POTAMIDID SNAILS OF VELLAR-COLEROON ESTUARINE AREA, SOUTHEAST COAST OF INDIA

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ABSTRACT

Shell sculpture, external morphology of the body and pallial organs, digestive system, reproductive organs and types of sperms of three species of potamidids, *Cerithidea (Cerithideopsilla) cingulata*, *C. (Cerithidea) obtusa* and *Telescopium telescopium* collected from Vellar-Coleroon estuarine complex are studied, described, illustrated and discussed in this account.

Electrophoretic analyses showed that the pattern of protein fractions indicated closer association between *C. (C.) cingulata* and *C. (C.) obtusa* at interspecific level and both differ from *T. telescopium*. Of the three species, *C. (C.) obtusa* appears to be more advanced and evolving gradually towards terrestrial mode of life.

INTRODUCTION

IN THE VELLAR-COLEROON estuarine area, snails of the family Potamididae are represented by three species, namely, *Cerithidea (Cerithideopsilla) cingulata* (Gmelin), *Cerithidea (Cerithidea) obtusa* (Lamark) and *Telescopium telescopium* (Linnaeus) under the subfamily Potamididinae. So far no detailed study has been carried out on these snails from this area. Therefore, detailed investigations were carried out on the organisation, habit and habitats, and biochemical systematics of these snails and results are presented here.

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MATERIAL AND METHODS

Cerithidea (C.) cingulata was collected from the Vellar Estuary and Killai Backwater. *C. (C.)*

obtusa from the mangrove of Pichavaram and *T. telescopium* from both the areas.

Terminology used in the description were those employed by Van Bentham Jutting (1956) and Houbrick (1978).

For electrophoresis, the three layered polyacrylamide gel electrophoresis (Ornstein, 1964, Davis and Lindsay, 1967 ; Smith, 1976) was used in the present investigations. Chemical formulations described by Canalco Bulletin (1968) were used for the preparation of various stock solutions and combination of them, in actual processing of electrophoresis. The separating gel was the standard 7.5% polyacrylamide gel. Extracts of foot and gonadal tissues from the three species were used for the analyses and electrophorased simultaneously. Comassie Brilliant Blue for general proteins and PAS reaction for glycoproteins, were the stains used.

Relative mobility (Rm) of the individual fraction of the proteins was calculated taking

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the distance from origin to the front as 1.0 unit. For convenience, the fractions were grouped into three, based upon their Rm values : (1) slow moving (upto 0.33), (2) intermediate (0.34 to 0.66) and (3) fast moving (0.67 to 1.00). The Rm values were calculated for each gel and the average for 20 runs were used for final analyses.

OBSERVATIONS

Shell

Shells of potamidids are characteristically elongate, turrated and fairly thick. The aperture is ovate with a short anterior siphonal canal. The outer lip is flared and grows beyond the

uniformly dark coloured or mottled with brownish yellow spots, particularly on the lower row of nodules in each whorl of the shell. *C.* (*C.*) *obtusa* (Pl. I D-F) is pale pinkish without any mottling. Protoconchs are small and normally lacking in older specimens, especially in *C.* (*C.*) *obtusa.* In *T. telescopium* (Pl. II A-C) the shell is dark in young specimens but greyish in older ones. Operculum is ovate with a central nucleus and concentric lines of growth. It is generally thin, chitinous and brown or dark.

External features (Fig. 1)

The visceral organs in general are greyish, but individual organs show different coloura-
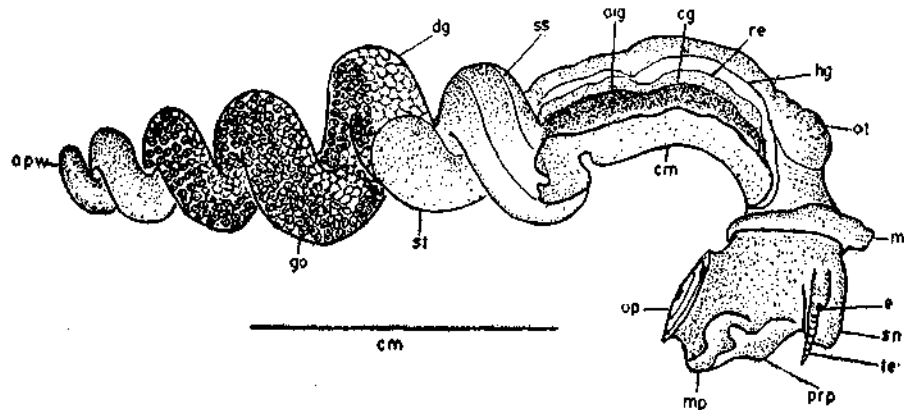

Fig. 1. *C.* (*C.*) *cingulata.* Female with shell removed exposing mantle, visceral mass and associated organs. (alg : albumen gland, an : anus, apw : apical whorl, blsi : blood sinus, cg : capsular gland, chc : cephalic haemocoel, cm : columellar muscle, cpg, : cerebro-pleural ganglion, cs : crystalline style, ct : ctenidium, dg : digestive gland, e : eye, go : gonad, he : heart, hg : hypobranchial gland, in : intestine, inh : inhalent siphon, k : kidney, la : lateral tooth, ll : lateral laminae, ma_1 and ma_2 : marginal teeth, mc : mantle cavity, md : median tooth, me : mantle edge, ml : median laminae, mp : metapodium, ng : pallial siphonal eye, o : oviduct, oc : oral cavity, od : odontophore, odg : oviducal groove, oe : oesophagus, op : operculum, osp : osphradium, ov : ovary, pdg : pedal ganglion, pgd : pallial gonoduct, prg : prostate gland, prp : propodium, rd : radula, re : rectum, rs : radular sac, ser : seminal receptacle, sg : seminal groove, sn : snout, spg : sperm collecting gutter, ss : style sac, t : testis: te : tentacle, vd : vas deferens).

columellar base. The outer lip is thickened in older specimens. The shell is strongly sculptured in both *Cerithidea* and *Telescopium.* In the former, both the axial and spiral sculptures are evident, while in the latter only spiral ridges are present. Periostracum is colourless. Shells of *C.* (*C.*) *cingulata* (Pl. I A-C) are

tion. Foot is dark in *C.* (*C.*) *cingulata* and *T. telescopium* while it is red in *C.* (*C.*) *obtusa.* The head is dark in the former two species while in the latter, it is red and black banded alternately. The stomach region is bluish-green while the gonads appear creamy (mature female) or bright yellow (mature male). Colu-

mellar muscle is invariably white. The region near the kidney is iridiscent.

The foot is massive, highly contractile and capable of considerable expansion during locomotion. The propodium, invested with mucus secreting cells, has a network of connective tissue and muscle fibres. The chitinous operculum is attached to the metapodium. The foot is innervated from the paired pedal ganglia situated at the juncture of head-foot region.
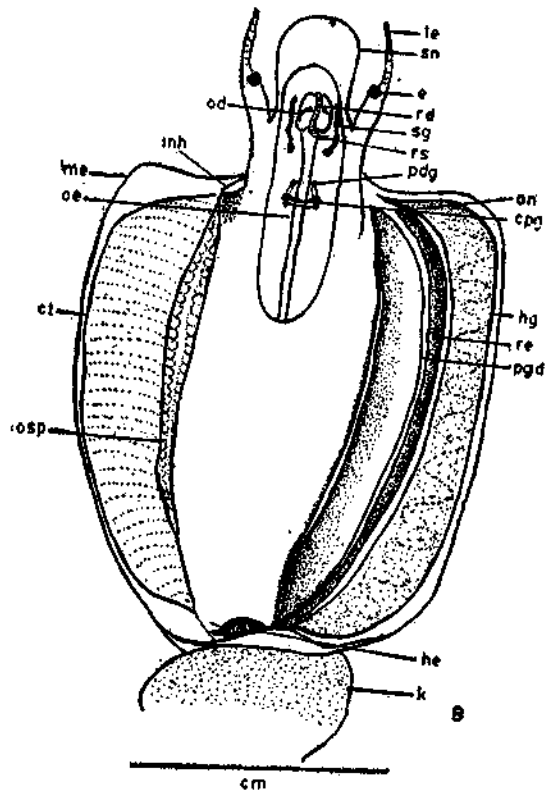

Fig. 2. *C. (C.) cingulata.* Mantle skirt medially cut ; two halves deflected laterally. Buccal cavity opened mid-dorsally exposing anterior alimentary tract and nerve ring. (for abbreviations, see Fig. 1).

The head is broad with a prominent snout which is wrinkled and highly contractile. The mouth is crescentic and situated at the anterior tip of the snout. The tentacles project from the neck, are stumpy at the base, but from the position of eye, somewhat thinner. The tentacles are spotted with black in *C. (C.) cingulata* and *T. telescopium,* but are banded in *C. (C.) obtusa* with red and black.

Mantle cavity and associated organs (Figs. 2 & 3)

The organs of the pallial complex are the ospharadium, ctenidium, hypobranchial gland, intestine, rectum and the genital tracts. The surrounding mantle is thick and muscular at its free edge. The dorsal and lateral edges of the mantle are smooth and without crenulation. In the inhalent siphon area, the mantle edge is modified into muscular fold, but not so distinctly in the exhalent siphon area. There is a very narrow groove leading from the exhalent siphon area to the foot in the females. The mantle cavity is very deep.

The osphradium is elongate and prominent extending from kidney-heart region anteriorly to the inhalent siphon. It is bifurcated and each part is triangular in shape. A thick nerve runs beneath the osphradium.

The well developed ctenidium is large and occupies a considerable portion of the mantle cavity, but it narrows down posteriorly. The ctenidium is separated from the osphradium by a narrow space. It is highly vascularised at the posterior region as an adaptation to partial aerial breathing.

In *C. (C.) cingulata,* the hypobranchial gland covers the entire region from the exhalent canal to the ctenidium anteriorly. It is traversed and bifurcated by the rectum anteriorly and the intestine posteriorly. The hypobranchial gland secretes copious mucus to bind the extruded faecal matter from the rectum so as to keep them away from the ctenidium to avoid contamination.

The intestinal and rectal portions of the digestive tract lie in the visceral complex between the hypobranchial gland and the gonoduct.

The anus is located slightly behind the mantle edge, near the exhalent siphon.

The genital ducts appear as folds and grooves and are coloured pale yellowish. They extend almost the full length of the mantle cavity from the anterior to the posterior end.

Digestive system (Fig. 4)

The terminal crescentic mouth opens into the buccal cavity. At the anterior end, the buccal cavity lodges a pair of triangular chitinous jaws embedded in the dorsal wall of the cavity. The buccal mass or odontophore is muscular, red in colour and anchored dorsally to the

bears about 5 to 6 cusps. The marginals are narrow and elongate and appear hook-like and bear strongly curved cusps. The number of rows of teeth varied from 65 to 71 in *C. (C.) cingulata*, 142 to 160 in *C. (C.) obtusa* and from 80 to 87 in *T. telescopium*. At its rear end, the radula confluences with radular sac which secretes the radula. This region is provided with strong musculature for the movement of the radula.

The salivary glands are thin and elongated. The dorsal food channel of the anterior oesophagus shows a characteristic twist at the region of torsion, posterior to the nerve ring
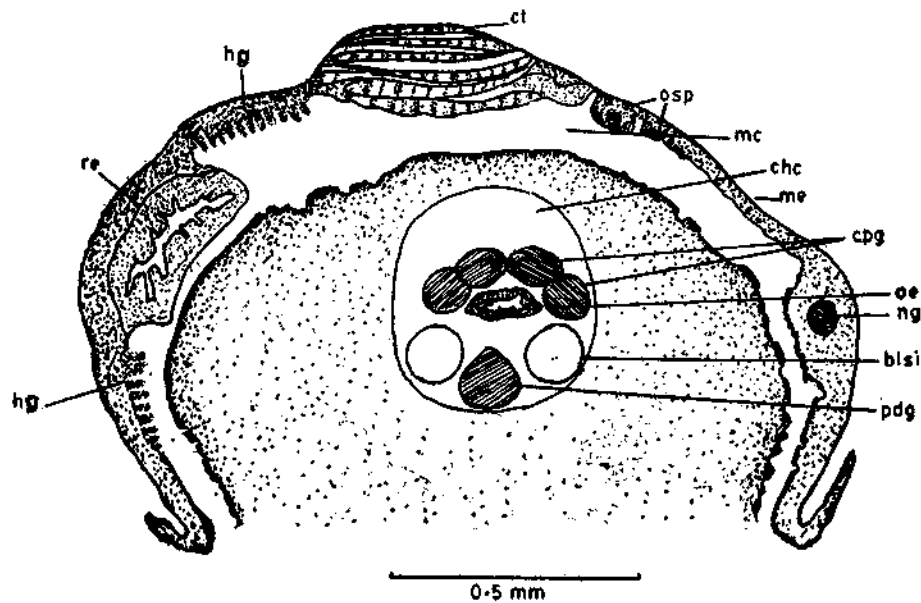

Fig. 3. *C. (C.) cingulata*. T.S. through anterior edge of the mantle cavity. (For abbreviations, see Fig. 1).

body wall by strong muscles. The radula is typically taenioglossate *viz.*, one median, one lateral and two marginals (2-1-1-1-2) (Fig. 5 a, b; Fig. 6). The median tooth, smaller than others, has a upper broader edge which bears a middle cusp and three lateral cusps on each side. The ventral triangular portion is smooth near the base. The lateral tooth

and comes to lie ventrally in the posterior oesophagus.

The stomach is quite large, with many muscular folds and ridges. Oesophagus opens into the stomach midventrally. Digestive gland opens by a pair of openings closer to that of the oesophagus. Style sac is well developed and

secretes the proteinecieous crystalline style, which dissolves to release the digestive enzymes. The hindgut includes the intestine and the dilated rectum, which opens into the mantle cavity by the anus. The digestive gland is an elaborate structure lying posteriorly to the stomach extending up to the apical whorls.

The entire alimentary tract is provided with thick cilia for transportation of food particles. Extensive mucus secreting cells are found in the foregut for binding the food particles and in the hindgut for binding the faecal matter.
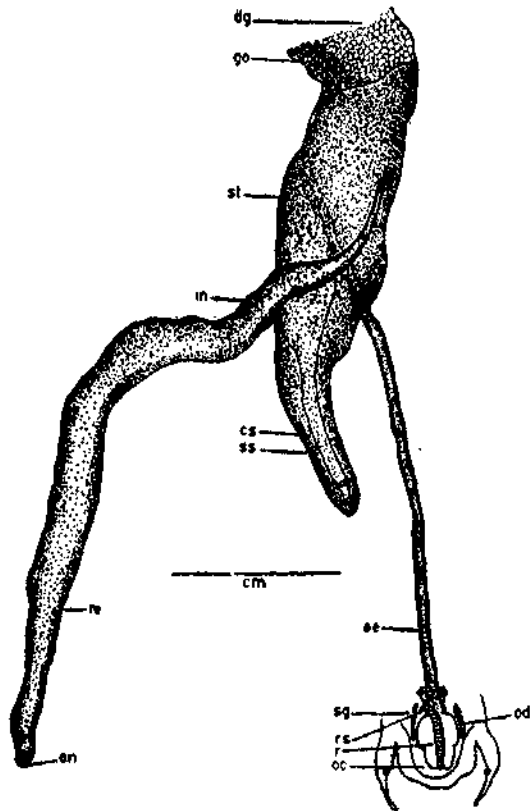
swallow along with it, a lot of sand particles. Benthic as well as the settled diatoms on the bottom are also found in the stomach contents. Algal bits are also quite common.

Reproductive system

Potamidids are dioecious and aphallic, rendering external sexual determination difficult. However, in adults, the colour of the gonads varies with sex—creamy colour in female and
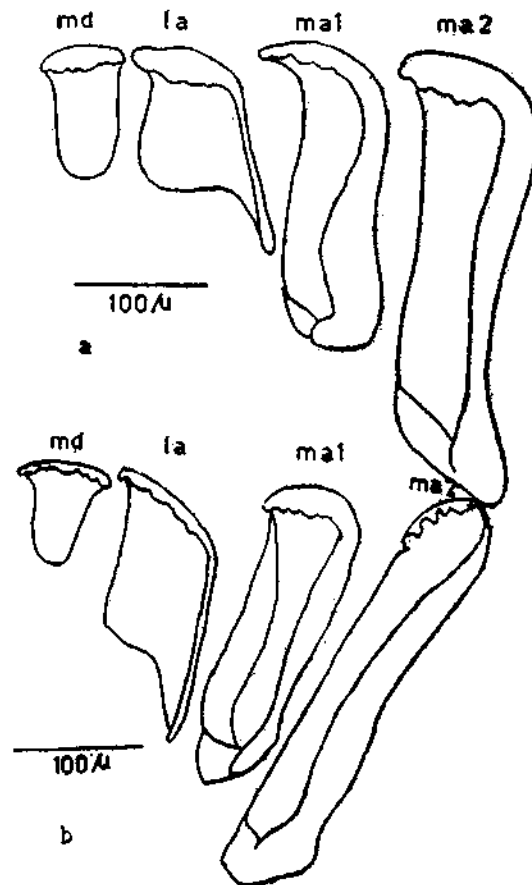

Fig. 4. Digestive system of *C. (C.) cingulata*. (For abbreviations, see Fig. 1).

Fig. 5. Radular teeth of *C. (C.) obtusa* and *T. telescopium.* (for abbreviations, see Fig. 1.)

Food of potamidids consists generally of fine organic, particulate detrital matter settled on the substratum. The snails scrap off the food matter with the help of the radula and

yellow in male. The female of *C. (C.) cingulata* possesses modified metapodium which is swollen and bright yellow and can be easily recognised.

Gonads are closely associated with the digestive gland making it difficult to separate them from each other. The testis is follicular in nature and each follicle leads into a tiny tubule, which in turn leads into a vas deferens, running along the columellar side of the visceral coil. The vas deferens enters the open pallial gonoduct near the stomach (Fig. 7 a). The pallial gonoduct possesses two laminae—lateral and median, which are fused dorsally to each

Fig. 6. Radular teeth of C. (C.) cingulata.
(For abbreviations, see Fig. 1).

other and to the mantle. The ventral margins are free and open into the mantle cavity. The proximal portion of the genital groove is glandular and acts as prostate. The epithelial lining of the inner walls of the laminae, thrown into folds, appear smooth.

Sperms are of two types, eupyrene and apyrene (Figs. 7 c, d) as found in other cerithiaceans. A spermatophore (Fig. 7 e) is formed to aid sperm transfer from the male to the female. Wall of the spermatophore is produced by the pallial gonoduct.

The ovaries are follicular and superficially interspersed over the digestive gland. The

oviduct runs along the columella similar to that of vas deferens. The open pallial oviduct is similar to that of male in general appearance (Fig. 7 b). The median lamina is non-glandular upto anterior—middle region and glandular from thereon. The posterior portion of this glandular region secretes the albumen and the anterior, the capsule of the egg. Anteriorly, a long slit, the sperm collecting gutter is present and leads into a ciliated tube-like channel, which runs posteriorly to the sperm collecting pouch. The latter has a fine opening into the lumen near the opening of the closed oviduct. This area is the site of fertilization from which egg moves anteriorly, via albuminous and capsular regions by ciliary currents. The eggs leave the mantle cavity and reach the exterior along the groove in the neck, to the pedal groove formed by the foot.
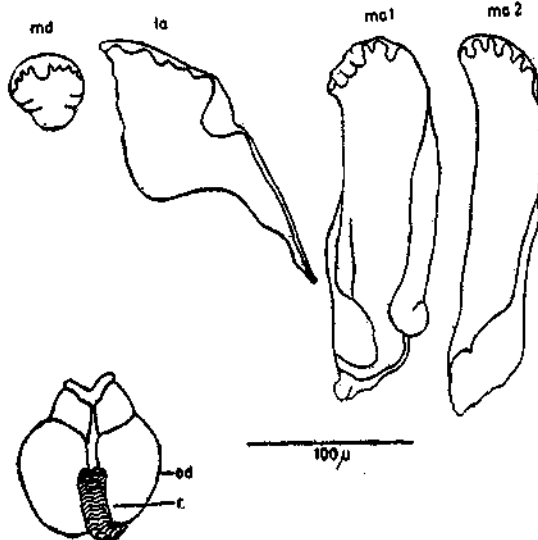
Other systems

The excretory organ in the potamidids is the kidney which is large, flat and spongy, appearing grey to brown in colour. It is located at the left side of the visceral hump. The elliptical slit-like renal opening is situated on the ventro-lateral part of the ascending portion of the kidney, close to the intestine. The opening is surrounded by cilia.

The vascular system of the potamidids is similar to that of the related cerithiids (Houbrick, 1978) and other mesogastropods. A two chambered heart is located in a pericardial cavity. The anterior aorta runs forward under the floor of the pericardial cavity, dorsally to the left of the posterior region of the oesophagus and ends in a series of sinuses in the head-foot region. The posterior aorta buds off from the anterior aorta and runs along outside of visceral mass and ends in visceral sinuses. The blood vessels and sinuses are open and poorly defined.

The nervous system of the potamidids is similar to that of *Littorina* (Fretter and Graham, 1962). The ganglia of nerve ring, the dorsally located cerebral and pleural and the ventrally

located pedal ganglia are all distinct. Commissures connecting the right and left ganglia to pedal ganglia are thin. Fine nerves branch off from the ganglia and run to various regions. There is a tiny ganglion in the inhalent siphon region in the mantle edge. The chief sensory organs of the potamidids are the eyes, osphradium and statocyst.

with clay substratum. Most dense populations are found near river mouth. dwindling gradually towards the upper reaches. The snail feeds on the detrital matter settled on the substratum. It is totally absent inside the mangrove proper.

C. (C.) obtusa is found only within the mangrove forest and endemic to that area.
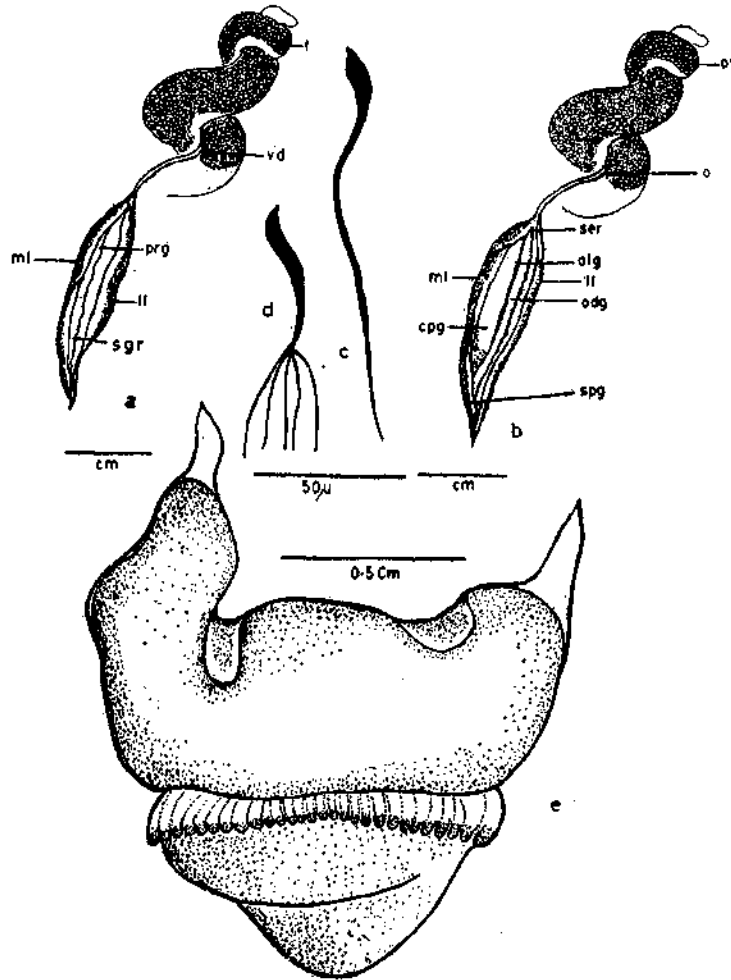

Fig. 7. C. (C.) obtusa : a. male reproductive system, b. female reproductive system, c. eupyrene sperm, d. apyrene sperm and e. spermatophore. (For abbreviations, see Fig. 1).

Habit and habitats

C. (C.) cingulata occupies the intertidal area of the Vellar-Coleroon area mainly between MTL and LTL. The snail prefers sand mixed

The snail climbs the *Rhizophora* tree upto one meter height and often found in the branches attached by a thin film of mucus. It prefers shady areas indicating its adaptation to humid

cool atmosphere. Aerial respiration appears to be dominant over aquatic respiration in this species. The snail subsists on detritus of decomposing leaves, rich in organic matter.

T. telescopium is found in the gradient and tidal zones of the Vellar Estuary as well as inside and out of the mangrove forest. T. telescopium is found mainly between HTL and MTL. The snail takes submersion and exposure with ease, indicating that the respiration

muscle, ovarian and testicular tissues of C. (C.) cingulata, C. (O.) obtusa and T. telescopium are given in Plate IV. There are 13, 10 and 14 fractions in the foot muscle of C. (O.) cingulata, C. (O.) obtusa and T. telescopium respectively. Of them, 5 fractions in C. (C.) cingulata and O. (C.) obtusa and 4 in T. telescopium are dense. Fast moving fractions are 4 in C. (O.) cingulata, 3 in C. (C.) obtusa and 4 in T. telescopium, while intermediate fractions
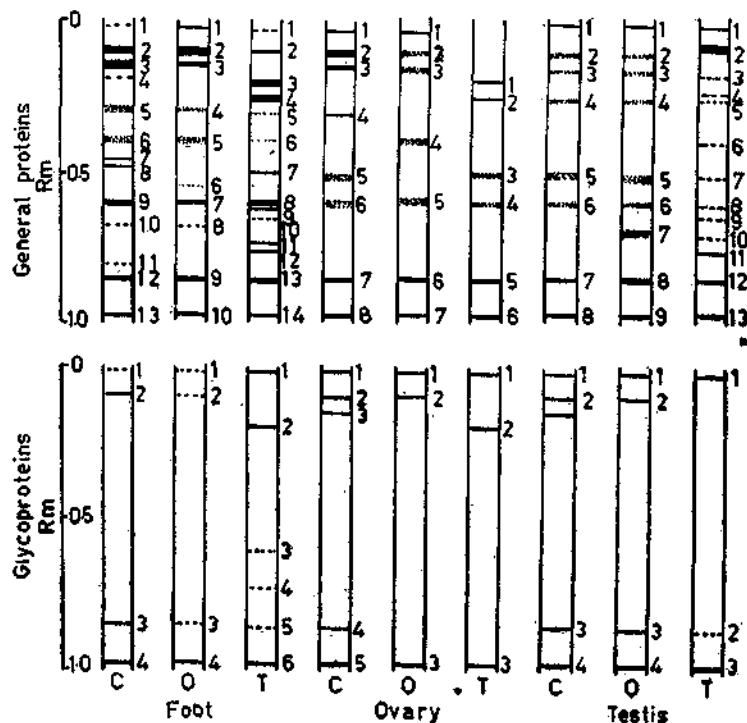

Fig. 8. Electrophorograms of general proteins and glycoproteins in the foot muscle, ovary and testis — C : C. (C.) cingulata, O : C. (C.) obtusa and T : T. telescopium. Rm : Relative mobility.

is both by aerial and aquatic modes. It also prefers a substratum of fine sand mixed with clay. The snail feeds on the detrital matter and diatoms settled on the substratum, similar to that of C. (C.) cingulata.

Electrophoretic studies

The pattern of the protein fractions stained by Comassie Brilliant Blue from the foot

number 4, 4 and 5 respectively. Between C. (C.) cingulata and O. (C.) obtusa there are 8 common fractions while between the three species there are only 5 common fractions.

In the ovarian tissue, there are 8, 7 and 6 fractions respectively in O. (C.) cingulata, C. (C.) obtusa and T. telescopium. The fractions recorded in the ovary are all represented in
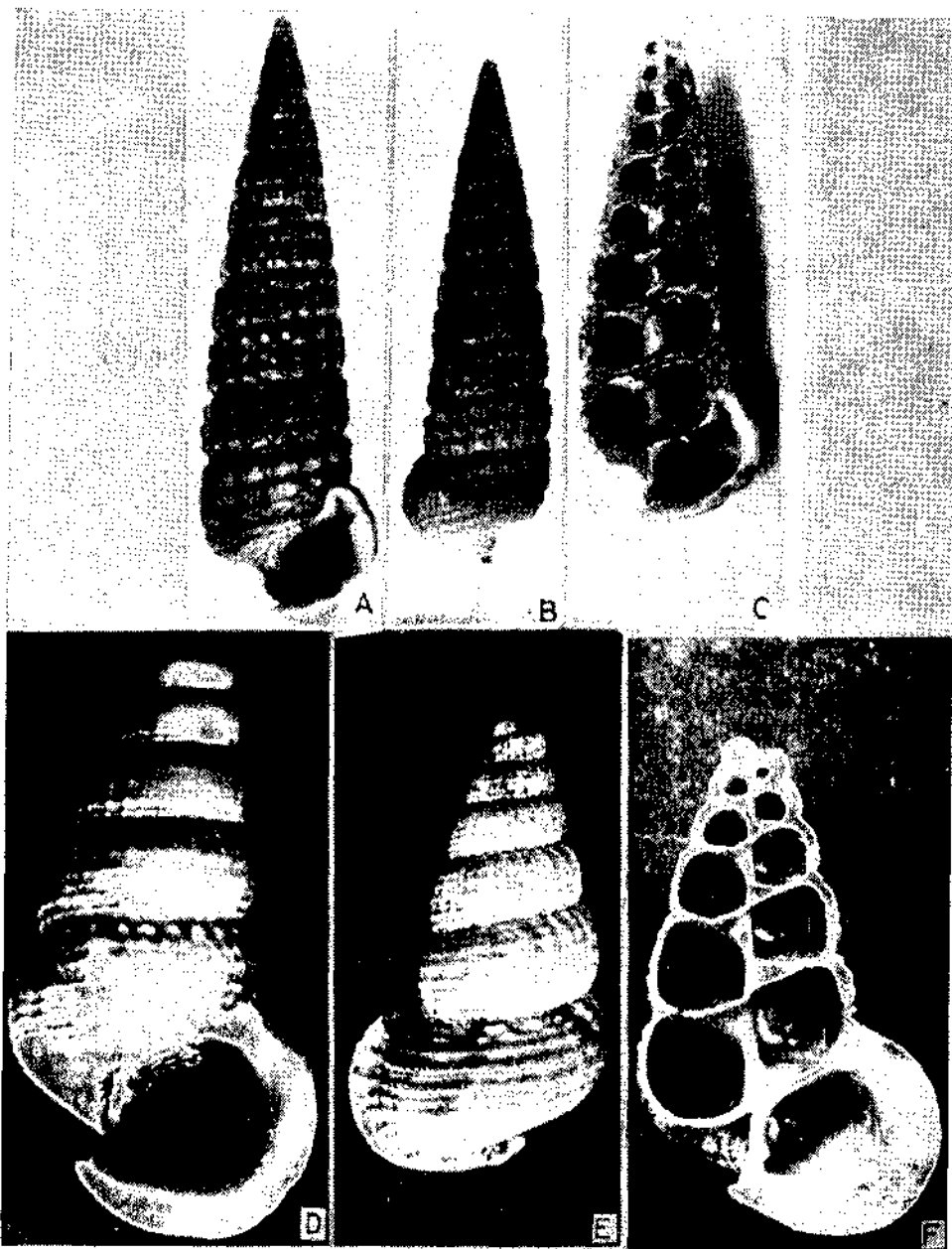
PLATE I. *C. (C.) cingulata* — A. Apertural view, B. Abapertural view, C. Longitudinally cut exposing columella ; *C. (C.) obtusa* —D. Apertural view, E. Abapertural view and *F.* Longitudinally cut to expose columella.
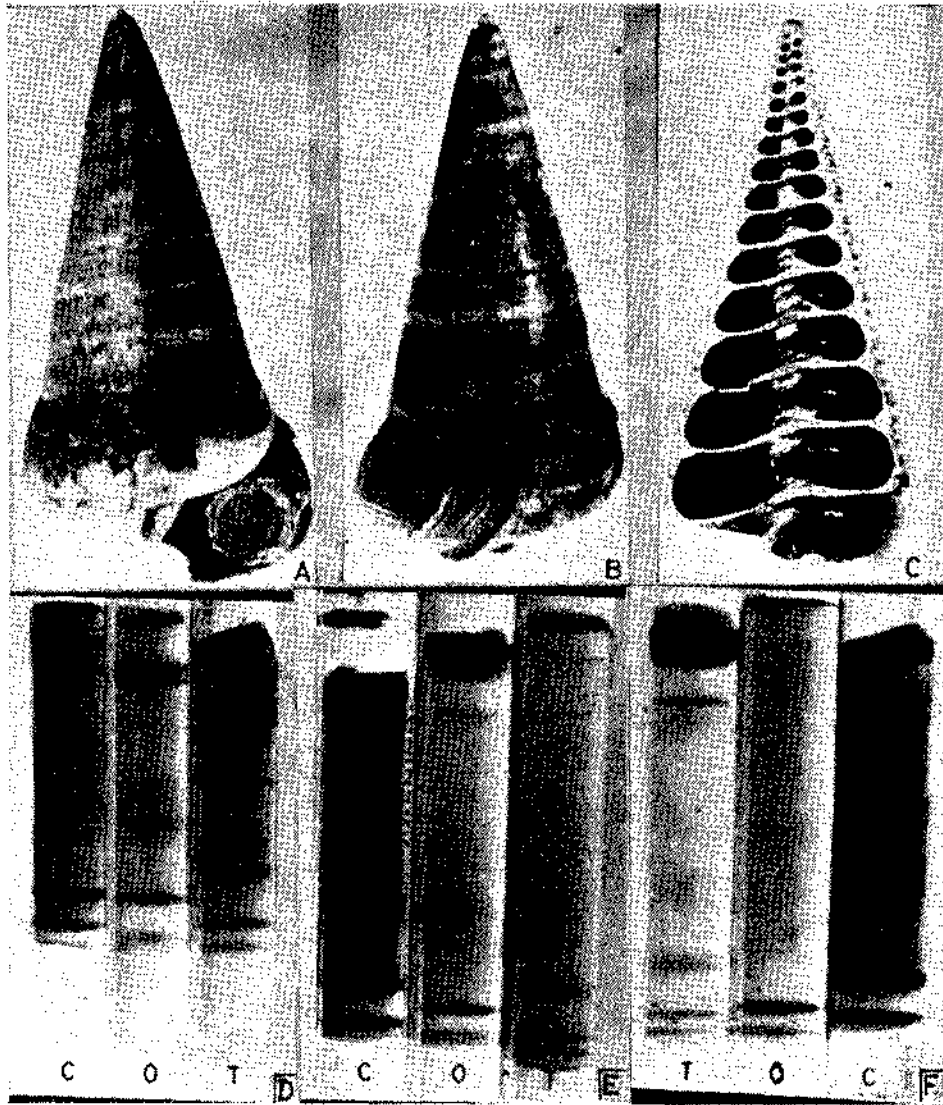
PLATE II.   *T. telescopium* — A. Apertural view, B. Abapertural view, C. Longitudinally cut exposing
columella ;   General   protein   fractions   in — D. foot   muscle,   E. ovary   and   F. testis.
C : *C. (C.) cingulata* O : *C. (C.) obtusa* and T : *T. telescopium.*

the foot muscle except in *C. (C.) cingulata*. Of these fractions, there are 2 fast moving and 2 intermediate fractions in all the three species. Five fractions of *C. (C.) cingulata*, 3 of *C. (C.) obtusa* and 2 of *T. telescopium* are dense. There are 3 common fractions between the three species.

In the testis, the number of fractions are similar to the female gonad in the case of *C. (C.) cingulata* (8), while they are more in *C. (C.) obtusa* and *T. telescopium*. Fast moving fractions are 2, 3 and 4 and intermediate moving are 2, 2 and 4 respectively in the three species.

The pattern of glycoproteins was much simpler in all the three species studied. In the foot muscle, there are 4 fractions in *C. (C.) cingulata* and *C. (C.) obtusa*, while there are 6 in *T. telescopium*. Of them, 2 are slow moving and the rest fast moving. There are no intermediate fractions.

In the ovarian tissue the total number of fractions varied from 3 to 5. Fast moving fractions are 2 in *C. (C.) cingulata*, and one each in *C. (C.) obtusa* and *T. telescopium*. In the testis, the total number of fractions varied from 3 to 5 and the fast moving fractions are
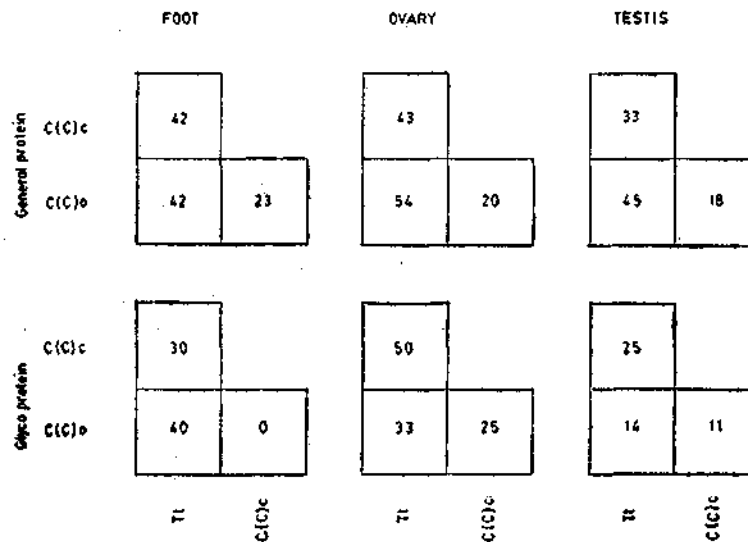

Fig. 9. Trelli's diagram showing the differences (in percentage) in general proteins and glycoproteins among the potamidids — C.C.C. : *C. (C.) cingulata*, C.C.O. : *C. (C.) obtusa* and T.t. : *T. telescopium*.

High density fractions are 2, 2 and 3 in *C. (C.) cingulata*, *C. (C.) obtusa* and *T. telescopium* respectively. Four fractions are common between the three species.

Davis and Lindsay (1967) suggested that for taxonomic purposes , the band pattern between midway and front (Rm 0.5 to 1.0) are more reliable. Three to eight such fractions were observed among the three species, of which 3 are common in the foot muscle and 2 in the gonadial tissues.

2 in all the three species. In the case of glycoproteins, the total number of fractions from midway to front are 2 except in the foot and ovary of *T. telescopium* and also in the ovary of *C. (C.) obtusa*.

The electrophorograms of the general proteins are glycoproteins in the foot muscle, ovary and testis of *C. (C.) cingulata*, *C. (C.) obtusa* and *T. telescopium* are given in Fig. 8.

To quantify the systematic affiliation between the three species, an attempt has been made

based on the number of protein fractions encountered in any of the two species following Bedford and Reid (1969). The number of fractions differed between any two species was scored. The percentage difference between them was found out from the formula :

$$\frac{\text{Number of fractions differed between each pair}}{\text{Total number of fractions present in each pair}} \times 100$$

The percentage obtained was plotted in Trelli's diagram (Fig. 9).

It was observed from the figure, that in general, the difference between $C.$ ($C.$) cingulata and $C.$ ($C.$) obtusa, is from 18 to 23%, while with $T.$ telescopium, it is between 33 and 54%. In the glycoproteins also, interspecific differences in the genus Cerithidea is only 0 to 25%, while the intergeneric difference is 25 to 50%.

The electrophoretic studies reveal without any doubt a strong affiliation between the three species at the family level ; $C.$ ($C.$) cingulata and $C.$ ($C.$) obtusa appear to be closely related and justify their inclusion in the same genus ; between the two species of Cerithidea and $T.$ telescopium, affinity to $C.$ ($C.$) cingulata is more than to that of $C.$ ($C.$) obtusa.

DISCUSSION

An anatomical study of three species of potamidids shows many similarities. Difference in shell size and sculpture between the members of potamidids, was observed by Vermeij (1973) who stated that higher shore forms have slender and larger shells, an adaptation to extreme desiccation and temperature. $T.$ telescopium and $C.$ ($C.$) obtusa have larger shells than their counterpart $C.$ ($C.$) cingulata, which inhabits the low levels, confirming the above view. Dissolution of the shell at the apex and erosion of axial rib found in $C.$ ($C.$) obtusa was attributed to high acidic conditions found in the sediment of mangrove and as a means of calcium carbonate conserving mechanism (Vermeij, 1973).

The external morphology, pallial organs, digestive system and reproductive system are all similar in all the three species. The organisation resembles that of lower mesogastropods and corresponds with the description of Littorina by Fretter and Graham (1962). Potamidids bear common characters to the super family Cerithiacea in having a crystalline style, ciliary mode of feeding and open pallial gonoduct. These are considered as primitive characters and the potamidids are positioned in the lower level of evolutionary ladder.

Driscoll (1971) ascribed the difference in the radular length to the nature of substratum on which the snails live and feed on. More number of teeth and lengthy radula in $C.$ ($C.$) obtusa indicate that it can feed on coarser particles too.

Regarding the presence of open pallial gonoducts of Cerithiacea, Johansson (1956) pointed out that open glandular grooves with sperm collecting gutter along the edge of the oviducal folds occur in several families with different habits of life e.g. Turtitellidae, Cerithiidae, Melaniidae, Pleuroceridae and Potamididae. He opined that such pallial gonoducts were primary characteristics of the group Cerithiacea and were ancestral recurrences of primitive grooves. Fretter (1951) and Fretter and Graham (1962) did not agree with the opinion of Johansson. They suggested that the open condition of the duct and absence of penis in these mesogastropods were correlated with a long, narrow mantle cavity. In such closely coiled visceral spires there is less space for the right half of the pallial complex. During the breeding season, the presence of a penis and its insertion into the pallial oviduct during copulation would interefere with the efficient functioning of the mantle cavity. Therefore, they concluded that the penis was lost and the spermatophore was transferred to the female through open ducts and that the open condition of the duct in such mesogastropods is probably secondary and advantageous.

Differences in the protein fractions bring out the taxonomic relation between the three species. Being placed in the same genus, *C. (C.) cingulata* and *C. (C.) obtusa* show a closer alliance. They differ significantly from *T. telescopium*. The interesting point is about the relationship between *C. (C.) cingulata* and *T. telescopium* on one hand and *C. (C.) obtusa* and *T. telescopium* on the other. The former two show close affiliation than the latter two. A perusal of the shell morphology itself brings out this striking similarity between these species. Both *C. (C.) cingulata* and *T. telescopium* have more than 10 whorls and more conical than *C. (C.) obtusa*. Decollation of the apical whorls is minimum in those two species. They also share a common habitat of intertidal substratum, while *C. (C.) obtusa* is a tree-associated form. *C. (C.) obtusa* is more adapted to air-breathing than aquatic respiration as evidenced by the behaviour of avoiding submersion. On the other hand, *C. (C.)*

cingulata and *T. telescopium* need periodical submersion and are adapted to aquatic respiration rather than to aerial respiration. So it can be concluded that among the three, *C. (C.) obtusa* is probably highly evolved than the other two species. It is more appropriate to quote the words of Morton (1967) here : ' Most terrestrial molluscs have early relationships with estuarine or freshwater species and they may share similar adaptations, especially in respiration and reproduction. Thus, lack of oxygen in estuarine waters may first lead to aerial respiration. Air breathing in aquatic snails in turn allows eastivation in response to occasional draught. This leads to further adaptations against desiccation and fully amphibious habit develops. With this comes changes in the mode of excretion, leading finally to a complete terrestrial life '. This seems to be most true in the case of *C. (C.) obtusa*, which appears to be evolving for terrestrial mode of life.

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