Aquaculture infrastructure as an emerging threat to waterbirds: observations from fish farms in Surat

Aquaculture has emerged as one of the fastest-growing sectors of global food production and plays a critical role in supporting food security and regional economies (FAO 2022). In India, coastal regions provide favorable environmental conditions for aquaculture, including suitable water resources, estuarine systems, and climatic conditions conducive to fish and shrimp farming. The city of Surat in Gujarat, located along the Arabian Sea coast and intersected by several rivers and estuarine ecosystems, has witnessed significant expansion of aquaculture activities over the past decades.

Aquaculture ponds and associated wetland habitats frequently attract a wide diversity of bird species, particularly waterbirds and piscivorous birds, due to the availability of food resources and suitable foraging habitats (Carss 1990; Little et al. 2016). These interactions between birds and aquaculture systems can be complex, encompassing both beneficial and adverse ecological relationships. Certain bird species contribute to ecosystem functioning by consuming insects, crustaceans, and other organisms that may otherwise affect aquaculture productivity. Additionally, birds can play roles in nutrient cycling within aquatic ecosystems through the redistribution of organic matter and nutrients.
However, aquaculture infrastructure may also create ecological conflicts. Predatory and piscivorous birds are often attracted to fishponds as feeding grounds, which can result in economic losses for aquaculture operators (Glahn & Stickley 1995). To mitigate predation, aquaculture facilities frequently deploy protective netting systems above ponds. While these nets can effectively reduce fish predation, they may also pose significant risks to birds through accidental entanglement and mortality.

Incidental capture or entanglement in fishing gear and netting structures has been recognized as a growing conservation concern for many bird species worldwide (Žydelis et al. 2009). In aquaculture landscapes, such interactions remain relatively under-documented in many parts of southern Asia, including India. Understanding the nature and extent of these interactions is essential for developing mitigation strategies that balance aquaculture productivity with biodiversity conservation.

This study documents incidental mortality of waterbirds associated with aquaculture netting systems in the Surat region of Gujarat. Observations recorded during wildlife surveys provide evidence of bird entanglement incidents and highlight the potential ecological implications for local avifaunal diversity.

The observations were recorded in aquaculture farms located in and around Surat, Gujarat, India. The region lies along the Arabian Sea coast and includes an extensive network of

rivers, estuaries, wetlands, and aquaculture ponds that support both freshwater and brackish water aquaculture. These habitats provide suitable conditions for the cultivation of species such as shrimp, prawns, tilapia *Oreochromis* spp., and catfish *Clarias* spp. Due to the availability of aquatic habitats and abundant food resources, the aquaculture landscape also attracts numerous species of resident and migratory birds, including wading birds, waterfowl, and piscivorous birds.

Field observations were recorded during otter surveys conducted in aquaculture farms in collaboration with Nature Club Surat and the Wildlife Trust of India. The surveys were carried out during September 2020 to February 2021.

During these surveys, opportunistic observations were made regarding wildlife interactions with aquaculture infrastructure, particularly netting systems installed above fishponds. Instances of bird mortality or entanglement were documented through direct field observations. Species identification was conducted using standard field guides to Indian birds (Grimmett et al. 2011).

During the survey period, multiple incidents of bird mortality associated with aquaculture netting systems were recorded. Several bird carcasses were found entangled in protective nets installed above aquaculture ponds. We encountered deceased birds, including Common Snipe *Gallinago gallinago*, Indian Pond Heron *Ardeola grayii*, Little Egret *Egretta garzetta*, and Little Cormorant *Microcarbo niger* ensnared in the very nets employed within these aquaculture facilities. The entanglement of multiple bird species in these nets suggests that this issue extends beyond a single avian species.

It serves as evidence of a broader problem that affects a diverse range of bird populations. Such incidents can lead to population declines, potentially jeopardizing the overall biodiversity of the area.

A deceased Common Snipe ensnared in the net. © Hiren Patel.

A deceased Pond Heron hanging in the net.
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A deceased Little Egret entangled in the net.
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The nets installed above aquaculture ponds function as barriers intended to prevent birds from accessing fish stocks. However, birds attempting to land on the nets, fly across ponds, or forage near the water surface may become entangled in the mesh. In many cases, such entanglement results in fatal injuries or prolonged suffering leading to death.

Incidental mortality of birds in aquaculture netting systems may have several ecological consequences. Birds play important roles in regulating aquatic and terrestrial food webs, including controlling populations of insects, fish, and other aquatic organisms (Whelan et al. 2008). The loss of predatory or insectivorous birds can disrupt local ecological balances and potentially alter trophic dynamics.

Additionally, repeated mortality events may negatively affect local bird populations, particularly if vulnerable or migratory species are involved. Many wetland birds already face pressures from habitat loss, pollution, and climate change (Kirby et al. 2008). Mortality associated with aquaculture infrastructure may represent an additional anthropogenic threat in coastal ecosystems.

To address this issue and reduce harm to birds, aquaculture farm owners may implement various mitigation measures. These can include implementing net designs that reduce the risk of bird entanglement. Using larger mesh sizes or positioning nets below the water's surface are examples of such measures. Farms can use scare tactics, such as noise-makers, reflective materials, or the presence of guard dogs, to deter birds from approaching aquaculture

ponds or structures. Continuous monitoring of bird interactions with aquaculture farms can help farm managers make informed decisions and implement appropriate mitigation measures. Research into the behavior of local bird populations can also inform management strategies. Some regions may have regulations in place to address the interaction between birds and aquaculture farms. These regulations may specify certain practices or measures that farms must follow to minimize negative impacts on wildlife.

Deceased birds suspended in the nets of aquaculture farms. © Krunal Trivedi.

A deceased Pond Heron entangled in the net, suspended by its neck. © Hiren Patel.

Aquaculture is an important economic activity in coastal Gujarat; however, its infrastructure can unintentionally affect local wildlife. Observations from aquaculture farms in Surat highlight the occurrence of incidental mortality of waterbirds due to entanglement in protective netting systems. These incidents demonstrate the need for greater awareness and implementation of mitigation strategies that reduce wildlife mortality while maintaining aquaculture productivity.

Balancing aquaculture development with biodiversity conservation will require collaborative efforts among aquaculture operators, conservation organizations, and regulatory agencies. Further systematic studies are needed to quantify the scale of bird mortality and develop effective, wildlife-friendly aquaculture practices.

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