In conclusion, this study conducted along the Gujarat coast documented seven mullet species, with three species — *Mugil cephalus*, *Planiliza tade*, and *Planiliza subviridis* — identified using molecular techniques. Notably, *P. subviridis* was barcoded for the first time in Gujarat state. The quality of genomic DNA allowed for successful amplification, resulting in COI sequences with high similarity (95-100%). Analysis of nucleotide frequencies revealed distinct composition, and Maximum Likelihood estimation indicated an overall mean pairwise distance of 2.97±0.73 for COI.

Phylogenetic analysis highlighted the evolutionary relationships among mullet species, with *P. subviridis* forming a monophyletic group with *M. seheli* and *M. cephalus* displaying paraphyly with *P. tade*. The resolved phylogeny was obtained as (*Oedalechilus labiosus* + *Osteomugil cf. perusii* + (*Planiliza subviridis* + *Moolgarda seheli* + (*Liza parsia* + *Liza klunzingeri* + (*Planiliza tade* + *Mugil cephalus* + (*Planiliza macrolepis* + *Moolgarda perusii* + (*Rhinomugil corsula* + (*Chelon carinatus* + (*Valamugil buchanani* + *Minimugil cascasia*)))))))). This study provides valuable insights into mullet species diversity and genetic structure along the Gujarat coast, contributing to our understanding of marine biodiversity and informing conservation and management strategies.

Comparing the physico-chemical parameters across all study sites – Diu, Bharuch, Bhadbhut, and Ambetha – can provide insights into the suitability of each location for aquaculture of *M. cephalus*: Diu and Ambetha have relatively higher pH values compared to Bharuch and Bhadbhut. Higher pH levels are generally favourable for aquaculture as they support optimal growth and survival rates of aquatic organisms, including *M. cephalus*. Bharuch and Bhadbhut exhibit slightly higher average temperatures compared to Diu and Ambetha. *M. cephalus* thrives in temperatures ranging from 20°C to 30°C. While all sites fall within this range, lower temperatures, as observed in Diu, may be more suitable for optimal growth. Diu has significantly higher salinity levels compared to the other sites, which could potentially affect the osmoregulation and health of *M. cephalus*. Bharuch and Bhadbhut have lower salinity levels, which may be more suitable for this species, as it prefers brackish water habitats. Diu and Ambetha have higher average DO levels compared to Bharuch and Bhadbhut. Adequate DO levels are crucial for the

respiratory function and overall health of *M. cephalus.* Therefore, Diu and Ambetha may be more suitable in this regard. Diu and Ambetha exhibit higher TDS levels compared to Bharuch and Bhadbhut. While some level of TDS is tolerable for *M. cephalus*, excessively high levels can adversely affect water quality and fish health.

Correlation analyses revealed significant relationships between physico-chemical parameters. For instance, pH exhibited positive correlations with DO and negative correlations with salinity at Diu Lagoon. Conversely, at different sites of the Narmada Estuary, pH displayed varied correlations with salinity, temperature, and DO, indicating complex interactions within these ecosystems. Considering these factors, Diu appears to be the most suitable site followed by Ambetha, Bhadbhut and Bharuch for aquaculture of *M. cephalus* among the study locations. Its relatively higher pH, lower temperature, and adequate levels of DO make it conducive for the growth and survival of this species. However, careful monitoring of salinity levels and mitigation of any potential environmental stressors would be essential for successful aquaculture operations.

Linear regression analysis on log-transformed data from all populations and research sites yielded highly significant results ($p < 0.01$), except for the male population (Dec-21 to Nov-22), which showed significant results ($p \leq 0.05$). The 'b' values for males and females in Diu lagoon and males in Bharuch were not significantly different from the cubic value expected by isometry ($H_0 = 3$), indicating negligible negative allometric growth. However, females in Bharuch, males and females in Bhadbhut, and males and females in Ambetha in the Narmada estuary exhibited significantly different 'b' values, suggesting negative allometric growth.

The combined populations of Diu lagoon did not significantly differ from the expected cubic value, indicating minimal negative allometric growth during both years of sampling. In contrast, the pooled populations of Bharuch, Bhadbhut, and Ambetha in the Narmada estuary showed a significant difference, indicating negative allometric growth. The growth conditions were influenced by various parameters including gonad development, sex, stomach fullness, health, season, habitat, temperature, salinity, and nutrition. The slope (b) of the LWR in the study area generally aligned with the expected range of 2.5–3.5, except for the female

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population in Bharuch and populations in Bhadbhut, which exhibited highly negative growth.

The coefficient of determination (R^2) varied between 0.93 and 0.97 in Diu lagoon, indicating a strong correlation in the LWR. R^2 values ranged from 0.60 to 0.85 in Bharuch, 0.73 to 0.92 in Bhadbhut, and 0.86 to 0.95 in Ambetha, indicating significant associations between length and weight. Overall, the study suggests that the relationship between the length and weight of *M. cephalus* is strongly associated and significant, with Diu lagoon exhibiting the most favourable correlation, followed by Ambetha, Bhadbhut, and Bharuch.

The study evaluated Fulton's *K* to assess the well-being of male, female, and overall populations of *M. cephalus* in Diu lagoon and the Narmada Estuary (Bharuch, Bhadbhut, and Ambetha). The mean *K* values for male *M. cephalus* ranged from 0.95 to 1.09 in Diu lagoon, Bharuch, Bhadbhut, and Ambetha during both study periods. Similarly, for female *M. cephalus*, the mean *K* values ranged from 0.99 to 1.13 across the same habitats and timeframes. A *K* value close to 1 signifies optimal fitness and well-being in fish. Male *M. cephalus* exhibited superior well-being in Diu, followed by Bhadbhut, Ambetha, and Bharuch. Likewise, females showed the highest well-being in Diu, followed by Bhadbhut, Ambetha, and Bharuch.

Both males and females displayed seasonal variations in *K* values, with increases observed from November to March/April and slight declines in September. Significant decreases were noted from May to August. The highest *K* values were observed in Diu for both males and females. Assessing the overall populations, Diu lagoon exhibited the highest average *K* values, followed closely by Ambetha, Bharuch, and Bhadbhut. These findings suggest that males generally had better conditions compared to females, and *M. cephalus* found in coastal areas like Diu and Ambetha exhibited superior well-being.

In males, Diu had the lowest average I_g levels (2.71 to 3.27) during both study periods, while Ambetha consistently had the highest levels (4.02 to 3.01). Bharuch and Bhadbhut showed intermediate I_g level. In females, Diu exhibited relatively lower I_g levels (7.87 to 8.85) compared to the other sites, while Bhadbhut

consistently had the highest levels (8.31 to 9.15). Bharuch and Ambetha had intermediate I_g levels. In males, Ambetha displayed the highest average I_h levels (1.90 to 2.22), followed by Diu, Bharuch, and Bhadbhut. The differences between sites were more pronounced during the second study period. In females, Diu had the highest average I_h levels (1.74 to 2.07), followed by Ambetha, Bhadbhut, and Bharuch. The differences between sites were consistent across both study periods.

Considering I_g, Ambetha appears to be the most suitable site due to consistently high levels, especially for males. However, for females, Bhadbhut shows the highest I_g levels. For I_h, Diu seems to be the most suitable site as it consistently exhibits higher levels, especially for females. I_g levels showed fluctuations over time, with certain months exhibiting lower or higher levels across all sites. However, Ambetha consistently showed higher I_g levels compared to other sites. I_h levels also varied over time, with Diu consistently showing higher levels, especially for females.

In moisture content analysis, both the detailed analysis and the discussion highlight the variability of moisture content across seasons, with higher levels during spawning and post-spawning periods. Consistently, females exhibited higher moisture content compared to males, indicating potential differences in physiological processes between the sexes. The discussion aligns with the findings by attributing the fluctuations in moisture content to changes in environmental conditions, particularly during the spawning season. The detailed analysis emphasizes the variability of ash content among study sites, sexes, and seasons. Females generally exhibit higher ash content, with fluctuations corresponding to reproductive cycles.

Present findings highlight significant variations in lipid content across tissues, sexes, and seasons, with liver tissues consistently exhibiting higher lipid content. The detailed analysis identifies Bhadbhut as having the highest lipid content for both males and females, aligning with the discussion's emphasis on the role of lipids in gonadal development and reproductive cycles. The variability in protein content across tissues, sexes, and seasons was showing higher levels during post-spawning and winter months. Liver tissues consistently show higher protein content, with Bhadbhut demonstrating the highest protein content for

both males and females. The fluctuations in carbohydrate content across tissues, sexes, and seasons, with liver tissues generally exhibiting lower carbohydrate content compared to muscles.

In terms of aquaculture potential, the study found that a salinity range near 20ppt provided optimal conditions for the growth and survival of *M. cephalus*. The proximate content analysis revealed that tank 2 with a salinity of 20ppt exhibited the maximum conversion of food, along with favourable levels of moisture, ash, lipid, protein, and carbohydrate content.

Overall, these findings underscore the importance of understanding the proximate composition of fish species in aquaculture settings, as it directly impacts their growth, survival, and nutritional value. Furthermore, optimizing environmental conditions, such as salinity levels, can significantly influence the overall productivity and success of aquaculture operations targeting *M. cephalus*.

Future Recommendations

❖ Present study provides the baseline data of the diversity and distribution of members of Family Mugilidae inhabiting in coastal areas of Gujarat.

❖ Being a complex monophyletic group, mullets require respective habitat based detailed investigation in morphology and molecular based identification.

❖ The length-weight relationship, condition factor, gonadosomatic index and hepatosomatic index data recorded in the present findings can be useful for the management of mullet fisheries in Gujarat state.

❖ The findings revealed that the growth and breeding seasons may vary according to habitats. Therefore, regional based aquaculture policies can be made.

❖ The biochemical findings will be helpful to estimate the nutritive values of *M. cephalus* and to enhance the aquacultural potential of this species. This study will emphasize the quality and longevity of *M. cephalus* which are essentials in aquaculture sector.

❖ Simultaneously, The Indian Council of Agricultural Research (ICAR)-Centre for Biotechnology Information (CIBA) has developed a hatchery for raising grey mullet fingerlings. The hatchery has a production capacity of 2 million and is the first brackish water/marine finfish hatchery in India.

❖ Contemporary research on the ecological and biological aspects of mullets will eventually help in aquaculture development of this highly consumed and nutritive fish.