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ON

AUGMENTING PRODUCTION AND DISEASE MITIGATION STRATEGIES IN FOOD-ANIMALS UNDER CHANGING CLIMATIC SCENARIO

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Augmenting Production and Disease Mitigation Strategies in Food-Animals under Changing Climatic Scenario

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Base Paper

Climate change vis-à-vis food-animal production and disease mitigation strategies

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Introduction

Global demand for animal-derived foods has been projected to double by 2050 due to rising affluence and population (Fukase and Martin, 2020). Climate change makes this task more difficult resulting adaptation of progressively climate-smart technological interventions with the occurrence of emerging vector-borne diseases and antimicrobial resistance concerning food safety (Awad *et al*., 2024; Rodríguez-Barillas *et al*., 2024). The modern animal-food production system should become more efficient in resource utilization to make food sustainably and become more resilient to changes and shocks through a holistic approach involving all the stakeholders.

Under these backgrounds, the Indian Journal of Animal Health call the seminar on "*Augmenting Production and Disease Mitigation Strategies in Food-Animals under Changing Climatic Scenario*" involving the leading academic and research institutes of West Bengal concerned with animal-food production. Researchers, faculties, students will share their research outcomes with professionals involved at the field to transfer the technologies directly to the farmers with the government infrastructure and Krishi Vigyan Kendras.

Various aspects of climatic factors affecting the food-animal productivity and their health, and mitigation attribute will direct prospective approaches at the grass root level and further research.

Effect on food-animal productivity

The impact of heat stress is perceived by reduced productivity and animal welfare. Moreover, under severe or prolonged conditions, livestock and fish mortality is not un-common. The biggest consequence of heat stress is reduced feed intake that results into decline in growth rates and production of fish, milk or eggs. Reduced fertility and susceptibility to diseases due to heat stress hampers animal production. Reduced ovarian function, reduced motility of spermatozoa, and inhibition of embryonic development in animals have got impacts on fertility (Polsky and von Keyserlingk, 2017; Nawab *et al*., 2018). Cattle showing reduced expression of estrus behaviour, causes reduction of the chances of reproductive success. Moreover, heat stress affects effectiveness of some vaccines by rendering immunosuppression in the body (Bagath *et al*., 2019; Hirakawa *et al*., 2020), thereby increasing the incidence of livestock diseases.

The impacts of heat stress on animals can be both immediate and long-lasting, and can also affect offspring exposed to heat stress *in utero*. Research in dairy cattle and pigs has shown that heat stress *in utero* reduces milk yield at first lactation (Monteiro *et al*., 2016), and alters nutrient partitioning and carcass composition (Johnson et al., 2015). Animals exposed to heat stress *in utero* may also be better adapted to heat stress conditions at maturity. Ahmed *et al*. (2017) reported that cows exposed to heat stress *in utero* are better able to regulate core body temperature. Heat stress can also impact the quality of animal products, reducing the size of eggs and thickness of eggshells (Mashaly *et al*., 2004) besides decreasing the fat and protein content of milk (Bernabucci *et al*., 2002; Sevi and Caroprese, 2012) and fish productivity. Moreover, it changes the colour and water-holding capacity of both red and white meat (Gonzalez-Rivas *et al*., 2020). These changes can make livestock products less appealing to customers, increase wastage, and reduce the price that producers receive for their products. Selection of breeds that are better adapted to high temperatures can also have implications for product quality; while *Bos indicus* cattle are better adapted to high temperatures and humidity than *Bos taurus*, their meat is less tender (Crouse *et al*., 1989; Johnson *et al*., 1990), and tends to score lower in meat quality assurance schemes such as the Meat Standards Australia index, receiving lower prices in some markets.

In addition to heat stress, the increased frequency and intensity of storms, fires, floods and cold waves can have significant repercussions for the livestock sector. Extreme flooding followed by cold weather in northern Australia in early 2019 caused the loss of approximately half a million livestock (mostly cattle, but also sheep, goats and horses. Similarly, in October 2018, Hurricane Michael destroyed an estimated 84 chicken houses and killed over 2 million chickens in Georgia, U.S (Georgia Department of Agriculture, 2018). In geographic areas with cold winters, such as in the Northeast US, warmer temperatures may also reduce animal cold stress and maintenance energy requirements, as well as housing heating (Hristov *et al*., 2018; Toghiani *et al*., 2020). Climate change may also impact infectious animal diseases by changing their spatial distributions, affecting annual and seasonal cycles, altering disease incidence and severity, and modifying susceptibility of animals to illness (Bagath *et al*., 2019; Filipe *et al*., 2020). Many infectious pathogens that cause disease in animals and fish are sensitive to changes in climate, primarily moisture, rainfall, temperature and particulate matter – many of these diseases are zoonotic (McIntyre *et al*., 2017).

Effect on animal health

Direct effect: Increased temperature along with the intensity and frequency of heat waves pose a direct effect on animal. The effects are mediated through heat stress of different orders. Based on the intensity and frequency, heat stress creates oxidative stress, metabolic disturbances, immunosuppression and even death (Gaughan *et al*., 2009). The effects are summarized under the following sub-head.

Oxidative stress- When heat stress conditions induce the production of excessive oxidant substances and reduce the production of anti-oxidants, there may be an imbalance between these two that results into oxidative stress. It has been observed that during summer, reactive oxygen metabolites were increased. However, carotenes and vitamin E were decreased. Such incidences are common in dairy cattle and buffalo cows. Heat stress has been reported to be associated with increased antioxidant enzyme activities of superoxide dismutase, catalase and glutathione peroxidase to adapt the situation by virtue of increased levels of reactive oxygen species (Mirzad *et al*., 2018).

Metabolic disorders- To avoid hyperthermia (elevated body temperature) livestock reduce heat production and enhance heat loss by decreasing feed intake and by increasing respiratory rates and sweating. Such physiological events in heat- stressed animals lead to contribute various forms of metabolic disorders. The major outcome of heat-stress related altered energy balance in dairy cattle is ruminal acidosis that may turn into lameness with sole ulcer. This happens due to reduced feed intake during hotter part of the day, followed by voracious feeding during evening hours. Moreover, upon heat stress, the respiratory rates increase with panting and open mouth breathing for which rapid loss of carbon dioxide takes place. It leads to respiratory alkalosis. While trying to compensate the situation by discarding bicarbonate through urine, rumen buffering may be affected. Further, altered energy metabolism in heat stressed animals cause mobilization of adipose tissue leading to subclinical or clinical ketosis. The animals may also be affected by liver lipidosis, accumulation of ketone bodies and reduced liver enzyme activities (Lacetera *et al*., 1996; Basirico *et al*., 2009; Ronchi *et al*., 1999).

Immune suppression- Upon heat stress functional activities of neutrophils are significantly hampered thereby increasing the probability of bacterial infections in udder, leading to mastitis. Studies showed mastitis cases rise during summer months. This might be due to suppressed immune activities to bacterial invasion besides thermal/mechanical injury to udder tissues (Morse *et al*., 1988; Waage *et al*., 1998). New emerging diseases can be linked to positive relationship with climate change and the survival of microorganisms and/or their vectors. These infectious diseases enhance the immune suppressive effect of heat stress mediated by the hypothalamic-pituitary-adrenal (HPA) and the sympathetic-adrenal-medullary (SAM) axes (Bagath *et al*., 2019). Heat stress has got negative impact on cell mediated and humoral immune responses by activating HPA axis and by increasing peripheral levels of glucocortocoids subsequently suppressing the synthesis and release of cytokines (Grandian, 1997; Smith and Vale, 2006). Heat stress increases blood cortisol concentrations that inhibit production of cytokines like interleukin-4 (IL-4), IL-5, IL-6, IL-12, Interferon-gamma (IFN-γ) (Elenkov *et al*., 2000). Heat stress negatively influences the lymphocyte proliferation under *in vitro* conditions (Kamanga-Sollo *et al*., 2011). In a study on dairy cows, it has been observed that during heat stress condition 85 proteins were differentially abundant while the complement components C1, C3, C5, C6, C7, C8 and C9, complement factor B and factor H were down-regulated (Min *et al*., 2016).

Water temperature can deeply affect fish immune system. Some studies suggest that it polarize the immune responses: at low temperatures fish may rely more on innate immune system, while at higher temperatures is the adaptive immunity that is more efficient (Bowden *et al*., 2007). Pattern recognition by glucan binding proteins was predominant in perch (*Perca fluviatilis*) acclimated at lower temperatures, while, opsonin was more effective at higher temperatures (Marnila and Lilius, 2015). The innate immunity of fishes is affected by water temperature; in Indian major carp (*Catla catla*) Toll Like Receptors (TLRs) and NOD-like receptors are modulated both by cold or warm water. TLR2, TLR4 and NOD2 expression increases with higher water temperatures, while TLR5 and NOD1 expression increases at both high and low temperatures (Basu *et al*., 2015). A common phenomenon associated to the response of immune system to high environmental temperature (water temperature) is the increase of the antibody levels. This has been reported in several studies with different fish species, where high temperatures seem to boost antibody levels indicating that a potential increment of oceans temperatures could actually help protecting some aquatic species against pathogens (Jansen *et al*. 2015).

Death- Increased air temperature leads to several heat-induced complications in livestock when the body temperature rises to 3-4ºC above normal. In this situation, heat stroke, heat exhaustion, heat syncope, heat cramps may be seen in animals causing organ dysfunction ultimately. Death due to severe heat waves is not un-common in livestock. Such cases of mortality have been documented in several studies during the hottest months of the year (Hahn *et al*., 2002; Dechow and Goodlin, 2008; Vitali *et al*., 2015).

Indirect effect: Climate change has got effect on proliferation, breeding and distribution of different vectors carrying infectious agents as also various pathogens, viz. bacteria, virus, fungus, parasites. The indirect effect of climate change on animals may be assessed by taking into account of microbial populations, distribution of vector-borne diseases, host resistance to infectious agents, feed and water shortage, food borne diseases etc. (Yatoo *et al*., 2012). Factors like range and abundance of wildlife reservoirs, vectors and survival of pathogens in environment are quite important (ESAP, 2009).

Effect on vectors- Changes in climatic parameters like air temperature, wind and precipitation pattern besides relative humidity influences reproductive ability, fecundity, and population density of vectors. Even, vectors of tropical region with established endemic zones may move to other parts of the world and are held responsible for various vector-borne diseases. The example of the vector (*Culicoides* sp.) responsible for Bluetongue (BT) disease in sheep may be given for clear understanding. Increment of air temperature by 2ºC may lead to widespread distribution of *C. imicola* and consequent rampant BT disease (Wittmann *et al*., 2001). Since 1990 changing pattern of BT epidemiology in different African, Asian and European countries could be correlated to distribution pattern of its vector (*Culicoides* midges).

Impact on pathogens- Increased temperature associated with high moisture content in air favours the growth of mycotoxin-producing fungi (Frank, 1991). Mycotoxins are basically immunosuppressive and induce other diseases in hosts (Bernabussi *et al*., 2011). Besides fungi, microorganisms like bacteria, mycoplasma, rickettsia, and virus get chance to proliferate in the susceptible hosts, already undergone environmental stress and immunosuppressive conditions. Spread of water borne bacterial and viral diseases depends on environmental parameters. Hence, related to climatic change and disease production in livestock. The major parasites, viz. trematodes, cestodes and nematodes with complex life cycles depend on favourable environmental conditions. Climate change affects the proliferation and spread of these helminthic diseases (Rose *et al*., 2015).

Conclusions

Climate change is now a global concern due to its multidimensional effects and impact on humans, animals, fish, plants, and environment. Climate change includes several dramatic phenomena such as global warming, rise of atmospheric CO_2 concentration, alteration of salinity and pH of oceans, reduction of O_2 concentration in waters that lead to desertification and wildfires, severe storms such as hurricanes and blizzards, increased sea levels resulting in flooding coastal cities. All these phenomena are tightly linked to one another. The climate change should be analyzed as complex problem and should be faced by an integrated strategy at different levels. Climate change impacts on production and reproduction of livestock causing important economic losses. The rapid growth of the livestock sector and its various contributions to the economy and human livelihoods highlight the importance of better understanding the impacts of climate change on livestock and aquatic animals. Tools and techniques for assessing animal productivity and disease surveillance system to incorporate animal data with relevant climate conditions are needed. Development and application of methodology to link climate data with disease surveillance systems should be implemented to improve prevention of diseases as well as mitigation and adaptation responses of animals to maintain their productivity. Given that climate change will progressively reduce the quantity and the quality of food for humans and animals, one strategy for future livestock management could be the propagation of native livestock breeds and fish known to be highly resilient and disease resistant, to have low dietary needs and to produce high quality products. Adaptation choices and risk management actions across temporal and spatial scales and contexts will need to build on robust methods of designing, implementing and evaluating detailed development pathways.

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Experts' Column

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Augmenting fish production and disease mitigation strategies under changing climatic scenario

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Introduction

India, recognized as one of the 17 mega-biodiverse countries, is home to an exceptional range of biodiversity due to its varied ecosystems and geographical features. It encompasses four key Biodiversity Hotspots viz., Western Ghats, North-East Region, Himalayas, and Andaman and Nicobar Islands. Collectively, these hotspots contribute significantly to India's status as a global biodiversity center, supporting approximately 7-8% of the world's total biodiversity (Venkataraman and Sivaperuman, 2018). This remarkable richness underscores the importance of conserving these areas to maintain global ecological balance. However, India's fish biodiversity remains remarkably rich yet increasingly threatened. The country boasts a diverse range of aquatic species across its numerous freshwater and marine ecosystems, including the Ganges River Dolphin (*Platanista gangetica*), various species of catfish, and a myriad of reef fish.

The total fish production of the country was estimated at an all-time high of 17.55 million tonnes in 2022-23 showing a growth of 7.39% compared to the previous year. Of these, 13.11 million tonnes comprised of inland fisheries and 4.43 million tonnes of marine fisheries (HoFS, 2023). The country has exported 17,35,286 tonnes of seafood to different foreign countries valued at an all-time high of 63,969.14 crores (8.09 billion USD), which contributes 6.72% to the agricultural economy and 1.10% to the Indian economy. India ranks 3rd largest exporter of fish and seafood globally, following China and Indonesia (HoFS, 2023).

The Aquatic Genetic Resource Information System of India (AqGRISI) documents 3246 native finfish species belonging to 1044 genera, 256 families, and 57 orders from Indian waters. This included approximately 1569 species exclusively marine and about 961 species exclusive to freshwater ecosystems. Family Cyprinidae contributes the highest number of species (*n*=335) followed by Gobiidae (*n*=164), Sisoridae (*n*=140), Nemacheilidae (*n*=115), and Serranidae (*n*=85) (NBFGR, 2024). As per the IUCN Red List of Threatened Species, 45 species were categorized as Critically Endangered (CE), 117 Endangered (EN) species, 184 Vulnerable (VU) species, 102 Near Threatened (NT) species, 1990 Least Concern (LC) species, and 348 Data Deficient (DD) species (NBFGR, 2024). The Critically Endangered species distributed in India are *Glyptothorax kudremukhensis*

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(Kudremukh Glyptothorax), *Puntius deccanensis* (Deccan Barb), *Schistura papulifera*, *Neolissochilus bovanicus* (Bovany Barb), *Pethia pookodensis* (Pookode Lake Barb), *Glyptothorax kashmirensis*, *Puntius madhusoodani*, *Tor remadevii* (Hump-backed Mahseer), *Triplophysa kashmirensis*, *Hypselobarbus pulchellus* (Haragi), *Hypselobarbus thomassi* (Red Canarese Barb) and *Garra arunachalami* (IUCN, 2024).

India's coastline extends 8,118 km with an Exclusive Economic Zone (EEZ) of 2.02 million km^2. This vast marine area is home to 2,275 species of teleosts, 174 species of elasmobranchs, 2,783 species of crustaceans, 3,400 species of molluscs, 936 species of seaweeds, 765 species of echinoderms, 14 species of seagrasses, and 486 species of sponges (CMFRI, 2023). Approximately 1000 species are commercially significant and are harvested by around 30 different fishing gear types across various regions of the Indian seas (CMFRI, 2023). However, the Indian fish biodiversity is under significant pressure from overfishing, habitat destruction, pollution, and climate change. Efforts to address these challenges include improved conservation strategies, such as the establishment of marine protected areas and sustainable fishing practices. Despite these efforts, ongoing habitat degradation and water quality issues continue to pose serious threats, underscoring the need for more robust and integrated approaches to the conservation and sustainable management of India's aquatic resources

Climate change and freshwater ecosystem

The climate of a region indicates average weather for a longer time, whereas "Climate Change" specifically refers to long-term shifts in global weather patterns that persist for decades or more, while "Climate Variability" includes all changes in climate extending beyond individual weather events. An example of this variability is an "Inland Heat Wave (IHW)" characterized by prolonged periods of extreme heat and humidity in inland water bodies, usually during summer (Ninawe *et al*., 2018; Niedrist *et al*., 2018). According to Sarkar *et al*. (2022), IHWs can significantly impact primary producers and water quality. The changing climatic conditions are primarily observed through global warming and an increase in the frequency of extreme weather events, such as heatwaves and cyclones (Field *et al*., 2014; Lin, 2019). The primary drivers of climate change include the burning of fossil fuels for production and transportation, which releases greenhouse gases (GHGs) that trap heat in the Earth's atmosphere. Additionally, deforestation and changes in land use and land cover reduce the capacity of vegetation to sequester carbon and release further GHGs into the atmosphere (Pellikka *et al*., 2018).

The impact of climate change is particularly severe on developing countries due to their limited carrying capacity and resources to address these challenges. India is highly vulnerable to climate change due to its significant exposure to climate-related disasters and its heavy reliance on climate-sensitive sectors such as agriculture, forests, tourism, and fisheries (Majra and Gur, 2009). The fisheries sector, one of the fastest-growing food production industries in the country, is crucial for ensuring food and nutritional security, generating employment, increasing income, and earning foreign exchange. The combined efforts of fisheries resources, resource users, and the environment have supported sustained fish production and improved the welfare of fishers through advancements in technology and increased capital investment in the sector (Subasinghe *et al*., 2009).

According to the Food and Agriculture Organization (FAO), climate change is a major factor contributing to predominantly negative impacts on both farmed aquatic genetic resources and their wild counterparts, especially in tropical regions. It influences fish production by disrupting biological processes at the individual, community, and ecosystem levels (FAO, 2019). Variations in climatic parameters can significantly affect fish genetic resources by altering their geographic distribution, community structure, and abundance. These changes can lead to species loss and impact various aspects of fish biology, including population dynamics, breeding patterns, migration routes, and physiological behaviors (Sarkar and Das, 2021).

Climate exerts a significant impact on the physical, chemical, and biological processes within freshwater ecosystems. Variations in rainfall affect river flow, which in turn impacts the lifecycle of dependent fish populations. The observed relationship between decreasing rainfall and rising temperatures in the floodplains of Lower Ganga Basin corresponds with reduced fish production, highlighting the effects of environmental and climatic changes on fish diversity (Sarkar *et al*., 2020a). Changes in temperature and rainfall have caused breeding failures in Indian Major Carps, leading to a decrease in fish spawn availability in the Ganga River (Vass et al., 2009). Additionally, heat waves have affected the feeding intensity and food composition of certain fish species, as indicated by their reduced Gastro-Somatic Index (GaSI) in India (Sarkar and Das, 2021). The moderate to high reproductive vulnerability observed by Lianthuamluaia *et al*. (2023) in Gangetic leaf fish (*Nandus nandus*) in floodplain wetlands of the major river basins in India highlights how regional climate change affects their population characteristics and breeding patterns.

Climate change and oceanic ecosystem

Oceans play a crucial role in climate dynamics. As they cover a significant portion of the Earth's surface and are home to diverse ecosystems, they are heavily impacted by the changes driven by global warming (Ninawe *et al*., 2018). The ocean has mitigated some of the severe effects of climate change by absorbing over 90% of excess heat and 25% of CO_2. However, this has come at a significant cost, leading to substantial damage to marine ecosystems (IPCC, 2019). The ocean absorbs the majority of excess heat from greenhouse gas emissions, resulting in rising ocean temperatures. These increased temperatures impact marine species and ecosystems, leading to coral bleaching and the loss of breeding grounds for fish and marine mammals. Additionally, the effects extend to human benefits derived from the ocean, threatening food security, increasing disease prevalence, exacerbating extreme weather events, and diminishing coastal protection (Laffoley and Baxter, 2016).

Effects of climate change on marine species physiology and growth

Changes in environmental conditions driven by climate change pose a threat to marine species by directly affecting their physiological processes, which in turn impacts their overall individual performance and survival. A summary of physical and morphological effects of ocean warming and acidification on marine species depending on life stage is shown in Fig. 1 (Booth *et al*., 2017).

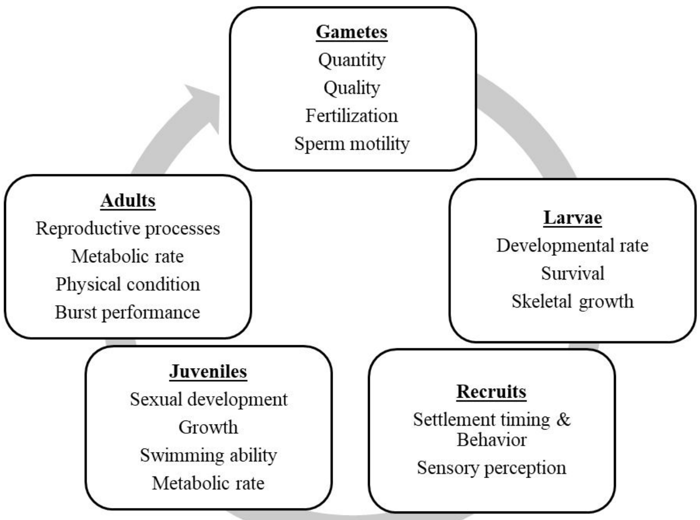

Fig. 1. Physical and morphological effects on different life history stages of marine fish due to climate change

Climate change complicates our efforts to develop sustainable management and conservation strategies for preserving biodiversity and ecosystem services. Marine biodiversity reacts to shifting temperatures and other oceanic conditions through alterations in physiological processes, life cycles, population dynamics, and distribution patterns. These responses are expected to result in modified species richness, changes in community structure and ecosystem functions, and subsequent impacts on marine goods and services (Jones and Cheung, 2015).

One notable example of climate change impact on the Indian oil sardine (*Sardinella longiceps*) is the observed shift in its distribution and spawning patterns due to rising sea temperatures. In recent years, increasing ocean temperatures have led to changes in the distribution of the Indian oil sardine along the Indian coast. Studies have shown that sardines move to cooler waters, often farther from their traditional spawning grounds. This shift can result in reduced spawning success as sardines may find it more challenging to locate suitable breeding areas (George *et al*., 2012; Rohit *et al*., 2018; Hamza *et al*., 2021). The genome assembly of the Indian oil sardine provides a crucial genomic resource for investigating adaptive variation and selection at the genomic level. This resource is particularly valuable for studying how pelagic fishes, like the Indian oil sardine, respond to climate change across diverse environmental conditions. It offers insights into the genetic mechanisms underlying adaptation and resilience in the face of changing oceanic conditions (Sukumaran *et al*., 2023).

A study by CMFRI examined the relationship between temperature and the abundance of threadfin breams off the Mangalore coast by comparing catch rates from two different periods (CMFRI, 2018). The data revealed a slight reduction in catch rates over time. During the experimental fishing period from 1993 to 1995, which covered depths ranging from 50 to 200 meters, the maximum catch rate of threadfin breams was 500-600 kg per hour. In contrast, the catch rate during 2013 to 2015 decreased to 250 kg per hour. The temperature data showed that in 1993-1995, the maximum temperature was 28.65°C and the minimum was 28.41°C. In comparison, during 2013-2015, temperatures had increased, with a maximum of 29.85°C and a minimum of 29.54°C (CMFRI, 2018).

Effects of climate change on coral reef ecosystem

Climate change represents a significant threat to coral reef ecosystems. Coral bleaching happens when corals and their photosynthetic symbionts, the zooxanthellae, experience thermal stress beyond their tolerance limits. When water temperatures rise too much, corals expel these algae from their tissues, leading to a loss of color and turning the coral completely white. This process weakens the corals, making them more vulnerable to disease and potentially leading to their death (Curran and Barnard, 2021). The rise in sea level, driven by thermal expansion and the melting of land ice, has varied across global regions, with an average increase of about 20 cm over the past century. This rise in sea level can exacerbate sedimentation processes, which may negatively impact essential physiological functions of coral reefs, including photosynthesis, feeding, and recruitment. These disruptions significantly threaten coral reefs and interconnected ecosystems, such as seagrass meadows and mangrove forests, by compromising their health and functionality (Field *et al*., 2014; Woodroffe and Webster, 2014; Tay *et al*., 2022).

Climate change and disease outbreak

Climate change presents a significant threat to aquatic animals, particularly in closed culture systems. It heightens risks by altering the distribution, prevalence, and virulence of pathogenic bacteria, viruses, fungi, and parasites within these systems, while also influencing the susceptibility of the hosts (Chang *et al*., 2023). Climate change studies on fish diseases focus on understanding how shifts in environmental conditions, such as temperature, ocean acidification, and altered habitats, impact the prevalence and severity of diseases affecting fish populations (Marcogliese, 2008; Marcos-Lopez *et al*., 2010; Pridgeon and Klesius, 2012; Mallick and Panigrahi, 2018; Combe *et al*., 2023).

Temperature effects: Research has shown that rising temperatures can influence pathogens' growth rates and virulence. For example, warmer waters can accelerate the life cycles of parasites and increase the susceptibility of fish to diseases like Ichthyophthiriasis (Ich), caused by the protozoan *Ichthyophthirius multifiliis*. Higher temperatures can also stress fish, making them more vulnerable to infections (War *et al*., 2022; Peng *et al*., 2023; Awad *et al*., 2024).

Ocean acidification: Increased CO_2 levels leading to ocean acidification can affect the immune responses of fish and disrupt their ability to fight off diseases. Acidic conditions may also impact the development and survival of pathogens and parasites (Heuer and Grosell, 2014).

Habitat changes: Climate-induced changes in habitat, such as coral reef degradation or alterations in aquatic vegetation, can influence the spread of diseases. For example, reduced coral cover can lead to changes in fish community structure and potentially increase disease transmission (Raymundo *et al*., 2009).

Pathogen distribution: Shifts in water temperature and salinity can alter the geographical distribution of pathogens and parasites. This can lead to the introduction of diseases into new areas where fish populations may not have evolved defenses against them (Lafferty, 2009; Bett *et al*., 2017).

Overall, these studies aim to improve our understanding of how climate change influences fish health and to develop strategies for mitigating disease risks in both natural and managed aquatic systems.

Climate change effect on livelihood of coastal communities

Coastal fishermen are highly susceptible to stress and disruptions caused by climate change factors such as rising sea levels, cyclones, erosion, and flooding. These climate changes impact the productivity of coastal ecosystems, biodiversity, fish stocks, and migration patterns. Key climate indicators like increasing sea surface temperatures, sea level rise, ocean acidification, heavy rainfall, extreme weather events, erosion, flooding, saltwater intrusion, cyclones, El Nino, and drought significantly affect the sustainability of fishing communities. As fishing is the primary livelihood for many coastal and marine fishermen, they are among the most vulnerable groups facing the effects of global climate change (NCSCM, 2024). Understanding vulnerability related to climate change and health provides a foundation for predicting disease risks and developing effective monitoring and mitigation strategies (Kathirvelpandian *et al*., 2024).

Adaptation strategies for the mitigation of climatic impacts are crucial. These may include:

- Diversifying livelihoods: Encouraging alternative livelihoods to reduce dependency on fishing.
- Strengthening infrastructure: Building more resilient fishing infrastructure and improving disaster preparedness.
- Monitoring and research: Enhancing monitoring of fish stocks and marine conditions to inform sustainable practices.
- Community engagement: Involving local communities in decision-making and management strategies.
- Policy support: Advocating for policies that address climate change impacts and support vulnerable communities.
- Addressing the impacts of climate change on coastal fishermen requires a multi-faceted approach that combines scientific research, community engagement, and policy action.

Innovative approaches

The adverse impact of climate change on fish genetic resources can be overcome through innovative approaches and climate-smart strategies developed in the regional context for fishery resources in India. Such approach has been demonstrated for several indigenous fishes viz., *Eutropiichthys vacha*, *Mystus cavasius*, *M. tengara*, *Johnius coitor*, *Channa punctata*, *Puntius sophore*, *Amblypharyngodon mola* and *Gudusia chapra* under changing climate scenario in India (Sarkar *et al*., 2018a, 2018b, 2019a, 2019b; Karnatak *et al*., 2020).

Climate-resilient fish species are anticipated to become increasingly necessary as climatic stressors rise daily. Certain native fish species, such as *Clarias magur*, *Heteropneustes fossilis*, *Anabas testudineus*, *Channa* spp., *Punius* spp., and *Notopterus notopterus*, demonstrated greater tolerance to climate change in India's inland waters (Sarkar *et al*., 2020a, 2020b, 2020c). *Amblypharyngodon mola* (Mola carplets), a species that inhabits wetlands in the lower Indo-Gangetic floodplains, was studied to validate the reproductive resilience of minnows to climate fluctuation (Sarkar *et al*., 2021). In marine ecosystems, *Sardinella gibbosa*, *S. fimbriata* and *S. longiceps* ranked high in vulnerability assessment. Similarly, *Nemipterus japonicus* and *N. randalli* possess high resilience making them particularly adaptable and robust species (Zacharia *et al*., 2016).

ICAR-NBFGR initiatives

Disease surveillance and fish health management: Following the successful completion of Phase I, the National Surveillance Programme on Aquatic Animal Diseases - Phase II is currently underway, covering 19 states and involving 31 Collaborating Centres. Pan-India coverage is achieved through 62 centres, with State Fisheries Departments actively engaged in improving the disease reporting process. Additionally, the Marine Products Export Development Authority (MPEDA) oversees shrimp disease surveillance nationwide.

Fish cell lines have long been recognized as one of the most effective alternatives to whole-animal research. They are widely used in studies focused on fish disease diagnosis, virus isolation, cytogenetic and genotoxicity screening, toxicology, gene expression analysis, biobanking, cryopreservation, and cellular agriculture. The National Repository of Fish Cell Lines (NRFC), the world's largest, was established by the bureau with support from the Government of India and currently houses approximately 83 fish cell lines.

The bureau has developed two exclusive applications to enhance disease surveillance and fish health management: "ReportFishDisease", which enables farmers to promptly report fish diseases, and "Exotic Fish", which documents the presence of exotic fish species. Additionally, the bureau introduced "OoNIL", a specialized formulation for treating oomycete diseases in freshwater fish, which has been well-received by fish farmers.

Indian Network of Fisheries and Animal Antimicrobial Resistance (INFAAR) is being implemented with ICAR -NBFGR as lead centre to document AMR in different production systems, describing the spread of resistant bacterial strains and resistance genes, identifying trends in resistance and generating hypotheses about sources and reservoirs of resistant bacteria through a structured national surveillance program. INFAAR is being operated through 18 organizations (15 ICAR institutions and three State Agriculture Universities) in 20 centres (nine centres from fisheries and 11 from the livestock sector) spread across the country.

Cataloguing and documentation of Fish Genetic Resources (FGR): Over the past decade, the discovery of 60 fish species, 8 shrimp species, and 2 unique fish parasites has significantly contributed to documenting the country's fish genetic resources. DNA barcodes using mitochondrial and nuclear markers were developed for over 600 fish and shellfish species to aid in accurate identification.

State fish concept for conservation linking local community: The innovative idea of designating a 'State fish,' introduced in 2006, engages local communities and various stakeholders in preserving and managing fish genetic resources to promote sustainable development. Currently, 22 Indian states have designated their state fish based on factors such as local preferences, popularity, ecological and commercial importance, cultural and historical significance, culinary value, endemism, aquaculture potential, and conservation prospects (Sarkar *et al*., 2024).

Genomic resources developed: The whole genomes of *Clarias magur*, *Labeo rohita*, *Tenualosa ilisha*, and two fish pathogens (Tilapia Lake Virus and *Aphanomyces invadans*) were deciphered. Population genetic structures for 16 fin and shellfish species were studied, and microsatellite markers for 50 prioritized fish species were developed. Four online databases, including Fish Karyome and Fish Barcode Information System, were created for stakeholders.

Captive breeding protocols: Captive breeding protocols for prioritized and endangered fishes such as *Cirrhinus reba*, *Chitala chitala*, and *Hemibagrus punctatus* were standardized. Protocols were also developed for 15 ornamental fish species and 2 marine ornamental shrimps.

Live Gene Banks with societal impact: Eight live gene banks were established across India to conserve and sustainably utilize indigenous fish species, including marine ornamental shrimp. Community aquaculture centers were also set up for livelihood development in coastal Maharashtra, Tamil Nadu, and Lakshadweep.

Sperm cryopreservation: Sperm cryopreservation protocols were developed for 35 fish species, with seed production for 24 species. Field-level validation of Indian Major Carps was conducted, and 370 hatchery professionals were trained, resulting in the production of 126 lakh spawn from cryopreserved milt in 38 hatcheries across 11 states.

Conclusion

Globally aquatic resources are undergoing substantial changes at the individual species, population-, community-, and ecosystem-level processes due to climate change. Hence, the vulnerability and resilience assessment of fish germplasm and ecosystems are vital for mitigating the climate change impacts and aid in the development of climate-smart fish species and resilient ecosystems. Understanding the role of climatic and environmental variables on gonadal maturation, and spawning periodicity of natural fish germplasm and aquaculture important species enable sustaining the fish production in the changing climatic scenario.

Way forward/Future studies

- The assessment of ecological conditions and fisheries concerning climate change needs to be done to formulate effective mitigation and adaptation strategies to combat losses due to climate change.
- It is also essential to identify the optimal climatic conditions for successful recruitment of natural fish stocks. The identification of climate-sensitive/resilient species will also help in prioritization of the conservation needs of species.
- Identification, development, and demonstration of climate-resilient adaptation strategies will help in building ecosystem resilience and adaptive capacity of fishers.
- Projections on fish distribution, abundance, and catches need to be developed under changing climatic conditions; and for mariculture, suitable candidate species, which would benefit from elevated temperature, need to be identified for planning better management adaptations.
- Modification and improvisation of the fish breeding and propagation to match with the changed environmental factors as well as the adoption of effective measures will help the fishers secure their livelihood.
- A more granular analysis at the block, district, regional, and state levels to discern specific long-term trends and changes that can aid in evolving adaptation and climate resilience measures.
- More climate smart aquaculture practices to be developed and implemented at regional level.

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Experts' Column

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Climate change and livestock health: Impact and mitigation

Climate change is the greatest global challenge in twenty-first century. Rise of temperature on surface of earth posed a great threat to biotic and abiotic entities. The substantial changes in the climate cast an adverse effect on ecosystem, economics and societies in several ways, The consequences of climate change are changes in weather patterns, melting of glaciers at the poles and an increase in sea levels, as well as modified precipitation patterns etc (Hoque *et al*., 2022; Sharma *et al*., 2024).

Contributory factors of climate change

-Human activities such as combustion of fossil fuel, industrialization, deforestation and rapid urbanisation are contributing to the transformation of the climate at an alarming rate by generation of greenhouse gases.
-Use of fossil fuel such as coal and oil in large scale generates carbon dioxide.
-Urban landfills, paddy cultivation, use of nitrogen fertilizers in agriculture and livestock farming produce methane and nitrous oxide.

Impact of climate change on livestock

Climate change is one of the major threats for the sustainability of livestock sector. Climatic factors such as ambient temperature, relative humidity, rain fall and direct and indirect solar radiation influence on feed and water availability, fodder quality, heat stress, livestock growth, production, reproduction and disease occurrence. These impacts are basically due to an increase in temperature and atmospheric carbon dioxide concentrations, precipitation variation and a combination of these factors.

Temperature affects most of the critical factors for livestock production, reproduction and health. Water availability, quality and quantity of forage are affected by a combination of increases in temperature, carbon dioxide and precipitation variation. Occurrence of diseases is mainly affected by an increase in temperature and variation in rain fall pattern. The effects of climate change on livestock health may be categorised in two heads- direct and indirect one. (Sharma *et al*., 2024).

Heat stress

Animals have a range of ambient environmental temperatures that are optimal for their physiological processes, known as their thermal comfort zone. Animals experience heat stress when the temperature rises above the critical temperature of the range. Heat stress in animals is dependent on temperature, humidity, species, breed, age and physiological status (Sharma *et al*., 2024).

Heat stress also affects their metabolism, physiology, hormones and immune system in animals. The physiological changes result in decreased rumen motility and rumination in ruminants (Nardone *et al*., 2010; Nejash *et al*., 2016; Rajas-Downing *et al*., 2017). Decrease in thyroid activity resulting further lesser metabolic heat production Feed intake and feed utilization efficiency of animal exposed to heat stress had decreased (Hooda *et al*., 2010).

Production and production diseases

The negative impacts on livestock productivity, health and animal performance are influenced and affected by various factors such as increasing environmental temperatures followed by humidity, wind velocity and radiation. Thermal stress due to climate changes causes a reduction in feed intakes. It also reduces the feed conversion ratio (FCR) and utilization of feeds, production disorders such as ketosis, milk fever, fat cow syndrome and various deficiency disorders may be an outcome of changing climate and improper nutrition. There have been estimated significant monetary losses of nearly 2% of the total milk production in India (Sharma *et al*., 2024).

Reproductive disorders

Reproduction efficiency of both male and female may be affected by heat stress. In male animals, semen quality and libido get affected by higher environmental temperature. The sertoli cells are primary target for heat stress (Ahmad *et al*., 2022). Heat stress has also been associated with lower sperm concentration and quality in bulls (Karaca *et al*., 2002; Kunavongkrita *et al*., 2005). In females, follicular dynamics and expression of estrus sign are disturbed due to rising environmental temperatures and humidity. This may lead to a high incidence of silent heat in animals. (Barati *et al*., 2008) reported the alteration in oocyte growth and quality of cow and pig leading to impairment of embryo development and pregnancy as adverse effect of heat stress. Poor fertility may be attributed to increased energy deficits and heat stress in cows (De Rensis and Scaramuzzi, 2003; King *et al*., 2006).

Indirect effects

Indirect effects of climate change on animal health and production are due to microbial density and distribution of vector-borne diseases, food and water shortages, or foodborne diseases (Lacetera, 2019).

Disease occurrence: The epidemiology of diseases will be influenced by any climate-related factor that modifies the interrelationship between hosts, pathogens and environment (triangle relationship). Under a changing climate scenario, there may be an increased probability of the emergence of many zoonotic and parasitic diseases. Climate change could change how diseases travel, outbreaks of serious illnesses or even the introduction of new diseases that could affect livestock that isn't typically exposed to these kinds of illnesses.

Vector borne diseases: Generally arthropod vectors are markedly increased in numbers during the hot, humid weather condition and animals are worst affected by them during these favorable climatic conditions (Sridhar *et al*., 2020).

Climate change affects pathogens: The number of infectious cycles that may occur for diseases related to the warm or cold seasons within a year may grow or decrease depending on how long the warm season is maintained. Extreme weather conditions such as flooding cause pollution to runoff from the agricultural land to animal farms and this runoff mixed with the water supply in farms can be the source of infection.

Feed and water availability: Climate change adversely affect the availability of feed and water which in turn poses health issues in livestock.

Climate change and zoonosis: The environmental changes affect the breeding, development and proliferation of specific parasite species and their hosts as well as their capacity to transmit diseases. Climate change is believed to increase the risk of human exposure to various zoonotic diseases.

Mitigation strategies

Adaptation strategies can improve the resilience of animals towards climate change (USDA, 2013). Mitigation measures could significantly reduce the impact of livestock on climate change (Dickie *et al*., 2014). Adaptation and mitigation can make significant impacts if they become part of national and regional policies.

Climate-resilient animal breeding: Selective breeding programs play a pivotal role in developing animal breeds that can withstand the challenges posed by a changing climate.

Management modifications: The modification of production and management systems involves diversification of livestock animals and crops, integration of livestock systems with forestry and crop production and changing the timing and locations of farm operations (IFAD, 2010).

Robust surveillance: Improved veterinary surveillance systems are essential for tracking the diseases that are impacted by climate change.

Effective preventive measures: The FAO Emergency Prevention System (EMPRES) (1994) has showed early warning, detection and response as the key to the prevention and control of both old and new infections and diseases in animals. Prevention and control of spread of disease across country boundaries has become the credo of the FAO/World Organization for Animal Health (OIE)/WHO initiative under the umbrella of 'One Health".

Conservation of natural habitat: Two essential tactics for reducing the negative effects of climate change on animals are the preservation of natural habitats and the restoration of damaged ecosystems.

Public awareness and education: Gaining support for mitigation initiatives requires educating the public about the complex relationship between livestock health and climate change.

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Experts' Column

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Enhancing resilience in livestock for sustainable production and disease tolerance under changing climatic scenario

Climate change is a major concern for livestock production. Global warming and its associated changes affect animal health and production adversely. The ability of current livestock production to support livelihoods and meet the increasing demand for livestock products is thus threatened. The livestock sector currently plays a key role in food supply and food security (Godde *et al*., 2021). Livestock products such as meat, milk and eggs contribute 15% and 31% of global per capita calorie and protein supply (FAOSTAT, 2020).

The climate change, especially global warming, may highly influence the production performance of livestock. Among the environmental variable that affect animals, heat stress seems to be the important factor making animal production challenging. Maintenance of homeothermy and homeostasis is essential for animals to survive, produce and reproduce. The animals are not able to maintain their optimum production under climatic stress because some energy is wasted in using the thermoregulatory mechanisms. If the animal is not able to get rid of the access heat load even by exhausting thermoregulatory mechanism, it tries to reduce the internal heat production by curtailing the feed intake. Reduction in the feed intake affects production adversely. Animal stress level due to rise temperature has been worked out using temperature humidity index (THI). If the THI is more than 72, livestock production is impacted. A thermal environment is a major factor that affects milk production in dairy cow, especially on high yielders. Milk yield declines by 0.2 kg per unit increase of THI when it exceeds 72. Heat stress adversely effect on reproductive performance also. During heat stress, incidence of anoestrus and silent ovulation is increased (Desalegn, 2016). Heat stress is a major cause of early embryonic losses. In male, heat stress causes reduced quantity and quality of sperm production and decline fertility. Climate change also affects the quantity and feed and fodder available for livestock.

The effect of climate change on animal health may be either direct or indirect. The direct effects of climate change on health include temperature related illness and death. This may result into metabolic disorders, oxidative stress, immunosuppression etc. Indirect impacts follow more complex pathways and include those derived from the influence of climate on microbial density and distribution, distribution of vector-borne diseases, food and water shortages, or foodborne diseases (Lacetera, 2019).

The animal husbandry contributes immensely to the food security and the demand of food is increasing as the population grows. Hence, efforts are needed to improve the resilience capacity of livestock to impart them the ability to withstand the adversities associated with climate change as well as to maintain their productivity ensuring both the livelihood security of poor and marginal farmers as well as ensuring the food security of growing human population.

Strengthening of climate-resilience in the livestock

Resilient capacity of livestock against heat stress is the ability of livestock to recover their normal biological functions after the exposure to extreme heat and maintain the physiological status and production (Rashamol and Sejian, 2018). No single strategy can ensure adaptation of livestock to climate change. On the one hand measures to reduce greenhouse gas production from livestock are management of ruminal function, waste management and enhancing feed conversion efficiency. On the other hand, ameliorative measures and enhancing resilience in livestock against heat stress are to be achieved by the following strategies.

Environmental modification and thermal comfort: These may be achieved by reducing the ambient temperature of the housing/resting areas by providing plantation of trees, suitable shelters, proper ventilation, sprinkling water, installation of cooling systems and reding stocking density. It is estimated that proper shelter/shades reduce heat load by 30% or more. Ventilation at an air speed @ 3- 5 mph during periods of heat stress helps the animals to dissipating body heat. Sprinklers, fans and misters may be useful for evaporative cooling and convection. Cooling system may be installed by flowing of cooler air through underground piping system. Reduction of stocking density helps the animals to sustain heat stress better. Provide 30-inch feed bunk space to encourage dry matter intake. If difficult to provide such space to the whole herd, at least, provide the same to fresh and high-production cows.

Nutritional interventions and management: Livestock consume less feed to reduce metabolic heat production during heat stress. The rumen function is altered due to lesser activity of ruminal microflora due to high temperature. High producing cattle are more vulnerable to heat stress. The ameliorative measures are to be undertaken are reducing the quantity of fibrous diets and increasing concentrate in ration, use of by-pass nutrient (fat/protein) feeding, use of feed additives like antioxidants (Vit C, Vit E, and Se) in diet, supplementing diet with buffers (Sodium bicarbonate) to reduce acidosis which commonly occurs in animals under heat stress. Supplementing with betaine, chromium, niacin and yeast in diet and adjusting potassium loss in diet which occurs due to increased sweating will help in maintaining production in livestock. Heat stress greatly increases water intake in cows, so, provide more water for drinking. Change feeding schedule to the cooler parts of the day e.g., early morning and late afternoon.

Animal health management: The heat stress induces metabolic disorders, oxidative stress, immunosuppression and even death. The proteins, including enzymes, may denature if the body temperature exceeds 50°C. The parasites and pathogens increase their development and arthropods (vectors) are more active at higher temperatures. Animal disease is the single greatest threat to livestock assets, a major risk to human health, and huge source of risk due to new emergent diseases. Majority of the animal diseases are climate sensitive. A report on climate and livestock disease from the International Livestock Research Institute shows that climate change can increase the burden of livestock diseases and suggested the following recommendation (Grace *et al*., 2015). The disease surveillance and response to detect changes in disease in a timely way and capacity to forecast the occurrence of climate-sensitive diseases, and to predict longer-term distribution of diseases through better epidemiological information are to be improved. Animal health service delivery requires to be revised by investing more in public sector and encouraging private sectors. Improvement in sanitation, hygiene or biosecurity at farm is essential. Increase the resilience of livestock systems by supporting diversification of livestock holding. Risk management for emerging disease are to be seriously addressed through *One Health* umbrella.

Genetic selection for disease resistance and thermotolerant livestock

Breeding strategies for climate and disease resilient livestock is to be opted for reducing cost of rearing and achieving sustained production. It has been demonstrated that for resilience and adaptive capacity in dairy animals are long legs, short hair coat, higher sweating rate, higher capacity for maintenance of heat balance, lower metabolic rate, higher feed efficiency, higher tolerance to dehydration and capacity to alter the hormone and biochemical profiles to adapt to a particular environment (Rashamol and Sejian, 2018).

Conventional selection: Inherent resilience for heat tolerance have been recorded in some breed, also individual animal within a breed. The most important tasks when modelling the effect of heat stress are the identification of an appropriate heat stress indicator and the availability of a heat stress function with detailed information regarding the stress threshold. The most widespread indicator for heat stress is the THI. Ravagnolo *et al*. (2000) identified that THI-72 was the threshold for the onset of heat stress. Common indicator traits for adaptive mechanism in livestock are respiration rate, rectal temperature, sweating rate, panting rate, PCV, Hb%, cortisol, thyroid hormone, heat shock protein (HSP). The thermal circulation index (TCI) described by Curtis (1983) quantifies the transfer of heat from the core of the body to the skin surface and then to the environment under steady-state thermal conditions. Improvement of heat tolerance ability in livestock can be achieved by including traits such as rectal temperature or panting score into selection indices (Schierenbeck *et al*., 2010). High heritability of some climate resilient traits (Table 1) indicates that genetic progress can be achieved faster through selection programme for thermotolerance, and also disease resistance.

Table 1. Climate resilient traits and their heritability

Climate resilient traits	Heritability (h^2)	References
Respiration rate	0.76 to 0.84	Burrow, 2001
Body temperature regulation	0.21 to 0.68	Dickmen *et al*., 2012
Rectal temperature	0.13 to 0.32	Gourdine *et al*., 2021
Thermoregulation (pig)	0.39 to 0.83	Kim et al., 2018; Brito *et al*., 2020
Thermoregulation (pig)	0.34 to 0.39	Gourdine *et al*., 2017
Resistance to TB	0.49	Mackintosh *et al*., 2000
Somatic Cell Count	0.11	Mrode and Swanson, 1996
Mastitis resistance	0.04	Mrode and Swanson, 1996

Genomic selection: Genomic selection uses genome wide DNA markers to capture the effects of the many mutations that influence variation in a complex trait like heat tolerance, and allows young bulls and heifers to be selected on their genomic estimated breeding values (GEBV), thereby accelerating genetic gain.

With the introduction of high-density SNP chips, including 50K markers in genomic selection became a reality (Van Tassell *et al*., 2008). Adoption of genomic selection breeding programs in the major dairy-producing countries has led to significant changes in the worldwide dairy industry.

Identification of causative genes and characterizing the casual variants and pathways underpinning the genetic basis for heat tolerance in cattle is gaining increased attention due to global warming, as demonstrated by a recent surge in published studies (Macciotta *et al*., 2017; Luo *et al*., 2018; Sigdel *et al*., 2019). So far, many Genome-Wide Association Studies (GWAS) studies aimed at understanding the biology of thermal stress have been focused on Holsteins (Dikmen *et al*., 2013; Sigdel *et al*., 2019; Cheruiyot *et al*., 2021). Cheruiyot *et al*. (2021) identified promising candidate genes for heat tolerance by (ACLY, PDHA2, MDH1, SUCLG2, and PCK1) and Garner *et al*. (2020) reported that many candidate genes are differentially expressed under heat stress. There are many candidate genes in goats that could be harnessed for better adaptation viz. genes related to heat stress (*HSF1*, *HSP20*, *HSP70*, *HSP90*), growth (*GH*, *GHR*, *IGF-*

1, *LEP*, *LEPR*, T_3, T_4, *THR*, *NOS*), reproduction (*GnRH*, *GnRHR*, *FSHR*, *LHR*, *inhibin*, *PROGR*, *ESTR*), and immunity (*TLR2*, *TLR3*, *TLR8*, *TLR10*, *IL2*, *IL10*). The *HSP70* is the commonest genetic-marker of thermotolerance. Higher expression of *HSP70* mRNA in tissues is an indication of higher thermotolerance (Abioja *et al*., 2023).

Genome editing technology: Traditional breeding approaches and transgenic technology have been widely used to mitigate the risks of environmental stresses in plants and animals. The discovery of engineered nucleases as genetic scissors to carry out precise manipulation in crop stress-responsive genes and associated molecular network has paved the way for sustainable management of abiotic stress conditions.

Genome editing tools enable precise changes in DNA by introducing targeted mutation, insertion, deletion and specific sequence alteration using specific nucleases. Commonly used such enzymes are Mega-nucleases (Puchta *et al*., 1993), *Transcription Activator-Like Nucleases* (TALENs) (Zhang *et al*., 2013) zinc-finger nucleases (ZFNs) (Zhang *et al*., 2010), and *Clustered Regularly Interspaced Short Palindromic Repeats* (CRISPR–Cas9) (Jiang *et al*., 2013). The CRISPR/Cas9 is the most successful genome editing system (Chen *et al*., 2019).

The genome editing can be applied in breeding programs of cattle for disease resistance, to control parasite population, and tolerance to heat stress and to control cattle methane emission. Gene editing together with genomic selection has the potential to double the genetic gain (Jenko *et al*., 2015).

Conclusion

The potential impacts of climate change on current livestock systems are a major concern. The net impacts of climate change on the livestock sector are not yet assessed properly. The risks of climate-related impacts are expected to be higher in tropical countries like India. Large uncertainties remain as to climate futures and therefore, adaptation choices will need to account for a wide range of possible interventions. The adaptation and mitigation strategies are not universally applicable i.e. location specific. Almost 70% of livestock in India is owned by small and marginal farmers, and landless labourers. The animals of these resource poor livestock owners are most vulnerable to climate change and are at greater risk since they do not possess necessary means for adaptation and mitigation. Due to financial constraints and unawareness about latest technologies the livestock systems are even more vulnerable to impacts of adverse climatic conditions. Thus, to cope up with the climatic vulnerability, the livestock production systems will warrant revisiting. It may be very difficult for the small livestock holding to sustain because newer and smart technologies are to be adopted for sustainable livestock production. Research is needed to identify locally appropriate mitigation and adaptation strategies, especially in the context of countries like India, as well as policy approach for appropriate breeding and implementing adoption.

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Experts' Column

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Climate change *vis-à-vis* livestock vulnerability to parasitic infections

Introduction

Climate change would influence and indeed is already influencing the functioning of many ecosystems and the seasonal cycles and geographic range of plants and creatures (IPCC, 2001), affecting quality food production and potable water availability. Similarly, there would be health impacts in human and livestock populations. The worst sufferers, of course, will be the developing and underdeveloped countries that have contributed least to global warming. Overall, scientists assess that most health impacts would be adverse. However, some impacts would be beneficial i.e., reduction of cold weather health effects.

It is well established that climate is an important determinant of the spatial and temporal distribution of vectors and pathogens. The effects of climate change become most evident if adaptive measures falter or cannot be extended to all population at risk. Rainfall can promote transmission by creating ground pools and other breeding sites. Shorter and milder winters will increase the survival of parasites through winter (overwintering), especially for subtropical species. The increasing energy levels in the atmosphere are likely to alter wind patterns and affect dispersal patterns of flying insects. Climate induced migrations of parasite-infested hosts may also occur. One effect of higher concentrations of CO_2 in this century could be enhanced water use efficiency and biomass in plants. This tendency will provide more shelter for free-living stages of parasites, such as worms and ticks (Chakraborty *et al*., 1998). The overall results are likely to be higher survival of free-living stages of parasites and vectors of disease through the winter or dry season.

Parasitic diseases transmitted from animals to humans and *vice versa* will also not remain untouched from this effect. Climate change is disrupting natural ecosystems by providing more suitable environments for parasitic diseases allowing these diseases to shift in new areas where animals as well as humans will be exposed to infections against which they have little immunity. It has been speculated that diseases that were previously limited to tropical countries will now spread to countries with sub-temperate and temperate climate. A classical example cited is that of malaria and fasciolosis (*Fasciola gigantica*), which were restricted to mostly African and Asian nations are laying its deadly hand on European nations. Vector borne diseases are particularly affected by weather patterns and long-term climatic factors because of the fact that population dynamics of arthropods is largely dependent upon the prevailing weather conditions, specifically temperature and humidity. However, the extent and intensity of parasitic diseases, not transmitted by arthropods or intermediate hosts (direct life cycle), will also change dramatically. Increased temperature and humidity will favour rapid growth and multiplication and development of their free-living stages in the environment resulting into increased prevalence and intensity of infection. On the other hand, it may be detrimental to the parasite leading to reduced incidence.

Influence of climate changes on parasitic diseases

The effect of climate change on parasitic diseases is due to a number of factors governing the distribution, increased/decreased regeneration time of parasite stages inside vector or in the environment, host availability, availability of feed and fodder, nutritional stress and even parasite modulated host behaviour alteration or a combined effect of all these.

Distribution of parasite/vector is largely dependent upon the prevailing temperature and humidity. It is now evident that diseases carried by insects and ticks are likely to be affected by environmental changes because these creatures are themselves very sensitive to vegetation type, temperature, humidity etc. The disappearance and reemergence of mosquitoes, ticks and other insects during different seasons of a year clarifies the point. Even slight rise in temperature and a spell of winter rains and cloudy weather during chilling winter months influence the resurgence of mosquitoes in human and animal dwellings. Cases of tick-borne diseases *viz*., babesiosis, theileriosis, anaplasmosis and ehrlichiosis, and the likes are not uncommon in winter months and this is a classical example of influence of climate change on animal diseases. Fasciolosis caused by *Fasciola gigantica*, infecting millions of herbivores and also humans can now be observed in areas above 4200 meters in the highlands of Andean countries like Peru and Bolivia as milder temperatures and altered environment conditions are more favourable for the survival of the fresh water snails acting as intermediate host.

Parasites have a definite period of development inside their vectors and it is dependent upon environmental temperature. The development of *Babesia* organisms inside larval ticks takes around 8 to 10 days to be transmitted to a susceptible host at 28°C, while increase in temperature will further reduce this lag phase. Similarly, *Fasciola gigantic* eggs embryonate in the environment and it takes around 10 -11 days at 37-38°C, 21-24 days at 25°C and 33 days at 17-22°C. Temperature above 43-44°C is lethal to the eggs. An increase in environmental temperature below threshold level will hasten the development and thus decrease the regeneration time. Environmental temperature also is crucial in deciding the rate of development inside the snail intermediate host. As far as effect of environmental temperature and humidity on the development of free-living stages of nematodes is concerned, the influence on gastrointestinal nematodes has been described in detail but serious attempts to relate altered incidence or seasonal patterns of disease to climate change are lacking.

Climate change will certainly affect the migration of animal hosts as well as humans to areas with availability of feed/food and potable water. Thus, animal migration towards congenial atmosphere will increase congregation of animals in favoured niches and thus enhanced host-parasite contact. This in turn, will result into increased intensity and rate of infection. In a study conducted in the University of Leicester it was proved that global warming had the potential to change the balance between parasite and host in spined stickleback fishes naturally infected with *Schistocephalus solidus* with potentially serious implications for fish populations. The results provide some of the first evidence that increasing environmental temperatures can lead to a shift in the delicate balance that exists between co-evolved hosts and parasites, increasing the speed with which parasites complete their life cycles that could lead to an increase in the overall level of parasitism in natural animal populations.

Nutrition plays an important role in deciding the outcome of parasitic diseases. Animals well off nutritionally can withstand a moderate infection and are known as resilient. In event of nutritional stress, animals succumb to even a moderate or even a low grade infection. Global climate change is known to cause reduction of crop production and ultimately feed and fodder for animals. In the face of fodder crisis, the animals will be subjected to deleterious effects of parasitism. Besides, natural calamities like drought and floods will certainly play a deciding factor in parasitic diseases of animals.

Parasites alter the behaviour of the hosts. Changed behaviour of parasitized hosts makes them prone to further infection. In a number of host-parasite model, it has been proved conclusively. The work on fish parasite from the University of Leicester's Department of Biology also observed behavioural change in infected fish - suggesting parasites may manipulate host behaviour to make them seek out warmer temperatures. In warmer temperature the parasites reach maximum size but the size of the host is reduced. Thus, parasites manipulate host behavior for their betterment.

Conclusion

It is speculated that climate change will certainly influence the disease pattern and demographic sketch of diseases, especially those transmitted by vectors. The average temperature in the world has increased in the last few years compared to the previous century and is expected to continue rising if measures are not taken particularly by industrialized countries to reduce greenhouse gases emissions. The increased incidence in infectious diseases of animals and man may be one of the most important immediate consequences of global warming. However, the degree of expansion of diseases is much more difficult to predict, because disease transmission involves many other factors, and not all will be affected to the same extent by environmental change. Therefore, by using historical disease records, present-day ground-based surveillance and remote sensing, mathematical models are being developed that will describe the past, explain the present, and predict the future of vector-borne infectious diseases.

Global climate change predictions suggest that far-ranging effects might occur in the population dynamics and distributions of livestock parasites, provoking fears of widespread increases in disease incidence and production loss. However, continuous monitoring and surveillance and rigorous assessment of the data on which these predictions are proposed is crucial. Moreover, several biological mechanisms (including increased parasite mortality and more rapid acquisition of immunity), coupled with changes in husbandry practices (including reproduction, housing, nutrition, breed selection, grazing patterns and other management interventions), might act to mitigate increased parasite development rates, preventing dramatic rises in overall levels of disease. Such changes might, therefore, counteract predicted climate-driven increases in parasite challenge.

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Experts' Column

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Combating fish diseases in the face of climate change

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Abstract

Climate change poses significant threat to the health and sustainability in aquaculture systems, intensifying the prevalence and severity of diseases. This article explores the multiple impacts of climate change on fish diseases and discusses effective mitigation and adaptation strategies. The main areas of focus include sustainable aquaculture practices, genetic approaches for breeding disease-resistant fish, the use of immunomodulatory agents such as medicinal herbs and probiotics, and the implementation of robust policy and management frameworks. By integrating these strategies, fish health might be safeguarded, and long-term viability in the aquatic ecosystem may be achieved in the face of climate change. Therefore, this article aims to provide valuable insights and practical recommendations for researchers, policymakers, and aquaculture practitioners dedicated to combating fish diseases in a changing climate.

Keywords: Climate change, Mitigation of Fish diseases, Host-pathogen interaction

Introduction

Aquaculture production has shown a significant increase over the last decade (Halwart, 2022). The intensification of culture systems and species diversification has led to an increase in total yield (FAO, 2022). However, this intensification has also led to a higher incidence of disease outbreaks, ultimately causing substantial economic losses. Fish pathogens pose a significant threat to both wild and cultured fishes, with deep economic and ecological consequences. These diseases, caused by a variety of pathogens including bacteria, viruses, fungi, and parasites, can lead to significant mortality rates, reduced growth, and compromised fish health, ultimately affecting the sustainability of fisheries and aquaculture industries (Murray and Peeler, 2005; Austin and Austin, 2016).

The economic impact of fish diseases is complicated and affects various stakeholders, i.e., from small-scale fish farmers to large commercial operations. A possible disease outbreak can lead to direct financial losses due to high mortality rates. In aquaculture, diseases can severely impact productivity and profitability. The global aquaculture industry, valued at over $250 billion, faces annual losses estimated in billions of

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dollars due to disease outbreaks (Kumar *et al*., 2024). The cost of managing these diseases includes not only the direct expenses of medications and vaccines but also the indirect costs associated with reduced growth rates, increased feed conversion ratios, and the need for enhanced biosecurity measures.

Fish diseases also have significant ecological implications, particularly in natural ecosystems. Disease outbreaks can lead to a decline in wild fish stocks, disrupting food webs and ecosystem dynamics (Nagelkerken *et al*., 2023). This not only affects the biodiversity of aquatic ecosystems but also has cascading effects on other species that rely on fish as a food source (Sneizsko, 1974; Gozlan *et al*., 2014). Moreover, the introduction of pathogens through aquaculture practices can have accidental consequences on wild fish stocks. The transfer of diseases from farmed to wild fish is a growing concern, particularly in regions where aquaculture operations are in close proximity to natural habitats. These interactions highlight the need for integrated management approaches that consider both aquaculture and wild fisheries (Gozlan *et al*., 2014).

Climate change is one of the major environmental concerns, not only for humans but also for animals and the livestock sector. An increase in Earth's average surface temperature by 0.8°C was observed in the 19^{th} century. In the current scenario, it has been noted that there is a rise of 0.1°C every decade (Hansen *et al*., 2010; Barange *et al*., 2018). This has created a very alarming situation, and currently, no effective measures have been developed to counter it. Climate change is greatly influencing the host-pathogen-environment relationship and is exacerbating the impact of fish diseases by altering the dynamics of pathogen-host interactions (Paukert *et al*., 2021). Rising water temperatures, changes in salinity, and increased frequency of extreme weather events can create favourable conditions for the proliferation of pathogens and the spread of diseases (Altizer *et al*., 2013; Burge *et al*., 2014). Additionally, climate change can stress the fish, making them more susceptible to infections and reducing their ability to recover from disease outbreaks (Marcogliese, 2008). This article focuses on the mitigation and adaptation strategies that have been used so far to control fish diseases in the context of climate change.

Impact of climate change on aquatic environments

Temperature changes: Climate change has led to significant increases in water temperatures, which directly affect fish physiology and behaviour. As ectothermic animals, fish rely on external temperatures to regulate their body functions. Elevated water temperatures increase the metabolic rates of fish, leading to higher energy demands. This can result in increased feeding rates to meet energy requirements. However, if food resources are limited, fish may experience energy deficits, affecting their growth and overall health (Lynch *et al*., 2016). Higher metabolic rates also mean that fish consume more oxygen, which can be problematic in warmer waters where oxygen levels are typically lower. Additionally, warmer water holds less dissolved oxygen, which can lead to hypoxic conditions, especially in stratified water bodies. Fish require adequate oxygen levels for respiration, and hypoxia can cause stress, reduce growth rates, and increase mortality (Ficke *et al*., 2007). Species that are less tolerant of low oxygen levels may be particularly vulnerable to these changes.

Increased water temperatures can weaken the immune systems of fish, making them more susceptible to diseases. Pathogens, such as bacteria, viruses, and parasites, often thrive in warmer conditions, leading to higher infection rates. For example, studies have shown that warmer temperatures can increase the prevalence of diseases like *Ichthyophthirius multifiliis* and bacterial infections in fish (Volkoff and Rønnestad, 2020). These physiological and behavioural changes highlight the complex ways in which temperature increases due to climate change and can impact fish health and aquatic ecosystems (Kasihmuddin *et al*., 2024). Understanding these effects is crucial for developing effective conservation and management strategies.

Ocean acidification: Ocean acidification, driven by increased CO absorption from the atmosphere, is a significant consequence of climate change that poses a serious threat to marine ecosystems. This leads to lower pH levels in seawater, which can disrupt the acid-base balance in fish. Fish gills, similar to human lungs, are responsible for gas exchange and maintaining blood pH within a narrow range. Acidified waters force fish to expend more energy on acid-base regulation, which can divert energy from other vital processes such as growth, reproduction, and immune function (Esbaugh, 2018). This physiological stress can make fish more vulnerable to diseases by weakening their immune systems and making them more susceptible to infections. Acidified waters can also create favourable conditions for pathogens, increasing the prevalence and severity of diseases. Studies have indicated that fish in acidified environments are more prone to bacterial and parasitic infections, which can lead to higher mortality rates (Burge *et al*., 2014; Overstreet, 2021; Franke *et al*., 2024).

Extreme weather events: The frequency and intensity of extreme weather events, such as storms, floods, and droughts, are increasing due to climate change. These events can cause significant disruptions to aquatic habitats. For example, storms and floods can lead to habitat destruction, increased sedimentation, and changes in water quality, which can negatively impact the fish (Altizer *et al*., 2013). Floods can also introduce pollutants and pathogens into aquatic environments, further stressing fish (Ficke *et al*., 2007). Droughts, on the other hand, can reduce water availability, concentrate pollutants, and increase water temperatures, creating harsh conditions for fish survival (Macusi *et al*., 2015). These changes can lead to reduced biodiversity, affecting the overall health of aquatic ecosystems.

Pathogen dynamics and climate change

Climate change is significantly altering marine and freshwater ecosystems, leading to profound impacts on the health and survival of aquatic organisms. One of the most concerning consequences of climate change is its influence on the dynamics of pathogens, particularly those affecting fish.

Impact of climate change on pathogen life cycles: Many pathogens have specific temperature ranges within which they can thrive and reproduce. As global temperatures rise, these pathogens may find increasingly suitable conditions for growth and proliferation, leading to increased disease prevalence (Karvonen *et al*., 2010; Sutherst *et al*., 2011; Reid *et al*., 2019). Elevated temperatures can speed up the life cycles of many pathogens. For instance, higher water temperatures can enhance the growth rates of bacteria and parasites, leading to shorter generation times and increased transmission rates (Ogden, 2018). This can result in more frequent and intense disease outbreaks in the culture systems.

Effect on virulence: Elevated temperatures can increase the metabolic rates of pathogens, boosting their growth and reproduction. This can lead to higher pathogen loads in infected fish, increasing the severity of infections (Cohen *et al*., 2018). For example, studies have shown that warmer waters can increase the virulence of *Vibrio* species, which are responsible for vibriosis in fish (Vezzulli *et al*., 2013; Mohamad *et al*., 2019; Ina Salwany, 2019). Climate-induced stress, such as temperature fluctuations and hypoxia, can weaken the immune systems of fish, making them more susceptible to infections (Ogden, 2018). Pathogens can exploit this weakened state to establish infections more easily and cause more severe disease outcomes. Climate change can drive the evolution of more virulent pathogen strains. Pathogens exposed to fluctuating environmental conditions may undergo genetic changes that enhance their ability to infect hosts and evade immune responses (Bote and Maes, 2024). This evolutionary pressure can lead to the emergence of more aggressive and resilient pathogen strains. These strains may be poorly adapted to existing host defenses, leading to severe disease outbreaks.

Effect of climate change on disease transmission

The effects of climate change can influence the disease transmission mechanisms of various fish pathogens.

The rise in temperature and altered salinity can influence the proliferation mechanisms of pathogens, ultimately leading to severe outbreaks. Fluctuations in salinity have led to the adaptation of pathogenic Vibrios in varying brackish water saline conditions (Baker-Austin *et al*., 2013). These conditions can lead to more frequent and severe outbreaks of vibriosis, particularly in coastal and estuarine environments. The increased frequency and intensity of extreme weather events, such as storms, floods, and droughts, due to climate change, can disrupt aquatic ecosystems and facilitate the spread of diseases. Floods can introduce pathogens into new areas, while storms can damage fish habitats and increase stress levels, making fish more susceptible to infections (Lõhmus and Björklund, 2015). Droughts can concentrate pathogens in smaller water bodies, increasing the likelihood of disease transmission among fish (Byers, 2020). Additionally, changes in environmental conditions can disrupt the natural behaviors of fish, such as migration and spawning, which can affect their exposure to pathogens and the timing of disease outbreaks (Williams *et al*., 2024).

Mitigation and adaptation strategies

Climate change is inevitable, and therefore, the adaptability of the pathogens will be more suitable in this environment to cause disease. Keeping this in mind, sustainable aquaculture practices can be taken up to mitigate the spread of disease during this global change. Preparedness and good management practices are essential to mitigate the risk of disease outbreaks in the culture system. Regular monitoring and management of water parameters such as temperature, pH, dissolved oxygen, and ammonia levels can help prevent stress and disease in fish. For instance, recirculating aquaculture systems (RAS) can provide controlled environments that minimize pathogen exposure (Trebilco *et al*., 2021). Implementing strict biosecurity protocols can reduce the introduction and spread of pathogens. This includes controlling the movement of fish, equipment, and personnel, as well as disinfecting tanks and facilities. Effective biosecurity measures have been shown to significantly reduce disease outbreaks in aquaculture (Paukert *et al*., 2021). Managing stocking densities to avoid overcrowding can reduce stress and the likelihood of disease transmission. Lower densities can improve water quality and reduce competition for resources, leading to healthier fish stock (Fawole and Nazeemashahul, 2023).

Selective breeding and genetic modification are powerful tools for enhancing disease resistance in aquaculture, and they can serve as a powerful tool in disease mitigation in the face of climate change. Selective breeding is one of the methods, in which it is possible to develop strains of fish that are more resilient to infections. This approach has been successfully used in species such as Atlantic salmon and tilapia (Fjalestad, 1993). Advances in genetic engineering, including CRISPR-Cas9 technology, allow for precise modifications of fish genomes to enhance disease resistance. For example, genes associated with immune responses can be edited to improve resistance to viral and bacterial pathogens (Houston *et al*., 2020). Another promising tool, i.e., Marker Assisted Selection (MAS), can be used to prevent the disease spreading. It involves using genetic markers linked to disease-resistance traits to guide breeding decisions. This method can accelerate the development of disease-resistant strains by identifying and selecting individuals with desirable genetic profiles (Yáñez *et al*., 2015).

Immunomodulatory agents, including medicinal herbs and other natural compounds, can enhance the immune responses of fish, making them more resilient to diseases. Various herbs, such as garlic (*Allium sativum*), turmeric (*Curcuma longa*), neem (*Azadirachta indica*), shatvari (*Asparagus racemosus*), tea leaf (*Camellia sinensis*), etc., have been shown to possess immunostimulatory properties (Harikrishnan *et al*., 2010; Van Hai, 2015; Wang *et al*., 2017; Monsang *et al*., 2021; Debbarma *et al*., 2022; Monsang *et al*., 2022). These herbs can be incorporated into fish diets to boost immune function and improve disease resistance. Not only the immunostimulants but also the probiotics (beneficial bacteria) and prebiotics (compounds that promote the growth of beneficial bacteria) can enhance gut health and overall immunity in fish (Pérez Sánchez *et al*., 2014; Wang *et al*., 2019). These agents can improve the balance of gut microbiota, leading to better disease resistance (Wang *et al*., 2008; El-Saadony *et al*., 2021; Bharathi Rathinam *et al*., 2024). As the best way to control a disease is to prevent it rather than treat it (Prevention is Better than Cure), the prophylactic measures are the sustainable methods in controlling fish diseases rather than the use of therapeutics. Vaccination is one of the best prophylactic measures for disease prevention and is a critical tool for preventing infectious diseases in aquaculture. Advances in vaccine development, including oral and immersion vaccines, have made it easier to immunize a large number of fish (Sommerset *et al*., 2005; Dadar *et al*., 2017; Mondal and Thomas, 2022).

Apart from adapting various sustainable methods effective policy and management practices are essential for mitigating the impact of climate change on fish diseases. Governments and international organizations must establish and enforce regulations that promote sustainable aquaculture practices and protect aquatic environments. This includes setting standards for water quality, disease control, and the use of chemicals and antibiotics (Subasinghe *et al*., 2023). Implementing robust monitoring and surveillance systems can help detect and respond to disease outbreaks quickly. Early detection and rapid response are crucial for preventing the spread of diseases and minimizing economic losses (Peeler and Taylor, 2011). Awareness programs and providing education and training to aquaculture practitioners on best practices for disease prevention and management are vital. This can include workshops, extension services, and the dissemination of guidelines and resources (Bondad-Reantaso *et al*., 2005). This will help in managing the diseases up to a certain level. Investing in research and development is essential for advancing our understanding of fish diseases and developing new mitigation and adaptation strategies (Houston *et al*., 2020). Collaborative efforts between academia, industry, and government can drive innovation and improve disease management.

Conclusion

Climate change is an ongoing process driven by anthropogenic activities. While these changes may not be reversible, mitigation and adaptation strategies are crucial for addressing the challenges posed by climate change on fish health and disease management. By implementing sustainable practices, leveraging genetic advancements, utilizing immunomodulatory agents, and enforcing effective policies, we can enhance the resilience of aquaculture systems and fisheries resources.

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ABS-01

Effect of parity and managemental practices on milk somatic cell count (SCC) and composition of crossbred goats

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Abstract

To evaluate the health status of the mammary gland and milk composition of dairy goats, the somatic cell counts and milk composition of 80 crossbred goats were compared in two categories: 24 goats on LRC Livestock Research Center NDRI Farm and 56 goats in adjoining villages of Karnal, Haryana. Further, these categories were divided into two groups based on their parity, i.e., primiparous and multiparous. The average range of SCC was between 4.26 and 4.81 lakh cells/mL under both farm and field conditions. SCC were significantly higher in farm conditions ($p<0.05$) than in field conditions. Based on parity, SCC were significantly lower in primiparous as compared to multiparous goats under farm and were non-significantly lower in field. There were no differences in the fat and SNF percent of goats between parity and between farm and field conditions. No significant differences were observed between protein and lactose concentrations within groups and between farm and field conditions. Milk pH and electric conductivity were significantly lower in primiparous as compared to the multiparous goats under both farm and field conditions. In conclusion, milk SCC in goats was higher as compared to other dairy animals, as milk secretion in goats is an apocrine process. Field goats graze freely, so herd immunity may be the factor for decreased SCC in the field as compared to the farm.

Keywords: Apocrine process, Electric conductivity, Multiparous, Primiparous, Somatic cells

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ABS-02

Computational analysis and functional importance of the Heat Shock Protein 70.1 gene family in *Capra hircus*

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Abstract

Heat shock proteins are related to stress management in the cell, popularly known as HSP70, which gained attention in protein folding and thermoregulation in cell machinery. This study aims to identify the evolution and sequence analysis of the HSP70 protein family in goats. To explore the HSP70 protein genes, we computationally analyzed the HSP70 gene protein secondary sequence data in goats. For this, the HSP70 sequence was retrieved from the NCBI and Blasted. The resulting sequences were employed to search the Pfam (Protein Family) database to identify the exact HSP70 protein domain sequences. The physicochemical properties are computed by the ProtParam tool. MEGA11 software was used to construct a phylogenetic tree, and HSP70 protein subcellular localization was detected by Wolf PSORT, a bioinformatic online tool. In silico analysis, we identified 66 goat HSP70 protein sequences belonging to the HSP70 protein family. The HSP70 protein genes are located in various chromosomes with a maximum number of 29 exons and a minimum

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number of one. We found the physiochemical properties of all the HSP70 proteins are thermostable and hydrophilic. The multiple sequence alignment and evolutionary relationship of the HSP70 protein gene is closely related to the sheep and buffalo. The HSP70 proteins are located in various organelles and participate in the nuclear localization signals. The characterization of the HSP70 protein gene family in goats is addressed for the functional importance of the protein and elucidates further deep investigation of the HSP70 protein in an intra- and inter-species manner.

Keywords: Protein sequence, Gene structure, Motif analysis, Phylogenetic tree, Subcellular localization

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ABS-03

Augmentation of milk production in dairy cows by dietary supplementation of condensed tannins through *Ficus benghalensis* leaves

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Abstract

To augment milk production, protection of dietary proteins is essential for productive ruminants, where protein requirements cannot be met from the sole source of microbial protein and condensed tannins (CT) of tropical tree leaves have the potentiality to reduce ruminal degradation of nitrogen. Milk production of crossbred cows may increase on supplementation of *Ficus benghalensis* leaves. Dried and ground leaves of *Ficus benghalensis* leaves were incorporated by partial replacement of rice bran in compound feed mixture (CFM), which is composed of maize (25%), mustard cake (30%), rice bran (30%), black gram husk (13%), mineral mixture (1%), and salt (1%). As a result, the average milk yield (kg/day) was significantly ($p<0.05$) increased by supplementation of CT, and the efficiency of milk production was also improved significantly ($p<0.05$), i.e., reduction of 12% milk production cost (per kg) by supplementation of 1.5 percent CT through *Ficus benghalensis* leaves. Therefore, it may be concluded that supplementation of condensed tannins at 1.5 percent in the compound feed mixture could be beneficial in increasing milk production.

Keywords: Dairy cow, Condensed tannins, Compound feed mixture, *Ficus benghalensis*, Milk production

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ABS-04

Climatic influence on the seasonal dynamics of glanders in India

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Abstract

Glanders, caused by *Burkholderia mallei* is an important, notifiable, highly contagious disease of equines with high fatality. Glanders is endemic in India, with high prevalence in northern states. This study investigates the seasonal distribution of glanders outbreaks across various regions in India, analyzing the correlation between climatic factors and the incidence of the disease. The latest epidemiological data over the past 9 years (2015-2023) showed a seasonal cycle, with a peak prevalence during summer up to 2018. Hot, humid, and damp environments may enable the survival and transmission of *B. mallei*. After 2018, an increasing trend of Glander cases was observed in dry winter months; it may be due to the short duration of the winter season, and prevailing stress carried forward from the monsoon period. Overall, maximum positive cases were

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observed during the summer months from the period of 2015-2023, followed by the winter period, giving an indication that the activity of this pathogen was somehow affected by temperature and humidity factors. The study also shows that disease outbreaks of glanders can be reduced through improved sero-monitoring when environmental risk is high. However, a long-term study is required to get more detailed information to analyze glanders prevalence in different agroclimatic zones.

Keywords: Glanders, *B. mallei*, Equines, Seasonal influence

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ABS-05

Occurrence and morphological description of *Trichodina centrostrigeata* Basson, Van As & Paperna, 1983, *Trichodina magna* Van As & Basson, 1989 and *Paratrichodina africana* Kazubski & El-Tantawy, 1986 in a cichlid fish, *Oreochromis mossambicus* Peters, 1852 from Churni River, West Bengal, India

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Abstract

Trichodinid ciliophorans, a group of minute protozoans within the phylum Ciliophora, are distinguished by their unique ciliary structures and parasitic behavior. In the exploration of trichodinid species diversity among Indian freshwater fishes in West Bengal, conducted from December 2023 to February 2024, the cichlid fish *Oreochromis mossambicus* Peters, 1852 was examined. This fish was identified as hosting three different species of trichodinid ciliophorans, of which two are of the *Trichodina* species, namely *Trichodina centrostrigeata* Basson, Van As & Paperna, 1983, *Trichodina magna* Van As & Basson, 1989 and one is of *Paratrichodina* species, namely *Paratrichodina africana* Kazubski & El-Tantawy, 1986. This study involves the redescriptions of these species, highlighting the morphological variations observed. The research employs a comprehensive morphological analysis to unveil the diversity within this group, which will help to understand their interaction with host fishes.

Keywords: Parasite, Ciliophora, *Trichodina centrostrigeata, Trichodina magna*, *Paratrichodina africana*, *Oreochromis mossambicus*

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ABS-06

Parasitic diversity of ciliates from a freshwater bivalve mollusc *Lamellidens marginalis* (Mollusca: Bivalvia: Unionida: Unionidae) in South 24 Parganas, West Bengal

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Abstract

Lamellidens marginalis (Lamarck, 1819) is a common freshwater bivalve mollusc, widely distributed across the Gangetic plains of India and Bangladesh, the terrain region of Nepal and also in Sri Lanka and Myanmar. They are rich in essential nutrients and are used as a source of food and feed in many parts of the world. This makes them an important part of the aquatic food chain. They are also a great contributor to the ecosystem services of the aquatic environment. They improve the water quality by filter-feeding on the

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zooplankton, algae, and bacteria. Therefore, these bivalves are considered a very important part of the freshwater ecosystem. *Lamellidens* spp. is often found to be infected by many parasites, which belong to the protozoan and metazoan groups. The protozoan parasites of these bivalve mussels often belong to the Phylum Ciliophora. Three genera, namely *Trichodina* sp., *Conchopthirus* sp., and *Ichthyopthirius* sp., were found to infect the mollusc in the following study. High infection with *Trichodina* results in a disease called trichodiniasis. TEM images of the food vacuole of the parasite have shown the presence of gill tissues, indicating that they ingest the gill, causing their damage. Infection caused by *Ichthyopthirius* sp. is also responsible for causing mortality in hosts. In the present study, these parasites have been reported from some selected areas in South 24 Parganas, West Bengal and have been identified based on their morphological features and morphometry.

Keywords: *Lamellidens marginalis, Trichodina* sp., *Conchopthirus* sp., *Ichthyopthirius* sp., Morphology, Morphometry

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ABS-07

Occurrence of lumpy skin disease in South 24-Parganas under changing climatic scenario

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Abstract

Lumpy skin disease (LSD) is a transboundary viral disease of cattle and water buffalo that causes severe economic losses due to a decrease in milk, meat, and hide production, sterility in males, and abortion in females. Increased environmental temperature, rainfall, and prolonged humidity due to climate change have increased the survivability of blood-sucking arthropod vectors, resulting in repeated disease outbreaks. In India, the disease was reported in August 2019. The present study was carried out to investigate the occurrence of the disease in South 24- Parganas. Records were collected from animal treatment reports of different animal health centers of two blocks, viz. Mathurapur-I and Basanti, for the period of 2020-2024. A total of 4940 animals with LSD-like symptoms were treated during the period of study, out of which 2282 males and 2658 females were treated. The disease mainly occurs in the hot and humid months of July to September. The highest prevalence (50–60%) was observed between the age groups of 2 months to 3 years. Calves between 15 days and 6 months of age were the most susceptible, with a high risk of mortality (4-6%). Out of LSD-infected cattle, 1129 were crossbred, and 3821 were indigenous cattle. But, considering the density of the indigenous cattle population in the area, the prevalence of the disease among crossbreds was much higher than that of indigenous cattle. Indigenous cattle may have some resistance to the disease and show early recovery if affected. The observations may be helpful for further research to combat the disease.

Keywords: Arthropod vectors, Cattle, Climate change, Lumpy skin disease

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ABS-08

A diagnostic study on livestock production system in Gazole block of Malda district: A comprehensive analysis

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Abstract

A preliminary study was conducted in Gazole Block under the Malda district of West Bengal. The aim of the study was to analyze the present scenario of livestock production, their problems, and future prospects for sustainable livestock farming. Data were collected from Adina, Ahora, Kailabad, Chandandighi, Shahidpur, Chaitpur, and Majhipara villages of Gazole block. Data collection was done using a structured interview schedule. A total of 250 farmers were interviewed for the purpose of the study. Out of 250 farmers, 100% showed interest in livestock rearing. However, due to a lack of scientific knowledge, training, and veterinary healthcare services, 90% of farmers still reared their livestock in the traditional method; only 5% of farmers adopted an intensive system of rearing. Goat is the most preferred species being maintained in every household, while the least contributing livestock species is buffalo in the region. Major constraints faced by the farmers are non-availability of feeds and fodders (70%), outbreak of epidemic diseases (15%) and technical support (10%). However, poor growth rate, anestrus, low conception rate, and waste management are some of the minor constraints. It was reported that pig keeping is only prevalent in weaker sections of society with no scientific knowledge and skills. The study concludes that this knowledge gap underscores the need for extension training, targeted education, and support initiatives to enhance skills and improve the standard of living by improving productivity, sustainability, and profitability for livestock farmer.

Keywords: Livestock, Training, Veterinary healthcare

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ABS-09

Seasonal variation in the pattern of artificial insemination and calf born in the district of Malda, West Bengal: 10 years retrospective study

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Abstract

In this study, data of artificial insemination (AI) and calf born (CB) from 2014-15 to 2023-24 in Malda district of West Bengal was collected. Total number of AI and CB was 2052781 and 583915, respectively. The highest number of AI (192132) and CB (57358) were reported during the months of March and January, respectively, in each year of study. The number of cows receiving AI was significantly higher during the pre-monsoon season (720188) followed by the winter (700960) and post-monsoon (631633) seasons. The number

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of calving was significantly higher in winter (208941), followed by pre-monsoon (198888) and post-monsoon (176086) seasons. Significant variation was observed in the number of AI done during the first five years compared to the last five years. During the first five years (2014-15 to 2018-19), a higher number of AI were performed during the winter (308558), while during the last five years (2019-20 to 2023-24), higher numbers of AI were done during the pre-monsoon season (421544). Calving rates were higher during winter for the first 5 years (2014-15 to 2018-19), whereas in later years (2019-20 to 2023-24), it was shifted to pre-monsoon. The mean CB: AI ratio was 0.31. The highest CB: AI ratio was reported during the month of April (0.35) in the last ten years. The CB: AI ratio was highest during the post-monsoon season (0.32) followed by the pre-monsoon (0.31) and winter (0.29) seasons, but during the last five years, the highest CB:AI ratio was reported during the pre-monsoon season. Based on these data, appropriate breeding strategies may be implemented in the Malda district of West Bengal.

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ABS-10

Climate change on food animals: A study with vector-borne diseases

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Abstract

Our climate is changing. Study shows that West Bengal has experienced significant climate change that causes an increase in temperature, rainfall, and humidity, which impacts the altered ecosystem and habitat of vectors that expands their geographical range, their production, and their reproduction rate, which eventually effects vector-borne disease transmission dynamics. Study shows some notable vector-borne diseases affecting animals in this region include tick-borne diseases like babesiosis, theileriosis, and anaplasmosis, trypanosomiasis (flies), lumpy skin disease (LSD) (insects, flies, and mosquitoes); those are of significant concern for livestock in West Bengal with special reference to the old alluvial agro-climatic zone. It is observed that changes in seasons (in length and intensity) impact directly on vector-borne disease prevalence. For theileria, incidence recorded high in pre-monsoon and monsoons mostly and in an increasing trend for the last several years. Whereas following extensive vaccination and monitoring, the incidence and intensity of LSD have decreased, as observed recently. Effective housing management towards adaptation and mitigation of VFDs like proper shelter design, sanitation, insect control, and quarantine measures are reported. The study includes an annual animal disease surveillance report of West Bengal with information on the health and management of livestock, focusing on vaccination and disease control strategies under various schemes that provide proper treatment, mass vaccination, and awareness to animal farmers to improve animal health and augment production through regular monitoring and reporting of disease outbreaks with timely intervention and management. In conclusion, proper adaptation and timely mitigation strategies could help to restrain these VBDs under changing climatic scenarios.

Keywords: Climate change, VBDs, Adaptation, Mitigation, Haemoprotozoan, LSD

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ABS-11

Climate change adaptation in aquaculture

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Abstract

Climate change is challenging the effectiveness of contemporary fisheries and aquaculture management in many parts of the world and gives rise to significant additional ecological and socio-economic uncertainties and risks to fishers, fish farmers, and fish-dependent communities. The main areas of documented climate change impacts relate to extreme events and the general impacts of climate change on the aquaculture sector. Aquaculture is vulnerable to a combination of climatic factors, such as global warming, rainfall variation, floods, droughts, temperature fluctuation, and salinity change. Three categories of adaptation to climate change are identified: water quality management techniques, multilevel adaptive strategies, adaptation planning, and community-based adaptation. This paper discusses good adaptation practices for adapting to climate change to reduce vulnerability to expected climate change. The study brings essential practical and theoretical insights to the aquaculture industry as well as to climate change adaptation research.

Keywords: Climate change, Adaptation, Aquaculture

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ABS-12

Prevention and control of epizootic ulcerative syndrome in Indian Major Carps (IMCs) in Malda district of West Bengal

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Abstract

Epizootic Ulcerative Syndrome (EUS), also known as red spot disease (RSD) or ulcerative mycosis (UM), is one of the most destructive diseases of farmed and wild fish caused by a consortium of bacteria, viruses, and fungus (*Aphanomyces* sp.) that results in substantial loss of fish production throughout the globe. An outbreak of EUS in Indian Major Carps (IMCs) viz. Catla, *Catla catla*; Rohu, *Labeo rohita*; and Mrigal, *Cirrhinus mrigala* in Malda district of West Bengal was observed, and necessary measures had been taken to mitigate the disease. Epizootic Ulcerative Syndrome (EUS) was registered in Indian Major Carp (IMC) in several ponds (n= 28) of different villages in the Malda district of West Bengal. Surveillance of disease in several stocking ponds (n =150) of 25 villages in the Malda district of West Bengal was carried out during the culture period. Twenty eight of the ponds were reported to have encountered heavy stock loss due to mass mortality of IMC out of EUS. The infected fish were observed to float near the surface of the water and become darker and hyperactive with jerky patterns of movements. The juvenile and advanced young stages (140 - 575 g)

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were mostly affected by the disease. The disease started off as tiny red spots or lesions on the base of the fins, other parts of the body and head of the infected fish. Gradually, these lesions ulcerated to become very large and deep haemorrhagic lesions on various parts of the body. The characteristic lesions and behavioural changes of the fish acted as signatures in the diagnosis of the disease as EUS by the practitioners. Although morbidity was 80 percent, the management of ponds with $KMNO_4$, lime, and turmeric powder treatment reduced the mortality by 22 percent and prevented the recurrence of the disease significantly.

Keywords: Epizootic Ulcerative Syndrome (EUS), Indian Major Carp (IMC), Prevalence

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ABS-13

Evaluation of bio-waste derived carbon dot nanoparticles in wound healing in an animal model

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Abstract

Being in an era of modernization, addressing health care with evolutionary approaches keeps bringing better treatment solutions, though some areas still assign challenges to the professionals, and among them, wound healing comprises a big part. Keeping the "waste to health" motto in mind, this study is designed to convert biowaste material, into a potent nanomaterial-based drug for the wound healing application. The river and water body-derived waste marigold flower has been collected, and processed into carbon dot nanoparticle-based gel, and the application of the product has been evaluated in a deep excisional cutaneous wound model in the rabbit model. The product has been characterized by studying the TEM, Zeta potential, FTIR, UV-Vis, and *In-vitro* studies including MTT, live dead assays, and scratch assays, to determine the dosage and compatibility of the material in the L929 cell line. The material was compared with commercially available standard gel and a control group with no treatment. The study was done in 9 New Zealand white rabbits, and the sample was collected on the 7th, 14^{th,} and 21st days of the time period. The wounds were created under the standard protocol, of 15 mm wound size. Samples collected were studied for H&E, Elastin, Masson's trichrome, CD31, and Collagen type-I study. Quantification analysis was also done by estimating the hydroxyproline assay data. The result showed excellent outcomes with the material, by contraction of the wound earlier than the control and standard group; also, the histopathology and immunohistochemical studies showed better outcomes and earlier healing with proper collagen deposition in the treatment group. Evaluating the results, it can be concluded that the formation of this material not only decreases pollution by involving the wastes in healthcare studies but also that the material showed better healing outcomes and earlier regeneration of wounds compared to the standard and control groups.

Keywords: Biowaste, Carbon dot (CD) nanomaterial, Wound healing, Deep excisional cutaneous wound

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ABS-14

Assessment of productivity and economic performance of carp fry in nursery ponds through application of a soil-mineral mixture

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Abstract

Nutrient supplementation in aquaculture systems is not a new technology, but in these trials, it was observed that it was much more crucial in the nursery phase for the quality and quantity of carp seed production. In the common practices, release spawn (6 million spawn/ha) in the prepared pond and apply organic and inorganic fertilizer (urea, SSP (1:2) @ 37.5 kg/ha and DAP @ 37.5 kg/ha) after 5 to 6 days of liming and nourishing with mustard oil cake, rice bran, wheat flour, etc. Now, farmers are facing different problems in nursery ponds, like less plankton production, size variation in fish seed, healthiness, being vulnerable to transportation stress, gas formation in pond bottom soil, ricket disease, etc. To solve these problems, Murshidabad KVK has designed one OFT trail (2023) having three treatments: FP (Farmer's Practice), TO-I (Technology Option-I) and TO-II (Technology Option-II) in 10 numbers of farmers' fields in 4 adoptive blocks in Murshidabad, West Bengal. In TO-I and TO-II treatments, a soil mineral mixture was maintained at 30 kg and 45 kg/ha per cycle per meter of water, respectively, and a fixed stocking ratio of 3 million spawn/ha per cycle with 3-3.5 ft. water depth. It was observed that there was no significant difference in the case of cost of cultivation in these treatments, but the best growth (yield) and economic performance were found in TO-I (16.9 q/ha/cycle), followed by TO-II (14.7 q/ha/cycle) and FP (11.6 q/ha/cycle). In these trials were also observed different water quality parameters giving the best results in TO-I, like pH (7.5±0.21) and DO (4.94±1.06 mgL-1). Other parameters, length (cm), weight (g), survival rate (4.94±1.06%), and DOC (14.27±6.12 days per cycle), were also recorded, and it was found that TO-I gives a better result than the other two treatments, TO-II, and FP in the case of fry production. The result reveals that TO-I gives the highest yield with a benefit-cost ratio of 4:1 followed by TO-II with a B:C ratio of 3.4:1 compared with a B:C ratio of 2.4:1 in farmers practice (FP). It is quite easy and inexpensive technology for progressive farmers, and they can apply it in their nursery phase for carp fry production.

Keywords: Carp fry, Nursery pond, Water quality, Stocking, Soil mineral mixture

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ABS-15

Training needs of member fish farmers of FFPO

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Abstract

The study assessed the training needs of fish farmers who are members of Fish Farmers Producer Organizations (FFPO) in the Purba Medinipur District of West Bengal in 2023. The study used a descriptive

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design, collecting data from 120 fish farmers across four FFPOs through a semi-structured questionnaire and interviews. Responses were rated on a four-point scale: most needed, needed, least needed, and not needed. A mean score of 2.50 or higher was considered indicative of training needs. This study identified the key training needs of the FFPO members. The primary areas requiring attention included fish disease management (identification and control) (x = 3.2), feeding strategies and feed formulation (x = 3.02), water quality management (x = 3.0), fish breeding (x = 2.67), pond construction or renovation (x = 2.65), marketing strategies (x = 2.61), and selection of quality seed, species, and stocking density (x = 2.52). Overall, most members exhibited medium (52.5%) to high (25.83%) training needs. Most members had attended two training programs in the past two years through FFPO. There is a need for targeted training in these critical areas to improve fish-farming practices. The majority of the respondents practiced mixed fish farming (55.83%) to maximize their output. Preferred trainers included private staff, input dealers, and medicine company representatives (77.5%), followed by fisheries institutes (65%) and government officials (40.83%). The study concluded that while FFPOs provide valuable training, there is a need for additional effort from other extension agencies to address the identified training gaps. This could significantly enhance fish production and help bridge the demand-supply gap in the region.

Keywords: Fish Farmers Producer Organizations (FFPOs), Fish farmers, Training needs

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ABS-16

Antimicrobial and antioxidant effects of sumac fruit (*Rhus chinensis* Mill) and prickly ash (*Zanthoxylum acanthopodium* DC) leaf extracts on quality aspects of chicken fillets

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Abstract

This study evaluated the antimicrobial and antioxidant properties of extracts from sumac fruits (*Rhus chinensis* Mill) and prickly ash leaves (*Zanthoxylum acanthopodium* DC) and their effects on the quality of raw chicken fillets stored at 4±1°C for 9 days. Chicken fillets were dipped in either sumac fruit (SF) extract (T1) or prickly ash leaf (PAL) extract (T2) and compared to untreated fillets (control). PAL extract showed a higher total phenolic content (148.90 µg GAE/mg), while SF extract had a greater flavonoid content (62.38 µg GAE/mg). The SF extract also exhibited superior DPPH and ABTS scavenging activity compared to PAL extract. Physico-chemical parameters such as pH, water holding capacity, thiobarbituric acid reactive substances (TBARS), and instrumental color, along with microbiological and sensory qualities, were monitored every other day over the 9-day storage period. Microbial counts were significantly lower in the treated samples, even on the 9th day, compared to the control group, which spoiled by the 5th day. TBARS values in samples treated with SF and PAL extracts remained within acceptable limits. Overall, the treated samples (T1

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and T2) demonstrated superior physico-chemical, microbiological, and sensory qualities compared to the control throughout the storage period. These results suggest that sumac fruit and prickly ash leaf extracts have notable antimicrobial and antioxidant properties, indicating their potential as natural preservatives for raw meat products.

Keywords: Chicken fillets, Quality aspects, *Rhus chinensis*, *Zanthoxylum acanthopodium*

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ABS-17

Effect of doramectin on gastrointestinal nematodosis in sheep in terms of productive and reproductive performances at upland farming situation of Birbhum district

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Abstract

The impact of gastrointestinal nematodosis was evaluated in terms of productive and reproductive performance in sheep. A front-line demonstration program on disease management in sheep was carried out by Rathindra Krishi Vigyan Kendra at the upland farming situation of Birbhum district. Forty nos. of three-month-old female lambs were selected for the FLD program for one year. The animals were divided into two equal groups; the anthelmintic doramectin was administered to one group @ 200 μg/ kg body weight at a monthly interval, and the other group was left untreated. All animals were reared under a semi-intensive system. The fecal egg count and body weight of all the animals were recorded at a monthly interval for one year. The highest egg count was recorded for the treated and untreated groups of the animal in the month of September, with a mean EPG of 321.23 and 753.24, respectively. The body weight of the treated and untreated animals at 12 months of age was recorded as 12.2 kg and 10.1 kg, respectively. The net loss in terms of rupees was analyzed by taking into account the final mean difference in body weight between the treated and untreated groups, the dressing percentage, the average rate of meat (Rs. 450/-) in West Bengal, and the cost of anthelmintic treatment. The mean loss in body weight was 2.1 kg. Therefore, the net economic losses due to gastrointestinal nematodosis were Rs. 513.05 in sheep. It has been recorded that oestrus in untreated animals was delayed for one month. Therefore, the strategic use of doramectin in sheep could be considered a viable tool for the management of helminthic infection and for enhancing the productive and reproductive performance of animals.

Keywords: Nematodosis, Doramectin, Anthelmintic, Sheep

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ABS-18

Seasonal pattern of Foot and Mouth Disease (FMD) outbreaks across West Bengal: Five-year retrospective study

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Abstract

The present study was intended to find out the seasonal pattern of FMD outbreaks across the state of West Bengal. A total of 96 incidences of FMD were recorded in five years starting from 2018-19 in an animal disease surveillance report published by the epidemiological unit, directorate of animal resources and animal health, Govt. of WB. The highest incidences were recorded during 2018-19 (62), which dropped significantly in 2019-20 (1), probably due to the FMDCP programme. In 2020-21 and 2021-22, the reported FMD incidences were 15 and 17, respectively, and came down to a single incidence in the year 2022-23. Irrespective of year, the highest incidences were reported in the month of August (19), followed by April (14) and September (13). But, the overall morbidity was highest in September (62.35%). Though the highest incidence, CFR and morbidity were recorded during post-monsoon seasons, changing patterns in incidence, CFR and morbidity were seen in the last couple of years. The higher incidences of FMD were shifted from post-monsoon to pre-monsoon seasons in 2020-21, 2021-22 and 2022-23. Higher CFR and morbidity % were recorded in winter in 2020-21 and 2021-22 instead of post-monsoon season. This changing pattern of FMD outbreaks in recent years should be considered to formulate preventive measures and therapeutic interventions in the State of West Bengal.

Keywords: FMD outbreaks, West Bengal, Season, Incidence, Morbidity, CFR

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ABS-19

A retrospective study on the seasonal occurrence of bovine theileriosis across West Bengal and its comparison with Nadia District during the last five years

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Abstract

The present study was intended to find out the seasonal pattern of Theileria outbreaks across the state of West Bengal. A total of 1135 incidences of theileriosis were recorded from 2018-19 to 2022-23 in the state of West Bengal, out of which 29 incidences occurred in the Nadia district as per the disease surveillance report published by epidemiological unit, directorate of animal resources and animal health, Govt. of WB. The highest incidence was recorded during the post-monsoon season (473), followed by pre-monsoon (333) and winter season (329) in West Bengal, whereas in Nadia district, the highest incidence was in winter (10) and pre-monsoon season (10). The highest morbidity in West Bengal due to theileriosis, irrespective of different

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years, was recorded in winter (27.37%) followed by post-monsoon (20.44) and pre-monsoon seasons (18.83). However, till 2021-22, higher morbidity was noted during post-monsoon seasons, but a significant shift in the morbidity pattern from post-monsoon to winter was recorded in 2022-23. The highest mortality and case fatality rates were recorded in pre-monsoon season (mortality 0.94%, CFR 20.94%) followed by winter (mortality 0.15%, CFR 2.28%) and post-monsoon season (mortality 0.106%, CFR 3.01%) in West Bengal, but only two cases were reported from Nadia district, one each from winter and pre-monsoon season. The highest incidence of Theileria during the post-monsoon season all over West Bengal may be attributed to the higher availability of its vector, *Hyaloma* spp. The highest mortality and case fatality during pre-monsoon may be due to summer stress. In this study, we found a significant shift in the morbidity pattern of bovine theileriosis that may be considered for the formulation of effective therapeutic and preventive strategies.

Keywords: Theileriosis, Seasonal occurrence, Vector-borne disease

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ABS-20

Effects of inclusion of varying levels of dried rice distillers grains with solubles on the performance of Vanaraja birds

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Abstract

Incorporation of unconventional feed ingredients in poultry ration plays a pivotal role in successful and economic poultry production. Distillers Dried Grains with Soluble is now becoming a popular unconventional ingredient for livestock as well as poultry feed due to its high nutritive value and lower price. In West Bengal, rice-based distillers dried grains with soluble (RDGS) are predominantly available. When it comes to feeding dried rice distillers grains with solubles (RDGS) to poultry birds, there is no formal recommendation regarding dietary concentration. Hence, the present study was conducted to assess the effects of varying levels of RDGS inclusion on "Vanaraja" chicken production performance. A total of 144 numbers of Vanaraja birds were included to conduct the present study. They were divided randomly into three (3) groups (n = 48) with three (3) different dietary treatments, which include Control (C) without inclusion of RDGS, Treatment – I (T1) with 6% RDGS inclusion of the total diet/day and Treatment – II (T2) with 12% RDGS inclusion of the total diet/day, respectively. The experiment continued up to 32 weeks of age for the birds. The performance parameters on the basis of body weight (BW) and egg production up to that age were recorded. The result showed that inclusion of RDGS increased the body weight of the birds significantly compared to the group without inclusion of RDGS. Among the two supplemented groups, treatment group II (T2) i.e. inclusion of RDGS @ 12% of the total diet/day, has the maximum body weight (2678.37±5.20 g/bird at 32 weeks). The egg production per hen also significantly increased in the supplemented groups than in the non-supplemented group. So, among the two doses of RDGS inclusion, the second group (T2) showed the best result. It can be concluded from the above study that in rural conditions where low-quality feed is available to the birds by scavenging method, inclusion of RDGS which has higher protein, is beneficial to the birds.

Keywords: Dried Rice Distillers Grains with Solubles (RDGS), Varying levels, Vanaraja birds, Production performance

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ABS-21

Alterations in the attributes of canine babesiosis under changing climate scenarios: A report from Bankura district of West Bengal

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Abstract

The present paper is intended to highlight some altered patterns in canine babesiosis under changing climate scenarios in the Bankura district of West Bengal. A total of 27 canine babesiosis cases were studied. Higher prevalence of *B. canis* (n=13) and *B. gibsoni* (n=13) were noted compared to *B. vogeli* (n=1). Affected dogs are having high fever, pale mucus membranes due to anemia. In the terminal stage of the disease, there is severe jaundice and hemoglobinuria of the affected animals. Apart from these classical symptoms, *B. gibsoni* infection showed jaundice and hypersalivation. A typical pattern of skin lesions were seen in the dogs infected with *B.gibsoni*. Regarding therapy, it has also been noted that some cases of babesiosis are resistant to doxicycline, sometimes atovaquinone. These patterns of changes should be considered to formulate effective therapeutic interventions against canine babesiosis.

Keywords: Babesiosis, Drug resistance, Doxicyclin, Atovaquinone, Jaundice, Anemia, Skin lesion

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ABS-22

Haemato-biochemical and immunological changes in Garole sheep naturally infected with gastrointestinal nematodes

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Abstract

Gastrointestinal nematode (GIN) infection is a major threat to sheep farming, affecting the production system and thereby causing significant economic losses worldwide. Gastrointestinal nematode infections are prevalent in livestock all around the year in India, including West Bengal. In the present study, about 57 sheep in the age group of 6 months to three years old were coprologically screened by sedimentation and floatation technique, and faecal egg count (FEC) in terms of eggs per gram of faeces (EPG) was estimated by McMaster Technique for three months (June to August 2023). In every month based on FEC, sheep were categorized into 3 groups; non-infective (EPG=0), highly infective (EPG >600) and low infective (EPG <200), and blood samples were collected every month after the estimation of FEC for estimation of haematological (haemoglobin; Hb, packed cell volume; PCV, total leucocyte count; TLC and peripheral

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eosinophil count; PEC), biochemical (total protein, albumin, globulin) and immunological (serum IgA and IgG) parameters in the selected sheep. Body scores as well as FAMACHA scores of sheep of all the three groups were also recorded for three months. Results of the study showed that the highly infected group had significantly ($P<0.01$) lower values of haemoglobin, PCV, PEC, TLC than the low infective and non-infective groups. Values of PEC and TLC were significantly higher in the low-infected group compared to non-infected animals. Serum protein concentration, including serum albumin and globulin concentration, was reduced significantly ($P<0.01$) in both the infected groups compared to the non-infected group. *Haemonchus contortus* specific serum IgA and IgG were compared only between the low and highly infected groups, and the values of both the immunoglobulins were comparatively higher in the low-infected group than the highly infected group. Body score was found to be significantly ($P<0.01$) lower in the highly infected group than the low infected group, in which the value was significantly lower compared to the non-infected group, and the result was found to be exactly reverse in the case of FAMACHA score in the selected sheep. From the present study, GIN infection causes alterations in various physiological parameters with imbalances in haemato-biochemical profile and IgA and IgG play an important role in reducing the intensity of infection.

Keywords: Sheep, *Haemonchus contortus*, Host response, Haemato-biochemical parameters, IgA, IgG

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ABS-23

Environmental DNA (eDNA): A biomonitoring tool and its application in biodiversity assessment

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Abstract

Environmental DNA is a non-invasive, effective, and powerful conservation tool for detecting the presence or absence of species, identifying rare and endangered species in a wide range of ecosystems, by genetic traces released in the surrounding environment by animals. eDNA research has exploded in popularity over the last decade because we've seen an increase in the number of studies that use DNA extracted from the environment, especially for freshwater and marine ecosystems. We can say that DNA extracted from the environment is changing the game in terms of discovering hidden diversity patterns. In fisheries, information on species composition and the biomass/abundance of commercially and unvalued exploited species is pivotal for resource management. This novel molecular method never affects any endangered species or ecosystem during sampling. Even though several scientists have explored the global biodiversity of aquatic environments through eDNA, in India, no one is focusing on this approach. Ultimately, we conclude that the eDNA approach has the potential to become a next-generation tool for biodiversity studies and their conservation, ecological, and environmental management of various aquatic ecosystems worldwide.

Keywords: Environmental DNA, Metabarcoding, Biodiversity conservation, Technology, PCR, BLAST

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ABS-24

Superworm (*Zophobas morio*): An alternative source of animal protein for sustainable and profitable aquaculture

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Abstract

The world aquaculture production was increased at an annual growth rate of 4.5% during 2010–2018 and even more in the future (FAO, 2020). On the other hand, the demand for fishmeal (FM) in aquaculture practices is coupled with a decrease in fish and shellfish natural stocks, which can be accompanied by the escalation of FM cost in the market. Therefore, there is an urgent need for alternative sources of animal proteins for feed production. Insect meals have been addressed by the FAO as a promising candidate feedstuff in animals' diets. The superworm larvae, *Zophobas morio* (ZM), are a species of darkling beetle (Tenebrionidae) and naturally larger (5–6 cm) than common commercial mealworms. It can be easily reared on a substrate containing different types of organic waste, such as garden and vegetable waste. Superworm is newly reported as one of the valuable sources of protein and lipid in poultry feed. It has relatively high crude protein (44%–47% in dry matter) and lipid (40%–41% in dry matter) contents with essential amino acids, fatty acids, as well as antimicrobial peptides. It has been successfully included in the diet of Nile tilapia, *Oreochromis niloticus*, at levels of 7.5–22.5% inclusion, thus replacing 25–75% of the dietary FM. In juvenile rainbow trout, *Oncorhynchus mykiss*, 5.5% and 11% of defatted ZM successfully replaced 10–20% of the dietary FM. In conclusion, we can say that ZM has the potential to replace FM in sustainable and profitable aquaculture.

Keywords: Superworm, *Zophobas morio*, Sustainable Aquaculture, Protein source

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ABS-25

Recent advances in solid-state fermentation technology using chitinolytic microbes to enhance the utilization of unconventional protein sources

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Abstract

In the search for alternative protein sources in aquaculture, insect meal has become a good substitution due to its nutritional profile, absence of anti-nutritional factors, and high energy conversion efficiency. Previous studies on insect meal in fish diets reported the presence of chitin polymers inhibiting nutrient availability and affecting digestibility. Chitinases are glycosidase enzymes that hydrolyze insoluble chitin into oligo and monomeric components. Chitinase can be produced by a variety of chitinolytic microorganisms found in nature, including bacteria such as *Enterobactor* sp., *Bacillus* sp. and *Paenibacillus* sp.; also, in fungi like *Aspergilus* sp., and *Trichoderma* sp. The low activity, high cost of production, and scarcity of organisms exhibiting high production rates have all limited the utilization of extracellular chitinases in the commercial

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sector. Solid-state fermentation (SSF) is a novel method of producing these enzymes with more production efficiency and less residue over submerged culture. Various insect meals, such as black soldier fly, yellow meal worm, and silkworm, could be used as substrates in fermentation. Following the steps of microorganism selection, inoculum preparation, fermentation setup, extraction, purification, and characterization, chitinases can be obtained. SSF offers numerous environmental advantages, is more affordable, sustainable, and energy-efficient, has a higher concentration of end product, and is less prone to contamination. However, to ascertain the efficacy of this technology, it is necessary to optimize physical-chemical parameters and focus on strain separation and quality control design implementation. Researchers and entrepreneurs must possess a holistic comprehension that can be employed to enhance the efficiency of SSF technology and formulate its scaling strategies to better utilize unconventional insect meal.

Keywords: SSF, Insect meal, Chitin, Fermentation, Sustainable

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ABS-26

Assessing climate change impacts on poultry health and productivity in backyard farming systems: Insights from the Dooars Region of North Bengal

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Abstract

Backyard poultry farming plays a pivotal role in the rural economic development and sustainable production system in West Bengal, contributing approximately 30% of the national poultry population, with 21% of eggs and 15% of meat derived from this sector. This practice, characterized by low investment and high economic returns, is particularly well-suited for rural families, including landless and poor farmers, and can be managed by women, children, and the elderly. In this context, a study was conducted in the Dooars region of North Bengal-covering the foothills of Darjeeling, the plains of Kalimpong, and the districts of Jalpaiguri, Alipurduar, and the upper region of Coochbehar-to assess the impact of climate change on backyard poultry health and productivity. The research involved 200 rural indigenous poultry farmers randomly selected from various blocks in the Dooars region, with data collected from April to July 2024. The findings revealed significant impacts of climate variables on poultry health and productivity, particularly in micro, small, and homestead semi-intensive poultry farming systems, with flock sizes ranging from 10 to 50 birds per family. Compared to a previous study conducted in 2018-19, egg production, body weight gain, and chick hatchability decreased by 2-3%, 3-4%, and 4-5%, respectively, due to higher temperatures, reduced rainfall, and other climatic changes. Additionally, the intake of concentrate feed and the incidence of diseases in birds increased by 2-3% and 5-6%, respectively. The study highlights that climate change significantly affects various aspects of poultry farming, including body weight gain, feed intake, egg production, feed conversion ratio (FCR), mortality rates, egg fertility, chick hatchability, and disease prevalence. Moreover, the research emphasizes the positive impact of extension education and awareness programs on improving animal husbandry practices, such as housing, feeding, and breed improvement.

Keywords: Dooars, Backyard farming, Poultry health, Productivity, Climate change

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ABS-27

Fish nutrition and feeding management in neo-climatic aquaculture practices

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Abstract

Fish, as poikilothermic animals, are directly impacted by changes in water temperature. So, the increase or decrease in water temperature impacts fish development and reproduction. Fish physiology and feed consumption are affected by a variety of factors, including seasonal variations in precipitation, extended winter and summer seasons, and fluctuating precipitation rates. Therefore, research on fish nutrition and feed formulations has to be reoriented in light of evolving environmental circumstances. The changes in the environment have a substantial impact on the requirements of both macro- and micronutrients. So, nutraceuticals can help fish to survive more effectively the stresses brought on by extreme temperatures. The gut microbiota is altered by temperature changes and other associated variables. Probiotics, prebiotics, synbiotics, postbiotics, and acidifier supplements can help to improve gut health and promote the growth of good bacteria. The addition of nutraceuticals to improve nutrition and stress mitigation physiology will be a better way to address the problems with the neo-climatic aquatic environment. Sustainable aquaculture production requires the use of eco-friendly feeds with reduced carbon footprints. Feeding the proper nutrients at the right level and in the right proportion may reduce waste and pollution while increasing feed utilization. In light of the changing climate, i.e., the neo-climatic scenario, proper and optimal management of nutrition and feeding can mitigate stress in fish bodies and simultaneously reduce pollution from unused aquafeeds.

Keywords: Neo Climatic, Sustainable aquaculture, Probiotics, Carbon footprint

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ABS-28

Encouraging the preservation of Chilika Lagoon fisheries in the light of the impending climate change scenario

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Abstract

Asia's largest brackish water lagoon is Chilika, the first Indian Ramsar site, covering an area of 1100 square kilometers during the monsoon and 907 square kilometers during the dry season. Because of the monsoon's freshwater input and seawater exchange at the mouth, Chilika Lagoon preserves a unique salinity gradient that supports an incredible array of life and a rich fisheries resource that supports the livelihoods and nutritional security of over 0.2 million local fishermen. Fish and shellfish production has been rapidly declining from 2014-2015; the most recent production is 12,950 MT for the year 2020-2021. The 317 finfish species that makeup Chilika's ichthyofauna are commercially significant species. These include *Mugil*

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cephalus, *Lates calcarifer*, *Eleutheronema tetradactylum*, *Tenualosa ilisha*, *Nematolosa nasus*, *Penaeus indicus*, *Penaeus monodon*, *Portunus* sp. and *Sylla serrata*, among others. However, the livelihoods of humans, fish populations that are commercially important, and reproduction are all significantly at risk because of climate change, including the rising temperatures that cause more floods, droughts, devastating cyclones, and siltation. Therefore, with the projected fishing strategies for climate change adaptations, the sustainable livelihood approach (SLA) helps researchers and policymakers to identify a wide variety of livelihood characteristics that provide a clue to find pressing limits and positive strengths of climate resilience.

Keywords: Chilika lagoon, Climate change, Sustainable livelihood approach (SLA)

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ABS-29

Potential diagnostic markers of antimicrobial resistant, biofilm forming pathogenic *Salmonella* isolated from ducks and associated environments

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Abstract

To explore suitable diagnostic markers for *Salmonella* spp. that exhibit distinct virulence, antibiotic resistance, and biofilm formation characteristics, 195 tracheal swabs, 192 cloacal swabs, and 75 environmental samples (soil, water, feed), were collected from Indigenous, Khaki Campbell, and Pekin ducks in West Bengal, India. All positive *Salmonella* isolates were screened by PCR for detecting antibiotic-resistant genes (bla_{TEM}, bla_{CTX-M}, bla_{SHV}, and bla_{AmpC}), biofilm genes (*csgA*, *sdiA*, *rpoS*, *rcsA*), and the virulent gene *invA*. Outer membrane protein preparation (assessed by SDS-PAGE) was considered the selection criteria of a prominent candidate (C-10a). Out of the 436 *Salmonella* spp. isolates tested, 184 (42.20%) were identified as ESBL producers. PCR delineated the notable occurrences of bla_{TEM} (36.47%), bla_{CTX-M} (20.64%), bla_{SHV} (17.66%), and bla_{AmpC} (32.57%) genes. Concurrently, a diverse prevalence of biofilm-associated genes, including *csgA* (54.59%), *sdiA* (52.52%), *rpoS* (80.28%), and *rcsA* (63.76%), was observed. Remarkably, the virulence gene *invA* was detected in 32.34% of the isolates. SDS-PAGE analysis of outer membrane proteins (OMPs) from six *Salmonella* spp. isolates revealed varied bands ranging from 5 kDa to 109 kDa. Western blot analysis revealed the immunodominant polypeptides of 69 and 35 kDa in all those isolates (n=8). In short, the study revealed apparently healthy duck might carry *Salmonella* spp. having a distinctive triad of antibiotic resistance, biofilm formation, and virulence genes. The data suggested two cross-reactive polypeptides of 69 and 35 kDa that might serve as diagnostic markers for identifying *Salmonella* spp. with specific traits like antibiotic resistance, biofilm formation, and virulence gene expression.

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ABS-30

Organic carbon, nitrogen, and phosphorus budget in carp polyculture ponds at Hooghly district of West Bengal, India

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Abstract

The study of nutrient budgets can provide a scientific basis for understanding the fate of nutrients in aquaculture systems to facilitate sustainable aquaculture management. In this study, organic carbon (OC), nitrogen (N) and phosphorus (P) budgets of nine aquaculture ponds practicing polyculture of Indian major carps and exotic carps at Hooghly district of West Bengal, India, were studied. The age of these village ponds was more than eighty years. The study showed that total input of OC was 2079±108 kg ha^{-1} in these ponds, while total output was 1989±98 kg ha^{-1} in these ponds. In these ponds, the total input of N was 104.58±11.17 kg ha^{-1}, and output was 101.56±9.23 kg ha^{-1}. The total input of P was 11.296±2.47 kg ha^{-1} in these ponds, while total outputs for these ponds were 11.017±2.08 kg ha^{-1}. Primary production from phytoplankton contributed the largest proportion of total OC (62.89±9%), while feed, fertilizers, and manures contributed the largest proportion of N (85.89±2%) and P (87.87±1.5%). The fish harvested from the aquaculture ponds accounted for the largest proportion of N (49.33±24%) and P (67.96±20%), and respiration accounted for the largest proportion of OC (10.83±8%) output from the system. The total OC, N, and P accumulated in sediment were 61.35±25%, 26.38±13%, and 24.73±12%, respectively. The OC, N and P use efficiency of harvested fish was 11.51±5%, 52.17±16% and 62.16±18% in these ponds, respectively.

Keywords: Carbon, Nitrogen, Phosphorus, Nutrient budget, Carps

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ABS-31

Prevalence of haemoprotozoan diseases in and around Burdwan district and its mitigating approaches - A field report

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Abstract

Haemoprotozoan diseases, especially theileriosis, babesiosis, and anaplasmosis, are vector-borne diseases of tropical and subtropical parts of the world, including India, and have always been a formidable barrier to the survival of exotic and crossbred cattle. The pattern of haemoprotozoan disease occurrence in the Burdwan district has been studied with laboratory reports from 2017-18 to 2023-24, collected from Regional Laboratory Burdwan and reports from surveillance studies on 50 crossbred animals. It has been observed that most of the slides were found positive for haemoprotozoan diseases, especially for *Theileria* and *Anaplasma* sp. Out of 5443 blood slides examined, 4655 slides (85.52%) were found positive for haemoprotozoan diseases. Out of 4655 slides, *Theileria* sp (2476, 53.19%), *Anaplasma* sp. (2079, 44.66%), *Babesia* sp. (100, 2.14%) and other diseases (168, 3.60%) were reported. In the surveillance studies, a good number (more than 80%) of animals presented before the laboratory for blood tests were in the transition phase, and most of them were on the verge of parturition. Crossbred cattle were found to be more susceptible, and diseases were prevalent throughout

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the year in the old alluvial zone. Interestingly, it was noticed that the animals brought from outside the state just before parturition and during or just after parturition were most susceptible to haemoprotozoan diseases along with gynaecological and metabolic diseases. Transition of the animals, therefore, should be a legal approach by the government, and a proper quarantine system should be adopted at the border of states.

Keywords: Haemoprotozoan disease, Theileriosis, Babesiosis, Anaplasmosis

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ABS-32

Adaptive changes of physiological functions of Black Bengal goats (*Capra hircus*) in coastal areas of Sundarban due to salt stress

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Abstract

Although sodium chloride salt (NaCl) is essential for regulating body water content, muscle and nerve functions and nutrient absorption, excessive long term salt intake may affect feed and water intake of animals or even cause severe health problems. The study was taken to assess the effects of salinity on physiological parameters of Black Bengal goats reared at coastal areas of Sundarban in comparison with goats of plain areas of West Bengal. Twenty (20) apparently healthy female Black Bengal Goats (*Capra hircus*) (1.5-2 years of age) of Sundarban coastal area were selected as Sundarban group and twenty apparently healthy female Black Bengal Goats were also selected from (plain area of Nadia district) as control group for the study. The study was done during three different seasons i.e. summer, winter and spring (as control). Packed cell volume (PCV%), haemoglobin, blood glucose level, blood total protein and blood albumin concentration, plasma electrolyte (sodium and potassium), urine sodium and potassium concentrations were estimated by standard methods. In both seasons (winter and summer), water intake (mL/day) by Sundarban group was significantly ($p<0.05$) higher compared to control group values. The packed cell volume (PCV) level during summer was significantly lower ($p<0.05$) for Sundarban compared to control group. The highest value of PCV for Sundarban group was recorded during winter. The highest value of Hb for Sundarban group was recorded during winter. The plasma glucose level was not affected by salinity of drinking water in both seasons. The mean plasma glucose level for control as well as treated groups was slightly higher ($p<0.05$) during winter compared to values obtained in summer. The serum total protein (Tp) and albumin (Alb) concentrations in Sundarban group was higher during winter compared to control groups. In both seasons, the serum concentrations of Na^+ were significantly higher ($p<0.05$) in Sundarban group compared to control group. The increase in NaCl concentration in the drinking water increased the serum Na^+ level significantly during summer. The serum potassium (K^+) level in both seasons was lower in Sundarban group as compared to control group due to higher NaCl in the drinking water. The urine Na values were significantly higher ($p<0.05$) in Sundarban group compared to control groups during winter. All the changes observed in this study may be due to their adaptation in the saline coastal areas of Sundarban.

Keywords: Black Bengal goat, Sundarban, Salt stress, Adoptive changes

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ABS-33

Bovine lactoferrin extraction from the milk of native and crossbred cattle breeds and its antibacterial activity

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Abstract

Bovine lactoferrin (BLf) is a glycoprotein which binds to the iron with various functions such as antimicrobial, antifungal and antiviral etc. The present work was done to study the antibacterial effect of BLf isolated from the milk samples of HF cross bred and indigenous breeds of cattle i.e. Sahiwal and Poda thurpu (newly recognised breed of cattle in Telangana). The lactoferrin concentration was also detected by using ELISA. The results indicated that Poda thurpu breed of cattle had higher concentration of Lf when compared to other breeds. The milk samples collected from the above mentioned breeds were processed and subjected to cation exchange chromatography for the purification of lactoferrin. When the purified sample was run through SDS-PAGE a molecular weight of approximately 80 kDa confirmed the protein identity. Further, the antibacterial activity of BLf among the mentioned breeds by using broth microdilution technique. A lower minimum inhibitory concentration was found in BLf isolated from indigenous breeds when compared with the HF cross bred. Therefore, from the present work it can be noted that the concentration as well as the antibacterial activity of BLf isolated from the Poda thurpu breed of cattle is highest followed by Sahiwal cow milk against selected gram-positive and gram-negative bacteria and lowest in the BLf isolated from the HF cross bred cow.

Keywords: Bovine lactoferrin, BLf, Poda thurpu, Antibacterial effect

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ABS-34

Developing strategies to manage emerging aquatic animal diseases amidst changing climatic scenario

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Abstract

Fisheries and aquaculture being one of the fastest growing food sectors, plays a pivotal role in ensuring livelihood, nutritional security, and the availability of healthy animal protein source. However, diseases in aquaculture still hinder its steady and sustainable growth, and huge economic losses are incurred by the farmers due to aquatic animal diseases. As per some of the estimates, almost 10% of the produce in aquaculture lost every year due to different forms of diseases and which amounted to be about US$ 10.0 billion, globally. However, preventing the disease-related loss needs coherent association of multiple stakeholders with unique region-specific targeted approach. Early detection is considered to be key to the control of diseases, and can only be achieved through a structured surveillance programme. Recognizing the importance of disease

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surveillance, Government of India has been implementing an ambitious National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) since 2013. In recent years, several technological innovations and improved management tools in the field of aquatic animal health hold immense potential to address the emerging challenges of infectious diseases in the changing climatic conditions. At the core of advancements is the One Health perspective which takes into account the interconnectedness between human, animal and environment health. Implementation of aquaculture biosecurity including use of specific pathogen-free, specific pathogen-resistant and specific pathogen-tolerant stocks as well as vaccines can pave way for preventing development of antimicrobial resistance in aquaculture. Studies on gut microbiome can help in increasing our understanding about host-pathogen interaction. Advanced diagnostic techniques such as quantitative PCR, digital PCR, isothermal amplification and CRISPR-mediated detection have helped in increasing the sensitivity and specificity of detection of pathogens, whereas use of rapid diagnostic tools like lateral flow kits can help in providing point of care diagnosis even by the untrained aquaculturists. The application of metagenomics and environmental DNA can help to identify novel pathogens and also early detection of pathogens. The new-age technology like artificial intelligence and application of predictive modeling will add new dimension to the disease diagnosis and prediction modelling in aquaculture. These technological advancements have played immense role in minimizing the disease risks in aquaculture. Often most of the disease incidences in aquaculture go unreported due to unavailability of the field-level disease reporting mechanism. Therefore, there is a necessity of a mechanism that can connect farmers, field-level officers and fish health experts for strengthening the farmer-based disease reporting. Keeping the same in consideration, for improving the reporting of aquatic animal diseases in the country, an android-based mobile application named as 'ReportFishDisease (RFD)' has been developed under NSPAAD programme with funding support under PMMSY Scheme by Department of Fisheries, Government of India. Using the RFD app, the farmers can report incidence of disease in finfish, shrimps and molluscs on their farms with the field level-officers and fish disease experts as and when required and get scientific advice for efficient management of diseases. The data regarding the diseases will be stored on temporal and spatial scale and can be used for mapping the disease cases. It is expected that the app would help in improving farmer-based reporting, getting scientific advice and reducing losses due to diseases. Further, with the proactive disease reporting by fish farmers and efforts of fish health experts in different strata of state or central government, this innovative mobile application will serve as an efficient platform for supporting implantation of eGovernance in aquatic animal disease management in the country. The proactive reporting of emerging aquatic animal diseases combining with advanced technological interventions for better understanding of the underlying disease-causing mechanisms will lead to develop climate-resilient practices and disease-specific targeted strategies, thereby ensuring sustainable aquaculture production and meeting the global food security.

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ABS-35

Effects of polyherbal formulation on growth performance and physio-biochemical parameters of post-weaned Ghoongroo piglets

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Abstract

Weaning condition is one of the critical and challenging phases of piglet where they get separated from mother and exposed to different environment. Sudden and abrupt changes in the total environment lead to

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the increase physical stress that leads to various diseases diarrhea to the piglets. Use of phytogenic feed additives other than antibiotics is safe not only to the livestock, but also to the consumers and environment. Experiments were conducted to evaluate the effect of Polyherbal formulations (herbs extracts mixture) on blood characteristics, blood biochemical profile in weanling pigs. A total of 84 Ghoongroo piglets with average body weight 7.6±0.6 kg were selected after weaning at 42 days and randomly allocated to 3 treatments. Treatments followed a 2 × 2 factorial design with 2 levels of PHF-I and PHF-II (T1 & T2) with three different concentrations (100 mg/BW, 200 mg/BW 250 mg/BW). At initial weeks piglets were fortified with PHF supplemented diets that led to a lower (P<0.05) average daily feed intake (ADFI) but enhanced the feed conversion ratio (FCR) than the control group. In case of blood profile, significantly higher (P>0.05) WBC values in T1 group as compare to T2 group. Whereas, no significant difference was found between T0 and T1 groups were recorded. There was no significant variation in biochemical profile of blood parameters among groups. In conclusion, the beneficial effect on WBC increases, lymphocyte suggested that these kind of PHF have a positive role on growth performance of weaning piglets.

Keywords: PHF-I & II, ADF, Blood biochemical

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ABS-36

Examining the molecular epidemiology, transmission dynamics, and characterization of Carbapenem-Resistant Enterobacteriaceae (CRE) and possible treatment strategies in dog population of Kolkata

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Abstract

A total of 173 samples taken from various stray dogs that were found unwell or brought to the veterinary clinics/hospitals in and around Kolkata resulted in the isolation and characterization of 35 drug-resistant Enterobacteriaceae, including 26 *Escherichia coli* and 9 *Klebsiella pneumoniae*. Out of 35 Enterobacteriaceae, 29 of them produced extended-spectrum â-lactamases, 33 produced â-lactamases of the AmpC type, and 8 were verified to be Metallo â-lactamases, possessing the *bla*NDM-1(3) and *bla*NDM-5 (5) genes. *bla*CTX-M (27), *bla*AmpC (35), *bla*TEM (11), *bla*SHV (2), *bla*OXA (9), *bla*FOX (1), *bla*DHA (1), *bla*CIT (5), *bla*CMY-2(3), *bla*GES (1), and *bla*VEB (1) were the most common genes found in the majority of these isolates. Other common resistance determinants were *sul*-1 (25), tetA (11), *tetB* (7), *aac-6'-Ib-cr* (4), and *qnr*S (9). Strong biofilm producers with adhesion genes such as *csg*A (21), *fim*A (19) and *fli*C (9), *sdi*A (27), *rcs*A (25), and *rpo*S (23), were discovered in almost 80% (28) of the isolates. The isolates also had a variety of virulence factors, including *tsh* (1), *ast*A (1), and *pap*C (5) and *iuc*D (15), The study reveals that *E. coli* is classified into various phylogroups, with Clade C being the most common. Eucalyptus oil has shown promise in managing *E. coli* infections, especially against CRE isolates. However, further research is needed to confirm its clinical efficacy. Stray dogs untreated with antibiotics may serve as reservoirs for AMR infections, highlighting the importance of combating antimicrobial resistance globally.

Keywords: Enterobacteriaceae, MDR, CRE, AMR

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ABS-37

Molecular detection of *Eimeria tenella* isolated from the broiler chickens in and around Kolkata, West Bengal

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Abstract

Coccidiosis is a major parasitic disease in poultry, with *Eimeria tenella* being the primary cause. This disease causes significant morbidity and financial loss in chicken production. Understanding the evolutionary origin of this species is crucial, as it is a model vaccine candidate for both homogeneous and heterogeneous coccidian infections. This study used species-specific primers to confirm the species identity of *Eimeria* samples. Genomic DNA was isolated from sporulated oocytes from broiler chicken fecal material and evaluated for quality, purity, and concentration. The results showed that all isolates were *E. tenella* based on distinct 594 bp using the *E. tenella* primer. Positive PCR products were subjected to Sanger sequencing, and sequences were edited and aligned. The nucleotide Basic Local Alignment Search Tool (BLAST) was used to compare the sequences with those in the NCBI database. A total of 99.73% to 100% homology was found between five PCR-positive samples and the DNA sequences included in the GenBank database. The results indicated a 76.2% overall prevalence of *Eimeria* infection, with *Eimeria tenella* being the cause of 48.4% of coccidiosis. These findings could be useful for future anticoccidial vaccine development and effective chemoprophylactic and control strategies.

Keywords: Coccidiosis, *Eimeria tenella,* DNA

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ABS-38

Optimizing *Azolla microphylla* cultivation for sustainable goat nutrition under changing climate conditions

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Abstract

Climate change threatens global food security, especially livestock production. Sustainable and climate-resilient feed options are essential for animal welfare and productivity. *Azolla microphylla*, a nitrogen-fixing fern, offers a sustainable and nutritious feed option for goats. This study investigated the effects of nutrient inputs and seasonal variations on its yield and nutritional composition. Twenty-one Azolla pits were divided into seven treatment groups and supplied with different combinations of cow dung, single superphosphate (SSP), and vermicompost (e.g., vermicompost made from cow dung). Results demonstrated that a combination of cow dung and single superphosphate at a weekly application rate of 0.5 kg/m² and 5 g/m², respectively, yielded the highest biomass production of 188.06 g/m²/day. Seasonal variations significantly influenced yield, with the highest (201.5 g/m²/day) observed in summer and the lowest (193.2 g/m²/day) in winter. *Azolla microphylla* was rich in crude protein (23.24%) and a very good source of macro and micro minerals. Replacing 20% of concentrate mixture by Azolla meal in the diet of Black Bengal kids significantly enhanced

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average daily live weight gain by 25.6% (from 32.94 g/day to 41.57 g/day) and feed conversion efficiency by 26.1% (from 11.41 kg/100 kg dry matter intake to 14.35 kg/100 kg). These findings highlight *Azolla microphylla* to be a promising economic solution for sustainable goat nutrition, particularly in the context of climate change. By optimizing nutrient management practices and considering seasonal factors, Azolla cultivation can be effectively integrated into livestock production systems, contributing to improved animal health, productivity, and resilience.

Keywords: *Azolla microphylla*, Feed supplement, Nutrient inputs, Seasonal variations, Yield, Nutritional value, Black Bengal kids

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ABS-39

A study on seasonal variation on bovine semen production

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Abstract

Artificial Insemination through frozen semen is an established way of augmenting milk production by means of breed up gradation and cross breeding programme. A study was conducted at Frozen Semen Bull Station, Salboni, Paschim Medinipur, West Bengal to find out the breed wise seasonal variation (Considering Summer- March to June, Rainy- July to October and Winter- November to February) on semen production performance involving different breeds (Jersey, Crossbred Jersey, Crossbred Holstein Friesian and Gir). These bulls were reared in the individual pens and feeding, management, semen harvesting and semen production had been made as per MSP (Minimum Standard Protocol) and SOP (Standard Operating Procedure) of Govt. of India. The present study clearly depicted that the rate of initial discard mainly due to low concentration (<500 million per mL) and low initial progressive motility (<70%) was highest during summer (22.78%), followed by rainy (20.32%) and lowest during winter (12.22%). It was also observed that rate of PTM (Post Thaw Motility) discard was highest during summer (28.79%), followed by rainy (23.46%) and lowest during winter (16.85%). Average per bull monthly production of Frozen Semen Doses (FSS) was highest during winter (3475 Doses), followed by rainy (2800 Doses) and least during summer season (2441 Doses). In case of Jersey breed Initial discard, PTM discard and average monthly per bull FSS production were recorded as 21.29%, 32.70% and 3520 doses, respectively during summer and17.84%, 25.55% and 3529 doses, respectively during rainy season, and 5.44%, 19.92% and 4784 doses, respectively during winter. In case of Crossbred Jersey Breed Initial discard, PTM discard and average monthly per bull FSS production were recorded as 24.79%, 31.25% and 2045 doses, respectively in summer, 19.02%, 20.82% and 2616 doses, respectively in monsoon and 12.79%, 14.22% and 3331 doses, respectively during winter. In case of Crossbred Holstein Friesian Initial discard, PTM discard and average monthly per bull FSS production were recorded as 19.65%, 25.15% and 2223 doses, respectively during summer, 19.50%, 23.53% and 2935 doses, respectively during rainy season and 14.41%, 14.47% and 3237 doses, respectively during winter season. In case of Gir Breed Initial discard, PTM discard and average monthly per bull FSS production were recorded as 25.39%, 26.07% and 1979 doses, respectively during summer season, 24.91%, 23.94% and 2123 doses, respectively during monsoon and 16.26%, 18.78% and 2548 doses, respectively during winter. The study clearly revealed that seasonal variation plays a vital role in bovine semen production and winter is the best season for harvesting of semen in the present study area which comes under tropical climate.

Keywords: Seasonal variation, Frozen semen, Bull

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ABS-40

The synergistic antimicrobial spectrum of turmeric and tamarind: A potential natural fish preservative

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Abstract

To increase the shelf life of perishable Croaker fish, the present study is aiming at determining the microbiological and sensory profile of Croaker fish fillets treated with both tamarind and turmeric together to justify the hurdle concept and to get the synergistic effect so that microorganism need more energy to break all the barriers. The proximate composition of Croaker was found as; protein (16.20±0.18%), fat (2.77±0.04%), moisture (79.23±0.17%) and ash (1.66±0.01%). The TPC value, gradually decreased from Control (5.524±0.006 log cfu/g) with increased concentration of turmeric and tamarind respectively to get the synergistic effect and finally the T8 treatment recorded lowest TPC score (4.92±0.01 log cfu/g) which may be due to synergistic antimicrobial effect of highest concentrations of turmeric (6%) and tamarind (4%). TPC values decreased inverse proportionately to the added tamarind concentration at the rate of 0%, 2% and 4%, respectively. Bacillus count followed exactly similar trend to TPC and finally T8 recorded lowest count. The lowest Staphylococcus count observed in T5 (3.91±0.01 log CFU/g). All the treatments including control are within safe limit of acceptability of Staphylococcus for human consumption. With increase in tamarind concentration, *E. coli* count decreases and finally the lowest *E. coli* count (3.55±0.02 log CFU/g) was observed in T8. *Vibrio* sp. count was seen least in T8 treatment (3.55±0.05 log cfu/g) due to synergistic effect of turmeric and tamarind in 6:4 ratio. *Salmonella* sp. count was nil; all the treated samples including control recorded nil or negligible (<1log cfu/g) fungal count, which may be due to the presence of turmeric and tamarind and good quality raw material. pH decreased inverse proportionately to the added tamarind concentration at the rate of 0%, 2% and 4% respectively. From the microbiological and pH assessment, both T5 and T8 exhibited best result in terms of preservation effect. Thus, the synergistic antimicrobial activity of turmeric and tamarind making a potential natural fish preservation practice.

Keywords: Turmeric, Tamarind, Microbial count, Croaker, Seafood borne pathogen

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ABS-41

Tetrabromobisphenol A exposure in *Labeo rohita*: evaluation of behavioural response, histological and haematological alterations

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Abstract

Tetrabromobisphenol A (TBBPA), a currently intensively used brominated flame retardant (BFR), is employed primarily as a reactive flame retardant in printed circuit boards but also has additive applications in several types of polymers. TBBPA and its metabolites are detected in a diverse aquatic environment and are major concerns in ecotoxicological point of view. The present study investigated the impact of acute exposure of TBBPA on behaviour, histopathology and haematological parameters of *Labeo rohita* (Hamilton,

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1822). The 96 h LC_{50} of TBBPA for *L. rohita* was estimated to be 1.50 mg L^{-1}. Acute toxicity of TBBPA resulted a definite behaviour change in treatment group. Significant alterations are also observed in histological architecture of gill and liver tissue in TBBPA exposed groups. There was a significant reduction in total erythrocyte count and haemoglobin content whereas the total leukocyte count was observed to increase significantly. The present ecotoxicological study provides valuable toxicological information of TBBPA and will facilitate a deeper understanding on its potential toxicity in realistic aquatic environments.

Keywords: Flame retardant, Tetrabromobisphenol A, Acute toxicity, Ecotoxicology

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ABS-42

Evaluation of anti-inflammatory effects of lactoferrin and dexamethasone sodium against acetic acid induced colitis in rats

L. Naveen[1*], A. K. Devarasetti[2], Jayasri A.[2], A. G. Reddy[3], S. Batabyal[1], A. Maity[1], S. Polley[1], Md. S. Murtuza[1] and D. D. V. Hanuman[3]

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Abstract

The present study was aimed to evaluate anti-inflammatory effect of lactoferrin in acetic acid-induced colitis in Wistar rats. The rats were divided into five groups viz. Group 1- sham. Group 2 - positive control. Group 3 - dexamethasone sodium @ 2 mg/kg b. wt. i/p from day 1 to 14. Group 4 - lactoferrin @ 200 mg/kg b. wt. p/o from day 1 to 14. Group 5 - dexamethasone sodium @ 1 mg/kg b. wt. i/p and with lactoferrin @ 100 mg/kg b. wt. p/o from day 1 to 14. Intra-colonic administration of 2 mL of acetic acid (4% v/v) on day 1 was given to groups 2, 3, 4 and 5. The rats were sacrificed on the day 14 of experiments, and the spleen were quickly collected and measured weight of spleens. The toxic group showed increased weight of spleen, whereas lactoferrin treated group showed opposite effect and also collected colon, liver and spleen tissue samples for estimation of anti-inflammatory markers. The toxic group showed increased levels of TNF-α and MPO activity, decreased levels of IL-10, whereas lactoferrin treated group showed opposite effect. The results suggest that lactoferrin has anti-inflammatory effect on acetic acid - induced colitis in rats. Therefore, lactoferrin is a potential therapeutic agent for the treatment of colitis.

Keywords: Dexamethasone sodium, Spleen, Colon, Lactoferrin

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ABS-43

Histopathological evaluation of efficacy of lactoferrin and dexamethasone sodium against acetic acid induced colitis in rats

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Abstract

The present study was aimed to evaluate the protective effect of lactoferrin in acetic acid-induced colitis in Wistar rats. The rats were divided into five groups viz. Group 1- sham. Group 2 - positive control. Group 3 - dexamethasone sodium @ 2 mg/kg b. wt. i/p from day 1 to 14. Group 4 - lactoferrin @ 200 mg/kg b. wt. p/o from day 1 to 14. Group 5 - dexamethasone sodium @ 1 mg/kg b. wt. i/p and with lactoferrin @ 100 mg/kg b. wt. p/o from day 1 to 14. Intra-colonic administration of 2 mL of acetic acid (4 % v/v) on day 1 was given to groups 2, 3, 4 and 5. Tissue samples of colon, spleen, liver and kidney were collected and processed for histopathological examination, that showed congestion, necrosis of epithelium and crypts, infiltration of inflammatory cells, depletion of goblet cells and ulceration of mucosa in colon, mild oedema and increased cellularity in spleen, mild congestion and mild sinusoidal dilation in liver and minimum tubular damage, mild degenerative changes, mild vacuolations in glomeruli of kidney in acetic acid induced groups. These changes were improved in group 5 followed by group 4 and group 3. The results suggest that Lf along with dexamethasone sodium has ameliorative and protective action against pathological changes on acetic acid induced colitis in rats. Therefore, Lf may be a potential therapeutic agent against acetic acid induced colitis in rats and promising nutraceutical compound for the treatment of colitis in rats.

Keywords: Goblet cells, Glomeruli, Dexamethasone sodium, Liver

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Synopsis of the Seminar
'Augmenting Production and Disease Mitigation Strategies in Food-animal under Changing Climatic Scenario'

Indian Journal of Animal Health (IJAH) published by the West Bengal Veterinary Association organized a National Seminar on '*Augmenting Production and Disease Mitigation Strategies in Food-animal under Changing Climatic Scenario*' on 14th September, 2024 at Vivek Bhawan, West Bengal University of Animal and Fishery Sciences, 68, Belgachia Road, Kolkata-37, West Bengal. Eminent personalities, viz. *Dr. Uttam Kumar Sarkar*, Director, ICAR-National Bureau of Fish Genetic Resources, Lucknow, *Dr. Sitanshu Mohan Deb*, Emeritus Professor, WBUAFS, *Dr. Dibyendu Kamilya*, Associate Professor, Agricultural and Food Engineering Department, IIT-Kharagpur and *Dr. Ashim Kumar Bhattacharya*, Former Vice Chancellor, WBUAFS were present in the Seminar.

Dignitaries of the Seminar

Prof. Barun Roy, Chief Editor, IJAH welcomed the dignitaries, participants and the organizing team for their whole hearted support in making it a success. *Dr. Nilratan Kole*, General Secretary, West Bengal Veterinary Association on behalf of the publisher, expressed his gratitude, to the Editorial Board, Advisory Board and the Publication Board members for their efforts to elevate the quality of the journal. He stated that the journal has been published since 1962 without interruption with the steady endeavor of the Editorial Board. *Dr. Ashim Kr. Bhattacharya*, Former Vice-chancellor, WBUAFS, was honoured with a memento and a Certificate with honour for his dedication to glorifying the journal since its inception. *Prof. Pradip Kumar Das*, Editor of the IJAH, narrated Dr. Bhattacharya's role as Assistant Editor, Editor, Chief Editor and Advisor from 1963 to 2024 with the help of a Power Point presentation. Apart from his administrative and academic work, he was very keen to upgrade the quality of the journal. *Dr. Bhattacharya* recalled his association with the founder editor *Late Anupam Chatterjee*. *Dr. Bhattacharya* explained the various hardships faced in the last 60 years to maintain the quality of the journal.

Dr. Ashim Kr. Bhattacharya, Former Advisory Board Member, IJAH was honoured with a memento and certificate

Prof. Siddhartha Narayan Joardar, Associate Editor of the IJAH vividly explained the impact of climate change on the health and production of livestock and aquatic animals in his presentation as lead paper of the national seminar. He said that vector-borne diseases and antimicrobial resistance, metabolic disorders, immune suppression etc. are the major issues that should be taken care of. *Prof. Joardar* emphasized the use of tools and techniques for assessing animal productivity and disease surveillance with relevant climate conditions. The perception of the participants about climate change issues was presented by *Dr. Srinibas Das*, Section Editor, IJAH as a preamble of the seminar.

The national seminar was inaugurated by *Dr. U.K. Sarkar*, Director, ICAR-NBFGR with releasing the compendium. In his inaugural speech, *Dr. Sarkar* said Indian fish biodiversity is under significant pressure from overfishing, habitat destruction, pollution, and climate change. Efforts are needed to improve conservation strategies, such as the establishment of marine protected areas and sustainable fishing practices. The adverse impact of climate change on fish genetic resources can be overcome through innovative approaches and climate-smart strategies developed in the regional context for fishery resources in India.

Dr. U. K. Sarkar, Director, ICAR-NBFGR inauguratedthe national seminar with releasing the compendium

Dr. S. M. Deb, Emeritus Professor, WBUAFS stated in his expert opinion that climate change, especially global warming, may highly influence the production performance of livestock as well as disease scenarios among them either directly or indirectly. In his opinion, ameliorative measures and enhancing resilience in livestock against heat stress are to be achieved by a number of strategies, like environmental modification and thermal comfort, nutritional interventions and management, animal health management, genetic selection for disease resistance and thermotolerant livestock, etc. Another expert, *Dr. D. Kamilya*, Associate Professor, Agricultural and Food Engineering Department, Indian Institute of Technology Kharagpur stated that climate change poses a significant threat to the health and sustainability of aquaculture systems, intensifying the prevalence and severity of fish diseases. Climate change has led to a significant increase in water temperatures, which directly affects fish physiology and behaviour. Selective breeding, genetic modification, use of immunomodulatory agents, etc are to be practised to combat this situation.

About 150 students, research scholars, scientists, teachers and field professionals participated in the seminar comprising six agro-climatic zones of India. A total of 13 presenters among students, research scholars and scientists from different institutes presented their research outcomes from the accepted 29 papers in a poster session. Thirteen field professionals presented their data/findings digitally in a parallel session. *Prof. Pradip Kumar Das*, Editor of the IJAH concluded the national seminar with some long-term and short-term recommendations. The conclusions and recommendations have been illustrated in a separate section in the compendium. It was decided that the accepted recommendations would be communicated to the government agencies, research institutes and universities.

A field veterinarian was encouraged conferring medal and certificate

Dr. Satabdi Das, *Prof. G. P. Mondal* and *Prof. Supratim Chowdhury* evaluated the presented posters and gave their judgments. The sessions of the entire seminar were nicely managed by *Dr. Ruma Jas* and *Dr. Joydip Mukherjee*, Editorial Board Members of the IJAH and *Dr. Gour Hari Mondal*, Secretary, Publication Board, IJAH. The seminar ended with a vote of thanks delivered by *Dr. Tuhin Adak*, Chairman, Publication Board, IJAH.

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Conclusions and Recommendations of the Seminar 'Augmenting Production and Disease Mitigation Strategies in Food-animal under Changing Climatic Scenario'

The Indian Journal of Animal Health convey the heartiest appreciation to the 43 abstract-submitting researchers, faculties, students, scientists, subject matter specialists and field professionals. The IJAH also express gratitude to the experts for their wise outlooks on various mitigating strategies for augmenting production from the food-animals under changing climatic scenarios. Most of the research works were survey-based with a few lab- and field-based experiments reflecting the ground reality on changed climatic circumstances.

The study areas of the research works comprise six major agro-climatic regions of India, *viz.* (i) the Terai under the foothills of the Eastern Himalayan region, (ii) Lower Gangetic Plains region including New Alluvial and Old Alluvial zones of the West Bengal, (iii) Middle Gangetic Plains region of Uttar Pradesh, (iv) Trans-Gangetic Plains region of Haryana, (v) Eastern Plateau and Hills region or Red Laterite zone of West Bengal, and (vi) East Coast Plains of Orissa and West Bengal.

The major outcomes of the presented articles may be summarized as:

i) Seasonal occurrence of different diseases such as Glanders, Foot and Mouth Disease (FMD) and tick-borne infections, *viz.* Theileriosis, Anaplasmosis, Babesiosis and Lumpy Skin Diseases (LSD) were discussed and their epidemiological data showed a change in the pattern in terms of incidence, morbidity, mortality and case fatality with the changing climatic scenario. The diversity of gastrointestinal nematodes and ciliates under changing climate conditions was also reported.

ii) Insights into the aquaculture industry under changing climatic scenarios with the occurrence of diseases were discussed and the adaptive strategies were highlighted.

iii) Climate change significantly altered the productive and reproductive performances of cows and goats with the occurrence of estrus behaviours during the last five years. Climate change considerably affects different attributes of poultry farming, such as body weight gain, feed intake, egg production, feed conversion ratio (FCR), mortality rates, egg fertility, chick hatchability, and disease prevalence.

iv) Cutting-edge biomonitoring tools, including environmental DNA (eDNA) approach to assess biodiversity in conjunction with physio-biochemical and molecular signature (heat shock proteins) of adaptations in livestock, fishes and molluscs as well as some potential molecular diagnostic markers of antimicrobial resistance were discussed. The application of bio-waste-derived carbon dot nanoparticles in therapeutics was presented and claimed to reduce environmental pollution.

v) Nutritional strategies to augment livestock and fish production have been reported. Some alternate feed resources, such as condensed tannins, dried rice distiller grains in cattle and poultry, chitinolytic microbes and super worms for fish were shown to be effective for sustainable production under neo-climatic scenarios.

Hence, it can be concluded that climate change, especially global warming, might adversely influence the production, reproduction and health of food animals, *viz.* livestock, poultry and fish. Some notable alterations in the occurrence and fatality of diseases in livestock and fish were seen with the changing climate scenario. Some short- and long-term measures should be taken to maintain sustainable production.

The following recommendations are suggested:

SHORT-TERM

1. *Environmental modification and thermal comfort*: These may be achieved by reducing the ambient temperature of the housing/ resting areas by providing the plantation of trees, suitable shelters, proper ventilation, sprinkling water, and installing cooling systems considering the stocking density.

2. *Nutritional interventions and management*: Interventions required by reducing the quantity of fibrous diets and increasing concentrate in the ration, use of by-pass nutrient (fat/ protein) feeding, use of feed additives like antioxidants (Vit C, Vit E, and Se) in the diet, supplementing diet with buffers (sodium bicarbonate), betaine, chromium, niacin and yeast in the diet provide more water for drinking to livestock. Change the feeding schedule to the cooler parts of the day *e.g.*, early morning and late afternoon.

   Additions of nutraceuticals to improve nutrition and stress mitigation physiology are to be addressed better way to resolve the problems with the neo-climatic aquatic environment. Sustainable aquaculture production requires the use of eco-friendly feeds with reduced carbon footprints. Feeding the proper nutrients at the right level and in the right proportion may reduce waste and pollution while increasing feed utilization.
3. *Animal health management*: The disease surveillance and response to detect changes in disease in a timely way and the capacity to forecast the occurrence of climate-sensitive diseases, and to predict the longer-term distribution of diseases through better epidemiological information are to be improved. Improvement in sanitation, hygiene or biosecurity at farms is essential. Increase the resilience of livestock systems by supporting the diversification of livestock holding. Risk management for emerging diseases and combating anti-microbial resistance (AMR) is to be seriously addressed through the *One Health* umbrella.
4. *Aquatic health management*: Field-level disease reporting mechanism should be upgraded and strengthened developing a network among farmers, field-level officers and fish health experts to recognise the disease incidences in aquaculture. The proactive reporting of emerging aquatic animal diseases combined with advanced technological interventions for a better understanding of the underlying disease-causing mechanisms will lead to the development of climate-resilient practices and disease-specific targeted strategies, thereby ensuring sustainable aquaculture production and meeting global food security.

LONG-TERM

1. *Reduction of GHG production*: Use of fossil fuel may be reduced to the extent possible. Reducing the number of cattle and selection of high-producing animals, management of fermentations in rumen and manure, use of lesser quantity of chemical fertilizers, plantation of more trees etc. are some efforts to be taken urgently.
2. *Selection for thermo-tolerant and disease-resistant livestock, poultry and fish:* Propagation of native livestock and fish breeds known to be highly resilient and disease resistant to be encouraged through conventional and genomic selection. Newer technologies like gene editing may also be an option.
3. *More research to assess the impact of climatic changes on livestock, poultry and fish:*
   (a) Tools and techniques for assessing animal productivity and disease surveillance systems to incorporate food-animal data with relevant climate conditions are to be strengthened.
   (b) Development and application of methodology to link climate data with food-animal disease surveillance systems should be implemented and adaptation choices and risk management actions across temporal and spatial scales and contexts are to be followed.
   (c) Understanding the effects at system-, organ- and cellular-levels due to environmental changes, will help to design ameliorative measures to be undertaken.
   (d) Different adaptive strategies like water quality management techniques, multilevel adaptation planning and community-based adaptations would help reduce vulnerability to expected climate change.

One Health perspective takes into account the interconnectedness between human, animal and environmental health. Implementation of aquaculture biosecurity including the use of specific pathogen-free, specific pathogen-resistant and specific pathogen-tolerant stocks as well as vaccines can pave the way for preventing the development of antimicrobial resistance in aquaculture.

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Glimpse of the Seminar

Prof. Barun Roy, Chief Editor, IJAH welcomed the dignitaries, participants and the organizing team

Dr. Nilratan Kole, General Secretary, West Bengal Veterinary Association on behalf of the publisher delivering the speech

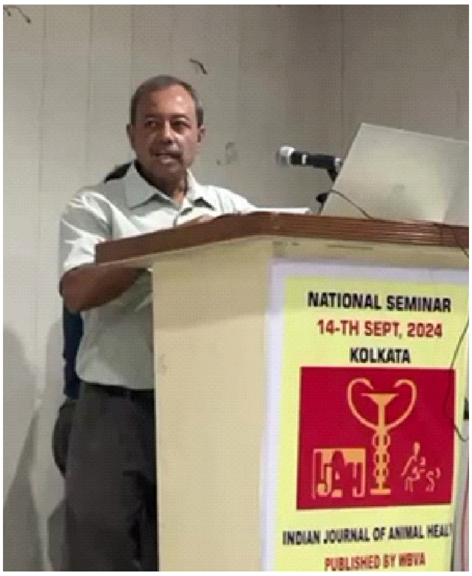
Dr. U. K. Sarkar, Director, ICAR-NBFGR, Lucknow delivering the speech

Dr. S. M. Deb, Emeritus Professor, WBUAFS delivering the speech

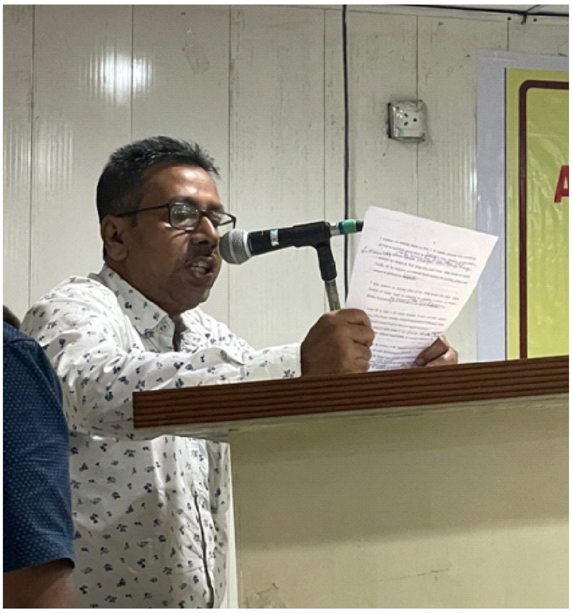
Dr. D. Kamilya, Associate Professor, Agricultural and Food Engineering Department, IIT Kharagpur delivering the speech

Prof. Siddhartha Narayan Joardar, Associate Editor, IJAH presented base paper on the impact of climate change on the health and production of livestock and aquatic animals

Dr. Satabdi Das, Prof. G. P. Mondal and Prof. Supratim Chowdhury evaluated the presented posters



Prof. Pradip Kumar Das, Editor, IJAH concluded the national seminar with recommendations



Dr. Tuhin Adak, Chairman, Publication Board, IJAH delivered vote of thanks speech

Certificate was presented to the researcher by Dr. A. Mukherjee, Editorial Board Member

Dr. Gopal Chakraborty, Advisory Board Member presented certificate and medel to a researcher

Young researcher was encouraged conferring medal and certificate by Dr. Gourhari Mondal, Secretary, Publication Board

About the Indian Journal of Animal Health

(www.ijah.in)

Indian Journal of Animal Health is a scientific journal on veterinary, fishery and dairy research & clinical trials on veterinary sciences, first published in 1962 in Calcutta, West Bengal by no less than a pioneer like the Late Dr. Anupam Chatterjee, the undisputed leader and thinker of Animal Husbandry Development in West Bengal. Great teachers and researchers like Dr. D. B. Mukherjee, Dr. M. S. Das, Dr. A. N. Chakraborty, and Dr. P. K. Sinha adorned as members of the Editorial Board of the Journal from time to time.

Aims & Scopes

1. To publish standard research works from different institutions and universities and to bring the latest information about the advancement of Veterinary, Fishery and Dairy Sciences to the doorstep of end users.
2. To publish innovative clinical trials of Veterinary practice.
3. To promote the art of Veterinary & Animal Husbandry, Fishery and Dairy Sciences including their relation to Public Health & Agriculture.

The devoted effort of Dr. Anupam Chatterjee is immemorial. Later, the Late Dr. Chatterjee handed over the management of the Journal in the year 1987 and since then the Journal has been published biannually by the West Bengal Veterinary Association (State affiliate of the Indian Veterinary Association) under the technical guidance of competent Advisory and Editorial Board constituted by eminent scientists, research workers in the field of Veterinary, Fishery, Dairy and Allied Sciences. In the last five years, one special issue has been regularly published in the contemporary issue each year.

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