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Morphology of Stomach Ossicles in Brachyura

Kaworu NAKAMURA* and Takayuki TAKEMOTO*

Abstract

For understanding of the mechanism of gastric mill function, medial and lateral teeth were morphologically investigated with their articulated ossicles and muscular connections.

In 15 brachyuran species of 5 families, the fundamental structure of the cardiac stomach was the same without remarkable difference among species. Based on positional relations, 13 ossicles and 9 muscles of the cardiac stomach were identified. High movability of the articulation suggested that the propyloric ossicles, linked at each end with the urocardiac or pyloric ossicles, would be a principal part of the gastric mill for manifesting the medial tooth movement. Finally, transcribed illustrations of the medial and lateral teeth of the species examined were presented.

Brachyura is a very specialized organization morphologically in decapod. For example, its digestive tracts diverge, spreading diverticula over the internal space, and the intestine is extremely short compared to other decapod because of degenerated abdomen[1]. These differentiations have been considered to be derived from its geological adaptability. One of the essential organs for the nutrimental ingestion is the stomach which consists of cardiac, pyloric and gastric mill parts. The gastric mill possesses two typed teeth named medial and lateral teeth, and has been investigated in the crayfish, crabs, lobsters and shrimps morphologically[2-7] and in the crabs and lobsters physiologically[8-12], since early times. In this report, investigation of the teeth morphology is conducted in about 15 brachyuran species of 5 families, as well as a functional examination of teeth movements for a preliminary basis of physiological approach.

Materials and Methods

Samplings were carried out from May to the middle of August, at each estuary of Inari, Isaku and Koutsuki rivers as well as the seashore of Hajima in Kagoshima Prefecture. Following species were collected as materials : family Grapsidae; *Chiromantes dehaani*, *C. haematocheir*, *Eriocheir japonicus*, *Gaetice depressus*, *Helice tridens*, *Hemigrapsus penicillatus*, *H. sanguineus*, *Parasesarma erythrodactylum*, *Perisesarma bidens*, *Sesarmops intermedium*. family Ocypodidae; *Ilyoplax pusilla*, *Macrophthalmus* (*Mareotis*) *japonicus*. family Xanthidae; *Eriphia smithii*. In addition, *Geothlphusa dehaani* (family Potamidae) and *Charybdis* (*Charybdis*)

* Lab. of Propagation Physiology, Fac. of Fisheries, Kagoshima University, 50-20 Shimoarata 4, Kagoshima 890, Japan.

feriata (family Portunidae) were collected at Imuretani of Ijuhin City in Kagoshima Pref. and Nishinoomote Island of Okinawa Pref., respectively.

After identifications of species, materials were supplied to two different experiments as follows : I) Investigation of mechanical relations of stomach ossicles and muscles with biting and grinding functions of the gastric mill. Articular movement of ossicles connected with the gastric mill composed of medial and lateral teeth was especially traced under a vivisectional condition, and their movability was examined. II) Morphological observation and description of medial and lateral teeth of the gastric mill. After fixation with 10 % formalin, medial and lateral teeth with their related ossicles were extirpated to illustrate their shapes and recognize a specific difference of medial tooth or a component number of lateral teeth. The nomenclature followed MAYNARD and DANDO'S article[7].

Results and Discussion

Fundamental structure of cardiac stomach (**Fig. 1** and **2**)

Ossicles and muscles distributed on the cardiac stomach were symmetrically arranged. The median ossicles of the dorsal wall were arc-shaped mesocardiac ossicle (MCO), spatula-shaped urocardiac os. (UCO) which was connected to MCO along the latter length and its ventro-posterior transformed to a medial tooth, and propyloric os. (PPO) with inferior part articulated at an obtuse angle with the posterior end of UCO. Apart from the midline, each paired ossicle of pterocardiac os. (PCO) connected to MCO at the end, zygocardiac os. (ZCO) which was a slender triangle distorted slightly and posteriorly its end being opposite to another pair as lateral teeth, exopyloric os. (EPO) and pyloric os. (PYO) was situated.

For the extrinsic muscle, anterior gastric muscle (AGM) at the frontal wall, each of the endo-lateral posterior gastric m. (ENLPGM), exo-lateral posterior gastric m. (EXLPGM) and mesial posterior gastric m. (MPGM) at the posterior wall, were recognized dorsally. AGM and MPGM had a thick bundle. As for the intrinsic muscle of the dorsal wall, mesial cardio-pyloric m. (MCPM) and lateral cardio-pyloric m. (LCPM) were distinguished. The latter showed superior to and larger than the former.

Connections of these muscles with previously mentioned ossicles were as follows : AGM attached itself to MCO and PCO. EXLPGM attached itself to EPO. ENLPGM and MPGM attached to PYO. LCPM connected MCO to PYO. MCPM connected MCO to PPO.

The median ossicles of the ventral wall was cardio-pyloric valve (CPV). Paired prepectineal os. (PRPO) articulated to PCO showed its slender body as a beam on the ventro-lateral part of the cardiac stomach. PRPO connected pectineal os. (PEO) at the posterior end, and the latter linked to postpectineal os. (POPO). PEO was an oval plate possessing many setae at its edge toward the cavity. POPO was a component of the anterior appendants of CPV. At the level of PEO, a rod-like subdentate os. (SDO) was situated. Dorsal tip of SDO showed a hook-shape connected to the ventral hollow of the lateral teeth, and the other end articulated with a protrusion of the inferior lateral cardiac os. (ILCO)

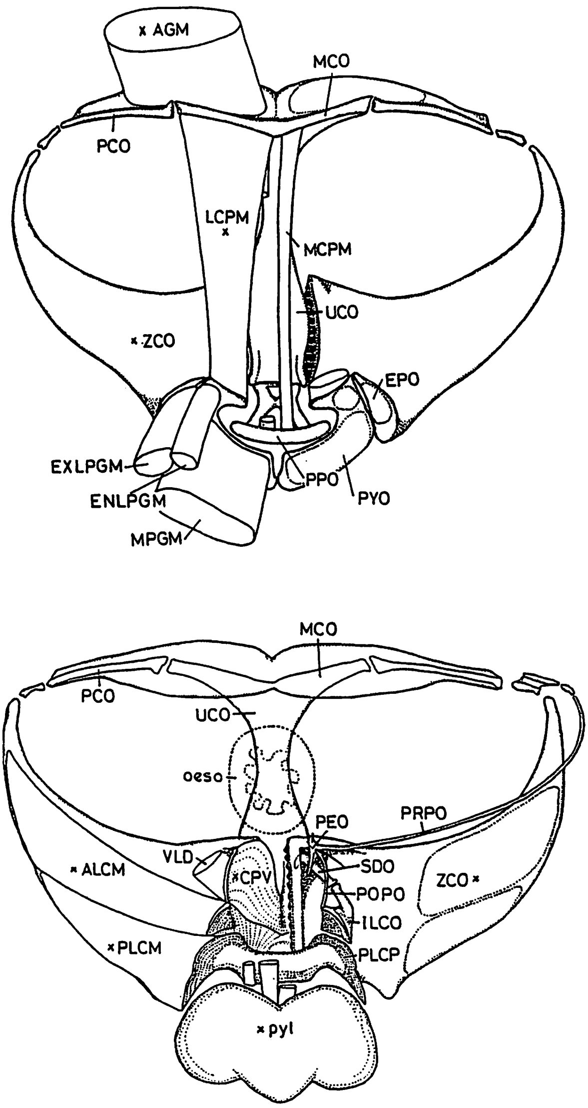

Fig. 1. Dorsal and ventral views of ossicles and muscles of the cardiac stomach in brachyura. Upper, dorsal; lower, ventral. Abbrev., oeso, oesophagus; pyl, pylorus: Ossicles; CPV, cardio-pyloric valve; EPO, exopyloric ossicle; ILCO, inferior lateral cardiac ossicle; MCO, mesocardiac ossicle; PCO, pterocardiac ossicle; PEO, pectineal ossicle; PLCP, postero-lateral cardiac plate; POPO, postpectineal ossicle; PPO, propyloric ossicle; PRPO, prepectineal ossicle; PYO, pyloric ossicle; SDO, subdentate ossicle; UCO, urocardiac ossicle; ZCO, zygocardiac ossicle: Muscles; AGM, anterior gastric muscle; ALCM, antero-lateral cardiac muscle; ENLPGM, endo-lateral posterior gastric muscle; EXLPGM, exo-lateral posterior gastric muscle; LCPM, lateral cardio-pyloric muscle; MCPM, mesial cardio-pyloric muscle; MPGM, mesial posterior gastric muscle; PLCM, postero-lateral cardiac muscle.

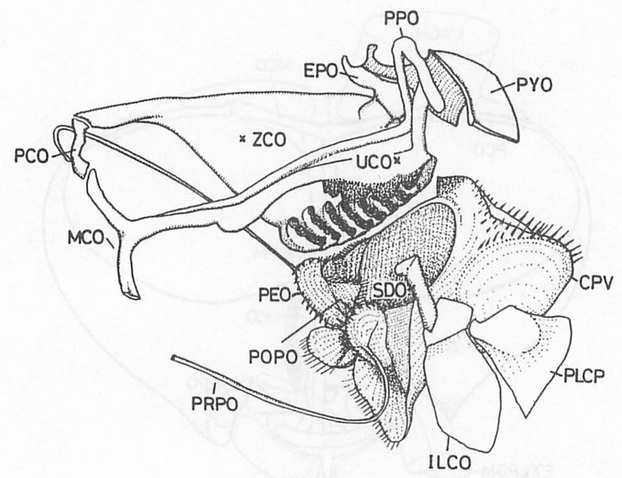

Fig. 2. Structural relation of medial and lateral teeth provided to urocardiac or zygocardiac ossicle, and their connection to other ossicles. Abbrev., CPV, cardio-pyloric valve; EPO, exopyloric ossicle; ILCO, inferior lateral cardiac ossicle; MCO, mesocardiac ossicle; PCO, pterocardiac ossicle; PEO, pectineal ossicle; PLCP, postero-lateral cardiac plate; POPO, postpectineal ossicle; PPO, propyloric ossicle; PRPO, prepectineal ossicle; PYO, pyloric ossicle; SDO, subdentate ossicle; UCO, urocardiac ossicle; ZCO, zygocardiac ossicle.

which formed, with POPO and posterio-lateral cardiac plate (PLCP), the anterior appendant of CPV.

As for ventral muscles, extrinsic ventro-lateral dilator (VLD) and two intrinsic muscles as antero-lateral and postero-lateral cardiac m. (ALCM and PLCM) were easily recognized among other muscles.

Connections of these muscles with ossicles were as follows : VLD attached to POPO. ALCM, connected ILCO with the ventro-anterior area of ZCO. PLCM connected PLCP with the ventro-posterior area of ZCO.

Movability of the articulation was different at each jointing site. Its high movability was observed at two connecting sites of PPO with UCO and PYO. It suggested a dynamic movement of the medial tooth provided to UCO during a grinding procedure.

Mechanical consideration of medial and lateral teeth movements (**Fig. 3**)

Gastric mill function could be divided into two movements, biting and grinding. These movements were conducted by specific muscles related with medial and lateral teeth. At closing procedure of biting, the lateral teeth came in contact with another, rising upward, as a result of coordinated movements of muscular contraction and relaxation. Due to examination of articular movability during biting, ZCO provided with lateral teeth was considered to rotate around an axis-line formed by two fulcra of EPO and PCO. Therefore,

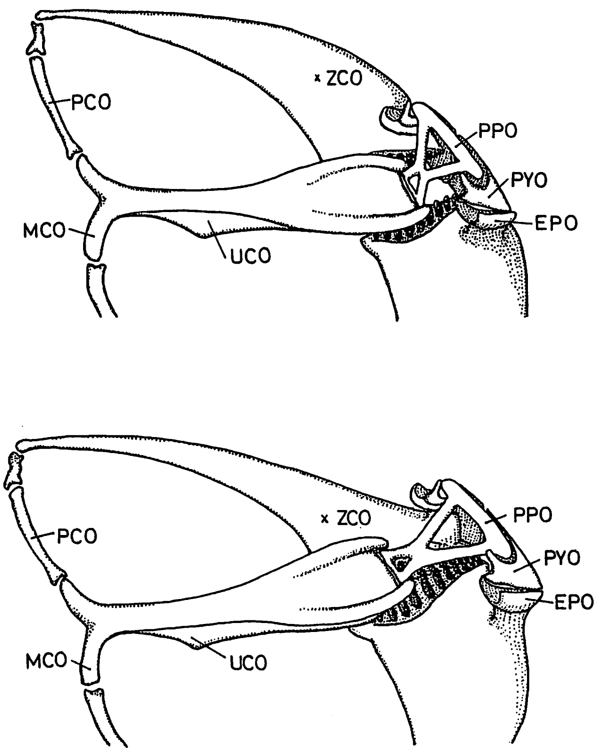

Fig. 3. Positional change of medial and lateral teeth together with their related ossicles. Upper, opening of lateral teeth; lower, closing of the teeth. Abbev., EPO, exopyloric ossicle; MCO, mesocardiac ossicle; PCO, pterocardiac ossicle; PPO, propyloric ossicle; PYO, pyloric ossicle; UCO, urocardiac ossicle; ZCO, zygocardiac ossicle.

muscles such as AGM, ALCM, ENLPGM, EXLPGM and PLCM would contract, and conversely MPGM seemed to be relaxed at closing movement. As for the medial tooth, its bearer UCO was moved upward or downward to bite or grind together with lateral teeth situated inferiorly. This movement of the medial tooth was conducted mainly by functions of a few UCO-connected or related muscles as AGM, LCPM and MCPM. As mentioned previously, UCO had an articular connection with PPO. The latter had further a fulcrum-linkage to PYO. Powerful and effective movement of UCO would be yielded by an assurance of the high movability of PPO. The latter seemed therefore to be a principal part of the gastric mill ossicles.

Morphology of medial and lateral teeth of brachyura

Some of medial and lateral teeth examined were drawn in **Plates** I-III. In same species, the size of both teeth and number of lateral teeth had some variance according to individual age and sexuality. However, their fundamental structure seemed to be equal not only in species but also in genus or family. As a result, it was difficult to show a phylogenic interpretation concerning teeth morphology of brachyura. Brachyura had been considered to be an extremely differentiated tribe in decapod. It was possible, therefore, to indicate that the characteristic constancy of brachyuran teeth had resulted from a convergence of functional rationality of the gastric mill.

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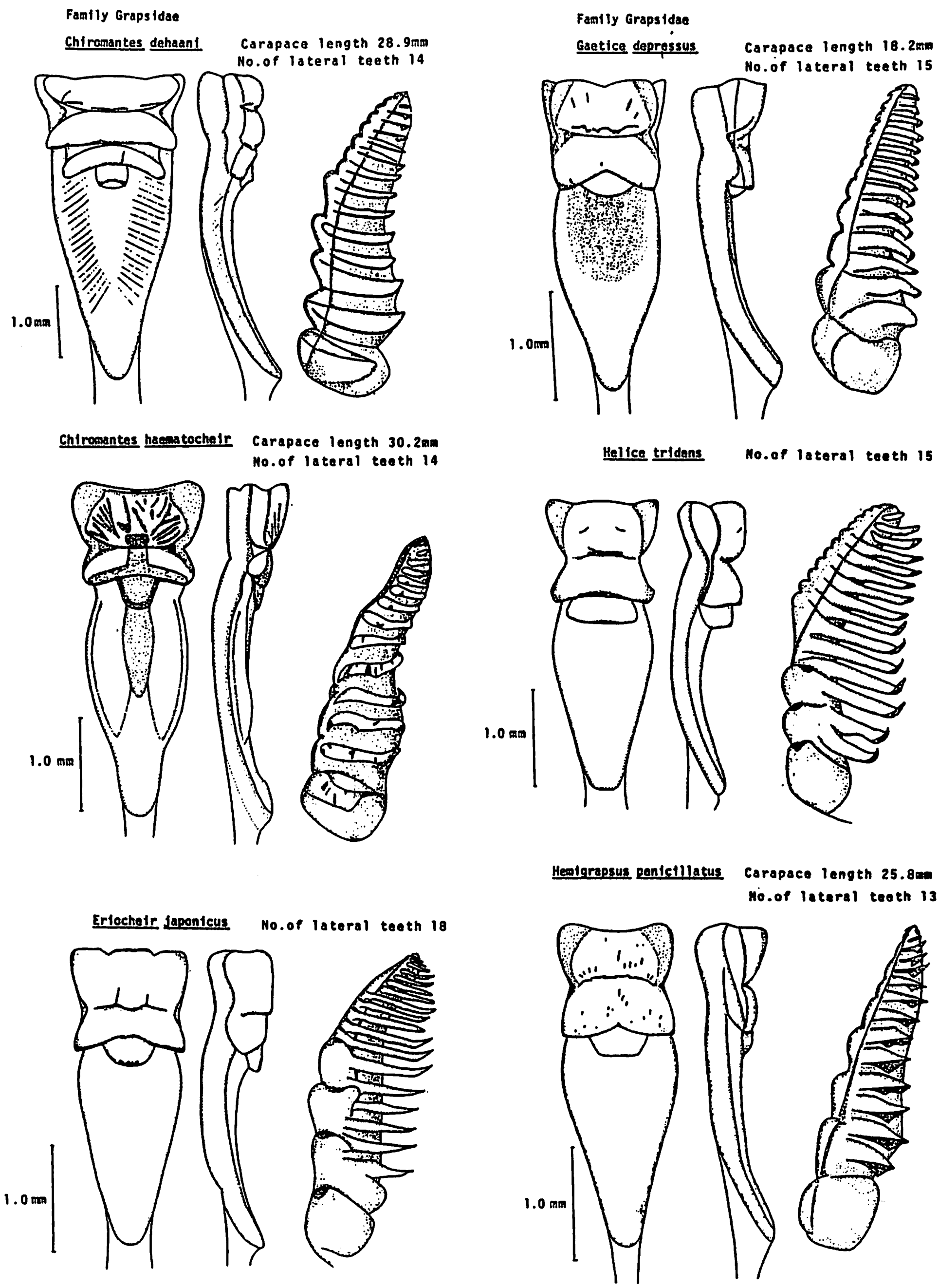

Plate I. Illustrations of the medial and lateral teeth of *Chiromantes dehaani*, *Chiromantes haematocheir*, *Eriocheir japonicus*, *Gaetice depressus*, *Helice tridens and Hemigrapsus penicillatus* (family Grapsidae).

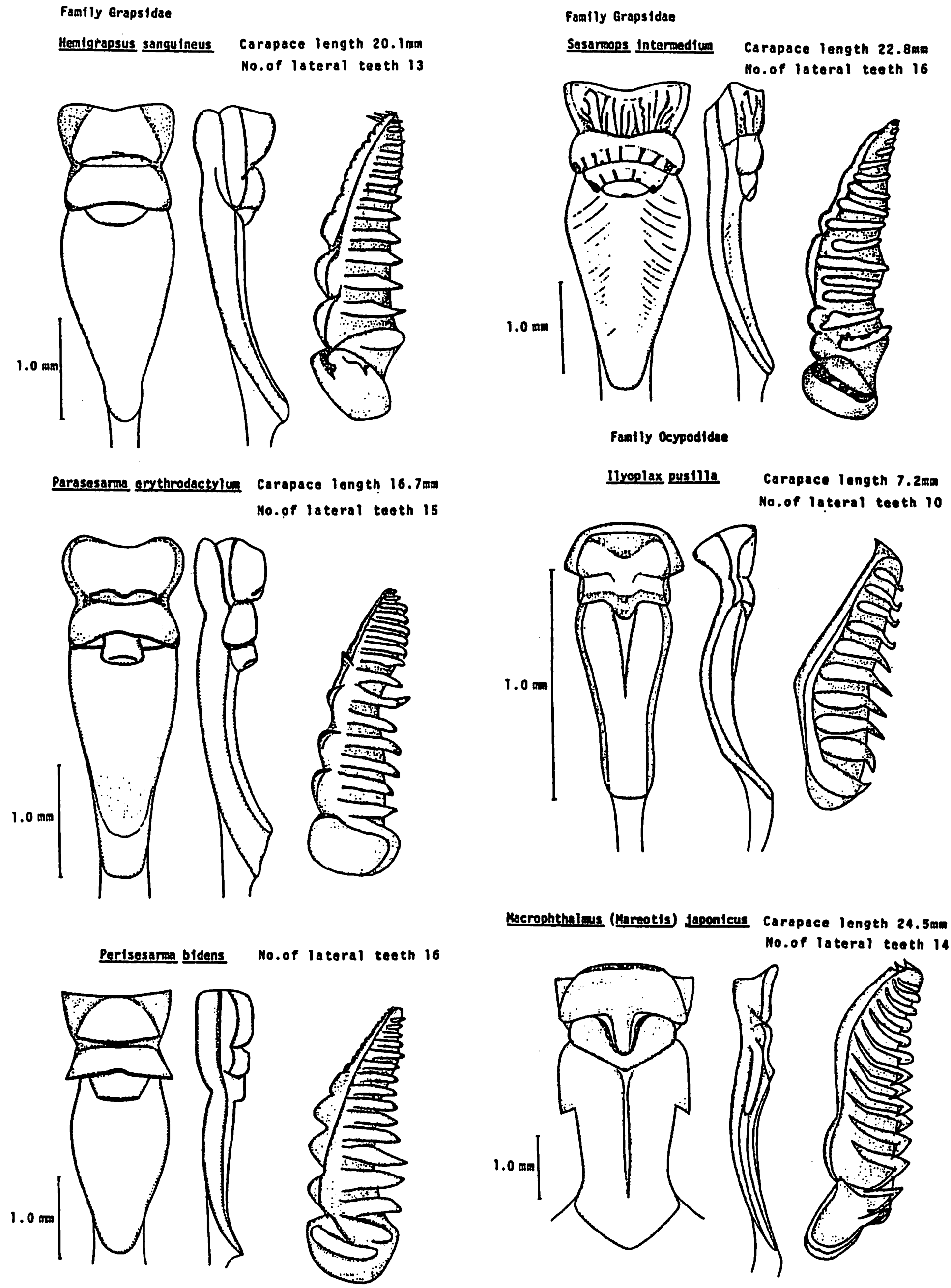

Plate II. Illustrations of the medial and lateral teeth of *Hemigrapsus sanguineus*, *Parasesarma erythrodactylum*, *Perisesarma bidens*, *Sesarmops intermedium* (family Grapsidae), and two species of family Ocypodidae as *Ilyoplax pusilla* and *Macrophthalmus*(*Mareotis*) *japonicus*.

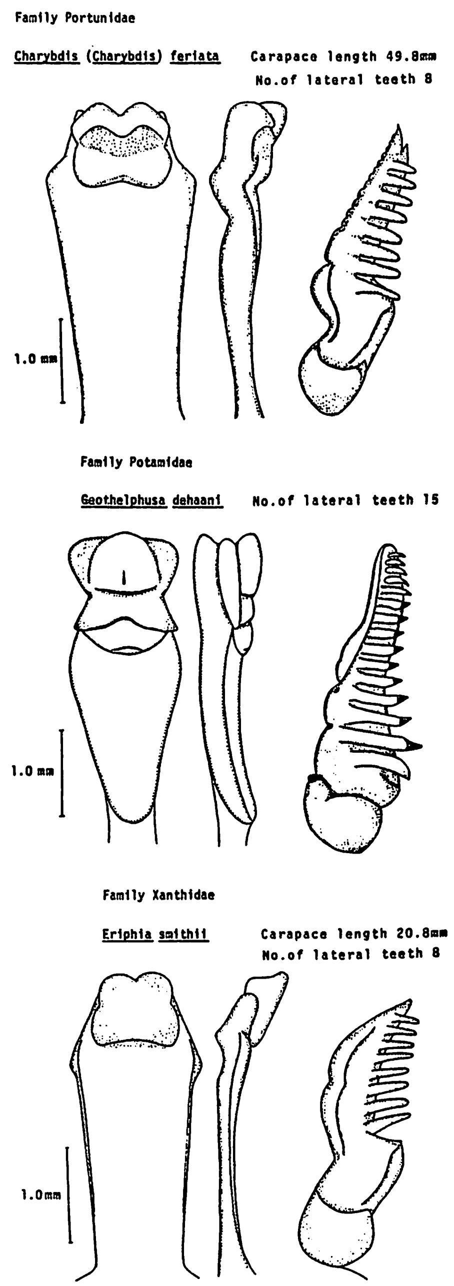

Plate III. Illustrations of the medial and lateral teeth of *Charybdis* (*Charybdis*) *feriata* (family Portunidae), *Geothelphusa dehaani* (family Potamidae) and *Eriphia smithii* (family Xanthidae).