La mer 30: 73-82, 1992
Société franco-japonaise d'océanographie, Tokyo

Two distinct growth stages of a deep-sea, giant white clam, *"Calyptogena"soyoae*, and its allied species*,**

Masuoki HORIKOSHI*** and Jun HASHIMOTO****

Abstract: Two distinct growth stages, the immature- and the adult stages, are recognized in a Japanese giant white clam, *"Calyptogena" soyoae* Okutani. In the immature stage the mode of living is endobiotic, a "subumbonal pit" exists on the hinge plate, and the relative length of hinge ligament to the shell length is small. In the adult stage, both valves become detached in the umbonal region, so that the subumbonal pit cannot become enlarged in its original position and is extended posteroventralwards showing a white chalky area on the nymph. After the mode of living changes to semiepibiotic, the shell shape and the ligamental length change abruptly. Nevertheless the growth of the ligament slows until the shell attains to near adult size, and then it grows rapidly with shell growth. Such abrupt post neanic change in the shell morphpology and mode of living in the present species is comparable to the metamorphosis in other invertebrate animal groups, and similar abrupt post neanic changes can also be found in some other bivalves. The hinge structure of the type species of the genus *Calyptogena, C. pacifica,* are quite different from those of *"C." soyoae*, and the present species is more closely related to *Akebiconcha kawamurai* and *"C." laubieri*.

1. Introduction

In a previous paper dealing with the identity of two Japanese giant white clams, *Akebiconcha kawamurai* Kuroda, 1943 and *"Calyptogena" soyoae* Okutani, 1957, the presence or absence of the "subumbonal pit", which is a newly named, hollow structure on the hinge plate, was recognized as one of the discriminating characteristics for these two species (HORIKOSHI, 1986). At that time, both a small, young specimen (Holotype) and larger, adult (and/or gerontic) specimens were available for *Akebiconcha kawamurai*, but only adult specimens of "Calyptogena" soyoae were studied. Subsequently, the junior author (J.H.) collected several smaller, younger specimens of *"C." soyoae*, during a dive of the submersible "Shinkai 2000" (JAMSTEC), and reported briefly on their life habit (HASHIMOTO *et al.*, 1987;1989). These young specimens were collected near a colony of adult shells of *"C." soyoae*. To our surprise, these smaller younger specimens were found to bear a subumbonal pit on their hinge plate.

The smaller, younger specimens are different from larger, adult or gerontic specimens not only in the hinge morphology and shell sizes, but also in their mode of living, or life habit. The life habit of younger individuals is entirely endobiotic, protruding only the tip of their siphons from the sediment surface, in contrast to that of the adult (gerontic) individuals which is semi-epibiotic, exposing the posterior half of their shells on the sea floor. Along with the change of life habit, the length of the ligament relative to the shell length becomes larger.

Such changes take place rather abruptly, and are considered to be a kind of metamorphosis, and two distinct growth stages can be recognized as the immature- and the adult (gerontic) stages.

* Received May 1, 1992
** Contributions to the molluscan fauna of Southeast Asia and West Pacific (9).
***University Museum, University of Tokyo, Research associate ; and Technology Center, Tokyo Kyuei Co., Technical adviser.
Home address(for correspondence): Pabiyon Meguro 302, Meguro 1-3-31, Meguro-ku, Tokyo, 153
****Japan Marine Science and Technology Center, 2-15, Natsushima-cho, Yokosuka, 237

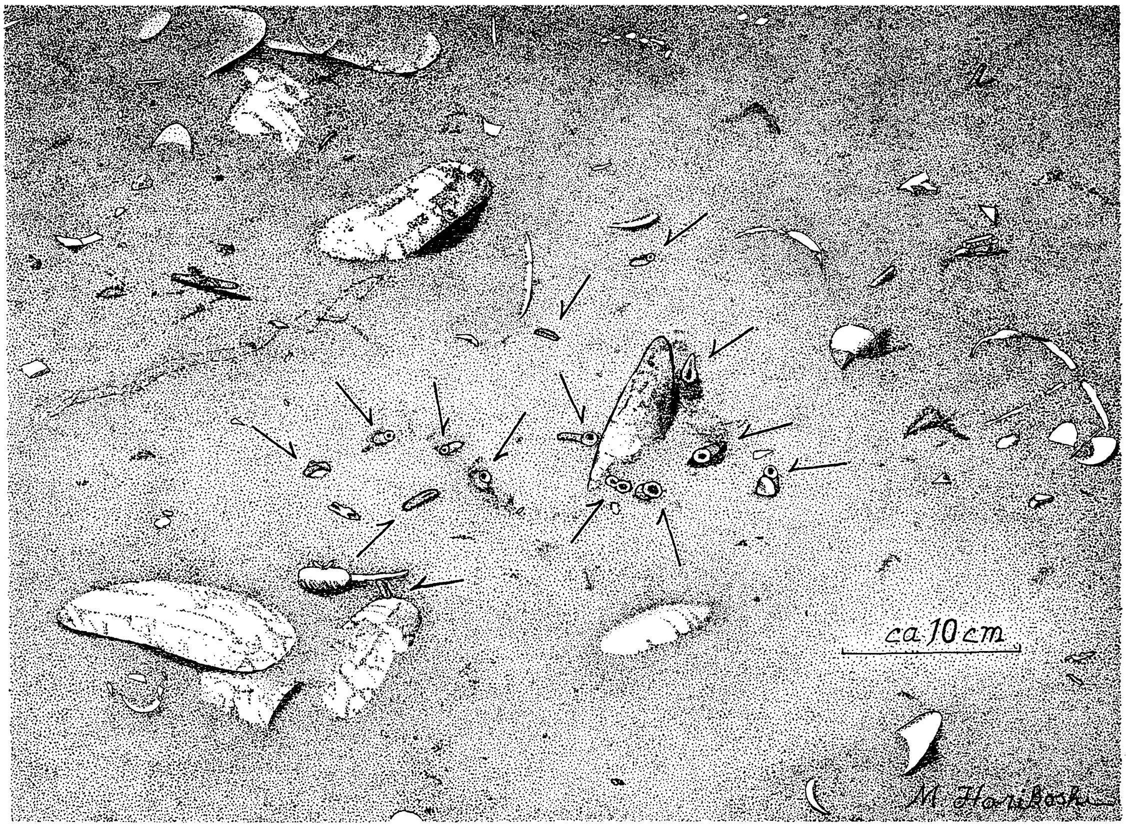


Fig.1. Mode of living (life habit) of immature shells of *"Calyptogena" soyoae*. Drawn from a colour photograph taken through a window of the Submersible "Shinkai 2000" at a station off Hatsushima Island, Sagami Bay: 1150m.

Comparing the hinge morphology of the present species with that of smaller specimens of *Calyptogena pacifica* Dall,1891, which is the type species of the genus, we briefly discuss the classification of "*Calyptogena* group" in the family Vesicomyidae.

2. Materials and method

Four specimens of the smaller younger shell of *"Calyptogena" soyoae* were collected by a grab sampler (20×20cm) during the Dive 228(9/VI/1986 : Jun Hashimoto) of the submersible, "Shinkai 2000" Japan Marine Science and Technology Center (JAMSTEC). The location of the collecting site was off Hatsu-shima (a small island off Ito City, Shizuoka Prefecture), in the northwestern part of Sagami Bay, and the precise position was 35°00.1' N, 139°13.6' E (1150m). Colour photographs showing the mode of living of the smaller, young individuals were taken through a window of the submersible.

Several adult specimens were collected by the manupulator of the submersible during two other dives, (Dive 225, 2/VI/1986: Suguru Ohta, and Dive 226, 3/VI/1986: Hitoshi Sakai) in practically the same locality : 34°59.9' N, 139°13.6' E(1170m).

A figure showing the mode of living of endobiotic, smallsized individuals was sketched from a colour photograph published by Hashimoto et al., 1987 (photo 4 : p. 49). A pencil drawing of the hinge part was drawn using a binocular microscope (NIKON SMZ-10) with a camera lucida of drawing-tube type.

3. Life haibit of smaller, younger shells

It is now well known that larger individuals of *"Calyptogena" soyoae*, inhabiting the sediment bottom, always expose thier posterior portion out of the sediment surface (OKUTANI and

EGAWA, 1985 ; HORIKOSHI, 1986, 1989 : pl.1, fig.1, etc.). In contrast, smaller, younger specimens were found to be burried entirely within the sediment, with only the tip of their siphons protruding (Fig.1). Although both the inhalent and exhalent siphons are recognized in some individuals, one of the two orifices is more prominent with a circular shape in some others. This is thought to be the inhalent siphon, if we take into account the general shape of siphons of the larger, adult individuals observed in the laboratory on board the mother ship of submersible, "Natsushima" (HORIKOSHI, unpublished observation).

The spatial distribution of smaller, younger individuals is rather dense, if not gregarious, within a small limited area. About ten individuals were found in an area of about 15 × 30cm, and practically no other individual was found in the surrounding area photographed (see Fig.1). Judging from the photograph, the surface of the sea-floor seems to be covered by fine grained sediment at this site.

4. Shell shapes of immature and adult stages

The shape in outline of immature shells of "*Calyptogena*" soyoae is rather elliptical, though that of the second largest specimen among four individuals becomes somewhat longer (Fig.2b) than that of the smallest one (Fig.2a). On the other hand, the outline of the smallest specimen among semiepibiotic adult shells shows the shape of the normal adult shell of this species (Fig.2c), being elongate and slightly contracted in the middle of the ventral margin.

The shape of the immature specimen of *Akebiconcha kawamurai* is also elliptical in outline (Fig.2d), but it is higher than that of *"C." soyoae*, being more roundish.

5. Hinge structure of smaller, young specimens

Termindogy of the hinge elements: For the terminology of hinge elements see Fig.3.

Subumbonal pit: In all of the four specimens examined the "subumbonal pit", a hollow structure just beneath the umbo (HORIKOSHI, 1987), was found on the hinge plate directly behind the posteriormost dental element in both the right and left valves. In the smallest, or youngest, individual, the pit is small but deep, and is clearly

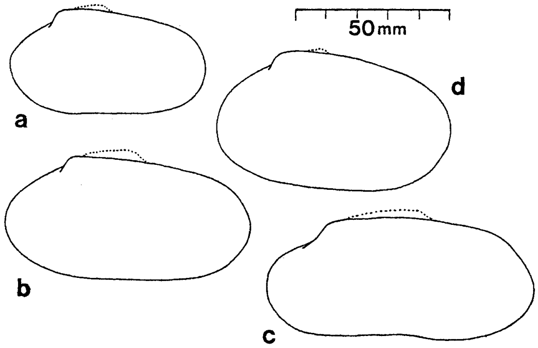


Fig.2. Outlines of shells of immature (a,b) and adult (c) stages of *"Calyptogena" soyoae*, and that of immature stage (Holotype) of *Akebiconcha kawamurai*. Dotted lines indicate the hinge ligament.

demarcated from the hinge plate by its distinct margin (Pl.1, fig.1). The shape of the pit differs somewhat from that of *Akebiconcha Kawamurai* of an equivalent growth stage (HORIKOSHI, 1987: fig.4a), being longer anteroposteriorly and narrower dorso-ventrally in the present species.

In the second largest or oldest individuals among the four smaller, younger specimens, however, the ventral margin of the pit spread out ventralwards, and becomes shallower along its ventral margin (Pl.1, fig.2). In this respect, the present species, *"C." soyoae*, is quite different from an allied species, *Akebiconcha kawamurai*. In the latter species, the pit is still deep and well demarcated even in full grown, adult specimens (HORIKOSHI, 1987, fig.4b), and it becomes larger and shallower with ill-defined ventral margin, only when the shell attains gerontic age (HORIKOSHI, 1. c., fig.4c).

In larger, adult and/or gerontic specimens of *"C." soyoae*, the right and left valves become detached in their umbonal region (HORIKOSHI, 1987: fig.5). Consequently the subumbonal pit can not become enlarged any more in its original position on the hinge plate, and its postero-ventral extension runs posteriorwards on the nymph along the ventral boader of the hinge ligament. Such an extended part of the pit can be recognized as a white, chalky area covered by yellowish membrane, as was pointed out in a previous paper (HORIKOSHI, 1988: p.254).

Dental elements: The morphology of dental

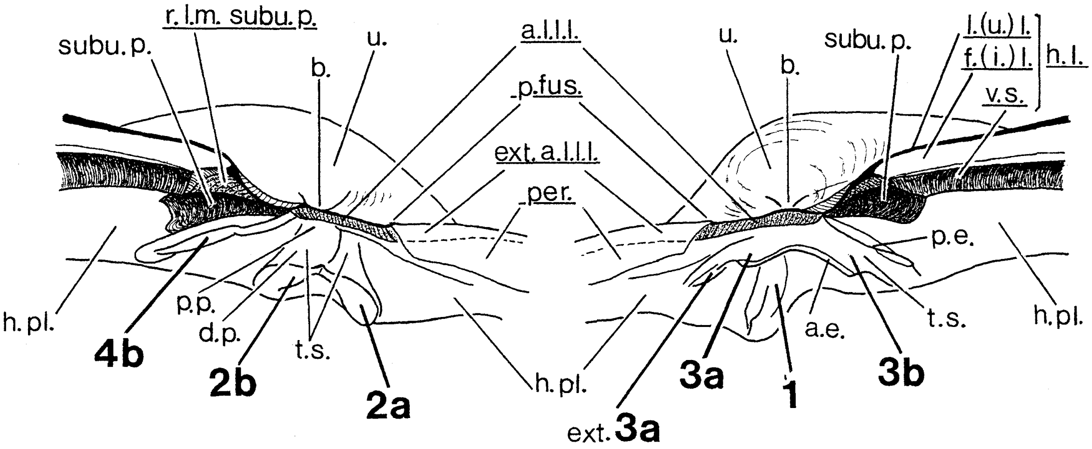


Fig.3. Terminology of hinge elements of "*Calyptogena*" (Horikoshi, 1989b: fig.1). Dental elements of left valve (left side in the figure); **2a**=ramus-**2a**=anterior ramus of subumbonal tooth; **2b**=ramus-**2b**=posterior ramus of the same tooth; **4b**=tooth-**4b**=posterodorsal cardinal tooth; Right valve (right side fig.); **1**=**tooth-1**=ventral (central) tooth; **3a**=ramus-**3a**=anterior ramus of subumbonal (dorsal) cardinal tooth; **3b**=ramus-**3b**=posterior ramus of the same tooth. a.e.=anterior edge of ramus **3b**; a.l.l.l.=anterior lamellar layer of ligament("cardinal ligament"); d.p.=distal portion of dental element; ex.a.l.l.l.=extension of anoterior lamellar layer of ligament, investing internal shell surface under the coverage of periostracum; ext.**3a**=extension of ramus-**3a**; f.(i.)l.=fibrous (inner) layer of hinge ligament; h.l.=hinge ligament; h.pl.=hinge plate; l.(u.)l.=lamellar (outer) layer of hinge ligament; p.e.=posterior edge of ramus-**3b**; per.=periostracum hanging freely from shell margin; p.fus.=point of fusion of periostracum; p.p.=proximal portion of dental element; r.l.m.subu.p.=roofing of lamellar membrane covering subumbonal pit; t.s.=top surface of dental element; v.s.=ventral surface of hinge ligament.

elements are also different in smaller, younger specimens from those of larger, adult (gerontic) specimens. In the right valve (see Pl.1.fig.1a, 2a), the top surface of the posterior ramus of the subumbonal (dorsal) cardinal tooth (**3b**) is clearly grooved, and furnished with a rather sharp ridge along either edge, anterior and posterior. Such features of this dental element (3b) are similar to those of the same dental element of *Akebiconcha kawamurai*, especially to those of a smaller, young specimen (holotype) of that species (HORIKOSHI, 1987: fig. 4a). On the other hand, the shape of the anterior ramus (**3a**) is rather similar to that of the larger, adult (gelontic) specimens of the present species, *"C". soyoae.* It is extended anteriorwards from the proximal part of the posterior ramus (**3b**) nearly pararell to the dorsal margin of the hinge plate, covering and concealing the proximal part of the ventral (central) tooth (**1**).

In the left valve (Pl.2, fig.1b), both anterior and posterior rami of the subumbonal tooth (**2a,b**) are also different from those of the larger, adult specimens. The posterior edge of the anterior ramus (**2a**) stands erect from the hinge plate, so that it looks more ordinary hinge tooth-like than plate-like, and it abuts against the posterior ramus (**2b**) at more proximal part of the rami than in the larger specimens, leaving an open, spacious socket in between them. In these respects, the morphology of the anterior ramus (**2a**) of the smaller, young specimens is somewhat more similar to that of *Akebiconcha kawamurai* than that of adult specimens of the same species *"C." soyoae.*

The posterior ramus (**2b**) has a blunt point of the posteroventral corner of the ramus and has a small ridge that branches out towards the anteroventral corner, so that the distal part of the ramus looks as if the ramus is bifurcated at its distal extremity.

The posterodorsal cardinal tooth (**4**), however, is not much different from that of the larger specimens. It is laminate or plate-like, and it leans anteriorwards hanging over the socket between this tooth (4) and the ramus **2b**.

6. Abrupt changes in ligamental length during growth

A remarkable change was found between relative lengths of the hinge ligament in the smaller, younger specimens and those in the larger, adult specimens.

In the case of the smaller,younger specimens bearing the subumbonal pit on the hinge plate (Fig. 4a: small solid circles), the ligamental length shows a linear relationship to the shell length, and the least squares line shows a good fit (Regression line A in the same figure). In the case of the larger, adult specimens without the subumbonal pit (open circles), the regression line shows entirely different trend (Line B). In this case, however, the points show a much wider scattering than in the case of smaller specimens. Closer inspection of the graph reveals that there are two categorically different groups among the individuals of the larger, adult specimens. One group consists of relatively small to larger individuals with short ligament of around 30 mm in length, and the other group includes still larger individuals with longer ligament of around 35 mm. If we obtain the least squares line separately for these two groups (Lines B' and B"), each of them shows a good fit.

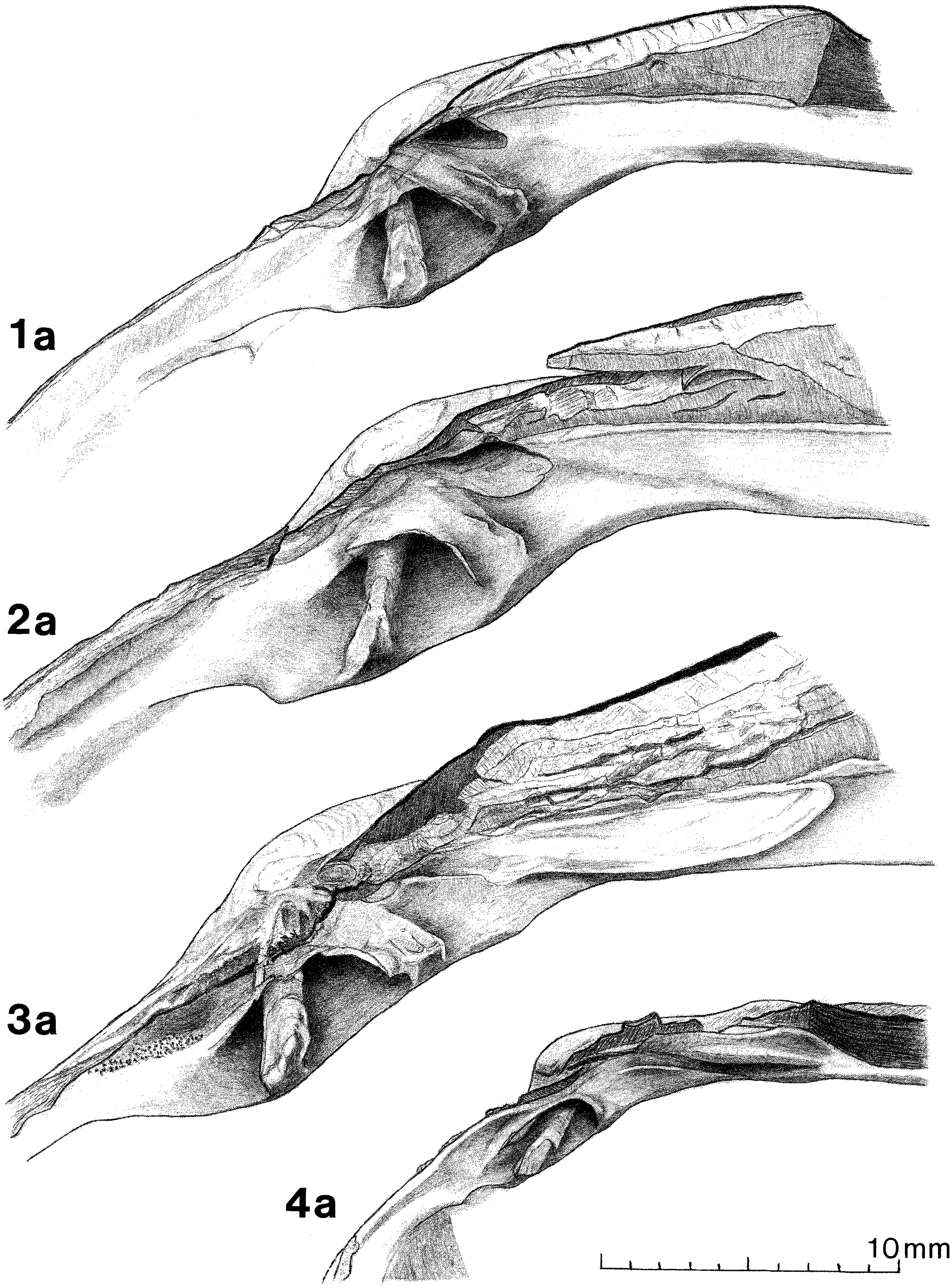
This means that, just after the mode of living changes from endobiotic to semiepibiotic, both the shell length and the ligamental length become longer rather abruptly. So that a clear gap is seen in the ligamental length between the largest individual of the endobiotic, smaller specimens (21,7mm in shell of 82.9mm long) and the smallest individual of the semi epibiotic, larger specimens (28.0mm in shell of 87.4mm). However, the growth of the hinge ligament slows until the shell attains to near adult size, and then it grows rapidly with shell growth.

Such abrupt changes in hinge morphologies (dental elements, subumbonal pits and ligamental length) as well as a change in the mode of living suggest that the smaller, younger specimens and the larger adult specimens can be recognized as two distinct growth stages, the immature- and adult (plus gerontic) stages.

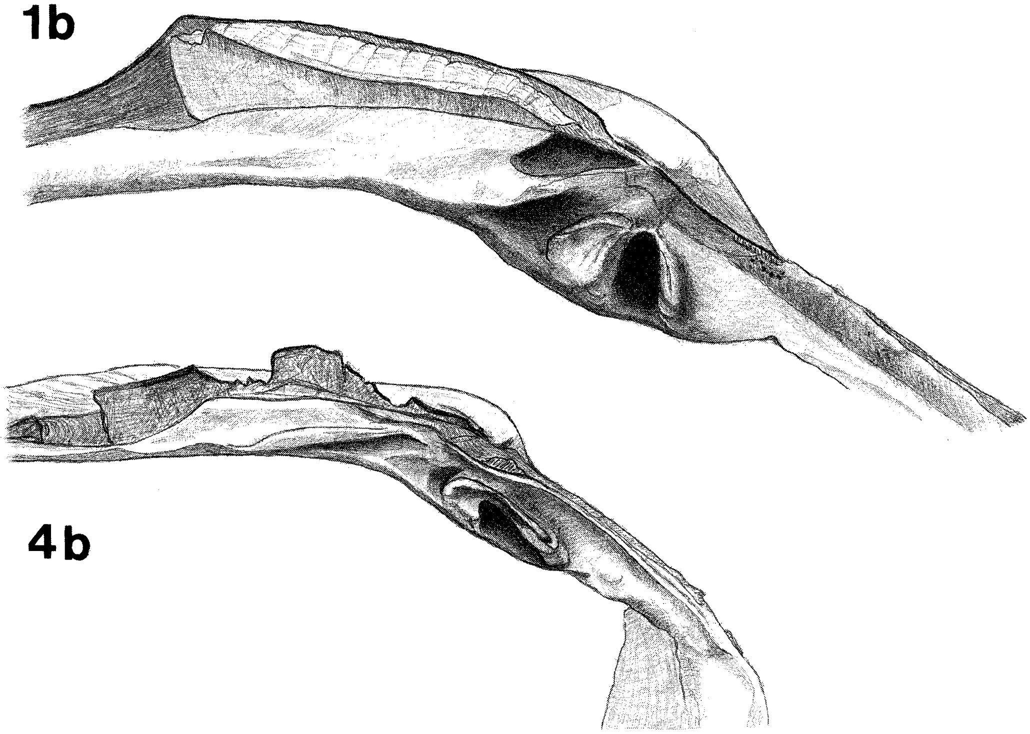
It is interensting to know that a similar features in the growth of the hinge ligament can be found in another species of the allied group of *"Calyptogena", "C." laubieri* Okutani et Métivier,1986, as described briefly elsewhere (HORIKOSHI, 1989). In that species, two distinct growth stages were also recognized, and similar regression lines of the hinge growth were obtained (Fig. 4b). In this case, however, the regression lines of both the immature and the adult (gerontic) stages are clealy recognized (A and B"), but the number of individuals of adult (gerontic) stage examined was so few that the transient regression line B' could not be obtained.

7. Hinge structures of *Calyptogena pacifica* Dall

Ligamental structure: The type species of the genus *Calyptogena, C, pacifica* Dall, lacks the subumbonal pit, so that the proximal part of the hinge ligament with calcified fibrous layer is not destroyed by the formation of the pit and still remains under the beak, if not fully functional (Pl.1, fig.4a). A horny ligamental membrane forms a roof-like bridge between both valves in the subumbonal region posteriorly from the point of fusion (anterior) of the periostracum, covering and connecting the anterodorsal margin of the right and left valves. The membrane seems to become detached progressivly from the proximal surface of the hinge along with the growth of the shell as in *C. soyoae* (HORIKOSHI, 1987,p. 254 and fig. 5). During this process of detachment, the membrane invades the hinge area including the proximal portions of the dental elements ventralwards parallel to the dorsal margin as in *C. kaikoi* Okutani et Métivier, 1986 (HORIKOSHI, 1989b: p.155, pl.4, figs.5,6), leaving a vacant area in between the line of attachment of this membrane and the ventral surface of the hinge ligament. The posterior end of this membrane abuts against the ventral surface of the hinge ligament at some distance posterior from the proximity of the hinge ligament situated beneath the beak. Through such an invasion, the proximal part of the dental elements are concealed by the ligamental membrane, and the area of concealment is broader in the older, larger specimen in the type materials (compare BOSS's (1986) fig.16 to fig.17). Along the ventral border of


1a
2a
3a
4a
10mm

1b



4b

Pls.1,2 Hinge structures of the right valve (Pl.1) and the left valve (Pl.2) of *"Calyptogena" soyoae* (1a-3a) and *C. pacifica* (4a,b). The smallest (1a,b) and the second largest (2a) specimens among immature individuals, and the smallest specimen of mature shell (3a). For further explanation see text. (For the terminology of the hinge elements see Fig.2). M.Horikoshi del. figs.
1a, b, 2a: *C. soyoae*, "Shinkai 2000" Dive 228, 35°00.1'N, 139°13.6'E, 1150m (1a,b: 62.7×33.9mm: Fig.2a: 2a: 78.8×41.0mm: Fig.2b), **3a**: Dive 222, 34°59.9'N, 139°13.6'E, 1170m (87.0×38.2mm: Fig.2c), 4a,b: *C. (C.) pacifica*, off Vancouver Island, Canada, 48°25.9'N, 126°14.3'W, 915m (31.8 ×21.6mm: Okutani Coll.)

this area of invasion, a deposit of shelly substance forms a slightly raised edge along the dorsal brim of the hinge plate, as in *C. kaikoi* (HORIKOSHI, 1989b: p.155).

Dental elements of right valve: The dental elements in the present material (see pl.1, fig.4a) are almost identical to those of the samller individual in the type materials (OKUTANI, 1966 : pl. 27,fig. 3 ; BOSS, 1968 : figs.16,19). The posterior ramus of the subumbonal (dorsal) cardinal tooth (**3b**) is much broader than that of *"C". soyoae*. The top surface is slightly concave, but both anterior and posterior edges are sharply ridged. The anterior ramus (**3a**) is well developed, running parallel to the anterodorsal margin of the shell, and has a blunt point on its distal end. Its ventral edge is rather sharp forming a weak ridge, and is continuous to the anterior edge of the posterior ramus (**3b**), describing a sharp curve at the corner of the junction of the anterior and posterior rami.

The ventral (central) tooth (**1**) runs obliquely from beneath the beak. It has two blunt points on its distal end, which looks as if it is bifucated. The proximal part is obsolete, sinking diagonaly into the hinge plate, and is concealed by the dorsal tooth (**3a,b**). A posteriorly radiating nymphal calosity looks as if it is a subobsolete, ridge-like dental element (cf. BOSS and TURNER, 1980: p. 163). A space between the posterior edge of the posterior ramus **3b** and this ridge-like nymphalo calosity forms a deep groove with a flattish bottom.

Dental elements of left valve: The posterior

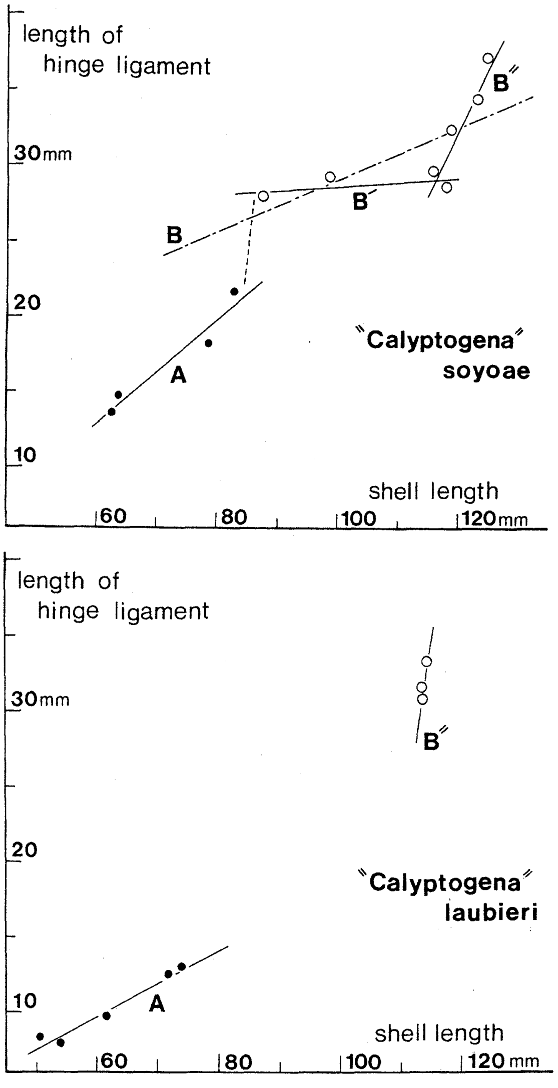


Fig.4a,b. Relationships between the shell length and the length of hinge ligament in *"Calyptogena" soyoae* (a; above) and *"C" laubieri* (b; below). Small solid circles indicate immature individuals and large empty circles adult shells. For further explanation see text.

ramus (**2b**) of the subumbonal cardinal teeth (Pl.2, fig.4), radiates ventralwards from beneath the beak perpendicularly, and is furnished with two small points at its distal extremity. The anterior ramus (**2a**) radiates obliquely anteroventralwards, and abuts against the posterior ramus at a distance of half its dorsoventral length.

A slender shelly callous runs along the ventral edge of the anterior ramus (**2a**), crosses the top surface of the posterior ramus (**2b**) and bends ventralwards forming nearly a right angle along the posterior edge of the posterior ramus. Such a structure seems to be rather normal in this species, since an almost indentical calous can be recognized in a photograph showing the details of the dentition of one of the type specimens (syntype) (BOSS, 1968, fig.19).

The posterodorsal cardinal tooth (4) radiates from beneath the beak obliquely, but its proximal part is concealed by shelly substance deposited along the dorsal brim of the hinge plate mentioned above. This tooth (**4**) stands far apart from the ramus (**2b**), forming a broad socket in between these dental elements, so as to form a spacious socket for the very broad posterior ramus (**3b**) of the dorsal tooth of the right valve.

8. Discussion

In *"Calyptogena" soyoae*, changes in the life habit, in the morphology of hinge structures and in the relative hinge length are rather abrupt, and are thought to take place rapidly within a rather short period of time. Such sudden changes remind us metamorphosis during the growth of some invertebrates. In some bivalves, e.g. mytilids, a distinct growth stage, called the "nepioconch" stage, is known between the larval stage (prodissoconch stages I, II) and the adult (dissoconch) stage. The nepioconch of mytilids is very small (ca. 1000 μm) and often has been confused with prodissoconch(OCKELMANN, 1983). In some other bivalves, such as corbulids, the nepioconch can be recognized easily with the nacked eye as a distinct apical shell (WRIGLEY, 1946; COX,1969:fig.83). It is much larger than the prodissoconch (protoconch), and its actual length is 7-8 mm in a 24-25mm long shell of *Corbula (Anisocorbula) erythrodon* Lamark (HORIKOSHI, unpublished data).

According to WRIGLEY (1946), one more stage can be recognized in between the nepioconch and adult stages, and was named "mesoconch" in the fossil *Plicatula* (COX, l.c.: fig.84, 1). In a living species of the same genus, *P. muricata* Sowerby (ca. 25 mm in hight), the mesoconch (7-8 mm in hight) is considered to be the shell of the sessil stage, which is firmly attached or cemented to the hard substratum, because it shows xenomorphic sculptrue (cf. STENZEL, 1971, p.*N* 1021) especially on the mesoconch of the lower (right) valve, which forms an attachment area. The adult shell becomes virtually free-lying, and shows idiomorphic or automorphic sculpture furnished with spiny ridges (HORIKOSHI, unpublished observation).

The most striking example can be found in pectinid genera *Hinnites* (Cox, l.c.: fig.84: 3b) and its allied genus *Classadoma* (BARNARD, 1986). The early stage shells (ca. 20mm in hight in *H. coralinus* Sowerby, and ca. 20-30 mm in *C. giganteus*: HORIKOSHI, unpublished data) are *Chlamys*-shaped until they become appressed or attached to the substratum, and then in the later stage the shell grows irregularly like *Spondylus*. It is interesting to find that the size of the early stages is similar in different species or genera, regardless of different full grown sizes in the later stage (The younger stage is ca.25mm in height even in an European, fossil species, *H. crispus* (Brocchi): measured from photographs illustrated in Cox, l.c., fig. 84: 3a, b). The changes in shell morphology and life habit between the two distinct stages, the immature and adult stages of the present species, *"C." soyoae*, are another striking example of abrupt postneanic changes in a bivalve. Changes in the physiology and functional anatomy, if any, are hoped to be studied in future.

As for the taxonomical relationship of the present species, *"Calyptogena" soyoae*, it is now clear that this species can not be regarded as a member of *Calyptogena* Dall, 1891 in the strict sense. It is rather closely related to *Akebiconcha* Kuroda, 1943 as suggested by Okutani (1966). Another close relative seems to be *Archivesica*, and we are inclined to concur with Keen's (1969: p.*N*664) opinion to put together *Archivesica* Dall,1908 and *Akebiconcha* into a single group outside *Calyptogena* in the family Vesicomyidae.

A new large-sized form (ca. 14 cm in length) has recently been collected from Iheya Sea Mount, west of Okinawa by dredging of German Vessel "Sonne" (H. SAKAI) and by diving of the Japanese submersible "Shinkai 2000" (S. OHTA). This is closely related to *"C." soyoae*, lacking the subumbonal pit in the adult stage and the proximal parts of dental elements are exposed on the outside of the shell. A newtaxon of the genus group (perhaps a subgeneric one) should be established for these two species.

9. Acknowledgement

We would like to express our sincere gratitude to the operation team of the submersible "Shinkai 2000" and the Captain and crew of the R.V. Natsushima. Our thanks are also due to Professors S.OHTA and H. SAKAI for their kindness in providing us with several adult specimens collected in their dives of the submersible. We are also grateful to Prof. Takashi OKUTANI of Tokyo University of Fisheries who kindly put a specimen of *Calyptogena pacifica* at our disposal. Thanks are also due to Dr. David D. SWINBANKS for reading our English mamuscript.

This work was supported in part by funds from the Cooperative Program (No.8813, 8903 and 9247) provided by the Ocean Research Institute of the University of Tokyo.

References

BERNARD, F.R. (1986): *Classadoma* gen.nov. for *"Hinites" giganteus* (Gray;1825) from the Northeastern Pacific Ocean (Bivalvia: Pectinidae). Venus (Jpn. J. Malacol.), **45**(1): 70–74

BOSS, K.J. (1968): New species of Vesicomyidae from the Gulf of Darien, Caribian Sea (Bivalve: Mollusca). Bull. Mar. Sci., **18**(3): 731–748.

BOSS, K. J. and R.D.TURNER (1980): The giant white clam from the Galapagos Rift, *Calyptogena magnifica* species novum. Malacologia, **20**(1): 161–194.

COX, L. R. (1969): General features of Bivalvia. *In* R.C. MOORE (ed.) Treatise on Invertebrate Palaeontology, Part N, Mollusca **6**, Bivalvia (vol, 1 of 3), Geol.Soc. Amer., Boulder,Colo.: pp. *N*3–*N*129.

HASHIMOTO, J., T. TANAKA, S. MATSUZAWA, H. HOTTA (1987): Survey of the deep-sea communities dominated by the giant [white] clam, *Calyptogena soyoae*, along the slope foot of Hatsushima Island, Sagami Bay. Tec. Rep. Mar. Sci. Tech. Center(JAMSTEC) Special Issue, (3): 37–50.

HASHIMOTO, J., S. OHTA, T. TANAKA, H. HOTTA, S. MATSUZAWA and H. SAKAI (1989) Deep-sea communities dominated by the giant [white] clam, *Calyptogena soyoae*, along the slope foot of Hatsushima Island, Sagami Bay, central Japan. Paleogeogr. Paleoclim. Paleoecol., **71**(1989): 179–192.

HORIKOSHI, M. (1986): Is *Akebiconcha* synonymous with *Calyptogena*? Deep-Sea Newsletter, (12): 7–9.

HORIKOSHI, M. (1987): Distinctions in the hinge structure between *Akebiconcha* and *Calyptogena*, with special reference to "subumbonal pit" and "cardinal ligament". Venus (Jpn. J. Malacol.), **45**(2): 245–257.

HORIKOSHI, M. (1989a): Deep-sea giant white clams, *Calyptogena* s.l., found in the hot-vent and cold-seep sites. Venus(Jpn. J.Malacol.), (Supplement 1): 59–73.

HORIKOSHI, M. (1989b): Hinge structures, their variations and changes during growth, of some Japanese deep-sea, giant white clams, *Calyptogena*, collected during the "Kaiko" project. Palaeogeogr. Palaeoclim. Palaeoecol., **71**(1989): 137–160.

KEEN, M. (1969): Family Vesicomyidae. *In* R.C. Moore (ed.) Treatise on Invertebrate Paleontology. Part N, Mollusca **6**, Bivalve, (vol.2 of 3): *N*663–*N*664.

OCKELMENN, K.W.(1983): Descriptions of my-tilid species and definition of the Dacryniinae n. subfam. (Mytilacea-Bivalvia). Ophelia, **22**(1): 81–123.

OKUTANI, T.(1966): Identity of *Calyptogena* and *Akebiconcha* (Bivalvia, Cyprinidae). Venus (Jpn.J.Malacol.), **24**(4): 297–303.

OKUTANI, T. and K.EGAWA (1985): The first underwater observation on living habit and thanatocoenosis of *Calyptogena soyoae* in bathyal depth of Sagami Bay. Venus (Jpn. J.Malacol.), **44**(4): 287–290.

STENZEL, H.B.(1971): Oysters. *In* R. C. MOORE (ed.) Treatise on Invertebrate Paleontology. Part N, Mollusca **6**, Bivalvia (vol.3 of 3), iv+*N*953-*N*1224 pp., Geol.Soc.Amer.and Univ. Kansas.

WRIGLEY, A.G.(1946): Observation on the structure of lamellibranch shell (Presidential address): Proc. Malacol. Soc. London, **27**, (1): 7–19 (cited from Cox, 1969).

深海大型二枚貝シロウリガイ "*Calyptogena*" *soyoae* 及びその近縁種における明確な2生長段階

堀越増興・橋本　惇

要旨：　地下湧水に伴い、硫黄細菌を共生させる深海大型二枚貝シロウリガイに，"未成殻段階" と "成殻段階" との明確な2段階が認められた。成殻段階では生活型が半外生的であるのに対し，未成殻段階では全く内生性で堆積物内に潜入し，水管の先端のみを海底に露出する。"殻頂下洞" は成殻段階の鉸板には見られず近縁種アケビガイ *Akebiconcha kawamurai* との区別点になるが，未成殻段階には明らかに存在する。成殻段階に移行すると，本種の特徴として，両殻の殻頂部分が左右に離れて来て靭帯膜のみで接合し，鉸歯の咬み合わせがゆるむために，殻頂下洞は原位置で拡大する事が不可能となり，歯丘上に黄褐色の膜で蔽われた白亜質の領域として後方に延長する。鉸歯の形態は生長段階で著しく異なり，未成殻段階ではむしろアケビガイに類似した点が多い。*Calyptogena* 属の模式種には殻頂下洞はなく，鉸歯も全く異なり，本種とは属か亜属のレベルで異なる。靭帯長は，未成殻段階では成長と共に増大する。半外生性の成殻段階に移行する際に殻長も靭帯長も速やかに増大するが，その後靭帯の成長は足踏みし，殻長がほぼ成長限度に達した後に再び靭帯長が増大する。同様な傾向は，近縁種テンリュウシロウリガイ "*C.*" *laubieri* にも見られた。成長段階の移行は，他の動物での変態を思わせるが，二枚貝類には，この様な未成殻期後（postneanic）の変態が2，3知られている。