INTERTIDAL BIVALVE DIVERSITYAND FISHERY OF THE GOSTANI ESTUARY, BHIMUNIPATNAM, VISAKHAPATNAM, EAST COAST OF INDIA

ABSTRACT

The results of the present investigation revealed that the occurrence of 13 species belonging to class bivalvia were dominant taxa in the Gostani estuary. Out of 13 species 6 orders, 8 families, and 11 genera were observed from Feb 2023 to March 2024.The samples were obtained by handpicking, digging, and trawling with bare feet by fisher community.A field survey was conducted to collect data on mollusc species, stocks, distribution, and marketing. The bivalves were collected from the bycatch for identification, mostly based on shell morphology, hinge, interlocking dentition, etc., with reference to the standard literature In this present study data was collected and analysed from fishermen community and traders. The *Crassostrea madrasensis*was more dominant availability species, its contributes to highest collection 5.867 T/ year and 2.78T in Apr-23, followed by *Meretrix casta*2.78 T *Meretrix meretrix*1.18 T, *Anadararhombea 0.87, Tegillarcagranosa*0.759 and followed by other species. According to IUCN status 13 species contributed to 53.84% are not evaluated (NE), followed by data deficient (DD) with 30.76%,and least concerned 15.38%. The monthly available bivalves at Gosthani estuary the data was comparison for abundance. The results of ANOVA for p-value of 0.9746 indicate significant support for H0, which is accepted. The difference between the sample averages of all groups is not big enough to be statistically significant. The p-value equals 0.231 indicates a greater support for H0.

Key words: Bivalves, Taxa, Diversity, Quantification, Intertidal zone, Molluscan fishery, ANOVA

Introduction

Bivalvia are entirely aquatic animals and the second most speciose class in the varied phylum Mollusca. Molluscs in this class are soft, unsegmented, bilaterally symmetrical, and laterally compressed, with calcified valves on the left and right sides joined by hinge, ligament, and adductor muscles (Poutiers, 1998; Leal, 2002). Clams, mussels, and oysters are among the bivalves found across India's coastlines. The local population harvests clams and oysters for home consumption, forming a subsistence fishery. The shallow seas near Indonesia have the greatest diversity of world bivalves; the Indo-Pacific area is the richest province of bivalve diversity and distribution, with 3,300 bivalve species reported (Huber, 2015). Studies on marine bivalve molluscans, including their distribution, abundance, and diversity in various coastal settings, aid in discovering new locations for shellfish farming and detecting anthropogenic activities that make ecosystems vulnerable to deterioration. The shallow-water bivalve fauna of littoral and continental coasts is described as resilient and diversified (Parulekar, 1981). Molluscs remain a major fisheries resource along India's coastlines. These are necessary for nature's

nourishment and are employed in food applications such as ornamentation, chicken and fish feed, the lime and pharmaceutical industries, and so on (Jaiswar and Kulkarni, 2005). Local fishing populations rely on these molluscs for a living, with bivalves in particular being consumed by humans. They are high in protein, minerals, and glycogen and are easier to digest than other animal meals (Manotosh Das, 2017). In 1996, shellfish landings were around 11.4 million metric tons. Aquaculture involved 62 nations globally, compared to 114 in fisheries, resulting in 8.5 million metric tons of production (FAO statistics). Several studies have been conducted on the topography of the north Andhra Coast, which is distinguished by vast stretches of sandy shores, tidal creeks, and backwaters interspersed between sea cliffs and shingle-strewn beaches, providing a diverse ecological habitat for bivalves and other marine fauna. However, the north of coastal Andhra Pradesh remains undiscovered in terms of bivalve mollusk variety and distribution, particularly in protected environments like as estuaries, backwaters, and creeks.

Productivity range, shelf area, and salinity emerge as best predictors of the species richness. During a strong demand for shellfish, boats (Katlatheppa) with 2-3 persons were used for fishing. Women and young children hand-picked clams from the inshore waters. As a result, there is not an existing study that compiles current information on molluscan diversity in the Gostani estuary.As a result, the current study aims to investigate the richness of molluscan fishery in uncharted backwaters and the study gives baseline information on malacofauna, which can help researchers conduct additional studies on molluscs and manage resources sustainably in the Gostani estuary.

Materials and methods

The shoreline runs along the Gosthani estuary from Bheemunipatnam to Tagarapuvalasa, and particular sampling locations have been selected. Current study involves identification and quantification of bivalves in the study area. The samples were obtained from April 23 to March 24 by handpicking, digging, and trawling with bare feet by fisher community. Clams and oysters are often obtained by wading in estuarine shallow areas, mud flats, tidal flats, tidal creeks and channels, where the nets may be easily operated and the catch cleaned. Hammers were used to separate cemented species such as oysters, while burrowing animals were dug to remove muscular meat. Seasonal monsoons, strong cyclonic storms, excessive rainfall, and river run-off all influence the number of samples collected. All bivalve specimens were segregated from the collected molluscan sample, cleaned, and sun-dried. The individual number was calculated by counting the articulated valves while accounting for the disarticulated valves. The statistical analysis of the one-way ANOVA calculator incorporates the Tukey HSD test. Calculates the impact magnitude and verifies the assumptions (normality, equality of variance test). A field survey was conducted to collect data on mollusc species, stocks, distribution, and marketing. The bivalves were collected from the bycatch for identification, mostly based on shell morphology, hinge, interlocking dentition, etc., with reference to the standard literature available (Gravely, 1941; Hornell, 1949; Satyamurti, 1956; Apte, 1998, 2012; Poutiers, 1998; Leal, 2002; Vannucci, 2002; Huber, 2010, 2015), with the assistance of world.

Fig: 1. Sampleing and data collection at Gostani estuary

RESULTS AND DISCUSSIONS

The results of the present investigation revealed that the occurrence of 13 species belonging to class bivalvia were dominant taxa in the Gostani estuary. Out of 13 species 6 orders, 8 families, and 11 genera were observed from Feb 2023 to March 2024. In the current study, a list of taxa were compiled, including their order, family, genus, species, habitat, economic use and IUCN status were shown in Table 1& Plate 1.Among the 6 orders, the order Cardiida was observed to have the highest contribution to the species diversity (37.5% families, 45.45% genera and 38.46% species), followed by Siluriformes (12.5% families, 18.18% genera and 23.07% species), Veneroida (12.5% families, 9.09% genera and 15.38% species), the lowest was observed Ostreoida, Mytiloida and Nuculida (12.5% families, 9.09% genera and 7.69% species) in the Gosthani estuary (Table 2, Fig 2). The similar study was reported by Arathi et al. (2017) observed 200 marine bivalve species classified into three subclasses, 13 orders, 42 families, and 111 genera. Among the recorded bivalves, 30 are new from India and 26 are new to the West Coast. Darwin and Padmavathi (2017) found seven bivalves from five families in the Bay of Bengal, Prakasam district, Andhra Pradesh. According to Rajendar Kumar (2014), 10 gastropod species and 5 bivalves were found in the Coringa mangroves of the Godavari estuary habitat. Banerjee et al., (2015) found 17 dominating species in the molluscan ecosystems, divided into two major classes: Bivalvia and Gastropoda. Macro-benthic molluscan diversity in the estuaries of the eastern coast of the Indian subcontinent The current study focused on intertidal mudflats in four Indian maritime states: West Bengal, Odisha, Andhra Pradesh, and Puducherry. Sandhya Leeda et al. (2001) found 15 species of bivalves in intertidal environments along the Karnataka coast, and their abundance of molluscs was noticed in the post-monsoon season. According to

Rajendra and Sivaperuman (2000), 17 species of bivalves were recorded. Gastropods found in a variety of substrates, including rocks, mud, and sand, but most bivalves live in soft substratums and burrow on coral and rocks in India's North Andaman Island.Several workers contributed to increase the diversity of mollusks in Andhra Pradesh. Recent research on molluscan diversity in Andhra Pradesh's east coast merits special attention. Six gastropod species and three bivalves have been found in the Nuvvalarevu backwaters of Srikakulam district (Chakravarty and Uday Ranjan, 2014).

In this present study data was collected and analysed from fishermen community and traders are the*Crassostrea madrasensis*was more dominant availability species, its contributes to highest collection 5.867 T/ year and 2.78T in Apr-23, followed by *Meretrix casta*2.78 T *Meretrix meretrix*1.18 T, *Anadararhombea 0.87*, *Tegillarcagranosa*0.759 and followed by other species (Table 3 Fig 4).From February 2023 to March 2024, the total wet weight of bivalves was 11.76 T, the dry shell weight was 10.37 T, and the muscle weight was 2.32 T (Table 3, Fig 3). Bivalve harvesting is more conducive to the post-monsoon season, which lasts from November to May. Men and women collect bivalves from shallow locations and mudflats, whilst men harvest from deeper places. Deeper portions of the estuary have a higher concentration of bivalves than shallow regions and mudflats.Laxmilatha et al., (2011) assessed the bivalve fishing in the Bhimili Estuary from 2003 to 2010, finding that the overall bivalve output from 2003 to 2010 was 4.7 t, with an average annual production of 0.59 t. *M. meretrix* was the dominant clam species at the time, and overall output was 0.53 t, with an average annual landing of 0.07 t. The total clam output during the time was 2.71 t, with an average yearly production of 0.34 t. The whole effort was 80983 units, with an average catch per unit effort of 58.1 kg. The major clam species was *M. meretrix*. During the research period, total bivalves production was more to documented compared the previous decade. Sujitha Thomas et al., (2003) stated that the average annual catch in the Dharmadom estuary's bivalve fishery from 2000 to 2002 was 2.49 t. The peak fishing season occurred in October. *P. Malabarica.*

According to IUCN status 13 species contributed to 53.84% are not evaluated (NE), followed by data deficient (DD) with 30.76%, and least concerned 15.38% (Fig 4).The monthly available bivalves at Gosthani estuary the data was comparison for abundance. The results of ANOVA for p-value of 0.9746 indicates significant support for H0, which is accepted. The difference between the sample averages of all groups, is too small to be statistically significant at the 0.05 level. The test statistic F is 0.342, which is within the 95% range of acceptability. There is no significant difference in the means of any combination. The measured effect size is small (0.16). This suggests that that the magnitude of the difference between the averages is minimal. $\eta 2$ equals 0.025. This suggests that the group accounts for 2.5% of the deviation from the average (Fig 7).The difference between the sample averages of all groups is not big enough to be statistically significant. The p-value equals 0.231 indicates a greater support for H0. The test statistic F equals 1.526465, which is in the 95% region of acceptance. The observed effect size f is medium (0.29). That indicates that the magnitude of the difference between the averages is medium. The $\eta 2$ equals 0.078. It means that the group explains 7.8% of the variance from the average (Table 3, Fig 8).Laxmilatha et al. (2011) recorded the overall production during the time was 0.53 t, with an average yearly landing of 0.07 t. A. rhombea was landed in small numbers of

0.04 t. The edible oyster C. madrasensis landed throughout the time weighed 1.99 tonnes, with an average yearly yield of 0.25 tonnes (Table 1). From 2003 to 2010, overall bivalve output in the Bhimili Estuary increased in both capture and effort, reaching 2005. The fisheries thereafter declined, falling by 83.3% in 2007. In 2008, the fisheries improved and rose greatly over the previous year, but then dropped.According to Pramod and Chakravarty (2005), 35 species of bivalve molluscs have been found in the shallow, exposed, and sheltered habitats of estuaries, creeks, and backwaters near the coastlines along the north-east Andhra coast. The fauna is diverse in terms of sediment type and habitat slope, and its distribution is typically irregular. Six bivalves (*Anadora granosa*, *Crassostrea cuttackensis*, *Dendrostrea folium*, *Donax cuneatus*,*Meretrix meretrix*, and *M. casta*) are researched in intertidal regions of marine and brackish water environments. They are found in greater abundance in protected brackish water tidal flats and streams than in surf-exposed marine environments. Human activities pose a danger to bivalve populations. In the present investigation basing on the statistical analysis of ANOVA the bivalve catch is significant in the Gostani estuary.

Table: 1 Economic importance molluscans diversity at Gostani estuary

S.no	Taxa	Commonname	Class	Order	Family	Hábitat	Economice use	IUCN status
1	*Anadarainaequivalvis (Bruguière, 1789)*	unequalarc	Bivalvia	Arcida	Arcidae	Estuaries, ,mudflats, Sandy ormuddybottoms.	Aqua culture and fisheries, foodsource, Tradition medicine, ormentation	NE
2	*Anadararhombea (Born, 1778)*	Diamondcockle	Bivalvia	Arcida	Arcidae	Estuaries, and coastalwater, Sandy and muddysubstrate.	Exporttrade, livelihood, foodsource, commercialfisheries	DD
3	*Tegillarca granosa (Linnaeus, 1758)*	Bloodcockle	Bivalvia	Arcida	Arcidae	Brackish, ,mudflats, Sandy substrate, Near shore coastalwater.	Exporttrade, livelihood, foodsource, commercialfisheries	LC
4	*Trachycardiumflavum (Linnaeus, 1758)*	Fan-shapedcockle	Bivalvia	Cardiida	Cardiidae	Substrate, Intertidal zones, coastalwater, Tropical and subtropical.	Commercialfisheries, livelihood, Exporttrade, Aquaculturepotential.	DD
5	*Donaxcuneatus (Linnaeus, 1758)*	CuneateDonax	Bivalvia	Cardiida	Donacidae	Sandy beaches, coastalareas, intertidal zones, warmwater.	Recreationalharvesting, local consumption, shellcraft and souvenirs.	NE
6	*Alaona ala (Hanley, 1845)*	Wingshell	Bivalvia	Cardiida	Tellinidae	Intertidal,coldwater, NearshoreEnvironment.	Commercialfisheries,local substience.	NE
7	*Serratinapristis (Lamarck, 1818)*	Smoothshell	Bivalvia	Cardiida	Tellinidae	Sandy, intertidal zones, coastal.	Culinaryuse,Bai, Harvesting.	DD
8	*Tellina iris (Say, 1822)*	Rainbowtellin	Bivalvia	Cardiida	Tellinidae	Sandy ormud, intertidal, shallowcoastalwater, Tropical.	Commercialfisheries, Aquaculturepotential, Scientific and Education.	NE
9	*Crassostreamadrasensis (Preston, 1916)*	Indianoyster	Bivalvia	Ostreoida	Ostreidae	Estuarine, Brack water, muddyor Sandy tropical intertidal.	Pearl production, livelihoods, Aquaculture, commercialfisheries.	DD
10	*Perna viridis (Linnaeus, 1758)*	Asiangreenmussel	Bivalvia	Mytiloida	Mitilidae	Intertidal,warmcoastalwater.	Commercialfisheries, Aquaculture,Biofiltration.	LC
11.	*Nucula convexa (Sowerby, 1833)*	Convexnutclam	Bivalvia	Nuculida	Nucilidae	Substrate,, Intertidal coastal, shallow,cooltotemperatewater.	Nutclam, commercialpurpose.	NE
12	*Meretrixmeretrix (Linnaeus, 1758)*	Asianhardclam	Bivalvia	Veneroida	Veneridae	Estuaries and coastalwater,Sandy and muddysubstrate.	Exporttrade, livelihood ,foodsource, commercialfisheries	NE
13	*Meretrix casta (Chemnitz, 1782)*	Backwaterhardclam	Bivalvia	Veneroida	Veneridae	Tropical and subtropical region, estuaries ,Sandy and muddy.	Exporttrade, livelihood ,foodsource, commercialfisheries,	NE

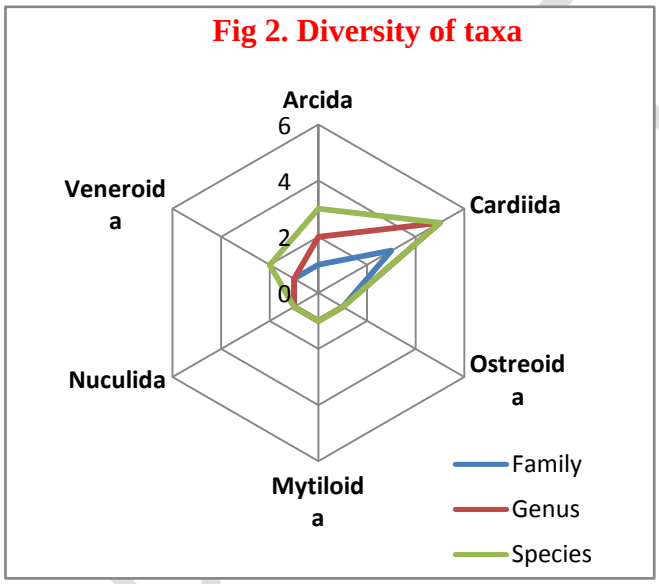
Aa

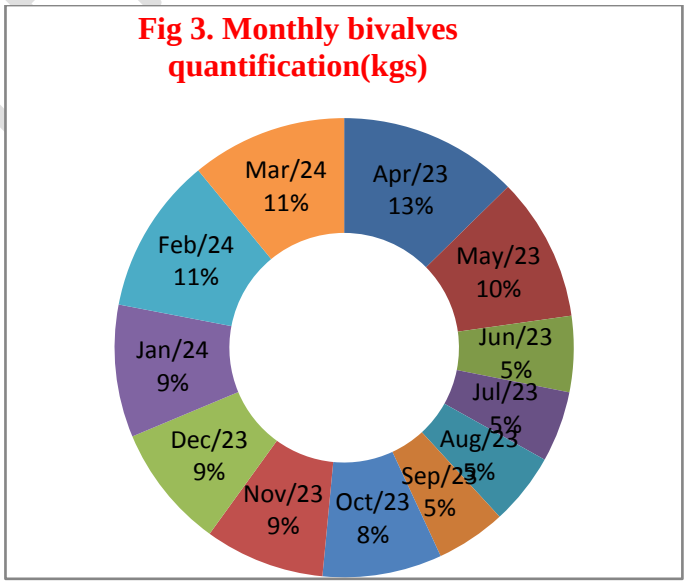
Table: 2 Taxa diversity in class bivalvia

Order	Family	Genus	Species
Arcida	12.5	18.18	23.07
Cardiida	37.5	45.45	38.46
Ostreoida	12.5	9.09	7.69
Mytiloida	12.5	9.09	7.69
Nuculida	12.5	9.09	7.69
Veneroida	12.5	9.09	15.38

Table: 3. Monthly bivalve shell collection and quantification (wet weight/kgs) at Gostani estuary

s no	species	Wet weight (kgs)	Shell dry weight (kgs)	Muscle weight (kgs)
1	*Anadarainaequivalvis*	130	105.3	11.7
2	*Anadararhombea*	787	654.6	86.5
3	*Tegillarca granosa*	759	636.2	90.8
4	*Trachycardiumflavum*	16	12.3	1.7
5	*Donaxcuneatus*	22	18.68	1.32
6	*Alaona ala*	10	6.3	1.7
7	*Serratinapristis*	23	18.7	2.3
8	*Tellina iris*	13	10.24	0.76
9	*Crassostreamadrasensis*	5866	5179.4	562.6
10	*Perna viridis*	121	76.8	31.8
11	*Nucula convexa*	65	48	5.2
12	*Meretrixmeretrix*	1179	985.52	24.24
13	*Meretrix casta*	2784	1049.31	1.8
	Total	11762	10369.35	2318.6





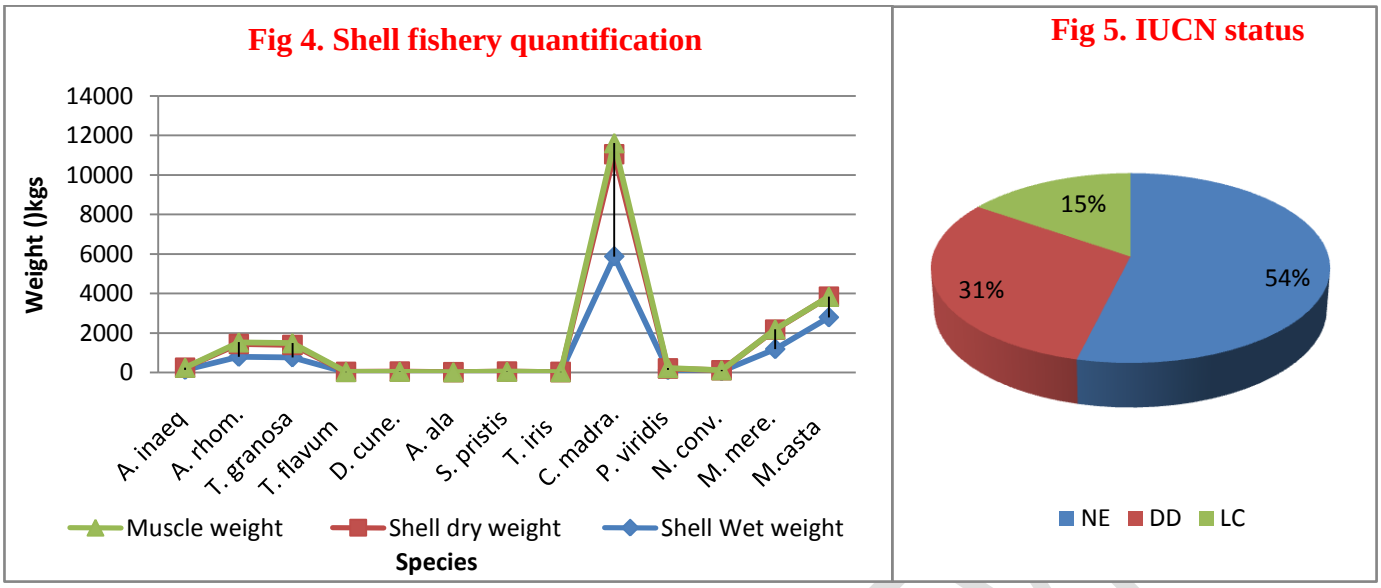


Fig: 6. ANOVA analysis for monthly collected 13 species bivalves wet weight at Gosthani estuary

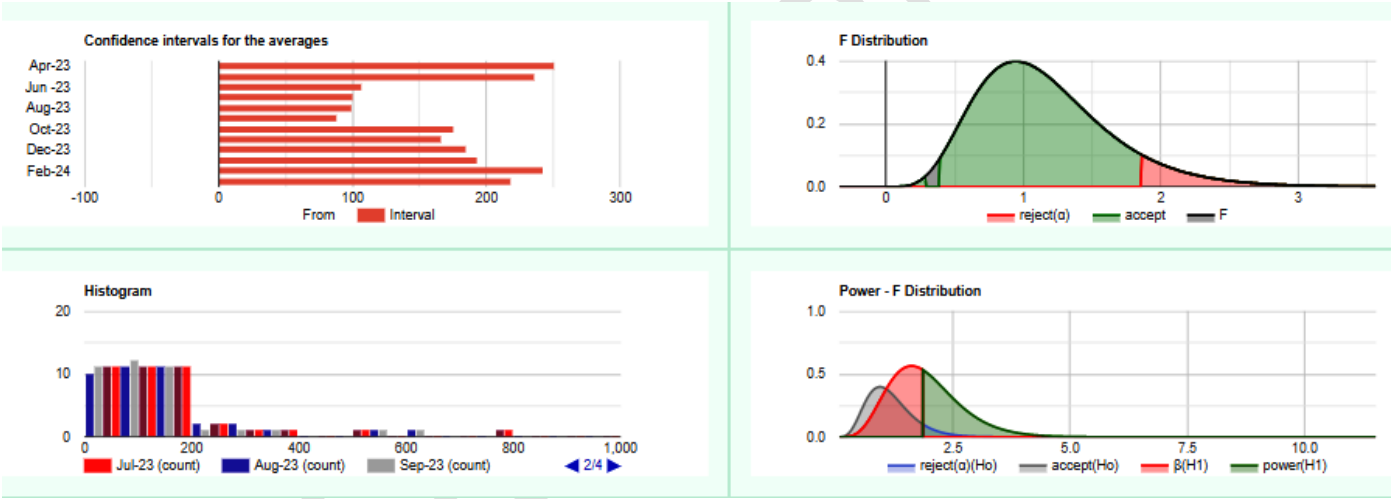


Fig: 7. ANOVA analysis for wet shells, dry shells and muscle weight from April 2023 to March 2024

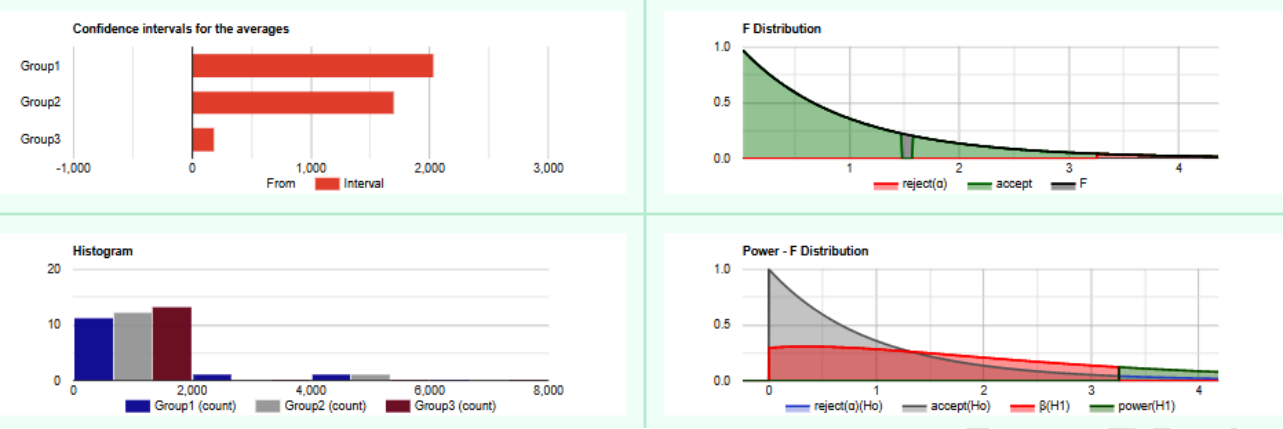


PLATE: I Bivalve fishery at Gosthani estuary

Anadora ineqivalvis

Anadararhombea

Tegillarcagranosa

Trachycardium flavum

Alaona ala

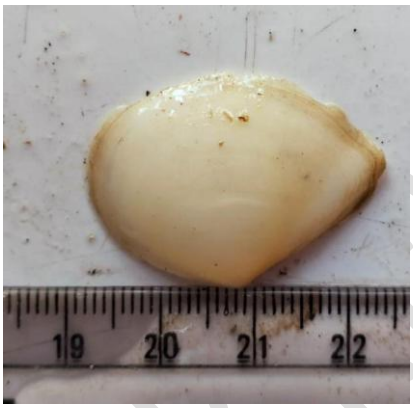
Serratinapristis

Donax cuneatus

Tellina iris

Crassostrea madrasensis

Perna viridis



Nuculaconvexa

Meretrix meretrix

Meretrix casta

Conclusion:

Bivalve harvesting is more appropriate to the pre-monsoon season, which extends from November to May. males and women pick bivalves from shallow areas and mudflats, whereas males harvest from deeper areas. Bivalves are more abundant in deeper parts of the estuary than in shallow sections and mudflats. In 2010, the fisheries saw another substantial decrease. The effort also declined with time, from 14839 in 2003 to just 2405 in 2010. The present study found that the bivalve mollescan fishery has grown significantly.According to the findings, estuarine molluscs are large macrobenthic animals that play an important role in the freshwater ecosystem's food chain. Molluscs are extremely important

because they provide food for many aquatic birds and estuarine inhabitants. It is critical to protect and conserve the diversity of freshwater molluscs in any particular aquatic body. More information is needed to compile a database of molluscan diversity from brackish water sources.

Ethical approval

This study was conducted according to international ethical standards set by the Institutional Animal Care and Use Committee (Vet CU 8/03/2022 /429)

Consent to participate

Not applicable as neither commercial trawls operating offshore and local fishermen supplied to middle man were involved in the research.

Data availability statement

The authors confirm that the data used to support the findings of this study are available within the article.

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The average quantity harvested is 65±24.78 kg/individual/day for men and 22±13.46 kg/day/

BCD – Bivalve collecting days; QHD – Quantity harvested per day

Bivalve harvested in this estuary is estimated at 22,006 t/yr, which generates a total primary annual net income of about Rs. 57.8 million (Rs. 57,018,710 from bivalve collection and Rs. 816,267 from supplementary products like empty shells and dried meat).

The estimated annual income from the sale of empty shells is Rs. 483,850 (Table 10) and from dried bivalve meat is Rs. 334,983

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