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Influence of salinity on commercial Clams of Uttara Kannada Estuaries

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Abstract

Estuaries are ranked among the most productive ecosystems of the earth due to a variety of factors, the most prominent being mixing up of freshwater from the rivers with the marine tides creating varying degrees of salinity in different parts of the estuary. When these natural tidal rhythms are affected due to natural causes or anthropogenic activities, estuarine organisms, especially sedentary ones, get affected. The sedentary organisms such as bivalves make ideal cases for assessment of especially anthropogenic environmental impacts on estuaries. The rivers of Uttara Kannada district, Karnataka particularly Sharavathi and Kali have been dammed for power production, which collapsed the clam fishery. Hence, a survey was conducted in dammed river estuaries Sharavathi and Kali to know the impact of dams constructed for the hydroelectric projects on the clams and compared with the studies from undammed river estuaries Aghanashini and Gangavali. The study revealed that the execution of hydroelectric projects in the Sharavathi and Kali rivers of Uttara Kannada district in Karnataka is the major cause for the elimination of most of the clam bivalves from the Sharavathi estuary, and habitat shifts and shrinkage for the bivalves in the Kali estuary due to decreased salinity on account of continuous discharge of freshwater after power generation, a situation not favouring the bivalves. River valley projects are drastic interventions by humans with far reaching implications affecting even the estuarine regions, primarily due to fall in salinity creating adverse conditions. The bivalve situation in two more estuaries, of the rivers Aghanashini and Gangavali in Uttara Kannada, undammed and more natural, is compared with that of the dam affected ones to understand the situation better.

Keywords: Bivalve, Dam, Hydroelectric Project, Kali, Sharavathi, Salinity.

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INTRODUCTION

The Molluscs are soft bodied invertebrates which inhabit marine, estuarine, freshwater and terrestrial areas. Estuaries are among the unique and fragile ecosystems of the earth, and the organisms of this habitat are living in an ever changing environment, especially in relation to salinity factor. Salinity in estuary keeps fluctuating constantly depending on the input of freshwater from upstream rivers and from rising and receding oceanic tides. The ocean salinity, in general, shows greater stability as compared to freshwater inputs into the estuary from land sources. Mainly due to their widely acknowledged high rates of productivity estuarine areas are often densely populated. Shallower parts of estuaries, in recent centuries, have been undergoing tremendous transformations due to their reclamations for human habitations, agriculture and fish and shrimp farming. Seldom was ever the impact of such transformations studied, especially on the molluscs which are known to be some of the very sensitive organisms. The impact of salinity increase in estuaries, as a consequence of upstream dam constructions to meet freshwater demands has been indeed a subject that has captured some attention (Seddon, 2000; Rodriguez *et al.*, 2001; Estevez, 2002; Chen, 2005; Dandekar, 2012). However, the subject of fall in estuarine salinity that is happening in many estuaries due to continuous release of freshwater after power generation, and the impact of it especially on molluscs, is hardly dealt with except in isolated studies – e.g. Parada *et al.* (2012) in Spain.

As far as Uttara Kannada district of the Indian west coast is concerned, there was hardly ever any concerted effort on documentation of estuarine molluscs, especially the ones that are used traditionally as food resources by scores of coastal people, and in the collection and trade of which thousands, more so women, have been engaged, have been made. Details of the molluscan species from Karnataka estuaries, particularly bivalves, exploited for food and lime shells are found in some of the earlier studies (Alagarswami and Narasimham, 1973; Rao and Rao, 1985; Rao *et al.*, 1989). Boominathan *et al.*

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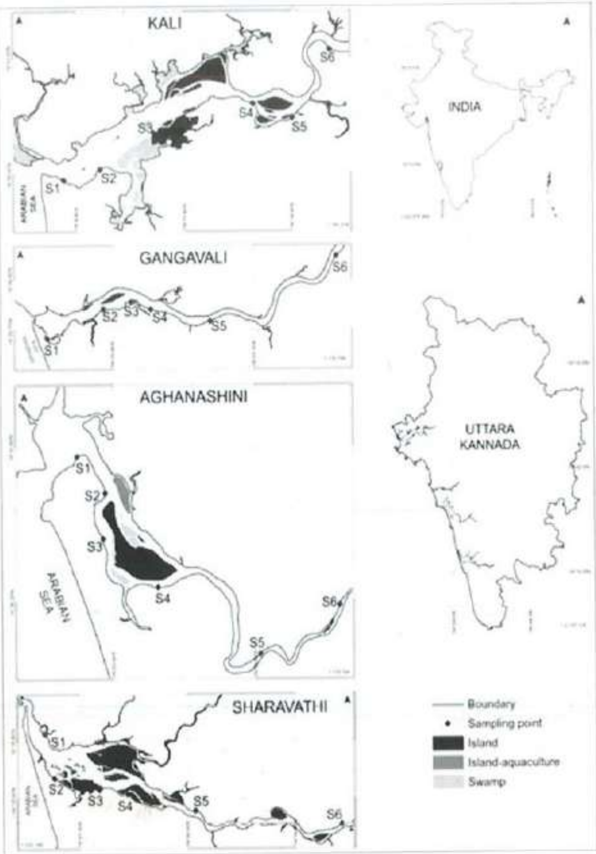

Fig. 1. Sampling stations in the Uttara Kannada estuaries. Details for station code S1 to S6 are given in Table 1.

(2008) dealt in detail about the dynamics of bivalve production and trade and village-wise and gender-wise employment generated in the Aghanashini estuary of Uttara Kannada. The annual production of edible bivalves from Aghanashini is based on at least eight species, and *Paphia malabarica*, *Meretrix meretrix* and *Meretrix casta* are leading among them, accounted for a phenomenal annual production of about 22,006 tonnes, generating 357,995 man-days of employment, altogether for about 2,347 bivalve collectors. However, Rao *et al.* (1989) alluded to a serious decline of clam resources of Sharavathi estuary, and raised apprehensions about a fall in such resources from Kali, incidentally both these estuaries have hydroelectric

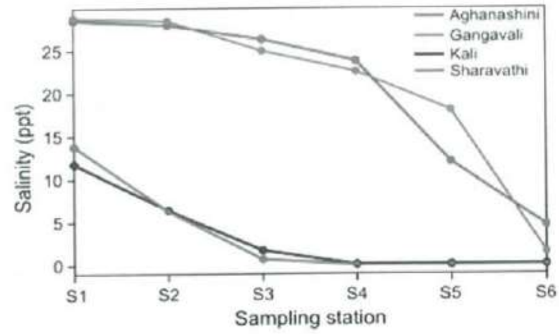

Fig. 2. Salinity trends of Uttara Kannada estuaries. Gangavali and Sharavathi (December 2011); Aghanashini and Kali (February 2012). Source: Boominathan *et al.* (2014a, 2014b).

projects executed in the upstream areas of the respective rivers. As especially many of the west flowing rivers from the Western Ghats are subjected to dam constructions, to meet the rising needs for freshwater and for hydroelectricity, hardly any study is found on the impact of such drastic developmental interventions on estuarine ecology, especially on clam bivalves. Hence in this paper, an attempt has been made to deal with the commercial clams of four major estuaries of Uttara Kannada district, namely Kali, Sharavathi, Gangavali, and Aghanashini, the first two of them, as earlier stated, having hydroelectric projects. The current work, while briefly reviewing the studies hitherto carried out on commercial clams of Uttara Kannada estuaries, is an attempt to understand the status of clam diversity and distribution in the district.

MATERIALS AND METHODS

The study was carried out during 2011-12 in the estuaries Kali, Sharavathi, Gangavali and Aghanashini of Uttara Kannada district, Karnataka, State of India (Fig. 1 and Table 1). Sharavathi River has two major hydel projects (Sharavathi and Gerusoppa) with total installed capacity of 1469.20 MW. Kali river has four hydel projects (Supa, Nagjhari, Kodashalli, and Kadra) with total installed capacity of 1255 MW. Kali, Sharavathi, and Aghanashini estuaries were larger in size in the range of 2813, 2842, and 1336 ha area respectively, whereas Gangavali was

Table 1. Sampling station name with approximate distance (km) from river mouth in parentheses.

Station	Aghanashini	Gangavali	Kali	Sharavathi
S1	Aghanashini (1.5)	Gangavali (1)	Kodibag (1)	Honavar (2.5)
S2	Gudkagal (4)	Agragone (3)	Sunkeri (3)	Kasarkod (4.5)
S3	Hini (6)	Joog (4.5)	Ambejug (6)	Hosapatna (6)
S4	Masur (9)	Sagadgeri (6)	Kinnar (12)	Kelagin-Idgunji (8)
S5	Divgi (16)	Ulware (8)	Wailwada (13)	Jalawalli (12)
S6	Hondad Hakkal (21)	Mangankan (15)	Kerwadi (18)	Upponi (23)

smaller estuary with 558 ha (Ramachandra *et al.*, 2013). The study area map was created in QGIS version 2.2.0 (Quantum GIS Development Team, 2014). Surface water salinity levels of these four estuaries were measured using EXTECH EC400 meter during high tide, during December-February, the winter period that marks the onset of full-fledged collection season for bivalves in the region, following the complete cessation of monsoon rains by mid-November. Clam bivalves were collected at different distances from the river mouth towards their upstream limits of distribution in the respective estuaries. A questionnaire based survey was also conducted among traditional bivalve harvesters to know the bivalve diversity and distribution range of individual species within respective estuaries currently as well as in the past. The clam bivalves were identified using available keys (Morton, 1984; Rao, 1989; Rao *et al.*, 1989; Apte, 1998; Dey, 2006). Line graph for salinity was prepared using PAST version 3.01 (Hammer *et al.*, 2001) and Kruskal-Wallis test was performed in R version 3.1.1 (R Core Team, 2014) and Rlplot version 1.5 to see the difference between estuaries using salinity values.

RESULTS

Salinity trend: dammed Vs undammed

Both the estuaries of undammed rivers, namely Aghanashini and Gangavali had higher salinity values towards the river mouth (28.55 and 28.85 ppt) than the river mouth of Kali and Sharavathi (11.75 and 13.80 ppt). The mid estuarine stations of

Table 2. Summary of Kruskal-Wallis test.

Groups	N	Median	25%-75%	Range	Rank Sums
Aghanashini	6	25.08	14.95 – 27.59	4.61 – 28.55	106
Gangavali	6	23.78	19.18 – 27.63	1.48 – 28.85	106
Kali	6	0.89	0.05 – 5.23	0.05 – 11.75	49
Sharavathi	6	0.35	0.02 – 4.89	0.01 – 13.8	39

Table 3. Station-wise clam distribution in four Uttara Kannada estuaries.

Station	Tg	Pm	Pe	Mm	Mc	Vc
S1	A, G, K	A, G, K	A, G, K, S	A, G, K	A, G, K	
S2		G	A, G, K, S	G, K	A, G, K	
S3			A, K		A, G	K
S4			A		A, G	A, G, K
S5						A, G
S6						A, G

A - Aghanashini, G - Gangavali, K - Kali, S - Sharavathi, Tg – *Tegillarca granosa* (Linnaeus), Pm – *Paphia malabarica* (Chemnitz), Pe - *Polymesoda erosa* (Solander), Mm – *Meretrix meretrix* (Linnaeus), Mc – *Meretrix casta* (Chemnitz), Vc – *Villorita cyprinoides* (Gray). Source: Boominathan *et al.* (2014a, 2014b).

undammed rivers had fairly high salinity (26.35 and 25.00 ppt) whereas the dammed ones had it as low as 1.71 and 0.67 ppt in Kali and Sharavathi respectively. Whereas the upstream salinity of dammed river estuaries were at 0.05 ppt in Kali and 0.01 ppt in Sharavathi, in the undammed river estuaries it was higher at 4.61 ppt in Aghanashini and 1.48 ppt in Gangavali (Fig. 2).

Clam diversity

The four estuaries of Uttara Kannada district studied had six notable commercial clam bivalves, viz. *Meretrix casta, Meretrix meretrix, Paphia malabarica, Polymesoda erosa, Tegillarca granosa*, and *Villorita cyprinoides*. All six species occurred in Aghanashini, Gangavali and Kali whereas, Sharavathi was impoverished of even clams like *M. casta* and *M. meretrix* which were recorded in abundance in earlier studies (Alagarswami and Narasimham, 1973; Rao and Rao, 1985). *Polymesoda erosa* was the only clam present during our survey.

Clam distribution

The station-wise distribution of the clams is given in the Table 3. In undammed river estuary Aghanashini all six commercial species were distributed as they were found at the time of earlier studies (Rao *et al.*, 1989). Likewise, in Gangavali, the species mentioned by Alagarswami and Narasimham (1973) were also recorded in the present study. Although in Kali all the clams continued to be present, the dam effect not withstanding, there has been notable shifts more towards the river mouths in their distribution ranges as well as certain shrinkage in their occupation zones as compared to the pre dam distribution details from earlier studies. Whereas before dam construction during 1978, *Meretrix meretrix* occurred from 2 to 12 km range from river mouth (Nair *et al.*, 1984) and in the post dam construction the distribution range was from 1-4 km in a 1984 study (Rao *et al.*, 1989). But the present study conducted in 2012 showed that the species was confined to still narrower range of 1-3 km. The range of *M. casta* was also got substantially diminished from 7-11 km in 1984 (Rao *et al.*, 1989) to 1-3 km in 2012. *V. cyprinoides* shifted its distribution range from 11 to 26 km in 1978 (Nair *et al.*, 1984) to 7-24 km in 1984 (Rao *et al.*, 1989) and interestingly it was found in the present study that there was a much greater range compression to 6-12 km from the river-mouth in 2012.

DISCUSSION

The result of Kruskal-Wallis test also was significant (H=12.98, d.f.=3, P=0.0047) and the rank sum was different among estuaries (Table 2). Undammed river estuaries were strikingly similar at the rank sum of 106 whereas the rank sum was considerably smaller for Kali at 49 and Sharavathi at 39. It clearly shows that the continuous releases of freshwater from the upstream hydel projects had serious impact on estuarine salinity. The river mouths were relatively better while the fall in salinity was more serious in the bulk of the estuaries of both the dammed rivers- in the mid and upstream parts as well, in comparison to the undammed rivers.

The major changes that have been taking in the upstream areas of Sharavathi were the addition of more hydroelectric power generators (from original installed capacity of 120 MW in 1948 to 1469.20 MW at present including power generation for Gerusoppa dam commissioned in the downstream of the river in 1999). The combined releases of freshwater from several generators, obviously, had taken a heavy toll on the clam resources of the Sharavathi estuary, through mainly a drastic reduction in salinity. This observation and findings are supported by the findings reported by Chandran *et al.* (2012) who noticed the precarious state or near absence of high salinity tolerant mangroves like *Rhizophora* spp., *Sonneratia alba*, and *Avicennia marina* from this estuary which are otherwise more well represented in other estuaries of the district and elsewhere along the Indian west coast. The rich presence throughout the estuary of the very low salinity tolerant *Sonneratia caseolaris* is a clear indication of the human altered ecological conditions, especially of salinity decline.

Despite lower salinity recorded from Kali during February 2012, the onset of the clam collection season, comparable in salinity with that of Sharavathi, the former had all the six commercial clam bivalves unlike a single surviving species in the latter. While admitting the need for year-round monitoring of salinity in the case study estuaries it may be pointed out that the rivers dammed for electricity generation might experience rise and fall of salinity in pulses, on day-to-day and hour to hour basis, as more generators keep working during demand-related power production peaks. Monthly observations made by Ramachandra *et al.* (2013) revealed that the salinity in the Sharavathi estuary was less than 0.5 ppt salinity throughout 2011-12. The same study placed Kali in a far better position with pre-monsoon salinity towards river mouth stations touching about 35 ppt, mid estuary around 15 ppt and upstream stations showing 8-10 ppt. Aghanashini and Gangavali, normal estuaries without any dams, showed highest pre-monsoon salinity closer to that of sea water towards river mouths, mid estuary in the range of 25-28 ppt and upstream stations in both showing 10 to a little above 20 ppt. Hence, the clam diversity in the Sharavathi estuary, most impacted by upstream hydel projects, is bound to be affected to the maximum extent among all the four case study areas.

CONCLUSION

Clam bivalves apparently did not merit as much importance as finfish and shrimp fishery along Karnataka coast, despite clam collection has been practiced through ages, employing thousands of people and the plentiful output from coastal estuaries providing protein rich food and relatively lower costs. This scenario has been changing over the last few decades due to ecological degradation on account of pollution, unregulated mining of sand and shell beds, mangrove degradation and diverse other causes. Seldom was any thought ever given that execution of hydroelectric projects in the upper reaches of rivers, as in the Western Ghats, could destabilise estuarine ecology, primarily through lowered salinity conditions caused by incessant discharge of freshwater after power generation, such unprecedented phenomena not favouring rise of natural salinity even during the dry months of summer. The decline of clam diversity and clam fishery seems to have started with beginning of electricity generation from the Linganmakki dam in the 1960s and the increases in installed capacity for power generation due to additional power houses and commencement of one more dam at Gersoppa, could be considered the major reasons for near total collapse of clam diversity and clam fishery altogether. Kali estuary being a bigger one and with relatively wider river mouth did not witness the elimination of clam bivalves despite a series of hydroelectric projects upstream. Nevertheless, almost bivalves showed shifts from their original occupation zones in the estuary towards the river mouth obviously seeking optimum salinity conditions. The Kali bivalves also were confined to narrower zones in the estuary than their earlier occupation zones. This study underscores the need for consideration of environmental impacts on a wider scale, incorporating even impacts on coastal and marine domains, from major river valley projects in the Western Ghats, and have a second look at the fresh proposals cropping up for diversions of west flowing rivers towards meeting the water needs of the drier Deccan region.

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