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An assessment on the influence of salinity in the growth of black clam (*Villorita cyprinoides)* in cage in Cochin Estuary with a special emphasis on the impact of Thanneermukkom salinity barrier

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Abstract. Regular tidal flow, estuarine circulation and other allied hydrographical parameters in the Cochin Estuary has changed due to regular closure and opening of Thanneermukkom bund and entry of saline water in to the estuary. Temperature, salinity and bottom sediment texture are found to be the important factors significant for the growth and survival of bivalves. The environmental condition on different parts of the estuary especially at station II (south of bund), station IV (north of bund) and station V (near to bar mouth) showed a clear and distinct variation in all the hydrographical parameters due to the existence of Thanneermukkom bund and bar mouth. At stations II the frequency of temperature fluctuation was high and the dominant environment was freshwater when compared with station IV. Sediment texture at station II was sandy silt and at station IV was silty sand. At station V the dominant condition was saline and sediment texture was clayey in nature. A higher salinity was noted throughout the study period at station V. At station II the annual average growth was 8.48 mm; at station IV it was 15.15 mm and at station V it was 9.64 mm. Moderate level of salinity is found to be a favourable factor for the growth of *Villorita cyprinoides*. Growth rates of smaller clams were found to be higher than larger clams.
Key Words: Bivalves, Thanneermukkom bund, cage culture, salinity.

സംഗ്രഹം : തണ്ണീർമുക്കം ബണ്ടിന്റെ അടയ്ക്കൽ – തുറക്കൽ പ്രവർത്തനം, ഓരുവെള്ളത്തിന്റെ പ്രവേശനം എന്നിവ കൊച്ചി കായലിലെ ക്രമമായ ജലനിരപ്പ്, ജലചംക്രമണം എന്നിവയിൽ വ്യതിയാനം വരുത്താറുണ്ട്. അവിടുത്തെ ഊഷ്മാവ്; ലവണാംശം, അടിത്തട്ടിലെ മണ്ണിന്റെ ഘടന എന്നിവ കക്കകളുടെ വളർച്ച, അതിജീവനം എന്നിവയിൽ ഇടപെടുന്ന നിർണായകമായ ഘടകങ്ങളാണ്. കായലിലെ വിവിധ ഭാഗങ്ങളിലെ പ്രത്യേകിച്ച് സ്റ്റേഷൻ II (ബണ്ടിന്റെ തെക്ക്), സ്റ്റേഷൻ IV (ബണ്ടിന്റെ വടക്ക്) സ്റ്റേഷൻ V (അഴിമുഖത്തിന് സമീപം) എന്നീ ഇടങ്ങളിലെ പാരിസ്ഥിതികാവസ്ഥയിൽ വ്യക്തമായ വ്യതിയാനം കാണിക്കുന്നുണ്ട്. അതിന് കാരണം തണ്ണീർമുക്കം ബണ്ടിന്റെയും അഴിമുഖത്തിന്റെയും സാന്നിദ്ധ്യമാണ്. നാലാമത്തെ സ്റ്റേഷനെ അപേക്ഷിച്ച് രണ്ടാമത്തെ സ്റ്റേഷനിൽ താപനിലയിലുള്ള ഏറ്റക്കുറച്ചിൽ വളരെ ഉയർന്നതാണ്, കൂടാതെ അവിടെ ശുദ്ധജലത്തിന്റെ ലഭ്യതയും അധികമാണ്. രണ്ടാമത്തെ സ്റ്റേഷനിൽ അടിത്തട്ടിലെ മണ്ണിന്റെ സ്വഭാവം പരിശോധിച്ചാൽ അത് സാന്റി സിൽറ്റ് ആണെന്ന് കാണം. നാലമത്തെ സ്റ്റേഷനിൽ അത് സിൽറ്റി സാന്റ് ആണ്. അഞ്ചാമത്തെ സ്റ്റേഷനിൽ ഓരുവെള്ളമാണ് കൂടുതൽ, കൂടാതെ അവിടെ ചെളിമണ്ണാണുള്ളത്. രണ്ടാമത്തെ സ്റ്റേഷനിൽ കക്കയുടെ ശരാശരി വാർഷിക വളർച്ച 8.48 mm ആണ്. നാലാമത്തെ സ്റ്റേഷനിൽ അത് 15.15 mm ഉം അഞ്ചാമത്തെ സ്റ്റേഷനിൽ 9.64 mm ഉം ആണ്. വില്ലോറിറ്റ സിപ്രിനോയ്ഡ്സ് എന്ന കക്കയുടെ വളർച്ചക്ക് ഒരുവെള്ളം അനുയോജ്യമായ ഘടകമാണ്. ചെറിയ കക്കകളുടെ വളർച്ച വലിയ കക്കകളെക്കാൾ കൂടുതലാണ്.

താക്കോൽ വാക്കുകൾ: കക്കകൾ, തണ്ണീർമുക്കം ബണ്ട്, കൂട്ടിലിട്ട് വളർത്തൽ, ഓരുജലം

Rezumat. Fluxul regulat, mișcările curenților în estuar și alți parametri hydrografici din Estuarul Cochin s-au schimbat datorită închiderii și deschiderii regulate a barajului Thanneermukkom și intrării apei saline în estuar. Temperatura, salinitatea și textura sedimentelor au fost identificate ca factori importanți semnificativ pentru creșterea și supraviețuirea bivalvelor. Condițiile de mediu pe diferite regiuni ale estuarului, în special la stația II (la sudul barajului), stația IV (la nordul barajului) și stația V (aproape de gura barierei) au arătat o clară și distinctă variație a tuturor parametrilor hidrografici datorită existenței acestui baraj Thanneermukkom. La stațiile II, frecvența fluctuațiilor de temperatură este mare iar mediul acvatic preponderent dulce raportat la cel al stației IV. Textura sedimentului la stația II este de mâl nisipos, pe când la stația IV de nisip mâlos. La stația V, factorul dominant este salinitatea ridicată iar

textura sedimentului este una argiloasă. De-a lungul întregii perioade de studiu, s-a observat o salinitate mai ridicată la stația V. La stația II, creșterea medie anuală a fost de 8.48 mm; la stația IV a fost de 15.15 mm iar la stația V a fost de 9.64 mm. Nivelul moderat al salinității este un factor favorabil de creștere a speciei *Villorita cyprinoides*. S-a constatat că rata de creștere a scoicilor mai mici este mai mare decât a scoicilor mai mari.
Cuvinte cheie: bivalve, barajul Thanneermukkom, cultură în viviere, salinitate.

Introduction. A variety of environmental factors such as seasons, regions, salinity, temperature, sediment texture etc. influence the growth and survival of molluscs. So an analysis of the growth of an organism with respect to its environment is important not only for interpreting its adaptation to environmental changes but also to understand the exact impact of rapidly changing environment on the species. In an environment the responses of an aquatic organism vary with the 'physiological state' of the organism. Alterations in the growth patterns occur during definite stages of growth and different seasons, because increasing proportion of energy consumed by the organism is utilized for different purposes, hence a thorough knowledge on the growth of bivalve mollusc along with its different life stages and seasons is very imperative especially for the successful exploitation of its fishery potential. Due to the paucity of this information in molluscs in general, and in *Villorita cyprinoides* (Hanley) (Plate 1) in particular, an investigation on this aspect has been taken up to fill up the vacuum.

Longevity and rate of growth are helpful in describing the present status and the past history of a population along with the future course of the fishery. In recent years, considerable emphasis has been given in India to culture the edible bivalve molluscs such as oysters, mussels and clams, since they form a subsidiary fishery in most of the coastal and estuarine regions. Though many species of commercially important bivalves occur along the Indian coast, little attention was paid by past workers on various aspects of growth despite the fact that this field offers a large number of unanswered questions.

Thanneermukkom bund (Plate 2 and 3) was constructed (1974) to prevent salt-water incursion and to promote two crops of paddy in about 50,000 ha. of low lying fields in the Kuttanadu area (Arun 2005). The bund has been functional since 1976 and remains closed from January to May every year. This has resulted in drastic ecological changes in the lake, particularly south of the bund, affecting the distribution, survival and abundance of the living resources in the estuary, and causing depletion of the black clam in several localities; besides this dredging conducted in several parts of the estuary has aggravated this problem.

Materials and Methods

Study Area. For the cage culture experiments three sites were selected; one on south of Thanneermukkom bund (station II), one on north of Thanneermukkom bund (station IV) and another in front of Cochin University Boat Jetty (station V). Regular fortnight sampling for hydrographic parameters was carried out from stations II, IV and V for one year (November 1998 to October 1999).

Hydrographic Parameters. Among different parameters temperature was measured by ordinary thermometer, salinity by Mohr's titration method (Strickland & Parsons 1968) and sediment texture by the method proposed by Carver (1971).

Cage Culture Experiments. Age and growth was studied by growing clams of varying length (1-3 cm) for one year in plastic boxes (9.6 x 15 x 5 cm^3). Four class ranges were selected for this study (1-1.5 cm, 1.5-2 cm, 2-2.5 cm and 2.5-3 cm). Cages in triplicates were arranged at three locations (Station II, IV and V). Each cage was filled with sediment obtained from the location of each clam bed, clams of fixed length were introduced in to each cage and the cages were covered by nylon mesh of 5 mm and placed in the clam bed. Monthly measurements of the clams were taken during one year.

Results

Temperature. Significant variation in temperature at different stations during different seasons was observed in this study. Being a tropical estuarine environment, the variation in bottom temperature was in similar trend to that of other tropical estuaries. While comparing stations on either side of bund, station situated south of bund (station II) showed frequent fluctuation in temperature. At station II it was between 33.5^{0}C and 27^{0}C and at IV the variation of temperature was between 32^{0}C and 26^{0}C, whereas at station V it was between 32^{0}C and 28^{0}C (see Figure 1). At all the stations the minimum temperature was noted during June and maximum during March except at station V. Among three stations, station II showed high annual average followed by station V and IV.

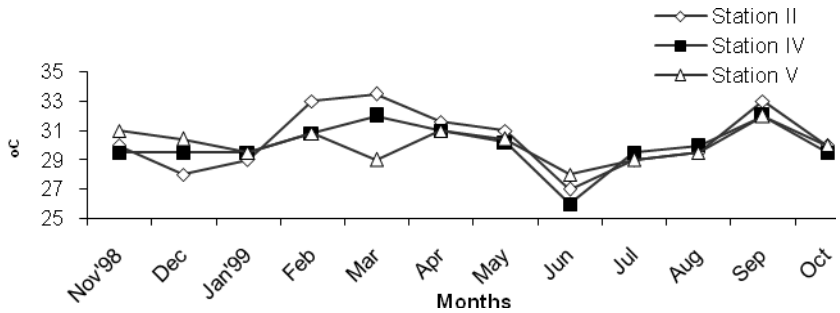


Figure 1. Variation in temperature in station II, IV and V

Salinity. The first two stations (Station II, IV) had a freshwater dominated environment with measurable salinity occurring only during pre-monsoon. At station V, the ambient salinity was high except during monsoon (Figure 2). Annual average salinity at stations II, IV and V were 0.29, 1.96 and 17.67 respectively.

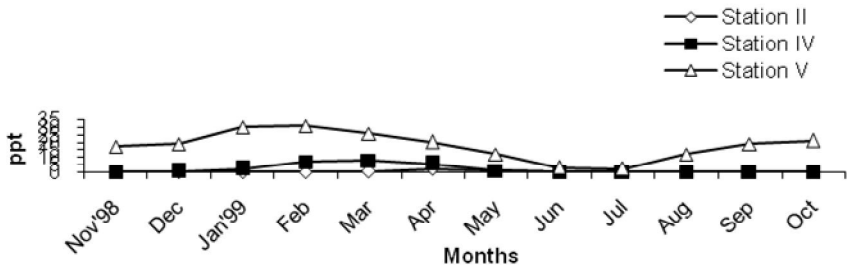


Figure 2. Variation in salinity in station II.IV and V

Sediment Texture. At station II the substratum was always silty sand except in March, April and May. During March it was sandy silt but in April and May it was clayey silt (Figure 3). At station IV the dominant sediment texture was sand and at station V it was clayey silt (see Figure 3, 4 and 5). At station IV the annual average value for sand was

97 %, where as at station V the annual average value for silt and clay was 61 % and 30 % respectively (Plate 4, 5 and 6).

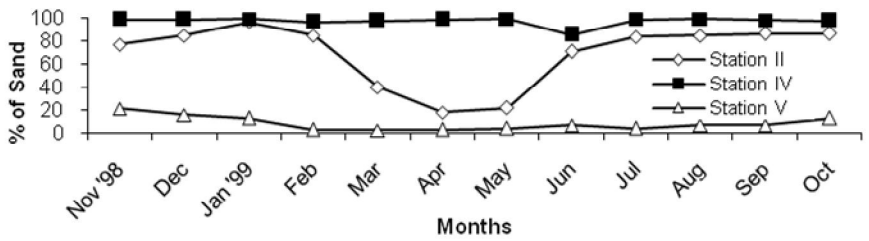


Figure 3. Variation in percentage of Sand in station II, IV and V

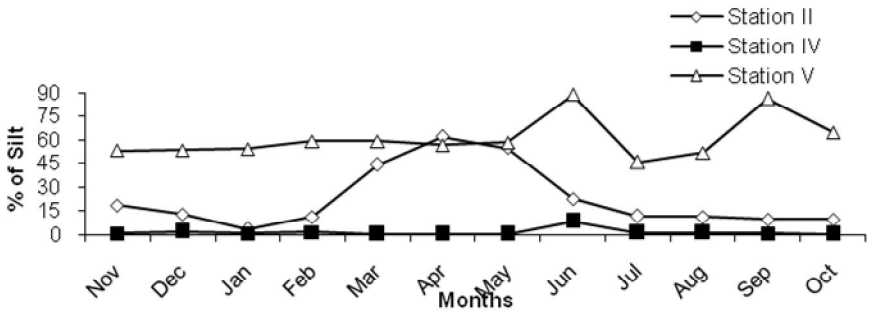


Figure 4. Variation in percentage of silt in station II, IV and V

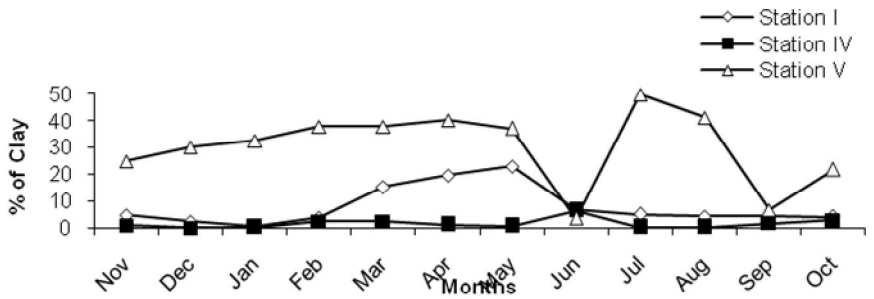


Figure 5. Variation in percentage of Clay in station II, IV and V

Growth of Clams in Cage. At station II the annual average growth was 8.48 mm (Figure 6). It was noticed that as the size of the clams increased the growth rate decreased. Among different class ranges (1-1.5 cm, 1.5–2 cm, 2-2.5 cm and 2.5–3 cm) of clams introduced in the cage, class range 1-1.5 cm (10.2 mm) showed higher growth rate and class range 2.5-3 cm (7.3 mm) showed lower growth rate. There was a gradual decrease in the growth of clams from February to May in all class ranges.

At station IV the growth rate was comparatively higher, annual average growth rate observed was 15.15 cm (Figure 7). Here also, as the size of clams increased the growth rate decreased. Maximum growth rate observed was for 1-1.5 cm class (16.25 mm) and minimum was for 2.5 – 3 cm class (13.82 cm). At this station growth was more or less constant during the study period. At station V the growth of clams were low

during most of the months with higher ambient salinity (Figure 8). Here annual average growth of clams were 9.64 mm. Minimum growth was observed for larger clams ie., 2.5-3 cm class (8.26 mm) and the maximum was for smaller clams ie., 1-1.5 cm (11.19 mm). As in the case of station II, at station V also the growth of the clams were very low during February to May. At stations IV and V, there was a significant difference in annual average growth rate between difference classes, where as at station II the difference was negligible.

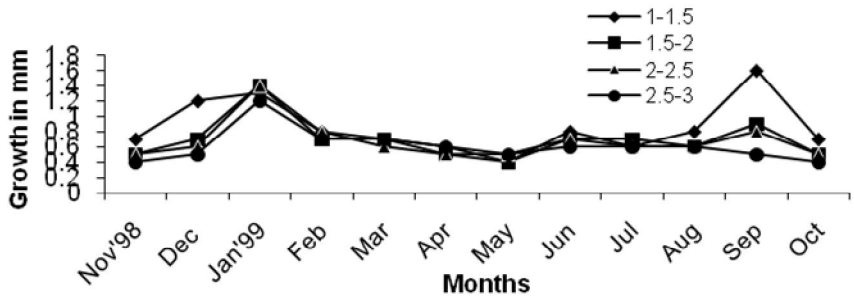


Figure 6. Growth in cage at station II

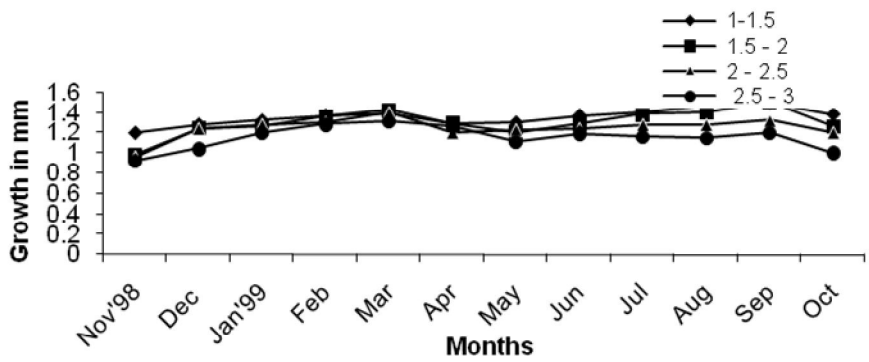
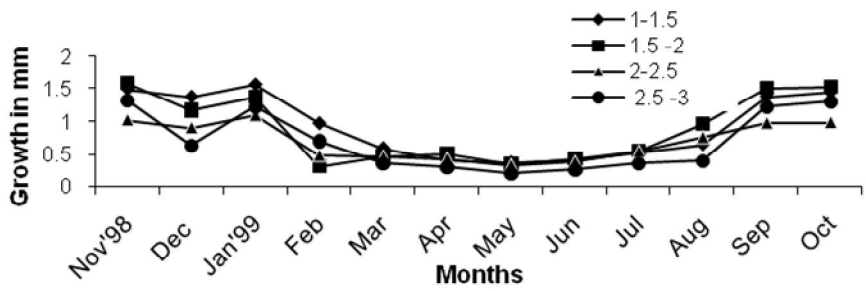


Figure 7. Growth in cage at station IV



Graph 8. Growth in cage at station V

Discussion

Cage culture growth studies revealed that smaller clams grow faster than larger ones. Among the four class ranges (1-1.5 cm, 1.5–2 cm, 2–2.5 cm and 2.5–3 cm) selected for studies at all the stations, class range 1-1.5 cm showed higher growth rate and class range 2.5–3 cm showed the lower growth rate. Similar observations were made by Rao

(1951) in *Katelysia opima*, Abraham (1953) in *Meretrix casta*, Nayar (1955) and Thalikedkar et al (1976) in *Donax cuneatus*, Alagarswami (1966) in *Donax fabe*, Mane (1974) in *Katelysia opima* and Rao (1988), and Thippeswamy & Joseph (1991) in *Donax incarnatus*. Spear & Glud (1957) have reported that environment and not heredity that is important in determining the growth of the soft clam *Mya arenaria*. Comparing station II and IV it was observed that higher growth rate was at station IV than station II, besides that, station II showed a decrease in growth rate from January to May in all class ranges. This may be due to the accumulation of silt and clay at station II during the closure of bund (December to May). Swan (1953) and Pratt (1953) reported that linear growth of clams *Mya arenaria* and *Mercenaria mercenaria* was higher in sediment with sandy texture than muddy one. Another reason for better growth at station IV compared to station II may be the prevalent typical estuarine environment (Saline mixed water) at station IV when compared to that at station II (freshwater). Abraham (1953) compared two clam beds at Adyar and concluded that growth of clams is much more rapid in the backwater than in the river. At station IV there was a sharp decrease in the growth of clam from January to May and then it gradually increased. This was due to the higher saline condition that prevailed at that station. According to Talikhedkar *et.al*.(1976), in tropical waters, changes in temperature are negligible and therefore, salinity has been found to influence the growth of bivalves. Durve (1970) reported that the retardation of growth may perhaps be attributed in some way to the increase in salinity in the ambient environment especially during summer months.

Hence, it can be concluded that existence and periodical opening and closure of Thanneermukkom bund has been controlling the ecology of clam beds and threatening the very existence of clams in the estuary. So proper management measures should be taken to maintain the ecology of clam beds and clam fishery of this estuary.

Conclusions. Temperature, salinity and bottom sediment texture are found to be the important factors significant for the growth and survival of bivalves. Environmental condition on different parts of the estuary is varied due to the existence of Thanneermukkom bund and bar mouth. At station II the frequency of temperature fluctuation was high and the dominant environment was freshwater. Sediment texture at station II was sandy silt and at station IV was silty sand. At station V the dominant condition was saline and sediment texture was clayey in nature. At station II the annual average growth was 8.48 mm; at station IV it was 15.15 cm and at station V it was 9.64 mm. Moderate level of salinity is found to be a favourable factor for the growth of *Villorita cyprinoides*. Growth rates of smaller clams were found to be higher than larger clams.

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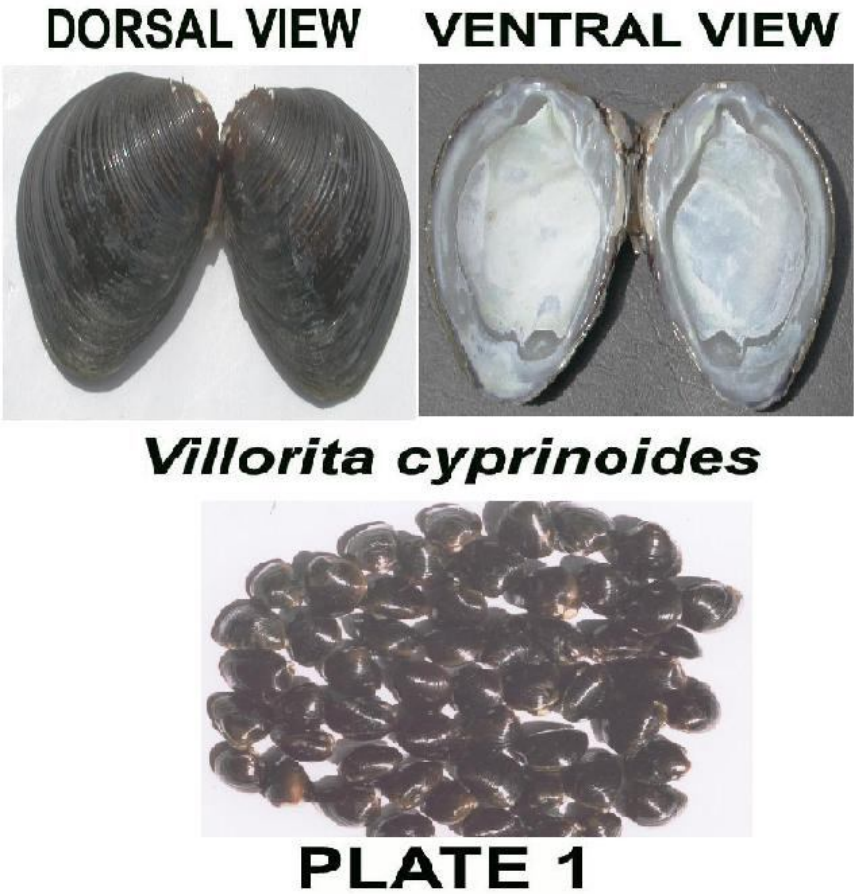

Plate 1. *Villorita cyprinoides*

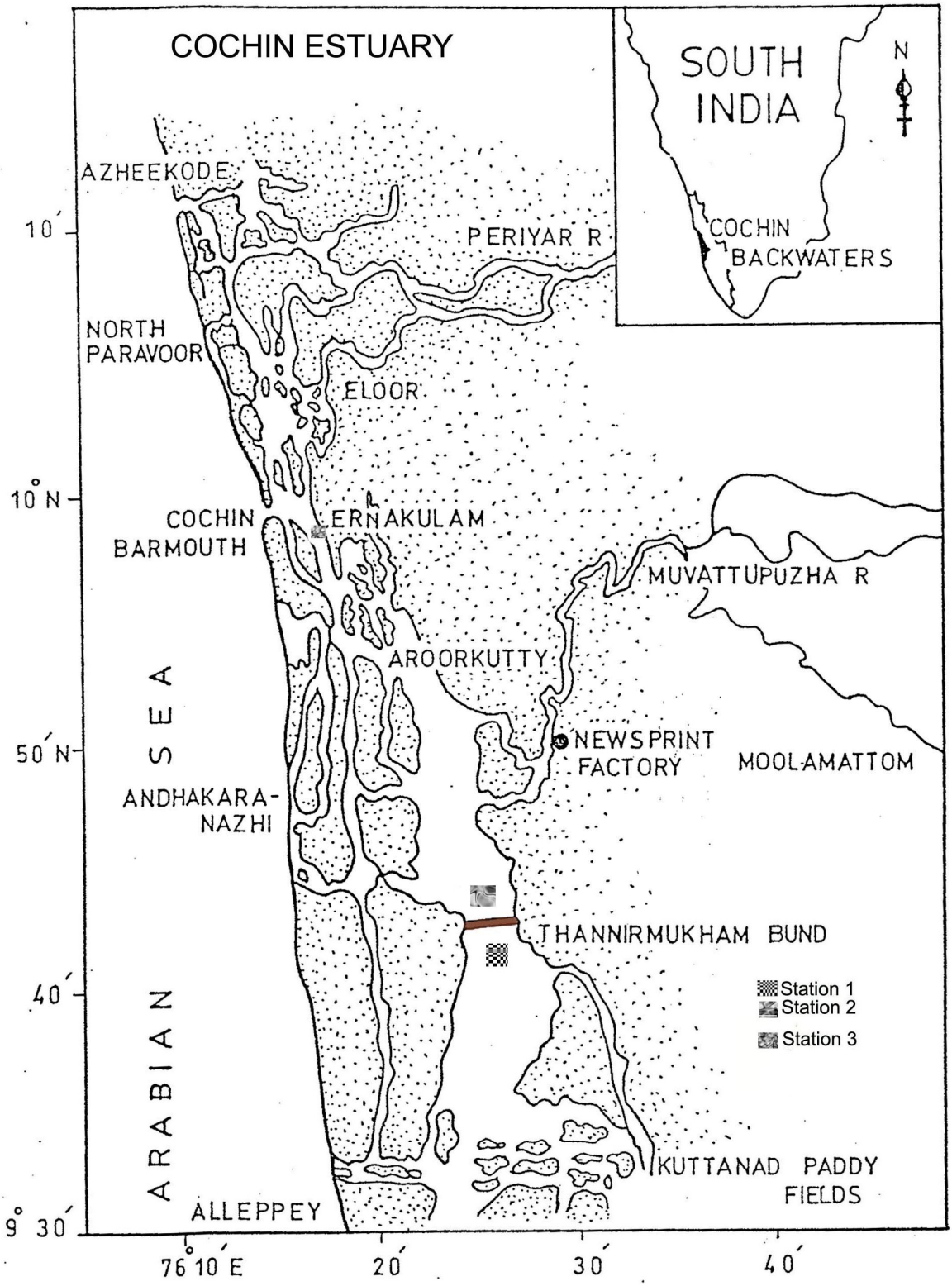

PLATE 2

Plate 2. Map pointing Thanneermukkom bund

PLATE 3

Plate 3. Thanneermukkom bund

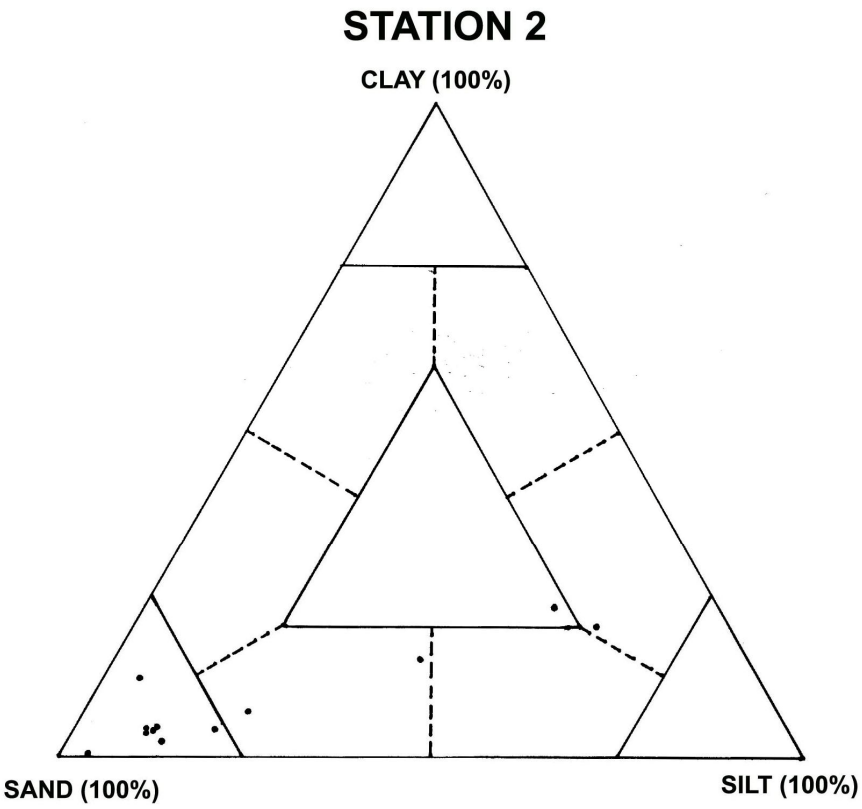

Plate 4. Substratum at station 2

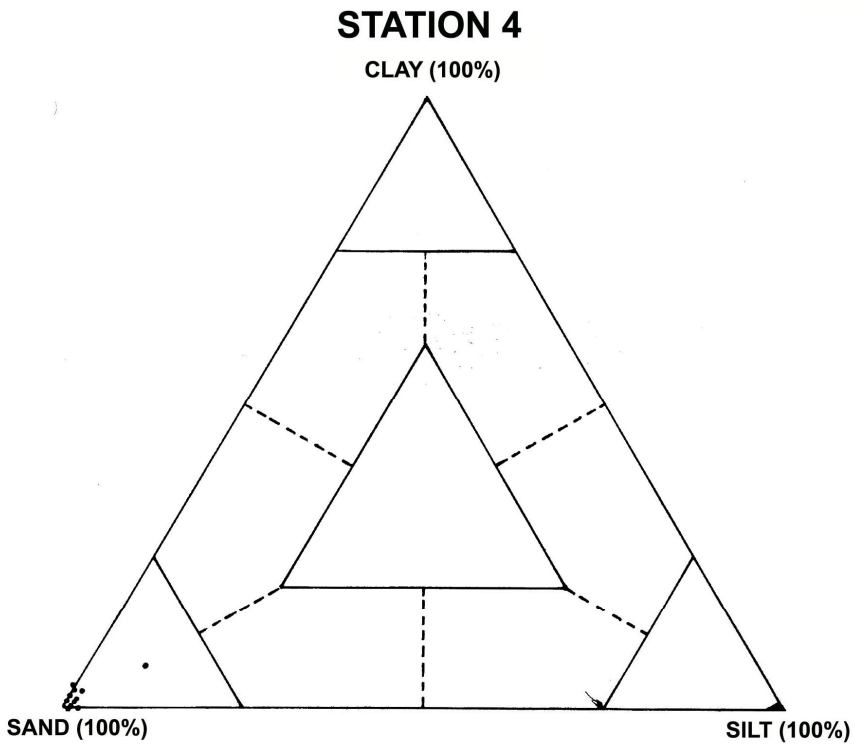

Plate 5. Substratum at station 4

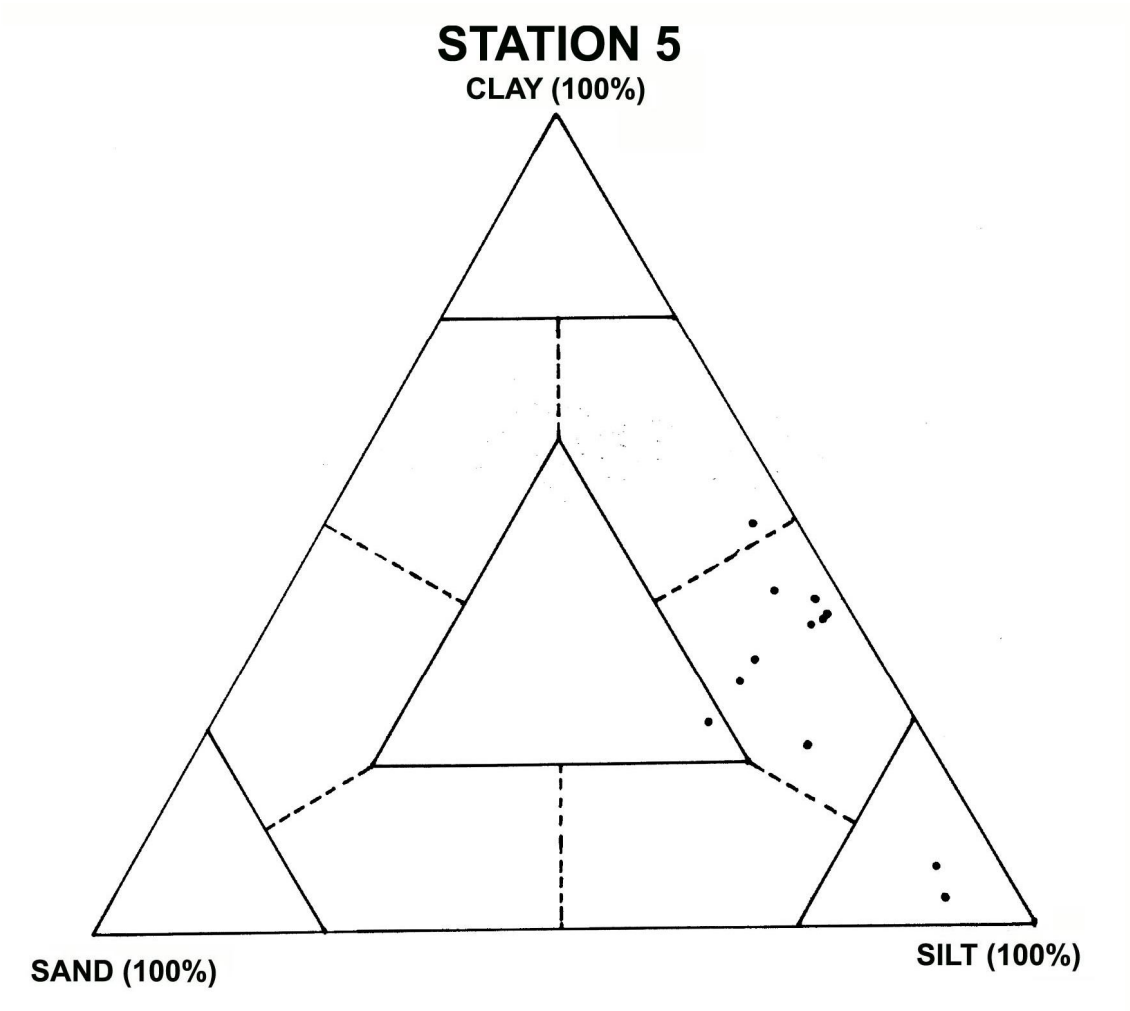

Plate 6. Substratum at station 5

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