, antifungals, antiprotozoal or

antiparasites, antivirals, and any of a wide range of chemical compounds and physical agents used to either destroy or stop the growth of microorganisms.

First Antimicrobial Agents (AMA) used in aquaculture

Since early researchers looked at the properties of azo dyes for potential antimicrobial action, the development of antimicrobial medicines to treat systemic bacterial infections is one of the most fascinating tales in the history of microbiology. The sulphonamides, a different class of substances directly derived from the chemical alteration of a synthetic product called "prontosil," were quickly identified as having early promise for the treatment of furunculosis in trout. The first naturally occurring antibacterial drug to be successfully used in a therapeutic setting was penicillin. Fleming did note that a contaminated Penicillium inhibited the growth of Staphylococcus aureus on an agar plate, but it took several years for other researchers to purify enough penicillin for use in clinical trials. Since the 1940s, chemotherapeutic drugs have been the subject of numerous documented investigations, leading to the development of antibiotics that are currently effective against almost all bacterial infections.

Therapy

Once a condition has been identified, therapy involves giving medications or chemical substances through feed or by any other method. Fish infections are primarily caused by three factors: the presence of environmental pathogens, inadequate fish stock resistance, and unfavourable water conditions.

Treatment process

Before using treatment, one should be aware of four things: 1. Understand the water 2. Recognise the fish 3. Understand the substance; 4. Understand the illness. Treatment needs to be evaluated in light of the population.

Routes of drug administration

There are three ways to administer drugs: intravenously, orally, and with water. Note that the fish should not be fed 24 hours before to treatment. Pre-treatment checklists, treatment checklists, and post-treatment checklists are the order of activities.

Waterborne treatments

Drugs added to water have the ability to treat both systemic and ectoparasitic disorders. The gastrointestinal tract, the gills, and the skin are the three routes. First, there

are two sorts of treatments: short exposure time with a high medication concentration. The second is a long exposure period with a low drug concentration.

Different type of water borne treatment

There are four types of treatment dip treatment bath treatment flush treatment and prolonged immersion treatment.

Advantages of water borne treatment

- Most common method.
- Common method when drugs of low therapeutic value are used

Disadvantages of water borne treatment

- Easy and non-stressful.
- Dosing problems.
- Unstable and formation of toxic by-products.
- Used mainly for surface dwelling pathogens.
- Can also be used for systemic diseases.

Oral medication

It's crucial to combine oral medications with pelleted feeds at the prescribed dosage. Fish raised in ponds and cages are the principal uses for it. Fish that are sickly refuse to eat. Two methods of taking medication orally are commercial medicated meals and artemia loading.

Advantages of oral medication

- Minimum stress.
- For mass treatment.
- Good for cages and ponds.

Disadvantagesof oral medication

- Fishes may be reluctant to feed.
- Poor pond conditions.
- Development of drug resistant bacteria.

Injection

Using this technique, the medication is injected into the fish's body. Because the fish needs to be sedated, it could be distressing. However, a specific dosage must be administered. It's important to weigh fish accurately, and injecting little fish might be

challenging. The first two types of injections are intramuscular and intraperitoneal. It is best to administer intraperitoneal injections close to the ventral midline. If the fish are little, it might be a better choice. Fish intended for intramuscular use should have a length of at least 13 cm. Adjacent to the dorsal fin is the ideal location for injection.

Name of disease	**Causative agent**	**Treatment**
Fin rot and tail rot	Pseudomaonas *sp*, Aeromonus *sp*	Baththreatment in 1:2000 copper sulphate for 2 minutes or swabbing of concentrated coppersulphate solution in the affected fishes.
Dropsy	*Aeromonas hydrophila* and myxozoan	Terramycin in the feed (80 ppm)
Eye disease	*Staphylococcus aureus*	Chloromycetin bath @ 8 - 10mg/L Disinfecting the environment with Potassium permanganate at a dose of 0.1 ppm followed by liming@300 ppm check the disease.
Ulcer	Areomonus sp, Pseudonomas *sp.*	0.5 ppm solusion of KMnO4, tetramycin 75-80 mg/kg mix with feed continue 10-12 days
EUS	*Aphanomyces invadans* (oomycete)	200 kg/hac quicklime or 0.1 ppm CIFAX
Ichthiriophthiriasis	*Ichthiriophthiriasis multiphilis*	2% NaCl for 7-10 day, quicklime 200 kg/ha
Dectylogyrosis & Gyrodectylosis	*Dectylogyrosis sp, Gyrodectylosis sp*	3-5% NaCl bath, effected pond treat with 25 ppm fomalin or 4 ppm KMnO4
White gill spot disease	*Mixobolus benjalensis*, *M. catlae*	Add yeast to feed 1g/kg, 2- 3% NaCl bath, reduce density

Argulosis	Argulus *sp*	5 ppm KMnO4 dip, treatment with Botux three times @ 35 ml/ha-m weekly intervals
Branchiomyces	Branchiomyces *sp*	3-5% NaCl or 5 ppm KMnO4 bath for 5-10 min and effected pond apply quicklime 50-100 kg/ha
Saprolegniasis	*Saprolegnia parasitica*	3-5% NaCl or 5 ppm KMnO4 bath for 5-10 min, 1-2 ppm of malachite green bath for 1 hr. effected pond can apply 20 ppm of formaline

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LYMPHOPHENIA DISEASE CONTROLLED BY POME FRUITY AND NUTTY BROWNIE

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Abstract:

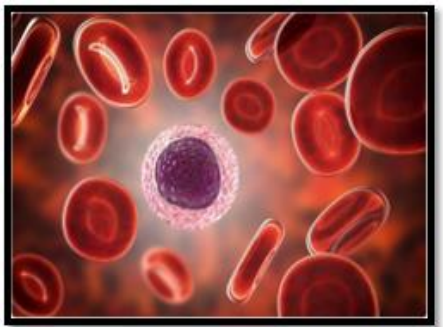
Lymphopenia, or insufficient lymphocyte count, also known as lymphocytopenia or lymphocytic leukopenia, is characterized by a depletion of white blood cells, specifically lymphocytes. In adults, the standard lymphocyte range is 1,000 to 4,800 per microliter of blood, with lymphopenia defined as falling below 1,000. For children, the acceptable range varies by age, with those under 2 years old considered to have lymphopenia if their count is below 3,000. Symptoms of this condition may include fever, cough, swollen lymph nodes, joint swelling, mouth ulcers, jaundice, and an enlarged spleen. Several factors can contribute to lymphopenia, including cancer treatments, drugs for autoimmune diseases, bone marrow transplants, chemotherapy, radiation therapy, and the use of immunosuppressants. In addressing this condition, nutrition therapy is crucial. Increasing the intake of nutrients such as Vitamin C, protein, zinc, vitamin B12, and folic acid is recommended. In the realm of nutrition therapy, a noteworthy addition to the diet is rice flakes brownies paired with pomegranate juice and amla. This combination is rich in protein, calcium, and iron, providing valuable support to the immune system. By incorporating these elements into one's dietary habits, individuals can foster the production of lymphocytes, contributing to a strengthened immune response.

Keywords: Lymphocytopenia, Immunosuppressant, Microliter of Blood, Nutrition Therapy

Introduction:

Robert Hooke used microscopy in the 17th century to identify white blood cells, which set the stage for later lymphocyte research. The 1980s saw the identification of HIV's deliberate assault on T cells, which provided insight into immunodeficiency and

autoimmune illnesses. Examining lymphocyte-based treatments for inflammatory, autoimmune, and cancerous disorder. Reduced lymphocyte number, termed lymphopenia, can mediate lymphopenia-induced proliferation (LIP) to maintain peripheral lymphocyte numbers. LIP not only occurs in normal physiological conditions but also correlates with autoimmunity.



Definition:

The lower limit of normal for a lymphocytic count is usually stated to be 1,500 per c.mm. (Wintrobe, 1939). Nutritional anemia due to iron deficiency is the most common cause of anemia. In this lymphophenia can cause by nutritional deficiencies of vitamin C and folic acid. A chocolate brownie, or simply a brownie, is a chocolate baked confection. Brownies come in a variety of forms and may be either fudgy or cakey, depending on their density. Brownies often, but not always, have a glossy "skin" on their upper crust. The amla puree was taken as main ingredients in the brownie .it contains high amount of vitamin c.

Sign and symptoms:

- Sinus infection
- Bronchitis
- Ear infection
- Swollen Lymph nodes
- Pneumonia& Fungal infection, Weight loses.

Causes

- Infections, such as HIV/AIDS, mononucleosis, and cytomegalovirus (CMV)
- Autoimmune diseases, such as lupus
- Rheumatoid arthritis
- Malnutrition
- Certain medications, such as chemotherapy drugs and steroids
- Severe stress

Risk factors:

- During the first two years of treatment, lymphopenia grade 2 or above was present in 28.5% of patients receiving DMF (diethyl fumarate) treatment.
- The likelihood of DMF-induced lymphopenia was higher in patients with low baseline absolute lymphocyte counts and lower in those with high baseline counts.
- The age of 56 years or older was found to be a significant risk factor for lymphopenia caused by DMF. Patients who had a body mass index of 30 kg/m2 or higher had a lower risk of lymphopenia caused by DMF.

Treatment:

- Gamma globulin (a substance rich in antibodies) may be given to help prevent infections in people with too few B cells (who therefore have a deficiency of antibody production).
- People with a hereditary immunodeficiency disorder may benefit from stem cell transplantation.

Diet and nutrition:

Children under the age 6 years mostly affected from this lymphophenia disease. Foods which can improve from the disease are protein and beta - carotene fruits and vegetables, the protein are made up of complete chain of amino acids which can boost the immune system. In which fruits are rich in beta carotene has the ability to increase the production of white blood cells or lymphocytes in the body because it is loaded with vitamin A and Vitamin C.

Product-pome fruity and nutty brownie

Brownies are not classified as cakes. This is a very interesting point about the brownie. The reason for this is that although the texture is similar to cakes, it is classed as finger food (whereas usually cake is eaten with a fork), therefore they are categorized as a cookie bar (in America). As you pick them up with your fingers much like a cookie, they don't sit in the cake category.

Objectives:

- To provide a nutritious brownie as compared to commercial brownies.

- To increase the count of white blood cells.
- To create new product that is both functional and delicious

Methodology:

Methodology pertaining to the study ‘‘The lymphophenia disease controlled by pome fruity & nutty brownie’’ are as follows:

Raw ingredients:

The brownie made with rice flakes, dark chocolate, jaggery, goose berry juice, pomegranate juice, all purpose flour, dates, and groundnut.

Selection and processing of raw materials:

- The raw materials Rice flakes, all purpose flour, pomegranate, Dark chocolate, Dry dates, Jaggery, amla and ground nut are purchased from the local market of sankagiri, Salem District, Tamil Nadu.
- Choose fresh samples and check manufacturing / packaging date & ensure no evidence of moisture, molds, or any dirt. Buy organic fruits when it is possible. Inspect fruits odour, which should smell fresh, avoid musty odour.

Standardization of the pome fruity and nutty brownie:

Table 1: Ingredients for preparation of brownie

Ingredients	X1	X2	X3
Rice flakes (gm)	9	7	7
Pomegranate (gm)	8	9	9
Dates (gm)	2	2	2
Banana (gm)	2	2	2
Jaggery – sugar cane (gm)	9	8	7
Dark chocolate (gm)	5	7	7
Groundnut (gm)	5.5	5.5	5.5
All purpose flour (gm)	8	8	9
Butter (gm)	1	1	1
Gooseberry (gm)	0.5	0.5	0.5

Flow chart of development of brownie:

⇩

Measuring the raw ingredients

⇩

Blending the all ingredients except dark chocolate, flour

⇩

mixing the all blended ingredients with flour and dark chocolate gently to make a batter

Baking the batter fof 190 C ,25 mins

⇩

The pome fruity &nutty brownie is ready to serve

Nutrition calculation

(Calculation Method-NIN, Revised -1989, Reprint -2018):

Ingredient	Quantity (g)	Energy (kcal)	Protein (gm)	Carbohydrate (gm)	Fat (gm)	Fibre (gm)	vitamin- C (mg)	Iron (mg)
Rice Flakes	15	51.9	0.99	11.5	0.18	0.105	0	3
Pomegranate	20	13	0.79	2.9	0.02	1.02	3.2	0.358
Black Dates	5	15.8	0.125	3.79	0.02	0.19	0.15	0.73
Country Banana	10	11.6	0.12	2.7	0.03	0.04	0.7	0.036
Jaggery (Sugar cane)	5	17	0.54	4.75	0.005	-----	0.35	0.132
Dark Chocolate	10	50	0.49	5.96	3.42	0.6	0	0.8
Roasted Groundnut	5	28.5	1.91	1.33	1.9	0.15	0	0.155
All purpose Flour	10	36	1.88	7.63	0.1	0.3	0	0.24
Butter	10	72.9	-----	-----	8.1	----	----	----
Gooseberry	10	5.3	0.188	1.11	0.02	0.32	4.9	0.2
Total		**304**	**6.84**	**41.69**	**13.795**	**2.725**	**9.3**	**5.651**

The nutritive value calculated by NIN book revised copy for the year of 1989 and reprinted was 2018. We have calculated the value for the Pome Fruity & Nutty Brownie, provides Energy – 304 kcal, Protein – 6.84g, Carbohydrates – 41.69g, of fat, 2.725g Fiber – 13.795g, Vitamin C – 9.3mg and Iron – 5.651mg accordingly

Sensory evaluation:

Panels Name	Appearance	Texture	Taste	Flavour	Overall Acceptability
Trained Panels					
N Indra	5	5	5	4	5
S Logeshwari	5	4	5	5	5
S Swathy	5	4	5	5	5
Semi Trained Panels					
N Dhanusri	5	4	5	5	5
A Raveena	5	5	4	4	5
P Vedhavithya	5	4	5	5	5
M Yuvasri	5	5	5	4	4
M Pavithra	5	4	5	5	5
R Madhumitha	5	5	5	5	5

The product made from all purpose flour was tested for evaluating of sensory characteristics and its acceptability. This measured the acceptability of the characteristics of the product in comparison to percentage of all purpose flour that it contains and identify which percentage variation is the most acceptable. Six students were randomly selected through convenience semi trained panel sampling to participate in the study also four faculties were selected as trained panels, and they were asked to accomplish informed consent forms. The sensory evaluation forms used a 5-point hedonic scale for the general attributes such as and texture taste, appearance, aroma. The best and least sample were also asked in the latter part of the questionnaire along with recommendations and suggestions. A trained panel consists of experts who have undergone extensive training and calibration to evaluate specific sensory attributes of food using standardized methods and scale.

Pome fruity and nutty brownie:

The benefits of this product, choosing of ingredients locally availabale and very nutritious especially to made rice flakes and pomegranate for a high nutritious dessert/snack with high nutritional value. Because it contains high in protein, calcium, iron, and vitamin C. Cocoa powder & dark chocolate are rich sources of iron, it will help to reduce stress and anxiety by quantity taken. Primary it helps to boosting the immunity system and immune metabolisms. Nowadays this product very trendy and popular easy to accept all the age groups, delicious color and aroma was major reason for the successful product. Nutritional imbalance caused malnutrition in this specific nutrition concentrated and additionally added at the time of manufacturing, in this process called as food fortification. All the age are suffered micro nutrients so we have iron fortified with in this product. This fortification helps to promote micro nutrient balance for all the people comfort happy choice.

Improvement from the complications of lymphophenia:

The protein which can help to reduce the immune system function and also iron and vitamin c which stimulate the immunity boost and metabolisms .and also help to absorbs portion of iron in your body it can decrease the effect of lymphopenia.

Nutrient composition of the standardised pome fruity and nutty brownie:

The main nutrients present in the brownie contains minerals, protein so the test are moisture, ash, protein, iron, of the standardized rice flakes with pomegranate brownie presence was analyzed and the results Are presented in Table with their values

Proximate analysis:

Nutrients	RPF Brownie (100g)	Method
Moisture (%)	22%	Gravimetric method (1935)
Ash (g)	0.7(g)	Dry ash test (1976)
Protein (g)	6.5 g	Ninhydrin test (1910) Biuret test (1833)
Iron (mg)	6.3 mg	Calorimetric test (1934)

The moisture content in the material is important because it determines the Shelf life of the food products. The less amount of water content to enhance and prolonged the

shell life of the food. The ash test is mainly testing for retain minerals values in the food material .it can help to determine the minerals.

Result and Discussion:

Lymphophenia is a disorder in which the blood doesn't have enough WBC, the food product "pome fruity and nutty brownie" rich in Iron, zinc, protein, which is helps to produce the new cells of WBC in the blood especially lymphocytes. The outcome result of the product is evaluated by various aspects of nutrients analysis and the appropriate sensory evaluation notes the human attires like taste, texture, flavour, appearance of the humans. The overall acceptability of the pomegranate fruity and nutty brownie (variation 2) was accepted by all age groups.

Conclusion:

Pome fruity and nutty brownie made from rice flakes, pomegranate, amla, and groundnut. Are nutritious and rich in Protein, iron, zinc, magnesium and some other micro nutrients, which is helps to regenerating and preventing the decreased amount of white blood cell(lymphophenia). The disorder lymphophenia mostly attack the young children, so this brownie is very attractive to the children

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ONE HEALTH APPROACH TO CONTROL PARASITES OF ZOONOTIC IMPORTANCE

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Abstract:

Parasites are the organisms that get food and shelter from an organism and cause harm to the host that they infect. Parasites are causes of disease in both humans and animals. Parasites affect the health of animals and also cause production losses. Parasites can infect all species of animals, cause diseases in them, and cause production and financial losses. In humans, they are the cause of different systemic problems, such as GIT disturbances, circulatory disturbances, infertility, and various skin diseases.

A number of parasites are multi-host parasites, i.e., they infect more than one host species, and many of them involve humans. These parasites may be transmitted via zoonotic, anthrapozoonose, zooanthroponose, and amphixenose routes of transmission between animals and humans. There are many invertebrates that serve as vectors and are involved in the transmission of parasites among animals, humans, and humans to animals. This shows the interconnectedness of human, animal, and environmental health and emphasizes the need for a One Health approach to combat zoonotic parasites. These parasites are not controllable by the efforts of humans or animal practitioners alone. There is a need for intersectoral collaboration for the control of these parasites. One health approach is necessary for the control of parasites. Physicians, veterinarians, entomologists, and environmental scientists can work together for effective control and prevention of parasitic diseases. This chapter presents a framework for combating parasites for zoonotics of major importance, describes the advantages of one health approach, and describes one health approach for the control of parasites. This chapter also describes sustainable practices that can be implemented and future interventions that can be developed for the control of parasitic diseases.

One health

The concept of One Health enlightens the interconnection between the well-being of humans' animals and the environment. (WHO, 2017) It states that if the health of one of these three is disturbed, the effects will also affect others. It is a multidisciplinary approach that involves the collaboration of different sectors at the national and international levels that works for the soundness of these tree objectives at the same time. (Rüegg & Häsler, 2020) According to the WHO, 60 percent of human diseases are of zoonotic origin, and according to the World Organization for Animal Health, 75 percent of emerging infectious diseases originate from animals. (Organization, 2014)

One health approach focuses on the control and prevention of parasites that are transmitted to humans from animals. (Overgaauw *et al.,* 2020; van der Giessen *et al.,* 2021) In this regard, public health interventions such as epidemiology, risk communication, and behavior change programs can play a crucial role in implementing One Health strategies for zoonotic parasite control. (Hong *et al.,* 2020)

Importance of one health for parasite control

1. Zoonotic parasites

Zoonotic parasites are those parasites that are transmitted to humans from animals. Zoonotic parasites are the major public health threat as they are contagious and fatal. Many parasitic diseases, such as Cryptosporidiosis, Intestinal Nematode Infections, Leishmaniasis, Schistosomiasis, and Lymphatic Filariasis, that have affected 8.37 million, 5.16 million, 3.32 million, 3.31 million, and 2.78 million people, respectively, are transmitted through the zoonotic mode of transmission. (Pisarski, 2019) Parasites may get transmitted to hosts via meat, household pets, and other vectors such as flies. (Hossain *et al.,* 2023) This is a major global public health risk that needs to be taken into consideration. The vaccination of parasitic diseases is not available in practice, so these diseases can only be controlled through prevention. (Checkley *et al.,* 2015)

For the prevention of parasitic diseases One health approach can be an effective way to control parasitic diseases. This involves public health, veterinary medicine, and an ecological approach. Parasitic control via one health approach is crucial because humans and animals share many parasites. (Guo *et al.,* 2021)

2. Antimicrobial resistance

The increasing prevalence of resistance (AMR) presents a concern in the battle against controlling parasites effectively. When parasites become resistant to used treatments, it not only impacts the health of animals but also undermines the effectiveness of therapeutic options for the treatment of humans. (McEwen & Collignon, 2018; Velazquez-Meza *et al.,* 2022) Antimicrobial resistance is a serious problem shared between human and veterinary medicine. (Tang *et al.,* 2023) Anti-parasitic drugs that are used in animals for the treatment of parasites also remain present in the meat and milk of productive animals, and the slaughtering of animals during treatment before elimination of these drugs can contribute to anti-parasitic drug resistance. (Hennessey *et al.,* 2020; Mequanent, 2022) The concept of One Health takes into account the interdependence of the usage of antimicrobial agents in both humans and animals and their potential effects on well-being. (Cella *et al.,* 2023) To effectively address and handle resistance (AMR), it is crucial for veterinarians, physicians, and environmental health specialists to collaborate and work together. (Mudenda *et al.,* 2023)

3. Environmental Impact

The environment is shared by parasites, humans, and animals. The life cycle of many parasites involves their life stage in the environment. (Al-Malki, 2021) Parasites get entry into the host, i.e., humans and animals, through environmental sources such as vegetables and grazing pasteur, respectively. (Vourc'h *et al.,* 2022) The life cycle of parasites can be broken, and the burden can be reduced in both humans and animals by focusing on factors that favor the transmission of parasites. (Geary & Haque, 2021)

Parasite control strategies usually involve either the use of chemical or pharmaceutical agents that have extensive environmental implications. (Picot *et al.,* 2022) These pesticides or anti-parasite drugs used after reaching the environment may contaminate water sources and soil, which may affect aquatic ecosystems and ultimately affect human populations. One health approach recognizes the relationship between human health and environmental health. (Marselle *et al.,* 2021) By considering environmental implications during the mapping of parasite control strategies, effective and sustainable control of parasites can be achieved. (Monnier *et al.,* 2020)

One health approaches

1. Collaborative surveillance

In one health Collaborative surveillance involves the study and monitoring of human and animal populations at the same time. (Panel *et al.,* 2023) This approach can help in the early identification of areas of outbreaks of parasitic diseases and populations that could be at risk of disease. (Amato *et al.,* 2020) By exchanging data and information between public health organizations, we can establish systems that provide warnings, allowing us to respond promptly to potential outbreaks. (Aarestrup *et al.,* 2021) This proactive surveillance strategy is crucial for detecting risks and implementing preventive measures in a timely manner. (Kheirallah *et al.,* 2021)

Collaborative surveillance plays a role in controlling parasites within the scope of overall animal and human health. This approach involves efforts between human health sectors to observe, monitor, and analyze the prevalence and spread of zoonotic parasites. (Ghai *et al.,* 2022) Through combined resources and expertise, collaborative surveillance enables an understanding of the epidemiological and host factors that influence the transmission dynamics of these parasites. (Bordier *et al.,* 2020) This integrated approach recognizes that effective surveillance surpasses boundaries and requires a holistic method to promptly detect and respond to emerging threats. (Righi *et al.,* 2021) This effective system of surveillance, as demonstrated above, acts as a strong early detection system. It allows for proactive measures to be taken and reduces the harm caused by zoonotic parasites to animals and humans alike. (Bardosh *et al.,* 2020)

2. Shared data and resources

The research conducted by Sack in 2021 demonstrates the significance of utilizing resources within the framework of One Health. Their study examines how cost-effective it is to share facilities for zoonotic parasites. The results emphasize the advantages of collaborating on resource allocation, showing that shared facilities help decrease costs and improve access to services for professionals in both human and animal health.(Sack, 2021)

The research conducted by Blake and Betson in 2017 demonstrates the effectiveness of collaborative research efforts. Their study delves into analyzing the genes of parasites that can be transmitted between animals and humans, shedding light on how genetic factors affect which hosts they can infect and how they spread. By bringing together knowledge

from both veterinary genetics and human genetics, this study provides an understanding of the molecular processes behind zoonotic infections.(Blake & Betson, 2017)

3. Integrated parasitic control

Effective management of zoonotic parasites as an aspect of the One Health approach involves a combined strategy that incorporates drugs, vector control measures, and vaccination programs. In a study conducted by Krecek *et al.* in 2020, it was found that integrated drug administration is crucial in managing resistance in areas with high zoonotic activity. (Krecek *et al.,* 2020) Another study by Ogden *et al.* (2019) demonstrated the effectiveness of integrated vector control programs in reducing the transmission of diseases. (Ogden *et al.,* 2019) Benelli & Duggan (2018) highlighted the impact of shared vaccination strategies on preventing infections in both humans and animals. (Benelli & Duggan, 2018) Furthermore, interventions as a means to disrupt species transmission cycles can help in parasitic control. (Waltner-Toews, 2017) These various studies collectively emphasize how integrated approaches can effectively control parasites and prevent their spread.

4. Community engagement

Engaging with the community plays a key role in the One Health approach. It involves educating communities about parasites, how they are transmitted, and ways to prevent them. This proactive involvement encourages communities to take responsibility and actively participate in monitoring, preventing, and managing zoonotic parasites. Studies conducted by Lemma *et al.* (2019) highlight the impact of community-based education programs in reducing rates of infections. (Lemma *et al.,* 2019) Similarly, He *et al.* (2022) demonstrate a connection between community engagement and lower rates of zoonotic infections, emphasizing how informed communities can bring about change. (He *et al.,* 2022) The research conducted by Anderson and Butala *et al.* (2021) emphasizes the importance of adapting engagement strategies to differences, which helps build trust and cooperation for the control of zoonotic parasites. (Butala *et al.,* 2021) In summary, community engagement is an aspect of the One Health paradigm as it contributes to a comprehensive and culturally sensitive approach towards managing zoonotic diseases.

5. Research and development

In the context of the One Health approach, research and development (R&D) play a role in managing emerging zoonotic parasites. This requires collaboration across

disciplines in the veterinary and human medical sciences. The main goal is to drive advancements in diagnostics, treatments, and vaccines to address the changing nature of threats. A significant study by Gebreyes *et al.* (2021) examines the genetic factors that contribute to the transmission of diseases, providing valuable insights into how these infectious agents spread across species. (Gebreyes *et al.,* 2020) The work of Ruckert *et al.* (2021) highlights the effectiveness of collaborative approaches in vaccine development, offering transformative and protective solutions. (Ruckert *et al.,* 2021) Lustgarten et al.'s contribution in 2020 to developing tools bridges critical gaps between veterinary and human diagnostics, ensuring a comprehensive approach to detecting zoonotic diseases. (Lustgarten *et al.,* 2020) The overarching ethos within One Health paradigm recognizes that substantive progress in R&D stands as a linchpin for the efficacious control of zoonotic parasites, effectuating a conduit for continual innovation, advancing scientific frontiers, and ultimately fortifying the health milieu of both human and animal cohorts.

Advantages of one health approach

1. Reduced disease burdens

The concept of One Health in the field of controlling zoonotic parasites offers significant benefits by reducing disease burdens. This approach involves collaboration between the human health sectors to implement comprehensive surveillance and control strategies. These measures not only decrease the occurrence of diseases but also lessen their impact on society. (Zinsstag *et al.,* 2021) A study conducted by Rabinowitz *et al.* (2013) provides evidence of the positive outcomes achieved through integrated disease control methods. The research demonstrates a decrease in disease burdens due to coordinated interventions.(Rabinowitz *et al.,* 2013) By addressing the root causes of zoonotic transmission, such as shared vectors or reservoirs, the One Health framework proves to be an effective way to sustainably reduce disease burdens. (Kelly *et al.,* 2020) This collaborative model highlights the importance of a strategy and emphasizes how animal and human health is interconnected in disease management on a broader scale. (Ellwanger *et al.,* 2021)

2. Improved public health

In the field of controlling parasites that can be transmitted between animals and humans, the One Health concept is seen as an effective factor in improving health standards. Collaborative efforts between human health sectors result in strategies that not

only prevent infections but also contribute to overall advancements in public health.(Osterhaus *et al.,* 2020) This integrated approach recognizes the connections between animal health and addressing health challenges at their core. The comprehensive study conducted by Mubareka *et al.* (2023) serves as an example of the impact achieved through integrated endeavors on public health. (Mubareka *et al.,* 2023) By implementing surveillance and preventive measures, the study highlights an improvement in public health indicators, providing concrete evidence of how a unified approach can positively influence the well-being of society. (Organization, 2022) In alignment with Riley research (2021), further strengthening the link between the One Health approach and better outcomes for health solidifies its role in mitigating risks associated with parasites transmitted between animals and humans. (Riley, 2021)

3. Sustainable practices

In the realm of controlling zoonotic parasites, the One Health approach represents a commitment to go beyond boundaries and adopt sustainable practices.. (Ribeiro *et al.,* 2019) Collaborative efforts between human health sectors extend beyond dealing with diseases in the present, emphasizing the importance of promoting long-term health and well-being. (Nunes *et al.,* 2016) This integrated model recognizes the connections between animal and human health, acknowledging the necessity of sustainable practices in mitigating the ongoing risks posed by zoonotic parasites. (Wilcox & Steele, 2020) Pioneering research in this field exemplified by studies on the intersection of practices and zoonotic parasite control highlights the proactive nature of the One Health approach. (Gwenzi *et al.,* 2022) It not only focuses on disease control but also serves as a guardian of enduring sustainable practices. Therefore, the One Health Framework emerges as more than a response to zoonotic threats; it actively fosters long-term resilience through sustainable practices. (Abunna *et al.,* 2022; Mubareka *et al.,* 2023)

Conclusion:

The emerging parasitic diseases and resistance among parasites against antiparasitic drugs are serious and continuously raise concerns. One health approach can be a beat approach because of its advantageous approaches and advantages, which can be the future of parasitological approaches. Thus, it is crucial to adopt one health approach for effective control and prevention of parasitic infections.

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AN OVERVIEW OF INTELLECTUAL DISABILITY SYNDROME ASSOCIATED WITH ALPHA-THALASSEMIA X

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Abstract:

ATR-X syndrome is characterized by craniofacial abnormalities, genital malformations, hypotonia, and mild-to-profound developmental delay/intellectual disability. Over time, cranial anomalies such small head circumference, telecanthus or widely separated eyes, short triangular nose, tented upper lip, and thick or everted lower lip coarsen facial characteristics. While all affected people have a normal 46, XY karyotype, genital abnormalities range from hypospadias and undescended testicles to severe hypospadias and ambiguous genitalia to normal female external genitalia. The ATRX chromatin regulator gene mutation causes ATR-X. Unknown pathways of ATR-X disease may entail epigenetic changes. ATRX gene mutations may cause epigenetic and transcriptional consequences by regulating histone H3 and DNA methylation. Understanding the epigenetic pathways disrupted in ATR-X will help us comprehend its pathobiology and develop new diagnostic biomarkers.

Keywords: Alpha Thalassemia/Mental Retardation X-Linked Syndrome (ATR-X), DNA Repair, Diagnosis, Molecular Pathogenesis

Introduction:

The X-chromosomal ID diseases are the primary reason why there are more males with intellectual disability (ID) than girls. Of these, fragile X syndrome predominates. Certain genetic conditions can manifest as syndromes; some examples include the Partington and Coffin-Lowry syndromes, as well as Alpha-thalassemia X-linked ID syndrome (ATRX-IDS). On chromosome Xq21.1, you'll find the ATRX gene, which codes for

a protein that belongs to the SWI/SNF family of chromatin remodeling proteins. Cellular functions include a variety of gene expression and DNA replication. One organ where the protein is highly expressed is the brain. ATRX-IDS is an X-linked disorder that arises from mutations in the ATRX gene. [1] There are now over 150 disease-causing ATRX variations; most of these variants are missense variations, while approximately one-third are loss-of-function mutations (such as nonsense, splice site, large deletions, frameshift, etc.). Evidence suggests that pathogenic mutations in the ATRX protein's helicase domain cause less severe symptoms, but changes in the zinc finger domain have been associated with significant psychomotor impairment. [2] Typical phenotypic features include microcephaly, genital anomalies, skeletal abnormalities, hypotonia, and ID, which can range from severe to profound. Patients with hemoglobin H inclusions, which indicate alpha-thalassemia, have been reported in many cases. The ATRX gene is located on the X chromosomes on the q arm. One possible explanation is that individuals with the condition have mutated or X-inactivated copies of the ATRX gene. Reduced protein levels are caused by mutations in ATRX, which shorten the protein. expressive speech. The complex that remodels chromatin includes ATRX, which, when functioning correctly, is an integral part of it. It and death domain-associated protein (DAXX) create a heterodimer. Mutations in the ATRX gene were first discovered in pancreatic neuroendocrine tumors; a better prognosis has been associated with mutations in both the ATRX and DADX genes. Additional study has shown that these mutations are present in a number of other cancer subtypes, including gliomas. [3]

ARTRX and repair of DNA

A chromatin-remodeling protein belonging to the SWI/SNF family, alpha thalassemia/mental retardation syndrome X-linked has two domains with other members of this family. One alpha helix, one PHD finger, and one GATA-like zinc finger make up the ATRX-Dnmt3-Dnmt3L (ADD) domain found at the protein's N-terminus. Its C-terminus contains the ATPase/helicase domain. Histone octamer sliding, facilitated by proteins in the SWI/SNF family, alters nucleosome conformation and makes chromatin remodeling easier by breaking down DNA-histone connections. [4]

Several enzymes that modify chromatin have been linked to various human diseases. An X-linked intellectual impairment disease known as ATRX syndrome can result from mutations in either the ATRX domain or the ADD domain, with the ADD domain

mutation typically having more severe implications. Eukaryotic gene expression regulation is aided by a non-covalent process in which the ATRX gene product forms a heterodimer with the transcription factor DAXX. This heterodimer has ATP-dependent chromatin-remodeling activities. While DAXX is a particular chaperone for the histone variation H3, ATRX binds histone H3 tail peptides that contain lysine 9 trimethylation (H3K9me3) marks. Telomeric and peri-centromeric chromatin are abundant with H3K9me3 marks, and the heterodimer helps to deposit H3. into these regions. Both ATRX and DAXX are linked to PML nuclear entities and are mainly found in the nucleus. [5]

Chromatin structure creation and maintenance have been associated with the histone variation H3. Independent of replication, chaperone proteins like DAXX construct nucleosomes containing H3. Three distinct hydrogen bonding domains are encoded by the mammalian genome. Unlike H3., which is expressed continuously throughout the cell cycle and is not dependent on replication, H3 and H3 are mostly expressed during S-phase. H3 requires the ATRX/DAXX complex to be incorporated, and prior research has shown that it is associated with heterochromatin and regulatory elements at telomeres. The typical mechanism of ATRX mutant pathogenicity is the disruption of H3K9me3 binding, caused by mutations in the Dnmt3-Dnmt3L domain, which is X-linked to alpha thalassemia/mental retardation syndrome. The PHD finger can distinguish between histone tails containing methylated and unmodified lysine residues, but the ADD domain's full function is still a mystery. The decrease of heterochromatic localization of the ATRX/DAXX complex in cells is caused by reduced ADD binding to H3 tail peptides. There is a connection between chromatin remodeling and DNA methylation, as mutations in the ATRX gene alter the methylation patterns of several CpG-rich repetitive stretches. Subtelomeric and rDNA gene areas, especially CpG-rich rDNA repeat regions, exhibit hypomethylation in ATRX syndrome patients. On the other hand, the Y-specific repeat (DYZ2) on the Y chromosome has confirmed hypermethylation. These results provide more evidence that ATRX may affect gene expression and that ATRX mutation may affect CpG-rich genomic areas. [6,7]

Medical features

Symptoms of the alpha-thalassemia X-linked intellectual impairment (ATR-X) syndrome include hypotonia, abnormalities in the genitourinary system, abnormal facial characteristics, and intellectual disability ranging from mild to severe. Congenital malformations of the skull and face include a small head circumference, widely separated

eyes (telecanthus), a short triangle-shaped nose, a thick or everted lower lip, a tented upper lip, and a gradual coarsening of the facial features. Genital abnormalities range from undescended testicles and mild hypospadias to ambiguous genitalia and severe hypospadias, while all afflicted individuals have a normal 46, XY karyotype. In some cases, the female external genitalia may appear normal. About 75% of people with alpha-thalassemia will not need therapy because the condition is minor. A small number of boys with germline pathogenic mutations have been observed to develop osteosarcoma. [8,9]

Evaluation and diagnosis

Molecular genetic testing revealed a hemizygous pathogenic mutation in ATRX, and a proband with suggestive symptoms and a 46, XY karyotype established the diagnosis of ATR-X syndrome. Individuals with the following clinical signs, hematologic results, and family history should be suspected of having Alpha-thalassemia X-linked intellectual impairment (ATR-X) syndrome, according to the diagnostic criteria. [10]

Clinical findings:

Some distinguishing craniofacial features include a small head circumference, upswept frontal hair, widely spread eyes or telecanthus, a short triangle nose, a thick or everted lower lip, an open mouth, and a tented upper lip. There are further observations of irregular pinnae architecture, widely spaced teeth, and a projecting tongue. The protrusion of the tongue and widely spaced teeth contribute to a coarser facial look, especially after a few years of life. Characterized by microcephaly and small height, a growth defect that is typically present at birth A variety of genital abnormalities, including hypospadias, undescended testes, ambiguous genitalia, and normal external female genitalia, are possible. Intellectual impairment and developmental delay, usually ranging from severe to profound Laboratory results related to blood. Upwards of 75% of men diagnosed with ATR-X syndrome have hemoglobin levels that indicate alpha-thalassemia. [11,12] Inoculation of fresh blood smears with 1% brilliant cresyl blue reveals HbH inclusions in erythrocytes. The percentage of cells that have HbH inclusions varies between 0.01% and 30%. It's possible to see HbH inclusions in every erythrocyte in some people, but in others it may take multiple tests before they manifest. Most clinical settings do not find this testing useful because a quarter of affected patients do not have HbH inclusions and an additional 40% have very rare inclusions (<1% of erythrocytes). Indices of red blood cells. While some people with alpha-thalassemia may experience the microcytic hypochromic anemia

that is so distinctive of the disease, the majority of affected individuals maintain normal red cell indices. Checking newborns. In extremely rare cases, neonatal hemoglobinopathy screenings have been able to detect ATR-X syndrome by detecting HgH. Family tree that points to X-linked inheritance (i.e., no passing the gene from father to son). Ignoring a known family history does not rule out a diagnosis. [13,14]

Management of signs and symptoms

Treatment of Manifestations in Individuals with ATR-X Syndrome

Manifestation/ Concern	**Treatment**	**Considerations/Other**
DD/ID	See Developmental Delay / Intellectual Disability Management Issues.	-
Seizures	Standardized treatment w/AEDs by experienced neurologist	Many AEDs may be effective; none demonstrated effective specifically for this disorder Education of parents/caregivers
Gastrointestinal/ Feeding	Feeding therapy; calorie-dense formula; gastrostomy tube placement as needed for persistent feeding issues	Usual treatment for GERD, constipation Treatment for gastric pseudo-obstruction per treating gastroenterologist/pediatric surgeon
Drooling	Anticholinergics, botulinum toxin type A injection of salivary glands &/or surgical redirecting of submandibular ducts	Options when drooling is a serious problem
Genital abnormalities	Per treating urologist	-
Musculoskeletal	Orthopedics / physical medicine & rehabilitation / PT / OT	Use of durable medical equipment & positioning devices as needed (e.g., wheelchairs, walkers, bath chairs, orthotics, adaptive strollers)

AED = antiepileptic drug; DD = developmental delay; ID = intellectual disability; OT = occupational therapy; PT = physical therapy

Surveillance

Table Recommended Surveillance for Individuals with ATR-X Syndrome

System/Concern	Evaluation	Frequency
Development	Monitor developmental progress & educational needs.	At each visit in infancy & childhood
Gastrointestinal/ Feeding	Measurement of growth parameters • Eval of nutritional status & safety of oral intake • Monitor for excessive vomiting, GERD, abdominal distention & pain, constipation.	
Genital abnormalities	Follow up w/treating urologist as needed.	At initial visit in infancy
Neurologic	• Monitor that w/seizures as clinically indicated. • Assess for new manifestations such as seizures, changes in tone, movement disorders.	At each visit
Congenital heart defects	Per treating cardiologist	Per treating cardiologist

Passage of genes

Alpha-thalassemia X-linked intellectual disability (ATR-X) syndrome is inherited in an X-linked manner.

Peril to relatives

A proband's parents

Since a father with a 46, XY karyotype is neither afflicted nor hemizygous for the ATRX pathogenic variation, additional testing and evaluation is not necessary for him. Mothers of affected individuals with 46, XY karyotypes are obligate heterozygotes in families when many individuals are affected. Attention: A woman is likely to have germline mosaicism if she has multiple affected children but no other affected relatives, and if the ATRX pathogenic variation cannot be found in her leukocyte DNA. If a person with the disease is the only one in their family who has the 46, XY karyotype, it's possible that the mother is a carrier or that the person has a de novoATRX pathogenic mutation; in the latter instance, the mother would not be a carrier. The percentage of affected males with a de novo pathogenic mutation is quite small, ranging from 10% to 20%.

The proband's siblings:

There is a 50% possibility of transmitting an ATRX pathogenic variant in each pregnancy to siblings of a proband with a 46, XY karyotype, although this risk is conditional on the mother's genetic status. The pathogenic variation will impact 46, XY karyotype siblings; on the other hand, 46, XX karyotype siblings will be heterozygous and rarely display clinical symptoms (for more on this, see Clinical Description, Heterozygous Females). In the case of a simplex case, where the ATRX pathogenic variant is not found in the mother's leukocyte DNA, the risk to siblings is lower than average but higher than in the general population due to the potential for maternal germline mosaicism. Two brothers have reported recurring ATR-X syndrome; two families have reported putative maternal mosaicism; and two cases of somatic and germline maternal mosaicism for a pathogenic version of ATRX have been documented. [15,16]

Identifying carriers

Following the identification of the ATRX pathogenic variation in the proband, molecular genetic testing of susceptible female relatives can provide the most useful information regarding their genetic condition. ATR-X syndrome symptoms are uncommon in females who are heterozygous for this X-linked illness (1). (a) The ATRX pathogenic

variant must already be known in the family for female heterozygotes to be identified. Alternatively, if there is no affected individual with a 46, XY karyotype, molecular genetic testing using sequence analysis first, and then gene-targeted deletion/duplication analysis, is necessary. [17]

Fundamentals of molecular pathophysiology

The ATRX gene genes for a transcription factor called ATRX. This factor has two domains: one that binds to DNA (the zinc finger domain) and another that opens double-stranded DNA (the helicase domain). During development, the ATRX protein may be involved in the silencing of gene expression through its involvement in chromatin remodeling in conjunction with other proteins associated with chromatin. [18]

The process by which chronic diseases manifest. Function decline. The majority of the variants are missense changes, with over 90% of these occurring in areas that encode zinc finger and helicase domains. Other types of variants include deletions, insertions, intragenic duplications, nonsense, and splice variants. The ¬-globin locus is downregulated by the aberrant ATRX protein, which causes thalassemia. Other genes are likely suppressed as a result of disruptions in transcription and chromatin structure, which leads to deformities and intellectual incapacity. ATRX-specific laboratory technical considerations. An ATRX cluster of helicase domains at the C-terminus and an ADD domain close to the N-terminus are the most common locations for pathogenic variants. [19,20]

Conclusion:

The unique epigenetic signature for this syndrome is provided by the most significant methylation changes in 14 genomic loci. This signature has the potential to be used as a sensitive and specific diagnostic biomarker to support the diagnosis of ATR-X, especially in patients with complex phenotypes or ATRX gene sequence variants with unknown significance.

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A COMPREHENSIVE REVIEW OF ANIMAL DIVERSITY FROM FRESHWATER RESERVOIRS IN INDIA

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Abstract:

The freshwater reservoirs of India host a remarkable diversity of animal life, representing a vital component of the country's aquatic ecosystems. This abstract provides a succinct overview of the rich tapestry of animal diversity found within these freshwater habitats. Fish fauna in Indian reservoirs exhibit remarkable variety, encompassing numerous species adapted to diverse ecological niches. Additionally, a plethora of aquatic invertebrates, including insects, crustaceans, and mollusks, contribute significantly to the ecosystem's biodiversity. Furthermore, amphibians and reptiles, although less studied, play integral roles in these aquatic environments. Factors influencing animal diversity in Indian freshwater reservoirs include water quality parameters, habitat availability, and anthropogenic disturbances such as pollution and habitat degradation. Understanding these factors is crucial for effective conservation and management strategies aimed at preserving biodiversity and ecosystem health. Moreover, ecological interactions among different animal groups, including trophic relationships and mutualistic interactions, shape the dynamics of these ecosystems. Conservation efforts must prioritize the protection of biodiversity in Indian freshwater reservoirs to mitigate the impacts of anthropogenic activities and ensure the sustainability of these vital ecosystems. Continued research is needed to fill knowledge gaps and address emerging threats, with an emphasis on interdisciplinary collaboration and long-term monitoring initiatives. Overall, this abstract highlights the importance of conserving animal diversity in Indian freshwater reservoirs and underscores the need for concerted efforts to safeguard these invaluable natural resources.

Keywords: Freshwater Reservoirs, Animal Diversity, India, Biodiversity, Conservation, Ecological Interactions, Anthropogenic Disturbances

Introduction:

Freshwater reservoirs play a crucial role in sustaining life and supporting diverse ecosystems worldwide, and India is no exception. With a vast network of rivers, lakes, wetlands, and man-made reservoirs, India's freshwater habitats are essential for both human livelihoods and ecological health. This introduction provides an overview of the importance of freshwater reservoirs in India, emphasizing their ecological, socio-economic, and cultural significance.

India's freshwater reservoirs serve as lifelines for millions of people, providing water for drinking, irrigation, industrial use, and hydropower generation. The perennial rivers originating from the Himalayas, such as the Ganges, Brahmaputra, and Indus, are the primary sources of freshwater in the country, sustaining agriculture, fisheries, and urban centers along their courses (Singh *et al.,* 2020). Additionally, numerous natural lakes, wetlands, and artificial reservoirs supplement the country's water resources, playing critical roles in water storage, flood regulation, and groundwater recharge (Kumar *et al.,* 2018).

Ecologically, freshwater reservoirs in India support a remarkable diversity of flora and fauna, including aquatic plants, fish, amphibians, reptiles, birds, and mammals. These ecosystems provide essential habitats for numerous species, serving as breeding grounds, feeding areas, and migration stopovers for migratory birds (Gopi *et al.,* 2019). Furthermore, freshwater habitats contribute to nutrient cycling, carbon sequestration, and sediment dynamics, regulating biogeochemical processes and maintaining ecosystem balance (Kumar *et al.,* 2018).

Socio-economically, freshwater reservoirs contribute significantly to India's economy through fisheries, tourism, transportation, and recreational activities. Fishery resources from rivers and reservoirs provide livelihoods for millions of people, particularly in rural areas where fishing is a primary source of income (Sarkar *et al.,* 2020). Moreover, freshwater ecosystems attract tourists and nature enthusiasts, contributing to local economies through hospitality services, eco-tourism, and wildlife viewing (Shukla *et al.,* 2017).

Culturally, freshwater reservoirs hold immense spiritual and religious significance in India, with many rivers and lakes considered sacred by various communities. Rituals, festivals, and ceremonies associated with these water bodies reflect the deep-rooted

cultural connections between humans and nature, emphasizing the need for their conservation and sustainable management (Bhatt & Singh, 2019).

Freshwater reservoirs are indispensable resources that underpin the ecological, socio-economic, and cultural fabric of India. Recognizing their importance is paramount for ensuring their sustainable management and safeguarding the well-being of present and future generations.

Importance of studying animal diversity in freshwater ecosystem:

Studying animal diversity in freshwater ecosystems is of paramount importance in India due to the critical roles these organisms play in ecosystem functioning, human well-being, and biodiversity conservation. This review explores the significance of investigating animal diversity in Indian freshwater ecosystems, focusing on its ecological, socio-economic, and conservation implications.

Ecologically, animal diversity serves as a key indicator of ecosystem health and resilience in Indian freshwater habitats. The composition and abundance of aquatic organisms, including fish, invertebrates, and amphibians, reflect the overall condition of these ecosystems and their capacity to provide ecosystem services such as water purification, nutrient cycling, and habitat provisioning (Dudgeon *et al.,* 2006). Understanding the dynamics of animal diversity is essential for assessing the ecological status of freshwater reservoirs and informing management decisions aimed at maintaining their integrity and functionality.

Socio-economically, animal diversity in Indian freshwater ecosystems supports diverse livelihoods and economic activities. Fisheries, in particular, are a significant source of income and protein for millions of people, especially in rural communities dependent on freshwater resources for sustenance (Sarkar *et al.,* 2020). Additionally, ecotourism and recreational activities centered around freshwater habitats contribute to local economies, generating revenue and employment opportunities (Shukla *et al.,* 2017). Studying animal diversity helps identify key species of economic importance and inform sustainable resource management practices to ensure the long-term viability of these socio-economic activities.

From a conservation perspective, studying animal diversity is essential for preserving India's rich freshwater biodiversity and mitigating threats to aquatic ecosystems. Anthropogenic activities such as pollution, habitat degradation, overfishing,

and invasive species introductions pose significant challenges to the conservation of freshwater fauna in India (Kumar *et al.,* 2018). By documenting species distributions, assessing population trends, and identifying conservation priorities, research on animal diversity provides valuable insights for designing and implementing effective conservation strategies (Sarkar *et al.,* 2020).

Studying animal diversity in Indian freshwater ecosystems is crucial for understanding ecosystem dynamics, supporting sustainable livelihoods, and conserving biodiversity. Continued research efforts are needed to address knowledge gaps, monitor changes in animal populations, and implement evidence-based management measures to safeguard these invaluable natural resources for future generations.

Diversity of fish species in freshwater reservoirs:

The diversity of fish species in freshwater reservoirs in India reflects the country's rich aquatic biodiversity and underscores the importance of these ecosystems for sustaining fish populations, livelihoods, and ecosystem functioning. This review examines the patterns, drivers, and implications of fish species diversity in Indian freshwater reservoirs, drawing on recent research and empirical evidence.

Indian freshwater reservoirs host a remarkable variety of fish species, ranging from indigenous and endemic taxa to introduced and exotic species (Sarkar *et al.,* 2020). The diversity of fish fauna is influenced by a myriad of factors, including habitat heterogeneity, water quality parameters, hydrological regimes, and human activities such as fishing and stocking (Jhingran, 1991). These reservoirs encompass diverse ecological niches, including riverine, lacustrine, and transitional habitats, providing opportunities for the coexistence of multiple fish species adapted to different environmental conditions (Srivastava *et al.,* 2017).

The ecological roles of fish species in Indian freshwater reservoirs are manifold, encompassing predator-prey dynamics, nutrient cycling, and trophic interactions. Native fish species play vital roles in regulating aquatic food webs, controlling populations of prey organisms, and maintaining ecosystem balance (Sarkar *et al.,* 2020). Conversely, non-native and invasive fish species can disrupt native ecosystems, leading to declines in native fish populations and alterations in community structure (Raghavan *et al.,* 2018).

Conservation and management of fish diversity in Indian freshwater reservoirs are imperative for sustaining fisheries, supporting livelihoods, and preserving ecosystem

integrity. Strategies for conserving fish species diversity include habitat restoration, sustainable fisheries management, regulation of invasive species, and establishment of protected areas (Sarkar *et al.,* 2020). Moreover, integrated approaches that consider socio-economic factors, stakeholder engagement, and traditional knowledge are essential for promoting the sustainable use and conservation of fish resources in Indian freshwater reservoirs (Shukla *et al.,* 2017).

The diversity of fish species in Indian freshwater reservoirs is a hallmark of the country's aquatic ecosystems, reflecting their ecological complexity and socio-economic importance. Understanding the drivers of fish diversity and implementing effective conservation measures are critical for ensuring the long-term sustainability of fisheries and the preservation of freshwater biodiversity in India.

Ecological roles of fish populations in freshwater reservoirs:

The ecological roles of fish populations in freshwater reservoirs in India are multifaceted, encompassing key functions in nutrient cycling, food webs, and ecosystem dynamics. This review examines the diverse ecological roles played by fish species in Indian freshwater reservoirs, highlighting their significance for maintaining ecosystem health and functioning.

Fish populations in Indian freshwater reservoirs contribute significantly to nutrient cycling through processes such as excretion and feeding. As omnivorous and carnivorous consumers, fish species regulate the abundance of prey organisms, including zooplankton, aquatic insects, and small fish, thereby influencing trophic dynamics and energy flow within aquatic food webs (Sarkar *et al.,* 2020). Moreover, fish serve as important vectors for nutrient transport between different habitats, redistributing organic matter and nutrients through their movements and feeding behaviors (Vander Zanden *et al.,* 1999).

In addition to nutrient cycling, fish populations in Indian freshwater reservoirs play vital roles in controlling populations of aquatic organisms and maintaining ecosystem balance. Predatory fish species help regulate prey populations, preventing overpopulation of certain species and maintaining biodiversity within the ecosystem (Vander Zanden *et al.,* 1999). Furthermore, fish serve as important prey for piscivorous birds, mammals, and larger fish species, contributing to the stability and resilience of food webs in freshwater ecosystems (Srivastava *et al.,* 2017).

Conserving fish populations and preserving their ecological roles is essential for maintaining the health and functionality of Indian freshwater reservoirs. Anthropogenic activities such as overfishing, habitat degradation, pollution, and introduction of invasive species can disrupt fish populations and alter ecosystem processes, leading to cascading effects on ecosystem structure and function (Kumar *et al.,* 2018). Implementing sustainable fisheries management practices, restoring degraded habitats, and mitigating anthropogenic impacts are critical for safeguarding the ecological roles of fish populations and promoting the resilience of freshwater ecosystems in India (Shukla *et al.,* 2017).

Fish populations in Indian freshwater reservoirs play diverse and indispensable ecological roles, contributing to nutrient cycling, trophic interactions, and ecosystem stability. Understanding and conserving these ecological functions are essential for sustaining the health and integrity of freshwater ecosystems in India and ensuring the long-term viability of fisheries and associated livelihoods.

Impacts of fishing and introduction of non-native species

The impacts of fishing and the introduction of non-native species in freshwater reservoirs in India are significant drivers of ecological change, with far-reaching implications for biodiversity, ecosystem functioning, and socio-economic well-being. This review examines the consequences of fishing pressure and non-native species introductions on Indian freshwater ecosystems, drawing on empirical evidence and scientific literature to elucidate their ecological and socio-economic ramifications.

Fishing pressure, driven by increasing demand for fish protein and livelihood opportunities, has profound effects on fish populations and aquatic communities in Indian freshwater reservoirs. Overfishing can lead to the depletion of target species, altering community structure, and trophic interactions (Sarkar *et al.,* 2020). Furthermore, indiscriminate fishing practices such as the use of illegal gear, dynamite fishing, and electrofishing can cause habitat destruction, mortality of non-target species, and disruption of spawning grounds, exacerbating the ecological impacts of fishing activities (Kumar *et al.,* 2018). These ecological consequences can have cascading effects on ecosystem dynamics, affecting nutrient cycling, food webs, and the resilience of freshwater ecosystems to environmental stressors.

The introduction of non-native species poses additional challenges to the integrity and functioning of Indian freshwater reservoirs. Non-native species, including fish,

invertebrates, and aquatic plants, are often introduced for aquaculture, sport fishing, or accidental release, with unintended consequences for native biodiversity and ecosystem processes (Raghavan *et al.,* 2018). Non-native species can outcompete native species for resources, predation pressure, and habitat space, leading to declines in native populations and alterations in community structure (Srivastava *et al.,* 2017). Moreover, some non-native species exhibit invasive behavior, rapidly colonizing new habitats, and disrupting ecosystem functioning through predation, habitat modification, and transmission of pathogens (Sarkar *et al.,* 2020).

The combined impacts of fishing pressure and non-native species introductions highlight the need for effective management and conservation strategies to safeguard Indian freshwater ecosystems. Implementing sustainable fisheries management practices, including the regulation of fishing effort, establishment of protected areas, and promotion of community-based resource management, is essential for maintaining fish stocks and preserving ecosystem integrity (Shukla *et al.,* 2017). Additionally, efforts to prevent the introduction and spread of non-native species through stricter regulations, monitoring programs, and public awareness campaigns are critical for mitigating their ecological impacts and preserving native biodiversity (Raghavan *et al.,* 2018).

Fishing pressure and the introduction of non-native species represent significant threats to the ecological integrity and socio-economic sustainability of Indian freshwater reservoirs. Addressing these challenges requires coordinated efforts among policymakers, resource managers, scientists, and local communities to promote sustainable resource use, conserve native biodiversity, and enhance the resilience of freshwater ecosystems in India.

Diversity of aquatic invertebrates

The diversity of aquatic invertebrates in freshwater ecosystems in India contributes significantly to the ecological richness and functioning of these habitats. This review explores the diverse array of aquatic invertebrates, including insects, crustaceans, and mollusks, found in Indian freshwater reservoirs, highlighting their ecological roles, distribution patterns, and conservation implications.

Aquatic invertebrates constitute a diverse and abundant group of organisms in Indian freshwater reservoirs, occupying various ecological niches and performing essential ecological functions. Insects such as dragonflies, mayflies, and caddisflies are ubiquitous inhabitants of freshwater habitats, playing critical roles in nutrient cycling, food webs, and

biological indicators of water quality (Dudgeon *et al.,* 2006). Additionally, crustaceans such as freshwater crabs, shrimps, and crayfish are important components of freshwater ecosystems, serving as prey for fish, birds, and mammals, and contributing to nutrient recycling and ecosystem stability (Das *et al.,* 2013). Furthermore, mollusks such as snails and mussels are integral to sediment dynamics, organic matter decomposition, and biofiltration, exerting significant influence on water quality and habitat structure (Lima *et al.,* 2019).

The distribution patterns of aquatic invertebrates in Indian freshwater reservoirs are influenced by a variety of factors, including habitat characteristics, hydrological regimes, water quality parameters, and anthropogenic disturbances. Different taxa exhibit specific habitat preferences and tolerances to environmental conditions, resulting in spatial heterogeneity and species turnover across different freshwater habitats (Jain *et al.,* 2016). Moreover, human activities such as habitat alteration, pollution, and climate change can disrupt invertebrate communities, leading to declines in species richness and shifts in community composition (Kumar *et al.,* 2018).

Conservation of aquatic invertebrates in Indian freshwater reservoirs is imperative for maintaining ecosystem health, biodiversity, and ecosystem services. Protecting and restoring habitat diversity, regulating water quality, and mitigating anthropogenic impacts are essential for safeguarding invertebrate communities and preserving their ecological functions (Sarkar *et al.,* 2020). Furthermore, monitoring programs, research initiatives, and public awareness campaigns are needed to assess the status of invertebrate diversity, identify conservation priorities, and promote sustainable management practices in Indian freshwater ecosystems.

The diversity of aquatic invertebrates in Indian freshwater reservoirs is a critical component of aquatic biodiversity, contributing to ecosystem functioning, nutrient cycling, and habitat dynamics. Understanding the ecological roles and distribution patterns of these invertebrates is essential for informing conservation and management strategies aimed at preserving the integrity and resilience of freshwater ecosystems in India.

Responses of invertebrates to environmental changes

In India, the responses of invertebrates to environmental changes, such as pollution and habitat alteration, are significant indicators of ecosystem health and resilience in freshwater habitats. This review examines the diverse array of responses exhibited by

invertebrate communities in Indian freshwater reservoirs to environmental stressors, highlighting their implications for biodiversity conservation and ecosystem management.

Pollution, stemming from urbanization, industrialization, and agricultural runoff, poses a considerable threat to invertebrate communities in Indian freshwater reservoirs. Elevated levels of nutrients, heavy metals, pesticides, and organic pollutants can adversely affect invertebrate abundance, diversity, and community composition (Kumar *et al.,* 2018). Pollution-induced stressors, such as hypoxia, toxicity, and habitat degradation, can impair invertebrate physiological functions, disrupt trophic interactions, and lead to population declines and local extinctions (Dudgeon *et al.,* 2006).

Habitat alteration, resulting from dam construction, land-use change, and river channelization, also exerts profound impacts on invertebrate communities in Indian freshwater reservoirs. Modifications to natural habitats, such as loss of riparian vegetation, sedimentation, and alteration of flow regimes, can fragment habitats, reduce connectivity, and disrupt migration patterns of invertebrate species (Jain *et al.,* 2016). Consequently, habitat alterations can lead to habitat loss, population isolation, and decreased genetic diversity among invertebrate populations, compromising their long-term viability and adaptive capacity (Kumar *et al.,* 2018).

The responses of invertebrates to environmental changes in Indian freshwater reservoirs vary across taxa, with some species exhibiting resilience to stressors, while others are more susceptible to environmental degradation. Pollution-tolerant species may proliferate in degraded habitats, leading to shifts in community composition and loss of sensitive taxa (Kumar *et al.,* 2018). Additionally, habitat specialists and endemic species may face heightened extinction risks due to habitat loss and fragmentation, highlighting the importance of conserving intact habitats and promoting habitat restoration efforts (Jain *et al.,* 2016).

Understanding the responses of invertebrates to environmental changes in Indian freshwater reservoirs is crucial for assessing the ecological impacts of anthropogenic activities and informing conservation and management strategies. Implementing pollution control measures, restoring degraded habitats, and promoting sustainable land-use practices are essential for mitigating the adverse effects of environmental stressors on invertebrate communities and preserving the integrity and resilience of freshwater ecosystems in India.

Factors influencing animal diversity from freshwater reservoirs

Factors influencing animal diversity in freshwater reservoirs in India are multifaceted, encompassing a range of ecological, hydrological, and anthropogenic variables that shape the composition, abundance, and distribution of aquatic fauna. This review explores the key factors influencing animal diversity in Indian freshwater reservoirs, highlighting their ecological significance, management implications, and conservation challenges.

Hydrological regimes: Hydrological variability, including water flow patterns, seasonal fluctuations, and water level changes, plays a crucial role in shaping animal diversity in Indian freshwater reservoirs. Hydrological regimes influence habitat availability, connectivity, and nutrient dynamics, affecting the distribution and abundance of aquatic species (Sarkar *et al.,* 2020). Alterations to natural flow regimes due to dam construction, water abstraction, and climate change can disrupt ecological processes, leading to changes in species composition and community structure (Kumar *et al.,* 2018).

Habitat heterogeneity: Habitat heterogeneity, encompassing a variety of physical and biological features such as substrate composition, vegetation cover, and aquatic habitats, promotes species diversity by providing niche differentiation and refuge for different taxa (Srivastava *et al.,* 2017). Diverse habitats, including riffles, pools, marshes, and submerged vegetation, support a wide range of aquatic organisms adapted to specific environmental conditions (Jain *et al.,* 2016). Habitat degradation, resulting from pollution, sedimentation, and habitat loss, reduces habitat complexity and limits available niches, negatively impacting animal diversity (Kumar *et al.,* 2018).

Water quality parameters: Water quality parameters, including temperature, dissolved oxygen, pH, turbidity, and nutrient concentrations, influence the physiological tolerances, reproductive success, and distribution patterns of aquatic fauna in Indian freshwater reservoirs (Dudgeon *et al.,* 2006). Pollution from urban, industrial, and agricultural sources can degrade water quality, impairing the health of aquatic ecosystems and affecting the abundance and diversity of aquatic species (Kumar *et al.,* 2018).

Anthropogenic disturbances: Anthropogenic disturbances, such as pollution, habitat alteration, overfishing, and introduction of non-native species, pose significant threats to animal diversity in Indian freshwater reservoirs (Sarkar *et al.,* 2020). Overexploitation of fish stocks through unsustainable fishing practices can deplete populations of

commercially important species and disrupt trophic interactions, leading to cascading effects on ecosystem structure and function (Shukla *et al.,* 2017). Furthermore, the introduction of non-native species can outcompete native fauna, alter community dynamics, and increase vulnerability to diseases and parasites (Raghavan *et al.,* 2018).

Climate change: Climate change, including alterations in temperature, precipitation patterns, and extreme weather events, poses emerging challenges to animal diversity in Indian freshwater reservoirs (Kumar *et al.,* 2018). Changes in hydrological regimes, water temperature, and habitat availability can influence the distribution, phenology, and behavior of aquatic species, potentially leading to range shifts, population declines, and local extinctions (Srivastava *et al.,* 2017).

In summary, understanding the complex interactions among hydrological, ecological, and anthropogenic factors is essential for conserving animal diversity in Indian freshwater reservoirs. Implementing integrated management approaches that address multiple stressors, promote habitat restoration, and mitigate anthropogenic impacts is crucial for preserving the ecological integrity and resilience of freshwater ecosystems in India.

Strategies for habitat preservation, restoration and management:

Strategies for habitat preservation and restoration in Indian freshwater reservoirs are essential for maintaining biodiversity, ecosystem services, and socio-economic benefits. Likewise, policy implications and management approaches play a crucial role in guiding conservation efforts and promoting sustainable use of freshwater resources. Here are some key strategies and considerations for habitat preservation and restoration, along with policy implications and management approaches:

Habitat preservation:

- **Protected areas:** Establishing protected areas, such as national parks, wildlife sanctuaries, and freshwater reserves, to safeguard critical habitats and key biodiversity areas.
- **Riparian buffer zones:** Implementing riparian buffer zones along water bodies to mitigate habitat degradation, prevent soil erosion, and enhance water quality.
- **Land-use planning:** Integrating habitat conservation into land-use planning processes to minimize habitat fragmentation, reduce habitat loss, and promote connectivity among natural habitats.

- **Regulatory mechanisms:** Enforcing regulations and zoning ordinances to restrict harmful activities, such as deforestation, mining, and urban sprawl, in ecologically sensitive areas.

Habitat restoration:

- **Riparian restoration:** Conducting riparian restoration projects to re-establish native vegetation, stabilize riverbanks, and enhance habitat complexity for aquatic fauna.
- **Wetland restoration:** Restoring degraded wetlands through hydrological restoration, invasive species control, and revegetation to improve habitat quality and support diverse aquatic communities.
- **Fish habitat enhancement:** Implementing fish habitat enhancement measures, such as artificial reefs, submerged vegetation, and woody debris, to create shelter, spawning grounds, and feeding areas for fish populations.
- **Ecological engineering:** Employing ecological engineering techniques, such as bioengineering, biomanipulation, and habitat creation, to restore natural processes and functions in degraded habitats.

Policy implications and management approaches:

- **Integrated water resource management:** Adopting integrated water resource management approaches that balance competing water uses, promote stakeholder engagement, and prioritize ecosystem conservation.
- **Ecosystem-based management:** Embracing ecosystem-based management principles that recognize the interconnectedness of ecological, social, and economic systems, and promote holistic approaches to conservation and sustainable development.
- **Adaptive governance:** Implementing adaptive governance frameworks that allow for flexible decision-making, iterative learning, and stakeholder participation to address complex and dynamic challenges in freshwater management.
- **Science-policy interface:** Strengthening collaboration between scientists, policymakers, and resource managers to integrate scientific knowledge into policy development, implementation, and evaluation processes.

- **Capacity Building and Awareness:** Investing in capacity building initiatives, training programs, and public awareness campaigns to enhance understanding of freshwater ecosystems, foster stewardship, and promote sustainable behavior.

By implementing these strategies and embracing policy implications and management approaches, India can enhance habitat preservation and restoration efforts, promote biodiversity conservation, and ensure the sustainable management of its freshwater resources for future generations.

Key Findings:

The key findings from the review on animal diversity in Indian freshwater reservoirs and related factors are as follows:

Rich diversity: Indian freshwater reservoirs host a remarkable diversity of animal life, including fish, aquatic invertebrates (such as insects, crustaceans, and mollusks), amphibians, and reptiles, representing vital components of the country's aquatic ecosystems.

Fish fauna diversity: The fish fauna in Indian reservoirs exhibit remarkable variety, encompassing numerous species adapted to diverse ecological niches. This diversity is crucial for maintaining ecosystem balance and supporting fisheries, which are significant for livelihoods and protein supply.

Aquatic invertebrates: In addition to fish, a plethora of aquatic invertebrates contribute significantly to the ecosystem's biodiversity. Insects, crustaceans, and mollusks play critical roles in nutrient cycling, food webs, and habitat provisioning.

Factors influencing diversity: Various factors influence animal diversity in Indian freshwater reservoirs, including hydrological regimes, habitat heterogeneity, water quality parameters, and anthropogenic disturbances such as pollution, habitat alteration, overfishing, and introduction of non-native species.

Ecological roles: Animal diversity in freshwater reservoirs plays crucial ecological roles, including nutrient cycling, trophic interactions, and ecosystem stability. Understanding these roles is essential for ecosystem management and conservation.

Conservation challenges: Conservation efforts face challenges such as pollution, habitat degradation, overfishing, and climate change, which threaten animal diversity and ecosystem health. Addressing these challenges requires integrated management approaches and policy interventions.

Management strategies: Strategies for habitat preservation and restoration, along with policy implications and management approaches, are crucial for promoting biodiversity conservation and ensuring sustainable freshwater resource management in India.

Overall, the review underscores the importance of conserving animal diversity in Indian freshwater reservoirs and emphasizes the need for concerted efforts to address threats and implement effective management and conservation strategies.

Interdisciplinary collaboration and continued research efforts:

A call for interdisciplinary collaboration and continued research efforts is crucial for advancing our understanding of animal diversity in Indian freshwater reservoirs and addressing conservation challenges effectively. Here's why:

Holistic understanding: Interdisciplinary collaboration brings together experts from diverse fields such as ecology, hydrology, fisheries science, policy, and socio-economics. This multidisciplinary approach enables a holistic understanding of the complex interactions between biological, environmental, and socio-economic factors shaping freshwater ecosystems.

Integrated solutions: Addressing conservation challenges in Indian freshwater reservoirs requires integrated solutions that consider ecological, social, and economic dimensions. Interdisciplinary collaboration facilitates the development of innovative approaches and management strategies that balance conservation goals with sustainable development objectives.

Data integration: Integrating data from multiple disciplines enhances the accuracy and reliability of scientific findings and informs evidence-based decision-making. Collaborative research efforts can leverage diverse datasets, methodologies, and expertise to generate comprehensive insights into animal diversity, ecosystem dynamics, and conservation needs.

Stakeholder engagement: Collaborative research initiatives foster engagement with stakeholders, including local communities, policymakers, resource managers, and non-governmental organizations. By involving stakeholders throughout the research process, interdisciplinary teams can co-produce knowledge, build trust, and promote participatory decision-making for conservation action.

Capacity building: Interdisciplinary collaboration provides opportunities for capacity building and knowledge exchange among researchers, practitioners, and stakeholders.

Training programs, workshops, and collaborative projects enhance scientific literacy, build technical skills, and foster collaboration across disciplinary boundaries.

Adaptive management: Continued research efforts support adaptive management approaches that enable learning from feedback and adjusting conservation strategies based on new knowledge and emerging threats. Interdisciplinary collaboration facilitates iterative processes of monitoring, evaluation, and adaptive management to enhance the effectiveness of conservation interventions.

Interdisciplinary collaboration and continued research efforts are essential for advancing conservation science, promoting sustainable freshwater management, and safeguarding animal diversity in Indian freshwater reservoirs. By working together across disciplines and sectors, we can address complex conservation challenges, build resilience in freshwater ecosystems, and secure the health and well-being of both human and aquatic communities for generations to come.

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