

**STATUS OF FRESHWATER RESOURCES OF CENTRAL
GUJARAT WITH SPECIAL REFERENCE TO FISH
DIVERSITY AND PARASITOLOGY**

SYNOPSIS

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DOCTOR OF PHILOSOPHY



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INTRODUCTION

India is one of the world's mega biodiversity countries, ranking ninth in terms of freshwater mega biodiversity. In 2006, global catch fisheries output was around 82 million tonnes from marine waters and a record 10 million tonnes from inland waters. India has significant aquaculture growth potential. The country has a 7,517-kilometer-long coastline and a 195,210-kilometer-long river and canal system that includes 14 major rivers, 44 medium rivers, and several small rivers and streams. Furthermore, 2.36 million hectares of pond and tank resources are predicted. These freshwater resources provide as a heaven for a diverse, rich, and many rare and endemic fish fauna (Bhakta and Bandyopadhyay, 2008). Wetlands are among the most productive ecosystems on the planet, producing water and food for countless plant and animal species. Wetlands provide numerous socioeconomic benefits, and if the system is adequately managed, capture and culture fishing activities may be carried out efficiently in these types of water-logged sites. Wetlands provide an important source of water not only for groundwater recharge but also for a variety of other activities such as laundry and cattle bathing. In India aquaculture practice has developed from extensive to intensive level mainly by increasing the stocking and by changing the supplementary feed management (De Jong, 2017). At present the Indian aquaculture production has reached to 3.9 million tons. Moreover, India has abundant fresh water and brackish water resources and there is a considerable scope for improving aquaculture production.

There are around 21,730 fish species in the globe, with Indian waters hosting 11.7% of them. There are 73 (3.32) species found in cold freshwater regimes, 544 (24.73%) in warm freshwater regimes, 143 (6.50%) in brackish water, and 1440 (65.45%) in marine environments out of the 2546 species known to date. The economic production perspective has been used to assess India's freshwater resources. They will receive sewage and industrial waste, provide irrigation, urban-industrial water supply, or hydropower, and may also produce edible fish (Bhakta and Bandyopadhyay, 2008).

Gujarat is one of the leading aquaculture states in India. According to a report by the Government of Gujarat's Department of Fisheries (Muniya *et al.*, 2019), 4.10 lakh ha of water area is suitable for aquaculture. According to a survey of the literature, several researchers have examined the taxonomy, biodiversity, and distribution of freshwater fishes from various rivers in India. David (1963) from the Godavari and Krishna rivers, Menon (1999) from the Himalayan rivers, Jayaram (2010) from the Cauvery river, Jadhav *et al.*, (2011) from the Koyana river, Kharat *et al.*, (2012) from the Krishna river, Sheikh (2014) from the Pranhita

river, Bhakta et al., (2019) from Narmada river and others. Gohil and Mankodi (2007), reported 26 species of fish from the downstream zone of the Mahisagar River in Gujarat, belonging to 3 orders and 12 families (Shinde *et al.*, 2009).

In developing countries, fisheries and aquaculture play a vital role in ensuring food security and offering alternative livelihoods. Aquaculture is the fastest expanding sector of the food production sector, accounting for 52% of fish for human consumption. Aquafarming has potential for growth in India, owing to increased awareness among farmers and entrepreneurs about the benefits of aquaculture and the growing demand for food production (O' Sullivan, 1992). With nearly 2,400 species, Cyprinidae, also known as carps, is the biggest family of freshwater fishes. Indian Major Carp (IMC) is considered to be the major aqua-crop species in tropical countries, contributing to about 97% of the total freshwater aquaculture production throughout India. The Indian Major Carps (IMCs) are fastest growing fishes reared in the artificial and natural ponds fertilized with organic and inorganic manures. Farmers usually rear these three species Catla, Rohu and Mrigala for 3 or 4 years in polyculture in static water earthen ponds (FAO, 2001). Indian major carps Catla (*Catla catla*), Rohu (*Labeo rohita*) and Mrigal (*Cirrhinus mrigala*) as well as three exotic carps silver carp (*Hypophthalmichthys molitrix*), Grass carp (*Ctenopharyngodon idella*) and Common carp (*Cyprinus carpio*) form the basis of carp culture systems (Talwar and Jhingran *et al.*, 1991).

Disease has emerged as a significant barrier to the cultivation of many aquatic species. Traditional treatments, synthetic chemicals, and antibiotics have been used to control disease in the aquaculture business (Bondad-Reantaso *et al.*, 2001; Sahu *et al.*, 2008). The disease is becoming a major impediment to the cultivation of many aquatic species. Disease is a major cause of fish death, especially in young fish. They have become an important obstacle to aquaculture output and commerce, negatively impacting the country's socioeconomic situation. Fish that can reduce the effects of diseases and parasites through behavioural or biochemical means have a reproductive advantage (Sarma *et al.*, 2012). Correct early pathogen identification, as well as an understanding of pathogenic processes, are critical for disease management in aquaculture. Among the diagnostic tools available, electron microscopy (EM) and standard histology techniques continue to be the most significant for determining pathogen etiology during illness conditions.

The physicochemical condition of water has been proven to have a major influence on fish health and disease development, primarily on fish resistance to pathogens and parasite fauna

(Plumb *et al.*, 1973 and Hossain *et al.*, 2009). Water quality degradation is the primary cause of the proliferation of pathogenic organisms known to influence carp growth and induce illness development. As parasitic diseases, this disease encompasses protozoan, viral, and bacterial infections, among others (Toor *et al.*, 1983). Protozoan illnesses are more harmful in that they cause abrupt mortality of the host fish as well as spreading and harming livestock affecting the aquaculturists' economy. In contrast to bacterial and parasitic diseases, only a few fungal species have been identified as pathogenic to fish. Whereas parasites are most commonly found on the host fish's exterior surface, they have also been observed parasitizing in the mouth (replacing the tongues, for example, the Cymothoids: Isopods) and gill arches, generating pressure on the gill surface and so decreasing the efficiency of respiration. Although the infestation did not result in immediate death, it did interfere with the normal growth of the host fish and most likely contributed to the high levels of secondary infections (Govindan and Ravichandran *et al.*, 2016).

The current study focuses on the number of water sheets that are suitable for aquaculture practices with their Ichthyofaunal diversity, which outnumbering the total number of ponds in the study area, as well as an inventory of fish disease and parasitology.

REVIEW OF LITERATURE

Biodiversity is an essential component of ecosystem functioning and defines its resilience to various stresses, yet it is declining globally. If we want to maintain or manage biodiversity, we must first understand the species involved, their distribution, habitats, ecology, and so on. The first step towards conservation is being able to identify all species that occur in a given area unambiguously. Exotic invasions are frequently cited as one of the leading causes of global biodiversity loss, although the mechanisms and consequences of species invasions may differ across ecosystems, taxa, and spatial scales (Hooper *et al.*, 2005). Competition from invasive species can act as an additional filter for native species, sometimes stronger than environmental gradients. Exotic species are a major contributor to the Mediterranean region's loss of biological diversity, particularly in freshwater habitats. The functional structure of Mediterranean freshwater fish communities is relatively uncharted, and an ecological trait characterization of native and exotic fish species has only been recently defined for some areas. Finally, this allows for more investigation into the relationships between biological invasions, functional diversity, and the environment (Milardi *et al.*, 2019). However, invasions appear to

be a major cause of biodiversity loss in some systems. According to a correlative analysis, introduced species, rather than habitat change, are the principal cause of population decreases and extinctions in California freshwater fishes (Light and Marchetti, 2007).

Inland waters and freshwater biodiversity are a rich natural resource in terms of economics, culture, aesthetics, science, and education. Conservation and management of these species are vital to the interests of all humans, nations, and governments. Throughout the world, streams and rivers face a variety of environmental issues, the majority of which are caused by anthropogenic activity in their catchment areas. The Indian contribution to the global fish community is approximately 3500 species, of which 2500 have been recorded. The Indian species account for around 8.9% of all known fish species worldwide (Jayaram,1999; Kar et al.,2003). In terms of biological resources, India is one of the 17 mega biodiversity hotspots, accounting for 60-70% of total worldwide biodiversity and ranking third in total fish output, accounting for 11.72% of total global fish biodiversity. Fish diversity and distribution have been intensively examined in the Kerala region of the Western Ghats (Vijaylaxmi *et al.*, 2010). There are 930 freshwater species in India, out of a total of 2500. In an annual report by the Zoological Survey of India, Devi and Indra (2012) identified 667 species classified into 12 orders, 35 families, and 149 genera (Mankodi, 2018). The study on Anjanapura reservoir in Karnataka found 25 species of fish belonging to four orders and nine families. 14 fish species belong to the Cyprinidae family, three to the Siluridae family, and one each to the Bagridae, Claridae, Heteropneustidae, Ambassidae, Gobidae, Channidae, Mastacembelidae, and Notopteridae (Bhakta *et al.*, 2019). In total, 140 fish species have been identified in the Ganga. However, it has been confirmed that over 69 fish species exist in the comparatively short section of the Ganga River between Kanpur and Ballia. The study of the alien species' impact has revealed a consistent drop in the capture of local fishes, particularly Indian major carps and others. The risks and ecological implications of foreign fishes in the Ganga River are especially concerning considering global concerns about fish biodiversity conservation. Introduced alien fish have resulted in significant community alterations in aquaculture and other naturalized ecosystems (Atul *et al.*, 2013). According to the Zoological Survey of India's annual report, Devi and Indra (2012), about 120 freshwater fishes may be found in Gujarat state. Gujarat is home to 96 freshwater fishes, according to authors Dholakia A. D., 1986; Patel M. I., and Chhaya N. D's 1980. The other main freshwater fish literature resource available is work done by Goswami and Mankodi (2010) and Gohil and Mankodi (2007) on the Nyari-II reservoir and Mahi River, where they identified fifteen and twenty-six species of fish, respectively (Mankodi,

2018). During the investigation period (July 2014 - June 2015), 85 finfish species from 65 genera, 35 families, and 12 orders were discovered within a 72-kilometer stretch of the Narmada estuary region (Bhakta *et al.*, 2019). However, many species remain to be dealt with in terms of molecular aspects.

As freshwater aquaculture grows in India, it is necessary to check the cultures for infectious and parasitic illnesses. The farmers' interviews revealed that they were tormented by white spot problems in the skin caused by *Ichthyophthirius spp.* Mostly in all season, and the value of the fish decreased when the white spots appeared. Another issue they encountered was the inability of the fish to grow due to intestinal parasites. The occurrences of the pathogens were high in summer and autumn months and low in winter months (Chanda *et al.*, 2011). Suitable preventive and control methods must be developed based on the occurrence of diseases and the economic losses they cause (Solanki *et al.*, 2016). Contaminated aquaculture units have resulted in lower aquaculture productivity, disease outbreaks in aquaculture organisms, economic loss, human health issues, and contamination of natural water bodies such as oceans and rivers when discharges from aquaculture units are released. Vibriosis, skin ulceration, albino derma, erythroderma furunculosis, and vertical scale disease are all frequent bacterial infections in Indian ponds (Chavda, 2012).

AIM AND OBJECTIVE

Aim:

To study the Freshwater resources of Central Gujarat with special reference to Ichthyofaunal diversity and Parasitology

Objectives:

1. To study the Inland water resources of Central Gujarat.
2. To study the Diversity of freshwater fishes along with their fishery and Aquaculture aspects.
3. To prepare an inventory on fish Parasites and its management.

MATERIALS AND METHODS

Study area

The study area consists of the 6 districts of central Gujarat.

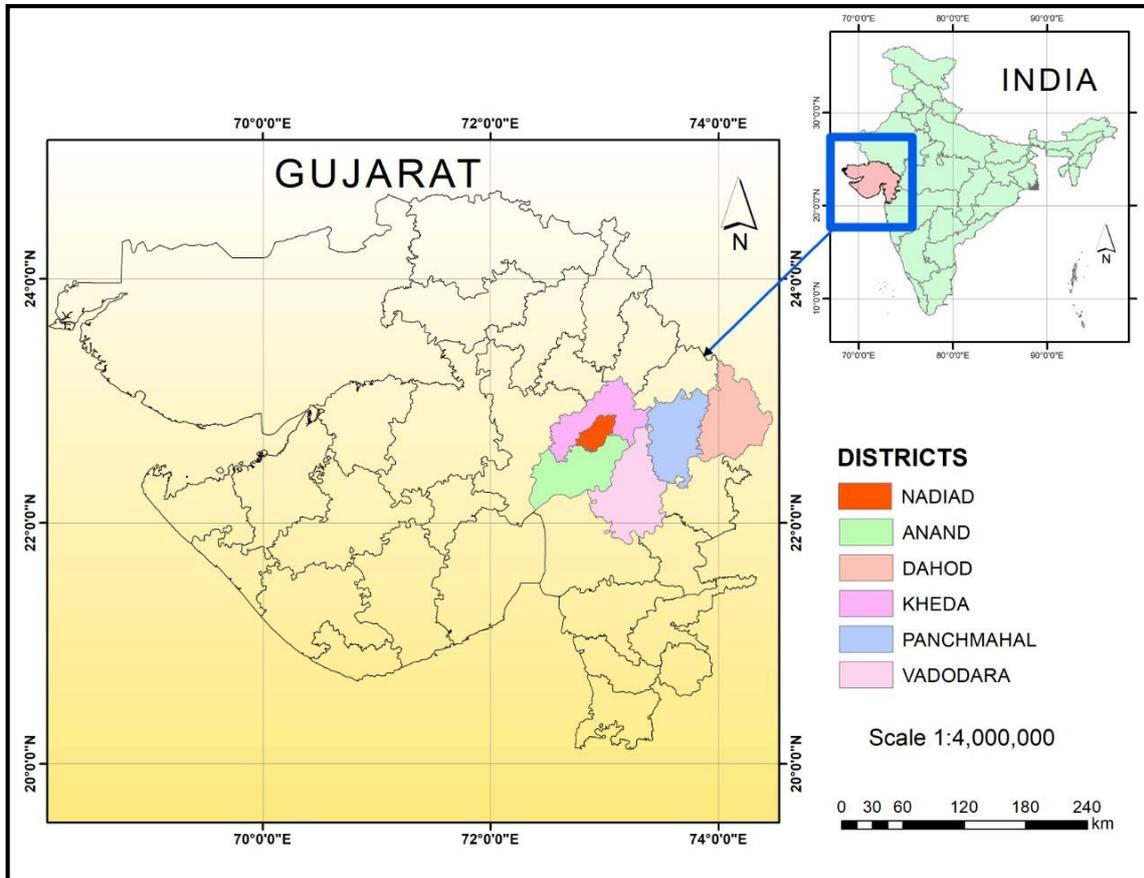


Fig. 1. Study area Map

- Largely covering the area between Mahi and Narmada rivers. Out of the total area, salient sites were selected for detailed study and sample collections.

For the first objective, the number of inland water resources (water sheets) data of the Central Gujarat area was collected from the Government Fisheries Department and Google maps. For study sites, six districts (Anand, Nadiad, Kheda, Vadodara, Panchmahal, Dahod) of the central Gujarat area were selected. The Watersheets data was then primarily surveyed and confirmed for its aquaculture use. An Excel sheet was formed of each districts containing the details of the Watersheets with their Names, Geolocations, Area (in hectares), their potential of ongoing Aquaculture activity or not. Then the Watersheets were classified and distinguished according to their area as large freshwater lakes, medium size lakes and small lakes. Also a list of the Aquaculture and Non-Aquaculture ponds is prepared with the aquaculture species diversity.

Secondly, the fishing activity was carried out for sampling of fishes and for diversity study, 3 samples of each species were collected and rough identification was done on the spot, based on morphology. Here random sampling method is used as the different species are collected. The samples were then brought to the laboratory for further identification studies. Immediate images of each fish were taken, and the fish are preserved at -20°C. The Morphometric and Meristic features were noted for species level identification, using appropriate identification keys by Day Francis (1994) and FishBase (Froese and Pauly, 2023). Further, Molecular confirmation was done using Phenol-Chloroform method for DNA extraction, followed by Sanger Sequencing. Phylogenetic relationship will be established. A fact sheet containing all details related to biology and fishery aspects of identified fishes has been created.

For the third objective, the fish diseases and parasitology study, the sampling sites were visited and the fish samples were analyzed for were examined for Ecto-parasites. Gills arches were examined individually immediately after the fish are taken out of water. The buccal cavity, opercula, and eyes were examined separately. The external surfaces of the internal organs were inspected for free or encapsulated parasites, and then separated and examined individually. The digestive tract was opened longitudinally to examine for Endo-parasites. Infections parameters that have been utilized are those proposed by Bush *et al.*, 1997, that is, prevalence (% infected) and mean intensity of infection (number of parasites per infected fish). Event of fish diseases or mortality due to such reasons was documented with required material and information. The parasites samples were then preserved some in 70% alcohol (for molecular confirmation) and others in 10% formalin. The further species confirmation of the parasites was done by using specific primers. The different kinds of endo- and ecto-parasitic diseases according to my findings were further referred too.

RESULT AND DISCUSSION

Objective 1

The Central Gujarat region includes the districts of Kheda, Anand, Vadodara, Ahmadabad, Gandhinagar, Panchmahal and Dahod. The total geographic area of the region comprises 34.13 lakh hectares. From which, we have selected six districts as Anand, Nadiad, Kheda, Vadodara, Panchmahal and Dahod for the study area. The study sites were surveyed for the data collection of ponds, lakes, dams or reservoirs, with their geolocations and area (in hectares) along with

their Aquaculture status. For each districts, the total inland surface water area was calculated. The mapping of the study area along with the ponds and their aquaculture status were depicted. The ponds were then distinguished on two bases; Firstly, depending upon their sizes into small, medium or large and secondly on their aquaculture and non-aquaculture status.

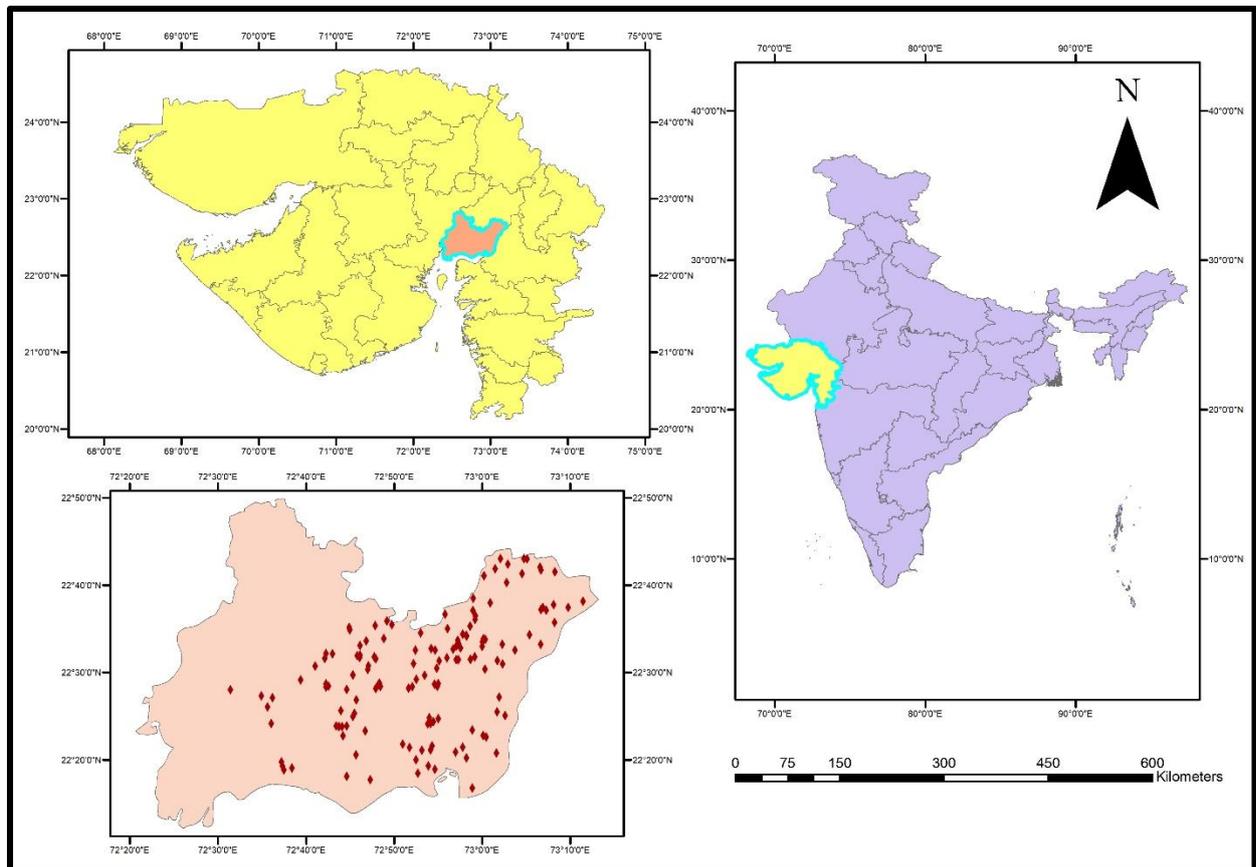


Fig. 2. The map showing the Anand districts total number of pond

Here, the study site for Anand district is shown. Anand is located at 22.57°N 72.93°E. It has an average elevation of 39 m (128 ft.). The district consists of 145 ponds of different sizes, belonging to large, medium and small categories. There are 94 ponds continuing with the aquaculture activity of IMC (Indian Major Carp) fishes, whereas the remaining 51 ponds didn't have any aquaculture activity and some were beautified by the state central government under smart city Project.

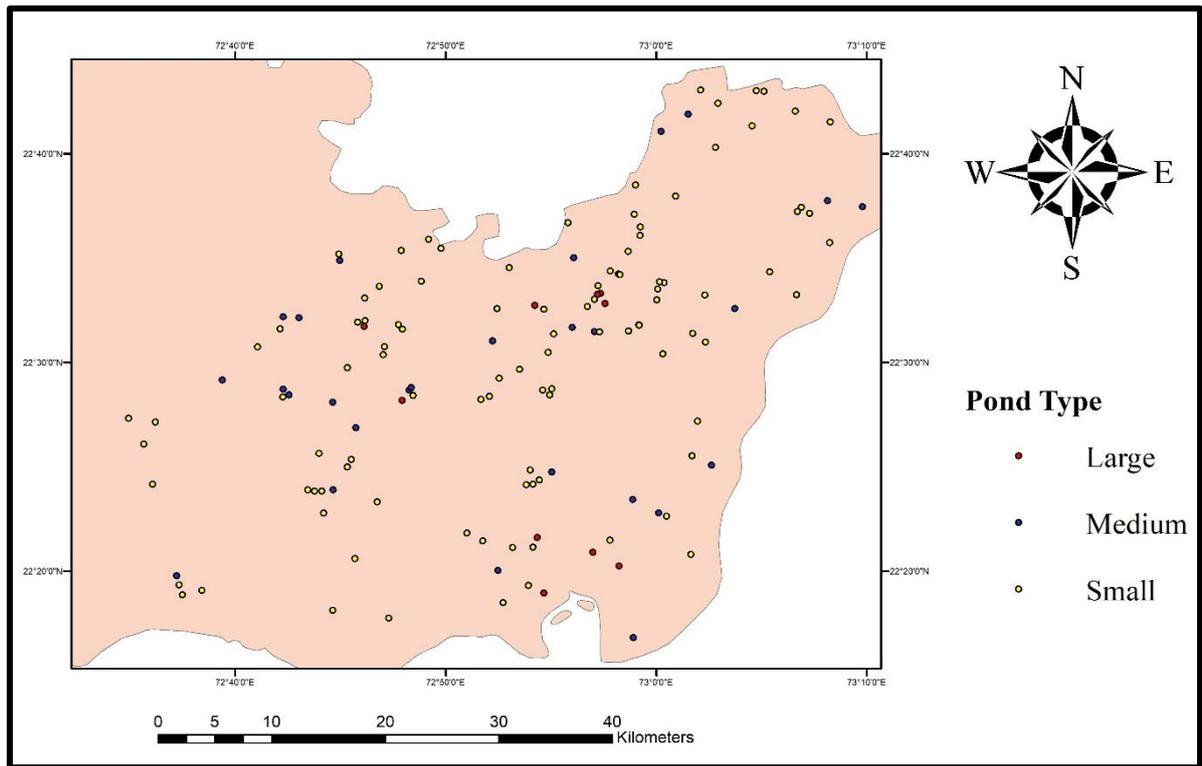


Fig. 3. Map depicting Classification of ponds based on Area (Hectares)

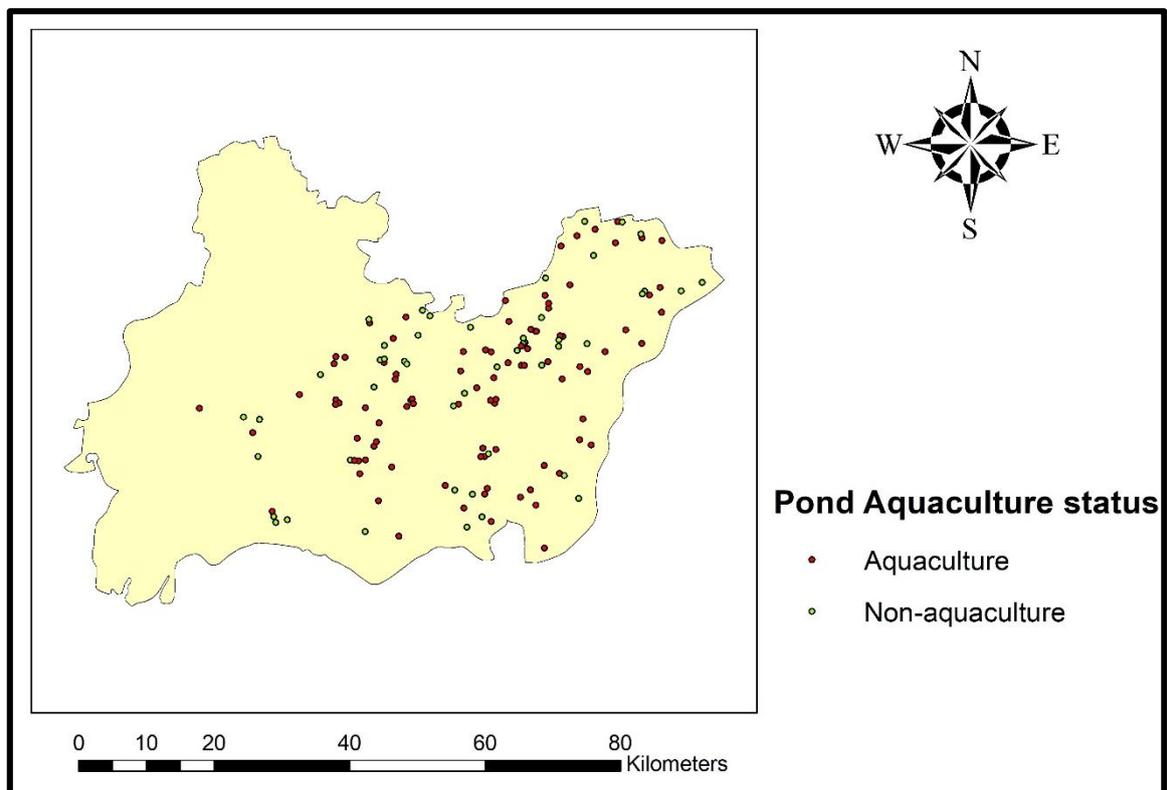


Fig. 4. Map showing the Aquaculture status

Further the data compilation will be done of total study area for depicting the total inland surface water cover area by Central Gujarat. The diversity of the freshwater resources was also noted for the further objective, along with sample collection for the Molecular species confirmation.

Objective 2

A total of 39 species are recorded from the different freshwater resources belonging to 11 orders, 19 families and 35 genera. Among all, Cypriniformes was dominated by 4 families and 17 species, followed by Siluriformes, consisting of 4 families and 6 species and Anabantiformes with three families and four species. Ovalentaria, Cichliformes, Osteoglossiformes orders were represented with one family each and 3, 2, 2 species respectively. Order Gobiiformes, Beloniformes, Synbranchiformes, Characiformes, Carangaria represented with one family with one species in each. The fact sheet of each species with its biology is been prepared. The molecular confirmation of one species *Parambassis ranga* has been obtained, which is further uploaded on NCBI with accession number [OP856488](#) and [OP856489](#) (Forward and Reverse sequence), respectively. These are the mitochondrial Cytochrome C Oxidase subunit I (COX1) gene. The molecular confirmation of the other species is in process.

Objective 3

In India, fish culture is a well-established hobby and industry. The knowledge of and experience with parasites that impact fish health, growth, and survival have expanded along with interest in fish culture. Fishes are potential hosts for a wide variety of parasites. Parasites are common in small quantities and probably cause little harm. In general, it is believed that the parasite ecology of marine fishes is more diverse and abundant than that of freshwater species (Sindermann, 1990; Rohde, 1993). All parasites, however, have a high capacity for reproduction and in the right circumstances, could easily outnumber fish in a tank or pond. Parasites can be largely divided into two types as Endo- and Ecto-parasites. Endoparasites are located inside tissues and organs, whereas Ectoparasites are found on external surfaces like the skin, fins and gills. The presence of endoparasites in aquarium fish is rare. However, there is a large variety of intestinal worms, blood parasites, and other parasites that can enter different organs and tissues. Many are rare in pond/aquarium fish because they need an intermediate host, such as snails, birds, or the introduction of an infected fish. Several clinical signs could point to the presence of endoparasites. Microscopic examination of tissues is frequently

necessary for the identification of sporozoan and protozoan endoparasites (Chanratchakool *et al.*, 1994). Ectoparasite includes various types of crustaceans, worms, and insects. Some common ectoparasites Fish lice, Gill flukes, Fish leeches, Anchor worms, etc. They can be easily observed under microscope for identification.

The ectoparasites observed during the study period were, the Fish Lice (*Argulus*) and the Anchor worm (*Lernaea* spp.), from freshwater and Aquarium fishes were as a few Isopods were found from the Marine fishes.

Few are described below:

1. Fish lice (*Argulus* spp.): Fish lice are crustacean parasites that attach themselves to the body of the host fish using their specialized appendages. *Argulus* is a Branchiuran parasite that causes severe problems in aquaculture throughout the world. *Argulus* infestation has been reported from almost all the major aquaculture zones in India. Conventionally, *Argulus* spp. are identified through the morphological descriptions (Tandel, *et al.*, 2021). Morphologically, the parasite had branched dorsal ridges of the carapace, clubbed shaped anterior respiratory area, curved shaped posterior respiratory area, three relative sharp teeth and chitinous shovel peg on the fourth swimming appendages. Females *Argulus* sp. were larger in size than males in their length and width. They feed on the fish's blood and tissues, causing irritation, inflammation, and secondary infections. The morphological evidences revealed that the species is *Argulus japonicus* and further species confirmation is in process.
2. Anchor worm (*Lernaea* spp.): Anchor worms are copepod parasites that burrow into the fish's skin and attach themselves with a hook-like structure. The female has an elongated, tubular body, which is differentiated into a cephalothorax, the remaining thoracic region and slightly broadened abdomen. Dorsally a distinct round head is situated between the unramified processes, with the antennae and antennules situated antero-laterally on the head. The female is attached to the host by means of large anchors. The anchors (a series of outgrowths of the posterior, cephalothoracic region) are cylindrical processes, of which a pair of ramified, Y-shaped processes form dorsally, and a second, unramified pair form ventrally. Male *L. cyprinacea* have a narrower urosome and genital segment than the female. They are smaller than the pre-metamorphosis females, about 1.1 mm in size (Robinson & Avenant-Oldewage, 1996). In the infected fish, circular ulcers surrounded by fibrinous granulomatous tissue, which later developed into a nodule were observed around the site of parasite attachment. They can cause tissue damage, ulceration, and secondary

infections. The morphological evidences revealed that the species is *Lernaea cyprinacea* and further species confirmation is in process.



Fig. 4. A. *Argulus spp.* and B. *Lernaea spp.*

Fish with these parasites may exhibit a variety of symptoms, including respiratory distress, decreased appetite, weight loss, lethargy, skin discoloration, fin erosion, and increased susceptibility to other illnesses. Fish that are infected may display altered behaviour, such as more frequent scratching against objects or flashing actions. Fish health management techniques, such as good sanitation habits, regular monitoring, and suitable treatment options, can be put into place to avoid and manage parasite infestations. To reduce the parasite burden and enhance fish health in wetland environments, these techniques may involve the use of chemical treatments, biological control agents, or environmental alterations. It's worth noting that the specific prevalence and distribution of parasites can vary across different wetlands in India and may depend on factors such as water quality, fish species present, and environmental conditions.

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CONFERENCE PRESENTATIONS

1. Oral presentation on “A case report of *Branchiomyces sp.* infection in carp (*Catla catla*) from Vadodara, Gujarat” at National Conference, Present Day Biology: Recent Advancements in Biological Sciences (Virtual) – 10th & 11th December 2021, Theme - Animal Science. Organized by St. Xavier’s College (Autonomous), Ahmedabad, Gujarat, India.
2. Oral presentation on “A Report on the occurrence of Cymothoids, Parasitizing the fishes from the fish market of Vadodara, Gujarat, India” at the International Conference on Restore Our Earth – ICORE 2021: Think, Act and transform (Virtual) – 21st & 22nd April 2021. Organized by PG & Research Department of Environmental Sciences, Bishop Heber College, Tamil Nadu, India.
3. Poster presented on “Survey of the Water sheets of Vadodara for their Feasibility for Freshwater Aquaculture” at the International Science Symposium 2021, on Recent Trends in Science and Technology (Virtual) – 8th & 9th April, 2021. Organized by Christ College, Rajkot, Vidya Niketan, Saurashtra University, Rajkot 360005, Gujarat, India.

PAPER PUBLISHED IN CONFERENCE PROCEEDING

1. Sheikh, G. F. & Mankodi, P. C. (2022). A case report of *Branchiomyces sp.* Infection in carp (*Catla catla*) from Vadodara, Gujarat. In National Conference on Present Day Biology: Recent Advancements in Biological Sciences, 34–39.

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1. Sheikh, G., Lende, S., Vasava, R., Bhadesiya, C. & Mankodi, P. (2023). Occurrence of *Argulus* (Crustacea: Branchiura) in fishes of the freshwater reservoirs and aquarium shops of Vadodara, Gujarat (India). *Ecology, Environment & Conservation*, (29, April Suppl. Issue), 181-185.
2. Sheikh, G. F., Bannelkar, P. & Mankodi, P. C. (2022). The Occurrence and Redescription of Cymothoids (Wagele, 1989) parasites in commercially available fishes from markets of Vadodara, Gujarat, India. *International Journal of Entomology Research*, 7(1), 49-54.

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