NOTES ON THE GENUS *DISTORSIO* (CYMATIIDAE) WITH DESCRIPTIONS OF NEW SPECIES

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ABSTRACT

Distorsio perdistorta *Fulton, 1938, whose known distribution has previously been limited to Japanese waters, has been discovered in the Gulf of Mexico, the Lesser Antilles, and the Indian Ocean.* Distorsio horrida *Kuroda and Habe, 1964, also originally limited to Japanese waters, is a synonym. A different species from Japan, misidentified by previous workers as* "perdistorta," *is described as a new subspecies,* Distorsio constricta habei *Lewis. The American tertiary progenitors of this species are believed to be* D. crassidens *(Conrad, 1848) of the Oligocene and* D. simillimus *(Sowerby, 1850) of the Miocene. The living species* D. constricta *is recognized as having three geographical subspecies* - constricta *(Broderip, 1833) from the tropical Eastern Pacific;* macgintyi *Emerson and Puffer, 1953, from the Western Atlantic; and* habei, *new subspecies from Japan. Similar subspecific distributions are known among the Cymatiidae, Cassidae and Volutidae.*

An unusual periostracal structure is described and illustrated along with various anatomical features of Distorsio.

Distorsio burgessi *is described as a new species from Hawaii which is sympatric with* Distorsio anus *(Linné).*

The lectotype of Distorsio ridens *Reeve is figured and* D. ridens *is clearly separated from* D. reticulata *Röding,* D. perdistorta *Fulton, and* D. decussatus *Valenciennes.*

INTRODUCTION

While examining shells in the collection of Mr. and Mrs. Riley Black of Fort Myers, Florida, three specimens of a *Distorsio* were brought to my attention. These matched a specimen first sent to me by Mrs. Elsie Malone of Sanibel, Florida, which had been misidentified as *Distorsio macgintyi* Emerson and Puffer, 1953. Surprisingly, these specimens proved to be indistinguishable from *Distorsio perdistorta* Fulton, 1938, a species living in Japanese waters which had been renamed *Distorsio horrida* by Kuroda and Habe in 1964. Unfortunately they also misidentified another taxon known as *"Distorsio perdistorta"* Kuroda and Habe, 1964, (not Fulton, 1938), which now requires a new name.

This paper will confirm *Distorsio perdistorta* Fulton as a valid species; substantiate its occurrence in the Western Atlantic and the Indian Ocean; clarify its history in the literature; differentiate it from *Distorsio clathrata* (Lamarck, 1816) and *Distorsio macgintyi* Emerson and Puffer, 1953, in the Western Atlantic; and describe the taxon previously known as *"Distorsio perdistorta"* Kuroda and Habe, 1964.

HISTORICAL DISCUSSION OF DISTORSIO PERDISTORTA

Emerson and Puffer, 1953, in their catalogue of the *Distorsio* suggested the possibility that *perdistorta* is a geographical subspecies of *Distorsio reticulata* Röding, 1798, and said, "Fulton states that this species possesses affinities with *D. ridens* (Reeve, 1844)" which they considered to be a "variant of *D. reticulata* 'Bolten' Röding, 1798."

An examination of *reticulata* and *perdistorta* has shown that there are consistent taxonomic differences. Table 3 was prepared to facilitate a comparison using characters which are helpful in separating *Distorsio.* The list of differences cited in Table 3 and the

specific description of *perdistorta* contained in this paper demonstrates that these are separate species.

Actually, Fulton (1938, p. 56) listed various characters which "separates this from *ridens* Reeve." They are "the shorter anterior canal and the much closer granular or reticulate spiral sculpture . . .; the line of numerous small plaits on the anterior part of the columella is perpendicular not oblique as in *ridens.*" Examination of the lectotype, syntypes and Reeve's figure shows that *ridens* is clearly separable from *perdistorta. D. ridens* is regularly fusiform, while *perdistorta* is grossly distorted. There are 25 to 30 axial ribs on the body whorl of *perdistorta* and only 12 on *ridens,* giving it a much more open sculpture.

The spiral cords of *perdistorta* are separated by a fine interstitial cord which is lacking in *ridens.* The parietal shield of *ridens* is medium-oval in shape with

TABLE 1. Specimens of Distortio perdistorta *examined from the Gulf of Mexico.*

Length (mm)	Width (mm)	Locality	Depth (meters)
82	44	Tampa, Florida	
81	45	West of Fort Myers, Florida	183
79	43	West of Tampa, Florida	201
77	42		
78	40	E.S.E. of Key West, Florida	274.50
67	36		
66	35		
64	36.5		
59	32		
36.5	21.5		
75	42	110 miles S. W. Egmont Key, Fla.	155-183
69	38	W.S.W. Tampa, Florida	192
66	36	West of Fort Myers, Florida	183
57	32	West of Sarasota, Florida	174
		The "Blake" Caribbean Exploration 1878-79, USNM	
20	12.5	Sta. 157	219
19	12.5	120 fms. off Montserrat	
26.5	19	Sta. 282	282
19	11.5	154 fms. sand, near Barbados	
13	7	Barbados	183
25.5	15.5	Barbados	133.5
30	18		
40	28	St. Vincent	208.6
37	25	Barbados	172
broken canal			

Length (mm)	Width (mm)	Locality	Depth (meters)
Japan:			
72	40	Tosa, Shikoku, Japan	183
64	35		
63	35		
61	35		
46.5	26		
40	22		
63	33	Tosa, Shikoku, Japan	110
56	32		
71	36	Tosa, Shikoku, Japan	110
71	38	Tosa, Shikoku, Japan	125
60	37	Sagami Bay, off Honshu, Japan	
52.5	29		
67	35	Kii, Honshu, Japan	
62	37		
54.5	30	Wakayama, Honshu, Japan	
56	32		
Madagascar:			
60	34	P2. Chalutage 10 12°43'S-48°15'E	300-340
43.5	20.5		

very coarse plicae along the columellar edge which curve posteriorly away from the aperture past the axis of the shell. The shield of *perdistorta* is more oblong with finer teeth on the columellar edge which are more or less in a straight line which ends at the axis of the shell. (See Table 3 for a comparison between *perdistorta, ridens,* and *reticulata*).

Until now, Western Atlantic specimens of *perdistorta* have been so rarely collected that they have failed to come to the attention of those who have worked with this genus. In 1951, Axel Olsson and Thomas L. McGinty described *Distorsio constricta floridana* as a subspecies of the Panamic *Distorsio constricta* Broderip 1833. Unfortunately, the name had previously been used by Gardner (1947, p. 535, pl. 53, fig. 8) for *Personella floridana* and it was necessary for Emerson and Puffer (1953, p. 101) to rename it *Distorsio mcgintyi.* The spelling is here emended to *macgintyi* to conform with the recommendations on the formation of names in Appendix D of the 1961 Code. Among the material with which Olsson and McGinty dealt were the *Distorsio* collected by the Blake expedition in the Gulf of Mexico, 1877-78 and in the Caribbean, 1879-80. While discussing the *Distorsio* in his well-known "Blake Report", Dall (1889, p. 221) referred to Link's (1807, p. 123) list which limited the genus to two living species. Dall stated that these were "the two species and only two species of which it is composed, even at the present day." While not mentioned by Dall, one of these species was *Distorsio anus* (Linné, 1758), the type for the genus, and the other was listed and discussed by him as *Distortrix reticulata* Link, 1807, which is *Distortio reticulata* Röding, 1798. Dall divided *reticulata* into "variety *reticulata*" and "variety *clathrata*" and considered it to be the only species in the Western Atlantic. Curiously, the taxon that Dall considered to be "variety *clathrata*" is the subspecies now known as *D. constricta macgintyi,* while what he regarded as "variety *reticulata*" is actually *Distorsio clathrata* (Lamarck, 1816).

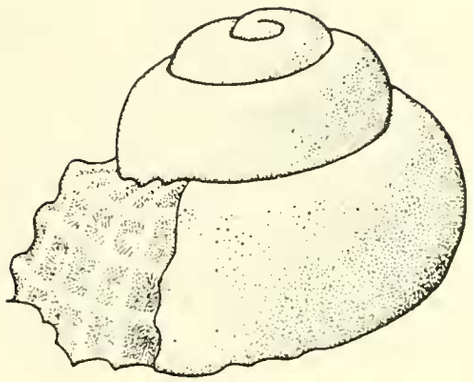


Fig. 1, Protoconch of Distorsio perdistorta, *Academy of Natural Sciences of Philadelphia, 241660, 100 fms. Tosa, Japan, height 2 mm.*

The history and synonomy of *D. reticulata* Roding was discussed and clarified by Puffer (1953, p. 113). The distribution of *reticulata* and *anus* is limited to the Indo-Pacific.

Emerson and Puffer, 1953, and Clench and Turner, 1957, limited the living species in the Western Atlantic to *Distorsio clathrata* and *Distorsio macgintyi.* Neither Dall nor later authors realized that the "Blake" expedition had actually collected a third and different species. I found seven specimens of this species (four from the dry collection and three from the alcohol collection) in the USNM. Some of these proved to be the actual specimens listed by Dall as *"Distortrix reticulata"* Link and were still labeled as such. They match the holotype, and other specimens of *Distorsio perdistorta* recently collected in the Western Atlantic in every detail, including penis, periostracum and operculum, although the shells are smaller in size.

Examination of the literature of fossil mollusca has failed to reveal any record of an ancestor of *Distorsio perdistorta* in the Western Atlantic although there is ample evidence of the ancestors of *Distorsio clathrata* and *Distorsio macgintyi.* A special effort was made to investigate the possibility that a Panamic species, such as *Distorsio decussata* (Valenciennes, 1832), could prove to be a Panamic analog of *Distorsio perdistorta* in either Recent or fossil form. Woodring, (1928, p. 495, pl. 18, figs. 7, 8, 9) illustrates a mixture of species which he misidentifies as *"Distorsio decussatus simillimus* (Sowerby, 1850)". Figures 7 and 8 are actually *Distorsio gatunensis* Toula, 1909, the fossil subspecies of *Distorsio decussata.* Figure 9 is *Distorsio simillima,* the fossil subspecies of *constricta.* The differences between *perdistorta* and the living and fossil forms of *decussata* suggest that a close relationship between the two species is unlikely, in spite of their relatively close distribution. This seems especially borne out when one observes the great similarity of Western Atlantic, Japanese, and Indian Ocean specimens, in spite of their extreme geographical separation.

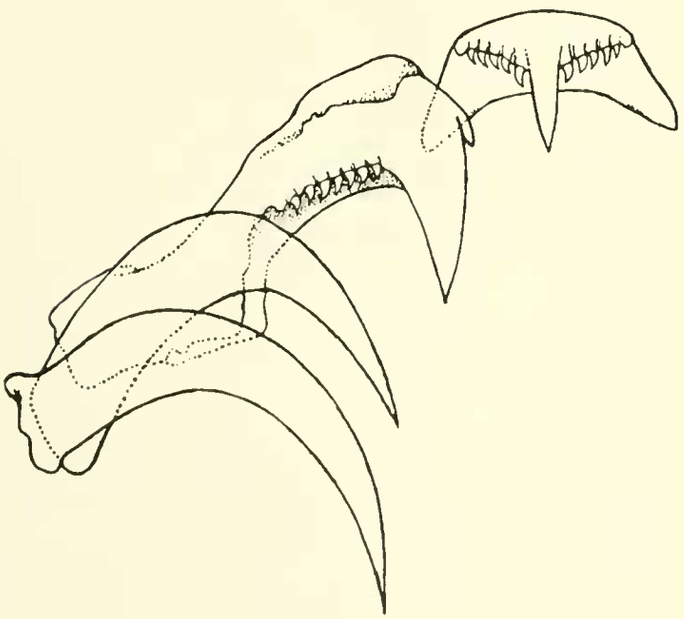


Fig. 2, Radula of Distorsio perdistorta *Fulton, 105 fms, WSW Tampa, Fla., width of rachidian: 120μ.*

Fig. 3, Left jaw of Distorsio perdistorta *Fulton, Gulf of Mexico, length: .75 mm.*

TABLE 2. Specimens of Distorsio constricta habei *Lewis, new subspecies, examined.*

Length (mm)	Width (mm)	Locality	Depth (meters)
53	28	Tosa Bay, Shikoku, Japan	
54	29	Tosa Bay, Shikoku, Japan	
51	30		
51	27		
45	26		
41	22		
53	28	Kii, Honshu, Japan	
45	25	Tosa, Shikoku, Japan	128
42	22		
54	31.5	Tosa, Shikoku, Japan	128

TABLE 3. Comparison of Distorsio perdistorta, Distorsio reticulata, *and* Distorsio ridens.

	perdistorta	*reticulata*	*ridens*
color of shell	white; cords can be orange-brown	diffused tan; cords can be lighter	white; some color on axial ribs
shape of whorls	rounded, very swollen and distorted	tabled whorls above angled periphery	rounded; shell is fusiform
axial ribs on body whorls	25 - 30	16 - 20	13
plicae at columellar edge	fine, usually formed in straight line	fine, usually formed in straight line	gross, recurve posteriorly away from aperture
shape of parietal shield	oblong	triangular to rounded oval	medium oval
color of shield	white or stained orange-brown on parietal area	solid dark tan to pink with white plicae	orange-brown with white apertural edge; to white
sculpture of shield	smooth to low coarse beading	fine beading formed by ribs and cords under shield	strong coarse beads, axially aligned
plicae at posterior canal	absent or very small	2 large strongly formed plicae	2 large strongly formed plicae
shape of aperture	constricted; third tooth on inner edge of outer lip is very prominent	more open; third tooth on inner edge of outer lip is slightly larger	constricted; third tooth on inner edge of outer lip is very prominent
teeth at inner edge of outer lip	9 to 10 large; first tooth below posterior canal is usually double	8 to 9 large	6 to 7 large; 3 very small

Fig. 4, Protoconch of Distorsio constricta habei *Lewis, height of protoconch: 1.8 mm.*

Genus *Distorsio* Röding, 1798

Distorsio Röding, 1798, Museum Boltenianum, pt. 2, p. 133. Type species, *Murex anus* Linné, 1758, subsequent designation J. E. Gray, 1847. (The Latin noun *distortio* is feminine).

Description - Shells range in length from 25 to 90 mm. They are strongly sculptured with spiral cords and axial ribs which can make them knobby or cancellated. The whorls are swollen and distorted because they bulge in order to accommodate the growing animal as it covers earlier whorls. There is a large parietal shield which joins with an expanded peristome to encircle the aperture. When partially covered by new growth, the old parietal shields serve as varices. The distorted whorls, parietal plicae and grossly-formed denticles on the inner edge of the outer lip, create a very irregular aperture. The shield has a groove and numerous irregular plicae on the lower left. A short anterior siphonal canal usually turns upwards.

The radula is taenioglossate. It is situated in the tip of an extremely long proboscis which lies folded in the proboscis sheath (figs. 14 to 22). The proboscis is capable of tremendous extension. This is typical of the genus and quite different from the typical cymatiid pleurembolic proboscis. In species which have been examined, the jaws are small, transparent, and not as strongly formed as in most genera of Cymatiidae.

OPERCULA

Previous workers have suggested that the pattern of the opercula of *Distorsio* varies intraspecifically between terminal (without a nucleus) and submarginal (with a nucleus). Personal observation of numerous broken and repaired opercula has indicated that there is a high incidence of breakage and repair. This is probably due to the difficulty of passing the operculum through the extreme constriction of the aperture. It is interesting to note that all of the opercula of *Distorsio* which show clear evidence of repair have a nucleus. Missing opercula are replaced by newly formed ones, which also always have a nucleus. I have observed this characteristic change in pattern from terminal (a-nuclear) to nuclear in the repaired opercula of other genera of Cymatiidae such as *Cymatium s.s.*, *Gyrineum* and *Monoplex*. Often the growth rings depart from the semicircular arc which is typical of the original terminal pattern. Furthermore, the specimens which have remained terminal are usually consistent in size and shape, while the nucleated opercula vary considerably. When dealing with perfect specimens of the opercula of *Distorsio*, the primary muscle scar pattern and the shape delineated by the varnish can prove to be a valuable taxonomic character.

Distribution - Species of *Distorsio* are found in most tropical portions of the world to a depth of 300

Fig. 5, Operculum of Distorsio perdistorta *Fulton, dredged WSW Tampa, Fla., 105 fms., height 9 mm.*

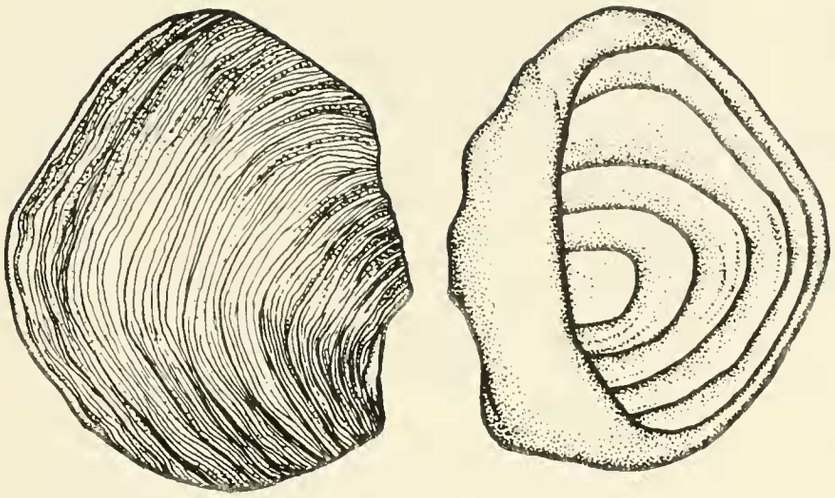
Fig. 6, Operculum of Distorsio perdistorta *Fulton, Academy of Natural Sciences of Philadelphia, 241652, Tosa, Japan, height 7 mm.*

Fig. 7, Operculum of Distorsio perdistorta *Fulton, Academy of Natural Sciences of Philadelphia, 241652, Japan, height 6.9 mm.*

Fig. 8, Operculum of Distorsio clathrata *Lamarck, 140 ft. S.W. Cape San Blas, Florida, 1969, height 5 mm.*

Fig. 9, Operculum of Distorsio constricta macgintyi *Emerson & Puffer, South of Loggerhead Lt., Tortugas, Fla., 25 fms., height 7.8 mm.*

Fig. 10, Operculum of Distorsio habei *Lewis, Academy of Natural Sciences of Philadelphia, 189639, Tosa Bay, Japan, 70 fms., height 6 mm.*



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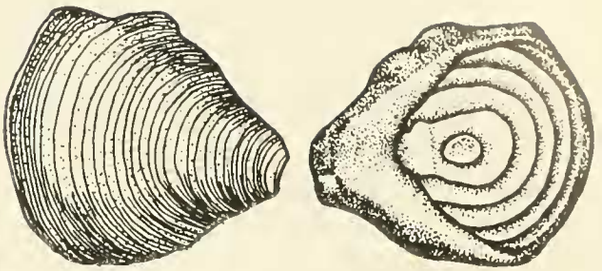

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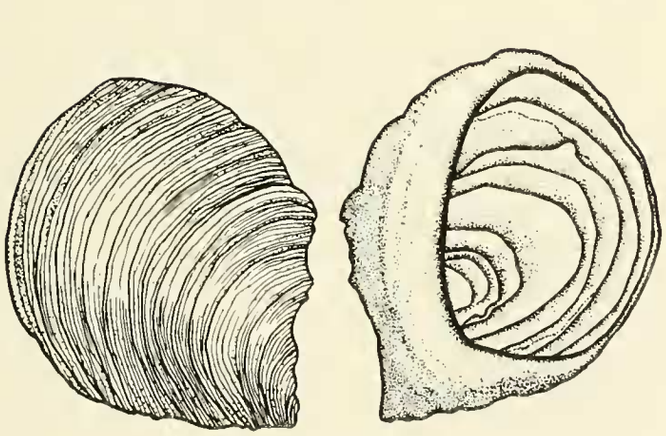

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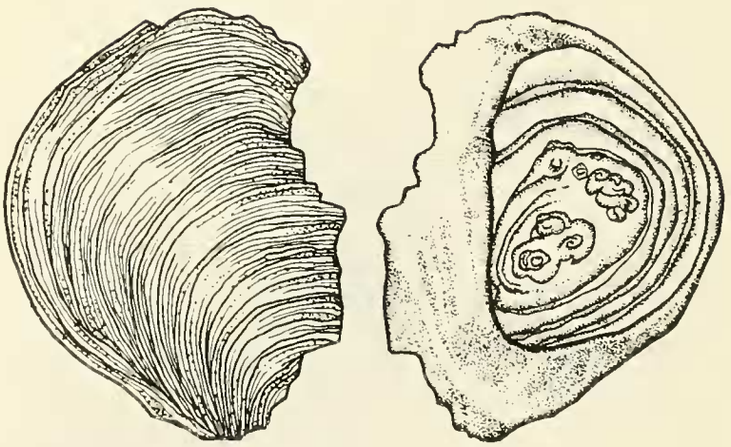

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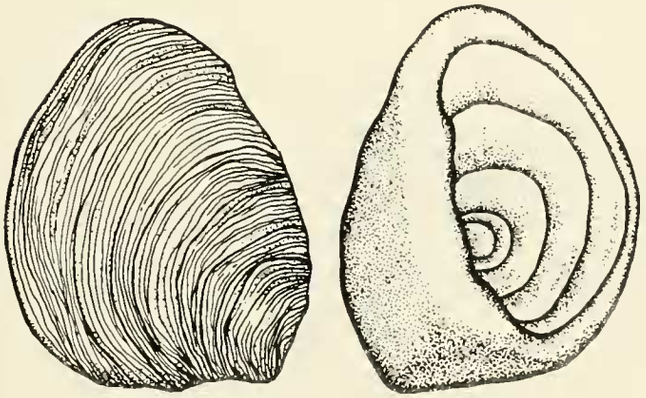

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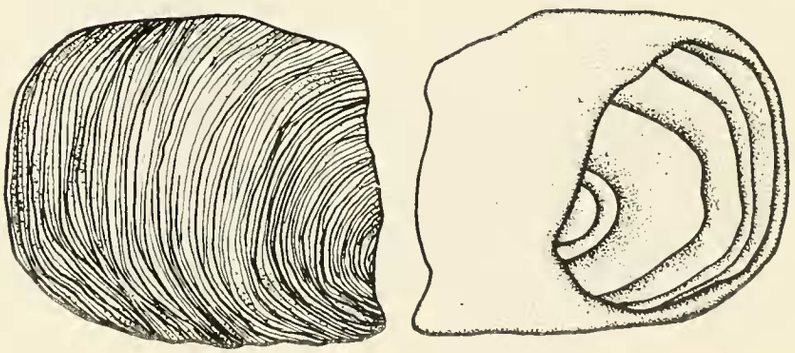

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Fig. 5-10, Explanation on opposite page.

fathoms. The earliest American fossils of the subgenus *Personella* appear to be from the Middle Eocene, while the earliest *Distorsio s.s.* appears to be *Distorsio crassidens* (Conrad, 1848), from the Oligocene of Vicksburg, Mississippi

REMARKS ON THE SUBGENERA

Subgenus *Rhysema* Clench, Wm. J. and Turner, Ruth D. 1957, Johnsonia, vol. 3, no. 36, p. 236. Type species *clathratus* Lamarck, 1816, by original designation.

When Clench and Turner, 1957, described the subgenus *Rhysema*, they differentiated it from *Distorsio s.s.* on the basis of two characters. They pointed out that *Distorsio anus*, the type for *Distorsio s.s.*, had a parietal shield which "extends well above the upper limits of the outer lip and covers the preceding two whorls" and a siphonal canal which is "nearly vertical." This limited *Distorsio s.s.* to one species and all other living species were then considered to be in the subgenus *Rhysema*. Up to the present day, there has been no additional evidence to justify two subgenera. It is true that the various species which comprise *Rhysema*, do not have a parietal shield which covers two preceding whorls, but the shield often covers one preceding whorl and quite often exceeds the upper limits of the outer lip. Furthermore, there are many specimens of various species whose siphonal canals are very recurved, although not vertical. These characters appear to be based upon differences of relative degree. While they might be considered valid when separating species, they do not appear to define separate subgenera. A new species is described later in this paper which is very similar to *Distorsio anus*. Because of this similarity most workers would agree that it is properly placed in *Distorsio s.s.* The definition of *Rhysema* would require placing it in *Rhysema* since its parietal shield does not exceed the two preceding whorls and its siphonal canal is not vertical. This example alone demonstrates the difficulty one would have in attempting to place the various species of *Distorsio* into separate subgenera based on these characters.

As an added example, *Distorsio clathrata* differs as much from *Distorsio macgintyi* as does *Distorsio anus* from either one. *Distorsio anus* is often considered a shallow water species but living specimens have been found in 45 meters. While the various species of *Rhysema* are considered to be from deep water, some species have been found living intertidally. Until more evidence becomes available, it seems unnecessary to retain two subgenera which are so weakly differentiated. Consequently, I consider *Rhysema* to be a synonym of *Distorsio*.

Distorsio perdistorta **Fulton, 1938**

Figs. 1, 3, 5-7, 11-34

Synonomy -

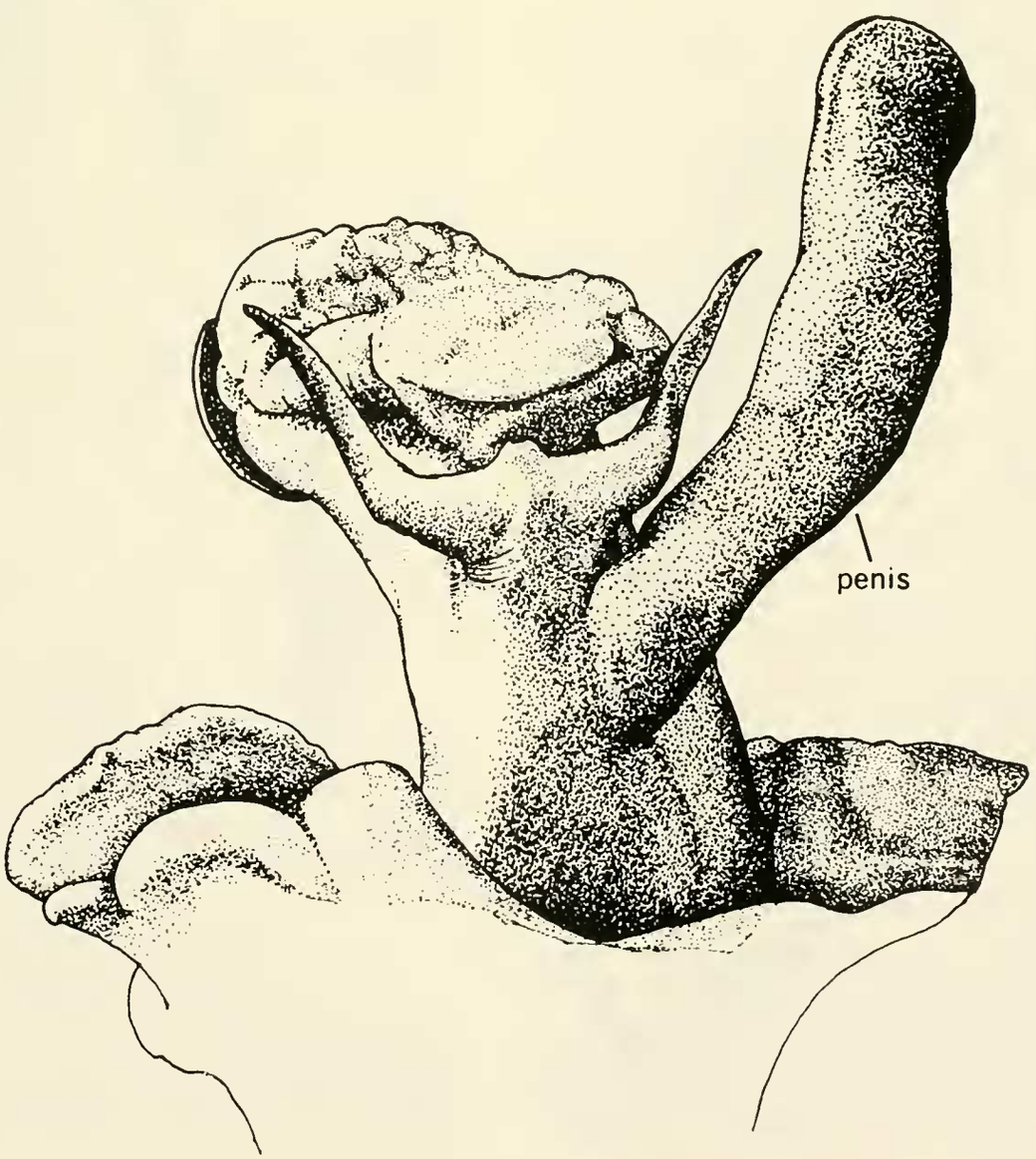
1938 *Distorsio perdistorta* Fulton, Proceedings of the Malacological Society of London, (March 16), vol. 23, pt. 1, pp. 55-56, pl. 13, figs. 3 and 3a. Type locality; Kii, Japan. Type in the British Museum of Natural History.

1964 *Distorsio (Rhysema) horrida* Kuroda and Habe, Shells of the Western Pacific in Color, vol. 2, p. 74, pl 23, figs. 3 and 3 (both figures numbered 3). Type locality; Tosa Bay, Shikoku, Japan. Type in the National Science Museum, Tokyo, Japan.

Description - The largest shell examined reached 82 mm. in length. The color of the shell is white, but pale orange-brown color may be present on the spiral cords. There are 8 to 10 convex whorls producing a spire of approximately 50°. The outer lip is thickened with the outer margin curving forward. There are 8 or 9 denticles on the inner edge of the outer lip. The third denticle below the posterior anal canal is much larger than the others and is opposite a deep indentation in the parietal wall, creating a constricted apertural shape. The parietal shield is thin, rather oblong, being wider posteriorly and narrowing anteriorly. The shield can be smooth or sculptured with very low spiral cords and axial ribs which form beads when they cross. There are numerous irregularly formed plicae on the left of the groove in the lower parietal shield. These are variable in sculpture and number, sometimes reaching the edge of the shield. The groove itself is more open and straighter than in most species of *Distorsio*. The siphonal canal is relatively straight for the genus, short and turned slightly upwards. It is bordered by 9 to 15 well-defined plicae, the greater number usually occurring on the larger specimens. The upper three plicae are the largest and the remainder diminish in size. The sculpture consists of 8 major spiral cords on the body whorl, the upper 5 or 6 being separated from one another by a single fine interstitial cord. There are 8 or 9 varices with 20 to

Fig. 11, Dorsal aspect of the mantle edge of Distorsio perdistorta *Fulton (female) flattened to show papillae.*

Fig. 12, Dorsal aspect of Distorsio perdistorta *Fulton (male). The mantle edge of this specimen lacks papillae.*



25 axial ribs between them which form beads when they cross and give the shell a reticulated appearance.

The operculum is small and distinct from that of *Distorsio clathrata* although it is similar to *Distorsio macgintyi* (figs. 5 to 10).

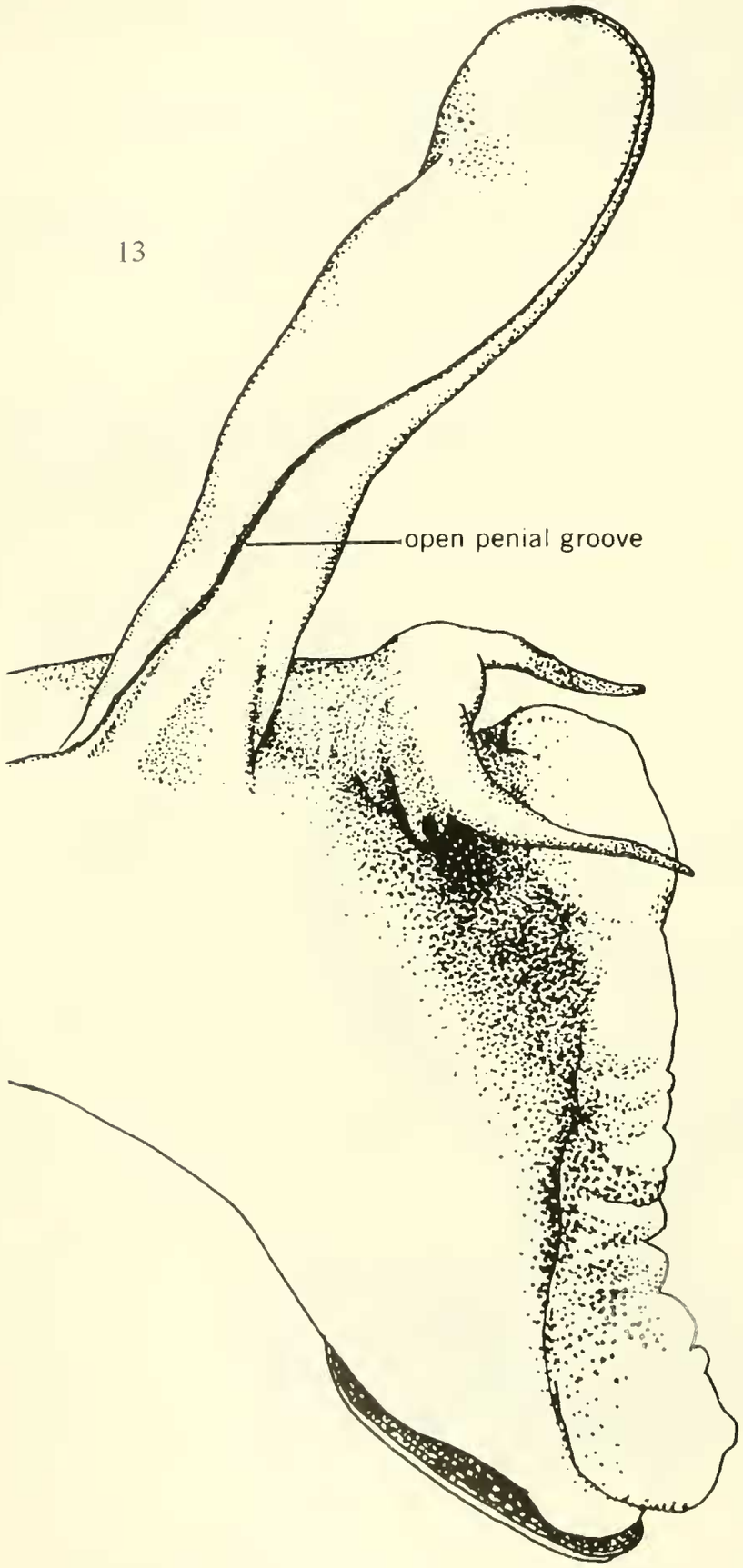


Fig. 13, Right lateral view of Distorsio perdistorta *Fulton.*

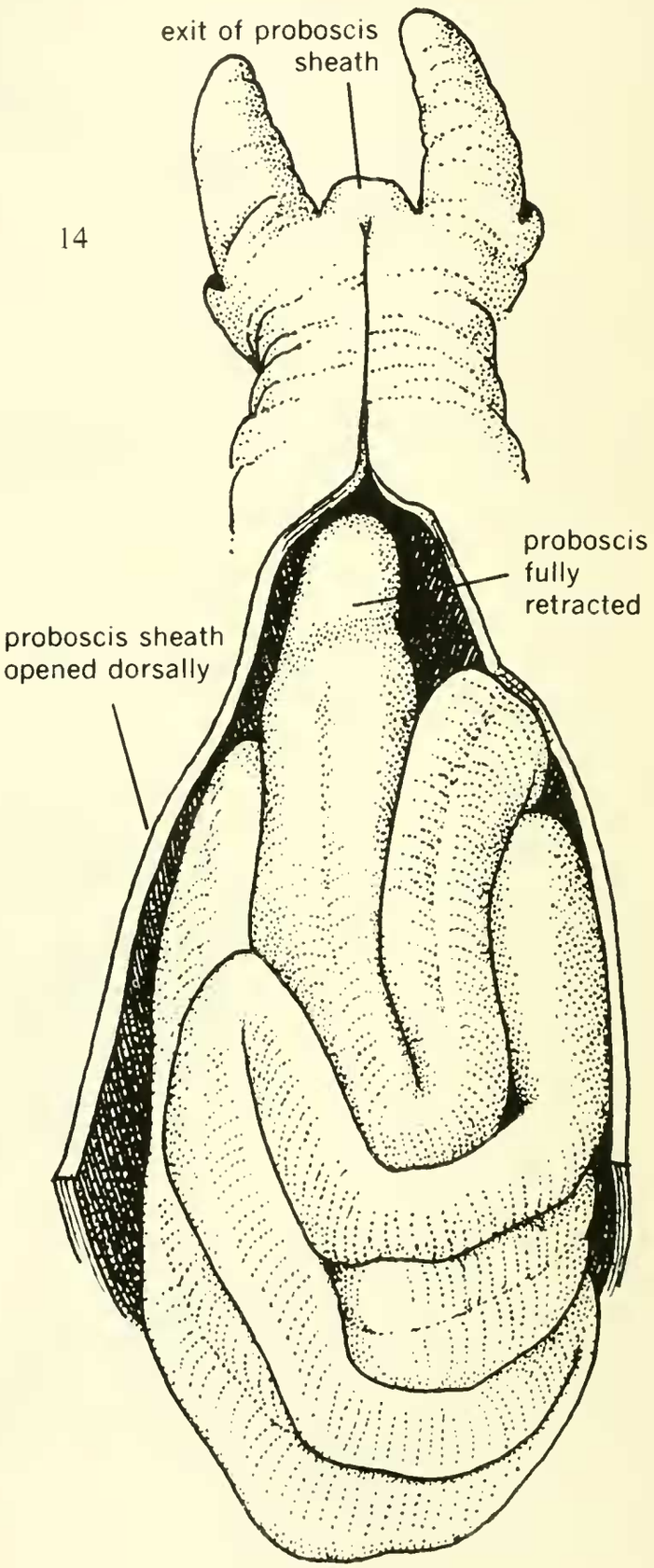


Fig. 14, Dorsal view of Distorsio perdistorta *Fulton.*

The soft body of the animal is tan, lacking the spots typical of many Cymatiidae. The mantle edge of the male animal examined was lacking in papillae (fig. 12); however the female specimen has large obvious papillae which are bisected by an open groove (fig. 11). Since only two specimens were examined, the differences in the mantle edge should not be construed as evidence of sexual dimorphism. The penis is very large with an open penial groove (figs. 12-13).

The rachidian and laterals of the radula are very powerfully formed (fig. 2). There is a long central cusp on the rachidian with 4 to 6 sharply-pointed shorter cusps on either side of it. The lateral has 6 to 9 small, sharply pointed cusps on the anterior lateral edge. There are no cusps on the marginals. Because of the extraordinary proboscis structure and the extremely small opening through which the proboscis is extended, the radula, jaws and buccal mass are very small in relationship to the body mass.

PERIOSTRACUM

The periostracum is yellowish and formed in numerous very low axial blades which are fringed with fine projections along their edges. There are long hair-like processes at the beads of the shell sculpture which gives fresh specimens a bristly appearance. Although the Japanese specimens of this species are more sparsely bladed than the Western Atlantic specimens, both exhibit an extraordinary periostracal structure. Below the visible upper surface, there is a second layer of tunnel-like chambers which run spirally around the shell (figs. 23 to 25). There is a periostracal floor which is attached to the shell and a roof which is parallel to the floor and shell surface. The roof is formed by flat connections between the small periostracal processes. The axial walls of the tunnels are formed by the axial blades and the spiral walls by flat, vertical connections between the processes. I have observed similar structures in *Distorsio reticulata, D. clathrata, D. decussata, D. constricta constricta,* and *D. constricta macgintyi.* Two species which do not have this type of periostracum are *D. anus* and *D. constricta habei.*

DISTRIBUTION

The distribution of *Distorsio perdistorta* has previously been known from Tosa Bay, Shikoku, Japan to Kii, Honshu, Japan. Based on the limited amount of material which has been collected in the Western Atlantic, it is difficult to judge the relative rarity of this species, but it certainly can be said that it has not proved to be as common as *Distorsio clathrata* or *Distorsio macgintyi.* Thus far the northern record in the Western Atlantic is west of Tampa, Florida, Gulf of Mexico, while the southern record is off Barbados, in the Lesser Antilles. Recently, two specimens were recorded from north-west Madagascar in the Mozambique Channel, Indian Ocean.

COMPARATIVE FEATURES

Fulton described *Distorsio perdistorta* as white, but examination of numerous specimens indicates an occasional pale-brown coloration limited to the spiral cords. This characteristic position of color pigment is present in both Western Atlantic and Japanese specimens, and appears to be a useful character in *Distorsio.*

Some workers might be tempted to designate the Western Atlantic representatives as a subspecies of the Japanese *perdistorta* because of geographical separation, heavier periostracum and an apparent tendency to reach a larger size. However, careful examination of all the material failed to show that these were significant differences. On the contrary, these characters varied within each geographical range. My work with the Cymatiidae has clearly demonstrated to me their great ability for intraspecific variation. Laxton, (1971), has shown that two distinct populations of *Cymatium spengleri* (Perry 1811), can vary in spire angle, number of varices, and other characters, when each lives in different ecological situations and feeds upon different species of ascidians which are available in different quantities. Bayer, (1971, pp. 114-115) discusses the close resemblance of various Japanese and Caribbean genera and species. It is widely known that other species of Cymatiidae are worldwide in distribution with various unexplained geographical relationships. The morphological consistency of the Japanese and Western Atlantic specimens of *Distorsio perdistorta* makes it unnecessary to establish a new subspecies in spite of their great geographical separation.

In order to clearly differentiate the three living species of *Distorsio* in the Western Atlantic, I have attempted to establish a diagnostic chart of their more obvious differences.

TABLE 4. Comparison of the three Caribbean species of Distorsio.

	Distorsio perdistorta	*Distorsio clathrata*	*Distorsio constricta macgintyi*
color	white; cords orange-brown	brown; cords and ribs white	diffused light orange-tan
shield shape	oblong; shallow or no sculpture	oval-round; strongly sculptured	oval-round; strong white beads, color in between
outer lip size	relatively smooth large; to 82 mm.	strongly denticulated large; to 90 mm.	raised spiral cords small; to 55 mm.
spire angle	50°	55°	42°

Distorsio constricta habei
new subspecies, **Lewis**
Figs. 4, 10, 38, 39

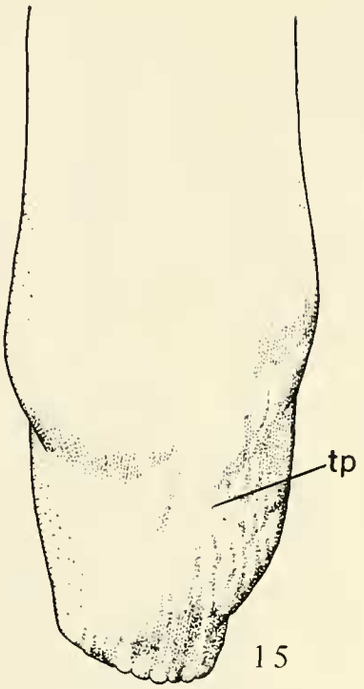
Synonomy -

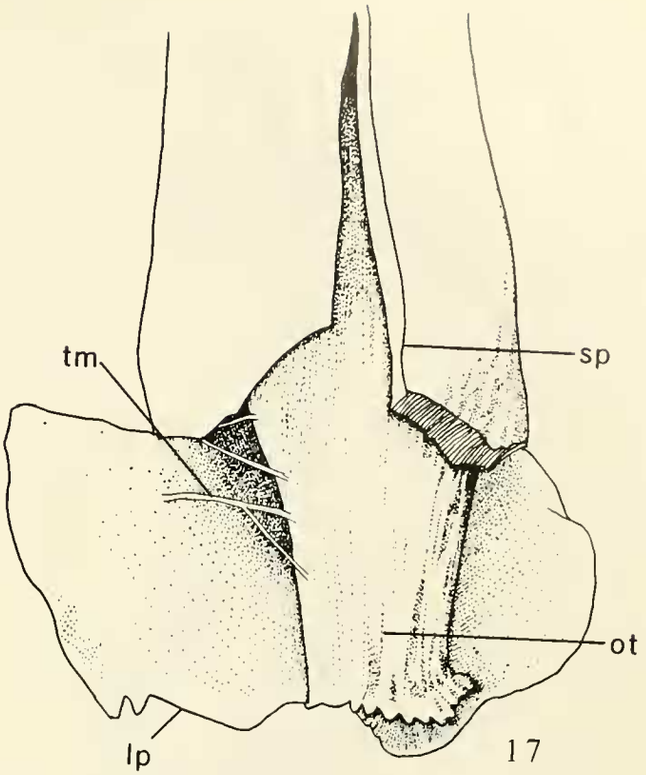
1964 *Distorsio (Rhysema) perdistorta* Fulton, Kuroda and Habe, Shells of the Western Pacific in Color, vol. 2, p. 74, pl. 23, fig. 1 (non Fulton, 1938).

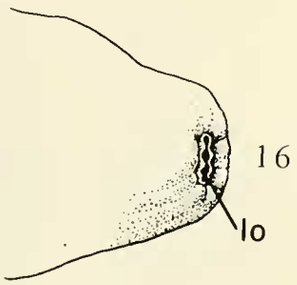
Description - The largest shell examined reached 54 mm. in length. There are 9 convex whorls which have a flattened plane above the periphery formed between the first and second spiral cords. The spire is produced at approximately 42°. The outer lip is slightly thickened with the outer margin curving forward. There are 8 denticles on the right edge of the aperture which extend to the edge of the outer lip and form low cords. The third denticle below the posterior anal canal is much larger than the others and is opposite a deep indentation in the parietal wall. The parietal shield is thin, oval and variably sculptured by spiral cords and axial ribs which form low beads when they cross. Color is a diffused pale orange-brown, with more intense color limited to the spiral cords. There is a clearly formed groove in the lower parietal shield, bordered on the right by 8 to 12 denticles on the columellar edge of the siphonal canal. The first denticle is the largest and the remainder diminish in size. There usually is denticulation on the left side of the groove, but in occasional specimens, the groove blends into the parietal shield without delineating denticulation. The siphonal canal is straight, short and curves slightly upwards. The sculpture consists of 8 major spiral cords on the body whorl and 3 cords on the dorsal surface of the anterior canal. Between the first and second cords below the suture, there are 2 or 3 fine interstitial cords. The second and third cords are close together with one fine interstitial cord separating them. The third and fourth cord are separated by 2 fine interstitial cords, while the remaining

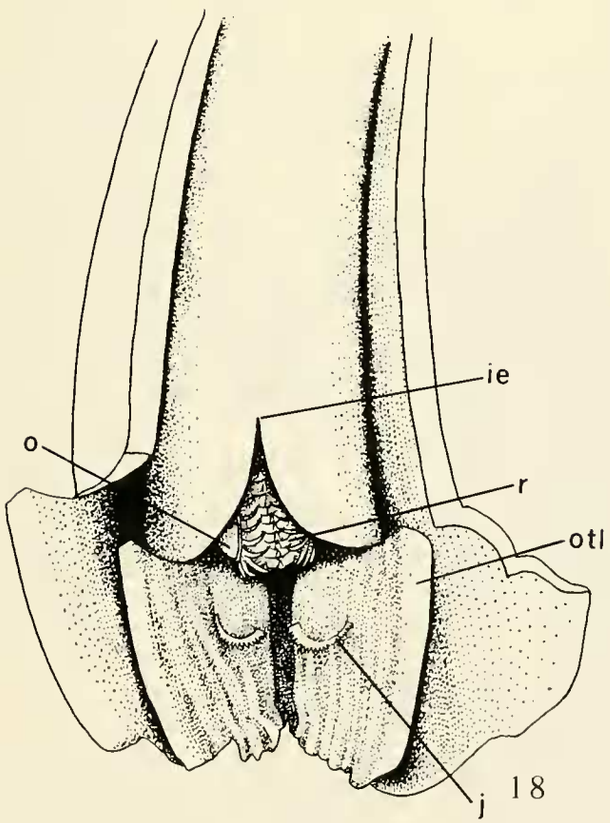
Fig. 15-19, Dissection of the tip of the proboscis of Distorsio perdistorta *Fulton (dorsal aspect):*

bm. buccal mass;
e. esophagus;
ev. esophagal valve;
ie. incision in esophagus;
j. jaws positioned considerably posterior to lip of oral tube;
lo. crenulated lip of oral tube (probably used for ingestion of food);
lp. lip of proboscis;
me. muscles of the esophagal valve;
n. buccal and labial nerves;
o. odontophore;
ot. oral tube;
otl. oral tube opened by longitudinal incision;
p. proboscis;
r. radula;
rm. retractor muscles;
sp. surface of proboscis, opened by dorsal longitudinal incision;
tm. tensor muscles;
tp. tip of proboscis;









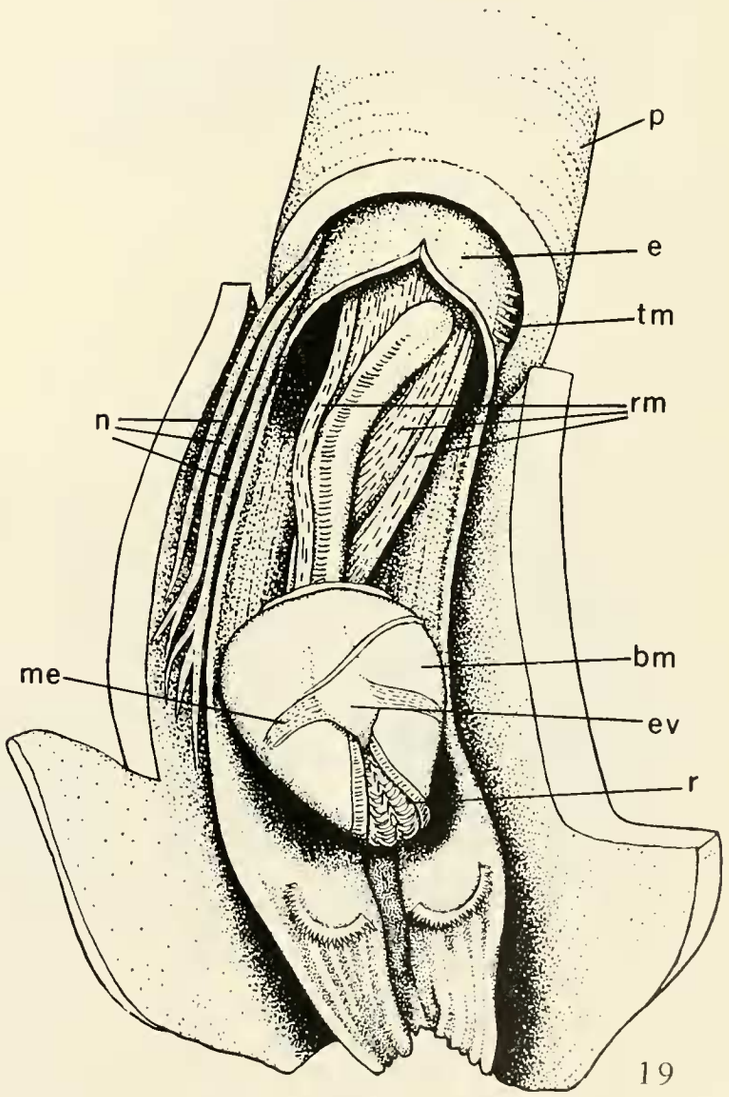


Fig. 15-19, Explanation on opposite page.

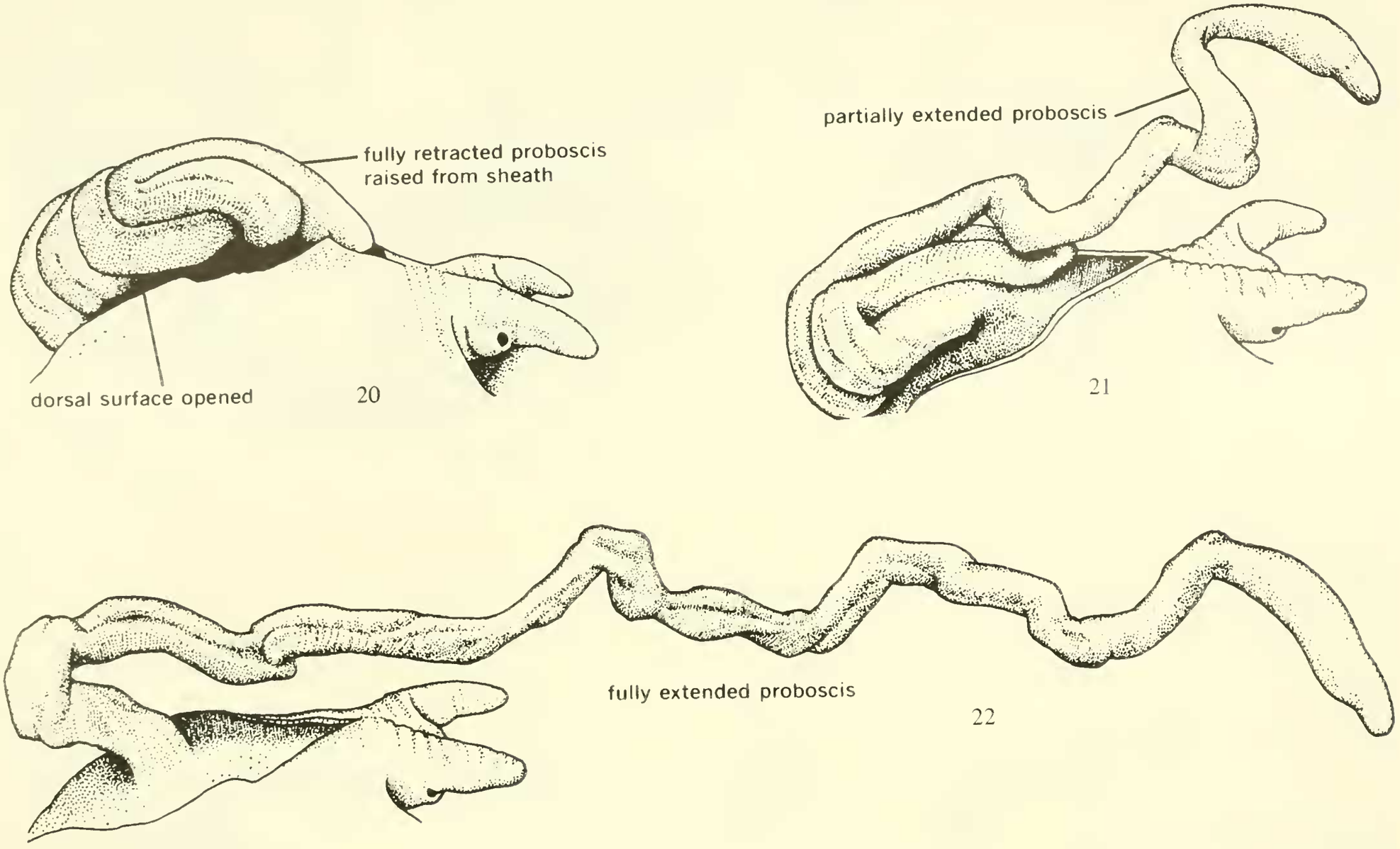
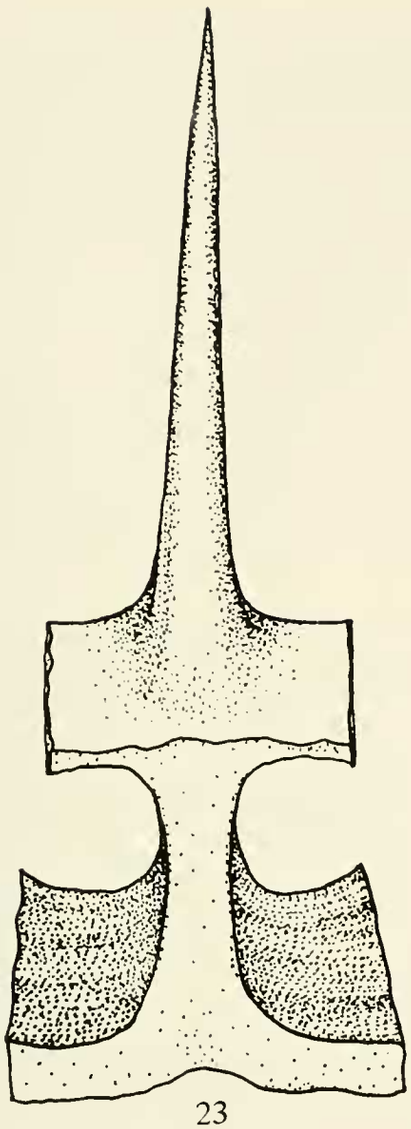


Fig. 20-22, Right lateral view of Distorsio perdistorta *Fulton. The thickened musculature in the extended proboscis probably aids in rapid extension and retraction and may aid in enabling food to pass through the entire length of the esophagus by separate contractions as it passes posteriorly.*



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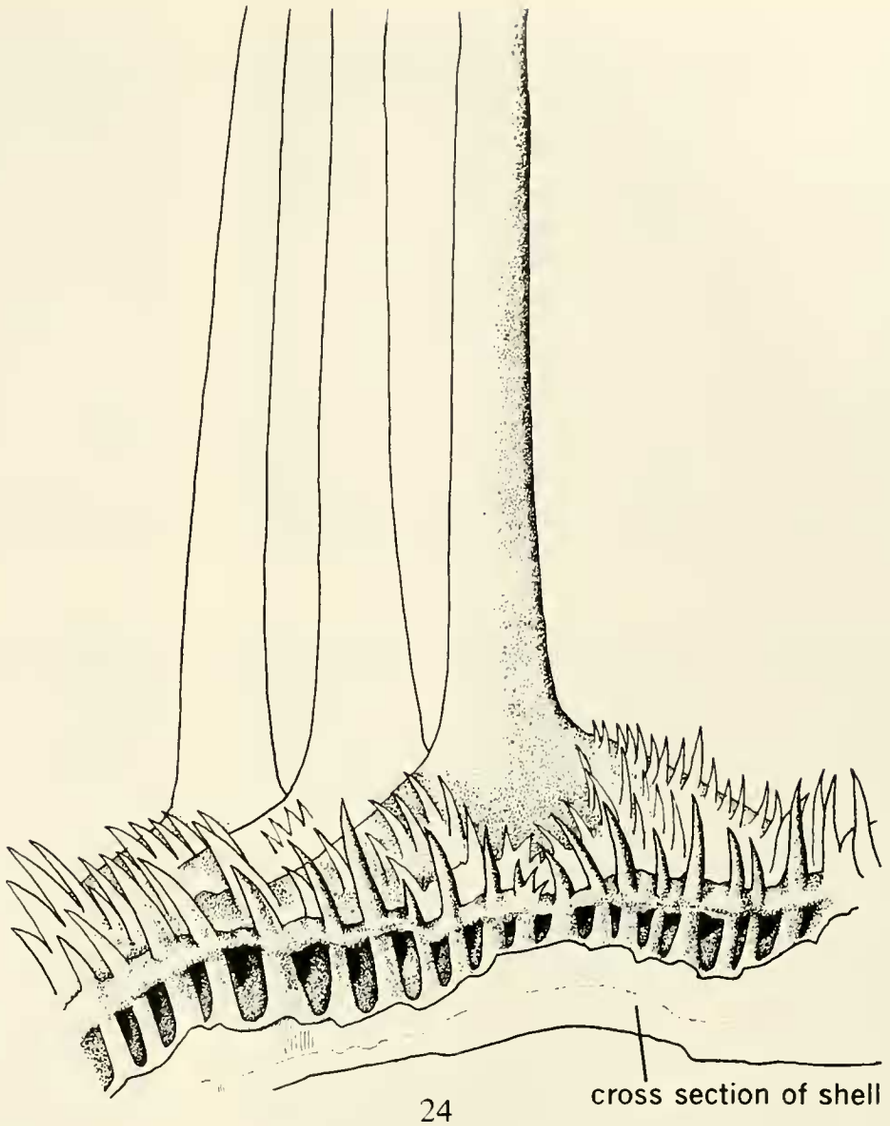

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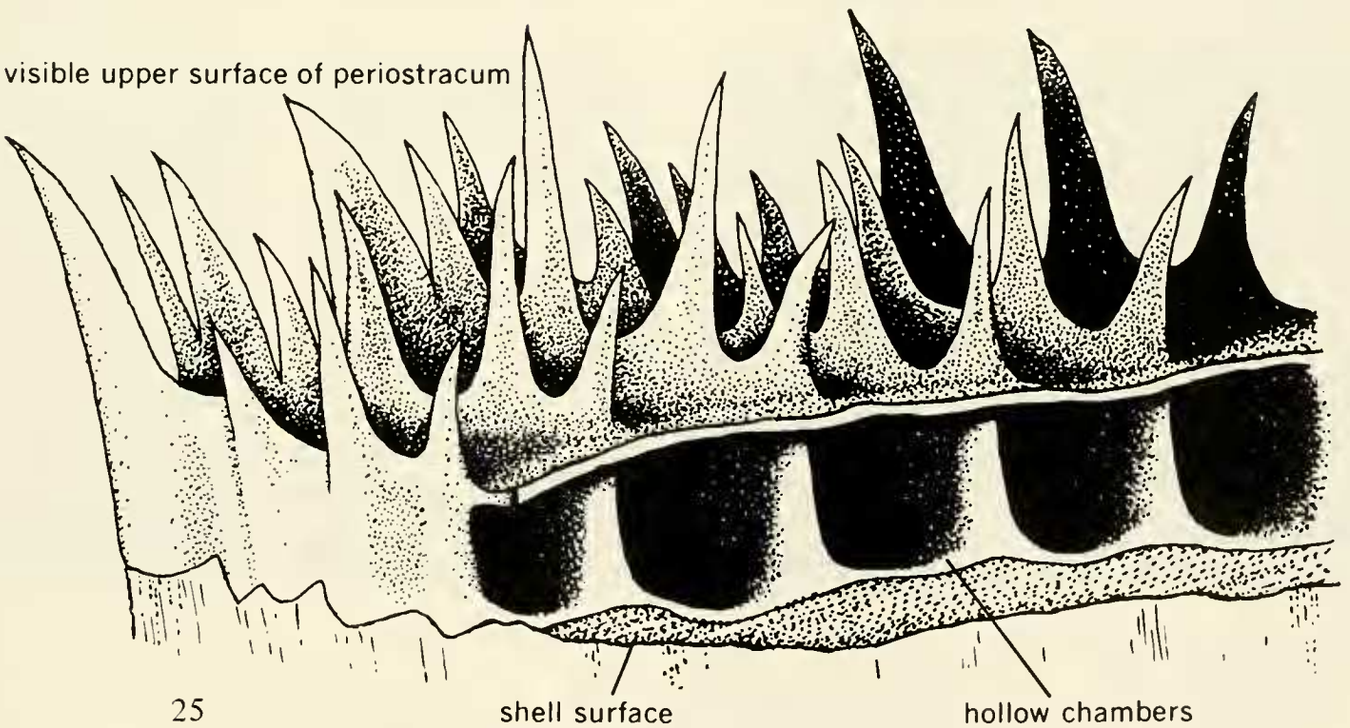

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Fig. 23, Single periostracal process of Distorsio perdistorta *Fulton.*

Fig. 24-25, Details of periostracal structure of Distorsio perdistorta *Fulton, 125 fms. W. of Ft. Myers, Fla.*

major cords are usually separated by a single fine cord. There are 8 to 10 varices with 12 to 17 axial ribs between the varices. Where the cords cross the axial ribs, they form beads.

The periostracum is thin, yellowish, formed in spiral rows which follow the cords of the shell in contrast to the numerous, fringed, axial blades of the other species. There are thin, low hairlike processes at regular intervals on the spiral rows and they align axially. Longer processes develop on the ribs of the shell. The periostracum is attached directly to the shell and lacks the second layer such as that found in *perdistorta* and the other two subspecies, *constricta* and *macgintyi*. The operculum is terminal (fig. 10). I have not examined an animal of this species.

Description of the holotype - The shell measures 53 mm. in length and 28 mm. in width. There are 8 denticles on the right edge of the aperture which extend across the expanded peristome to the edge of the outer lip, forming low cords. The lower left edge of the parietal shield is lacking in denticulation. There are 9 denticles on the columellar edge of the shield. There are 15 axial ribs on the body whorl.

Distribution and type locality - Most of the specimens which I have examined were taken in Tosa Bay, Shikoku, Japan, which is designated the type locality. There is one specimen from Kii, Honshu, Japan. Kuroda and Habe list the distribution as Boso Peninsula, Honshu, to Tosa Bay, Shikoku, Japan at depths of 100 to 200 m. They state that the species is uncommon. The holotype is in the ANSP no. 325380; four paratypes in ANSP 325381; one paratype in Del. Mus. Nat. Hist. no. 50943.

Differentiating features - *Distorsio habei* is very similar in general appearance to *Distorsio constricta* and *Distorsio macgintyi*. The differences are not significant enough to justify specific separation. However, unlike the Western Atlantic specimens of *Distorsio perdistorta,* they can be separated when the three subspecies are compared. The taxonomic characters which are consistent enough to use are: pigmentation, the pattern of cords and interstitials, denticulation on the expanded peristome and the structure of the anterior siphonal canal.

The shells of all three subspecies are irregularly stained with orange-brown, but the cords on the shell of *habei* are always colored with a darker pigmentation. On the parietal shield of *macgintyi* and *constricta* there are strongly formed white beads outlined by a rich brown color in between the beads which gives the shields a markedly reticulated appearance. This character is very consistent in *macgintyi* but varies in some specimens of *constricta*. I have examined large specimens of *constricta* from the Galapagos Islands which have no beading on the shield at all. All of the specimens of *habei* examined had beaded sculpture on the shield, but the strength of the beading and color are variable, lower, and finer than the beading and color on *macgintyi*. The shield of *habei* is either white or very light orange-brown. In some specimens of *habei*, the parietal shield was well-below the suture, but all of the specimens of *constricta* and *macgintyi* which I have examined had parietal shields which were at the suture or above it.

The regular pattern of interstitial cords which is always present in *habei* is absent from *constricta* and irregularly variable when present in *macgintyi*. In *habei*, the right posterior edge of the anterior canal slants toward the posterior columellar edge, almost closing the canal externally at the point where they

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Fig. 26-27, Distorsio perdistorta *Fulton, Holotype, British Museum (Natural History), Kii, Japan, 60 mm. x 35 mm.*

Fig. 28-29, Distorsio perdistorta *Fulton. Gulf of Mexico, 57 mm. x 32 mm.*

Fig. 30-31, Distorsio perdistorta, *Fulton. West of Tampa, Fla. 110 fms. The heavy periostracum on this specimen is variable within the species. 66 mm. x 36 mm.*

Fig. 32-33, Distorsio perdistorta *Fulton. Tosa Bay, Japan, 63 mm. x 33 mm.*

Fig. 34, Distorsio perdistorta, *Fulton. Dredged West of Tampa, Fla. This specimen has a periostracum that closely corresponds to the average Japanese specimen. 82 mm. x 44 mm.*

Fig. 35, Distorsio clathrata *Lamarck. Dredged 65 fms. off Tortugas, Florida, 67 mm. x 36 mm.*

Fig. 36-37, Distorsio decussata, *Valenciennes. Trawled near Topolobamp, Sinaola, Mexico, 40 fms. 64.5 mm. x 33 mm.*

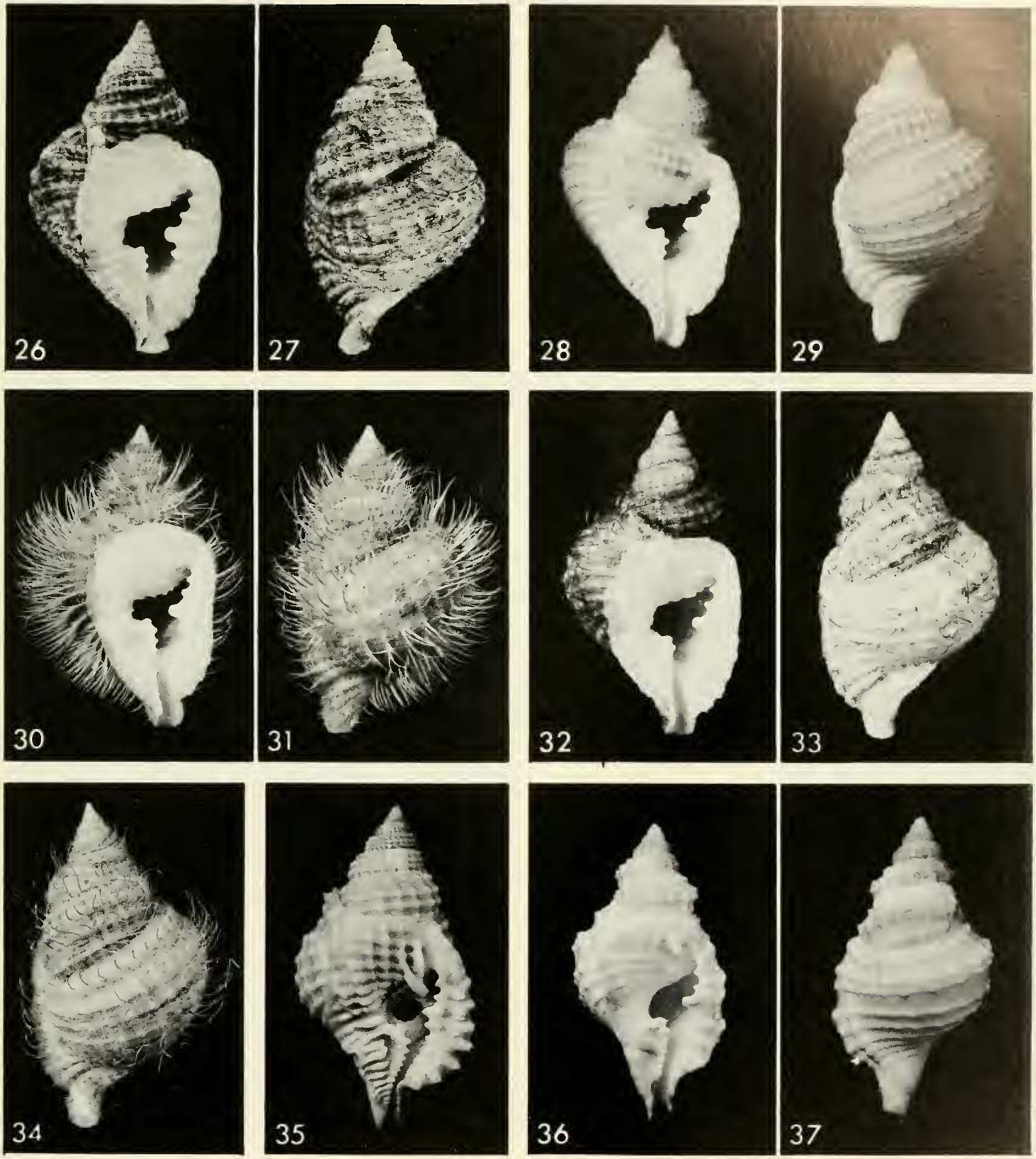

Fig. 26-37, Explanation on opposite page.

come together. The edges of the anterior canals of *constricta* and *macgintyi* remain parallel and leave the canal open.

While discussing the holotype of *habei,* I described how the denticles on the right edge of the aperture continue across the expanded peristome to the outer edge of the shield, forming low cords. If the cords do not continue from the apertural edge, there are no denticles formed at the outer edge of the shield, although there is a shallow groove which runs parallel to the aperture down the length of the expanded peristome. In both *constricta* and *macgintyi*, this groove is stained with a darker orange-brown color. Clearly defined denticles are formed on the right outside edge of the shield. Although separate, these denticles align with those at the apertural edge.

In the specimens examined there were 8 to 13 axial ribs between the varices of *constricta,* (an average of 10.6); 11 to 20 on *macgintyi* (an average of 14.7); and 12 to 17 in *habei* (an average of 15.6).

Distorsio habei differs from *Distorsio perdistorta* by being smaller, more distorted, having a more angled whorl which is tabled above the periphery, fewer axials (15.6) than *perdistorta* (20 to 25), a different pattern of interstitial cords, a different periostracal structure and richer pigmentation than the Japanese specimens of *perdistorta.* The spire angle of *habei* is 42° while the spire angle of *perdistorta* is 50°.

HISTORICAL DISCUSSION OF *HABEI*

Kuroda and Habe in "Shells of the Western Pacific in Color", (1964, vol. 2, p. 23, figs. 1 and 3) described *Distorsio horrida* (their fig. 3) as a new species and differentiated it from what they identified as *"Distorsio perdistorta* Fulton" (their fig. 1). Examination of a photo of the type specimen of *Distorsio perdistorta* kindly supplied by the British Museum of Natural History and correspondence with Dr. Tadashige Habe of the National Science Museum of Tokyo proved that *Distorsio horrida* Kuroda and Habe, 1964, is a synonym of *Distorsio perdistorta* Fulton, 1938, and that *"Distorsio perdistorta"* Kuroda and Habe (not Fulton) is an unnamed species. This taxon is described as *Distorsio constricta habei* in honor of Dr. Tadashige Habe whose many contributions to malacology are known throughout the world. Careful comparison of this species with specimens of worldwide species of *Distorsio* has led me to realize that *Distorsio constricta habei* from Japanese waters along with *Distorsio constricta constricta* from the Eastern Pacific and *Distorsio constricta macgintyi* from the Western Atlantic are geographical subspecies. These three subspecies give evidence once again of the amazing distribution of some of the Cymatiidae.

FOSSIL RELATIVES

There is some confusion in the literature that deals with the ancestors of the recent Caribbean and Panamic species of *Distorsio.* Various authors have considered the Antillean Miocene fossil *Distorsio similima* (Sowerby, 1850), to be a paleosubspecies of three different recent *Distorsio* i.e.: *decussata, clathrata* and *constricta.* The matter was further complicated because they confused specimens of *Dis-*

Fig. 38-39, Distorsio constricta habei *Lewis, Holotype, Tosa Bay, Shikoku, Japan, 53 mm. x 28 mm.*

Fig. 40, Distorsio constricta macgintyi *Emerson and Puffer, dredged 280 ft. S. W. of Key West, Fla., 43 mm. x 25 mm.*

Fig. 41, Distorsio constricta constricta *Broderip, dredged 200 m. off Southern Coast of Santa Cruz Is., Glalpagos, 49 mm. x 27.5 mm.*

Fig. 42, Distorsio anus (Linnê). *Hawaii.*

Fig. 43-44, Distorsio burgessi *Lewis, Hawaii, Holotype, The Academy of Natural Sciences of Philadelphia, No. 326470, 39 mm. x 25 mm.*

Fig. 45-46, Distorsio ridens *Reeve, Philippines, Syntype, The British Museum of Natural History, No. 1967630, 77.5 mm. x 38 mm.*

Fig. 47, Reeve's figure of Distorsio ridens.

Fig. 48, Distorsio ridens *Reeve, Lectotype, American Museum of Natural History, 64.5 mm. x 35 mm.*

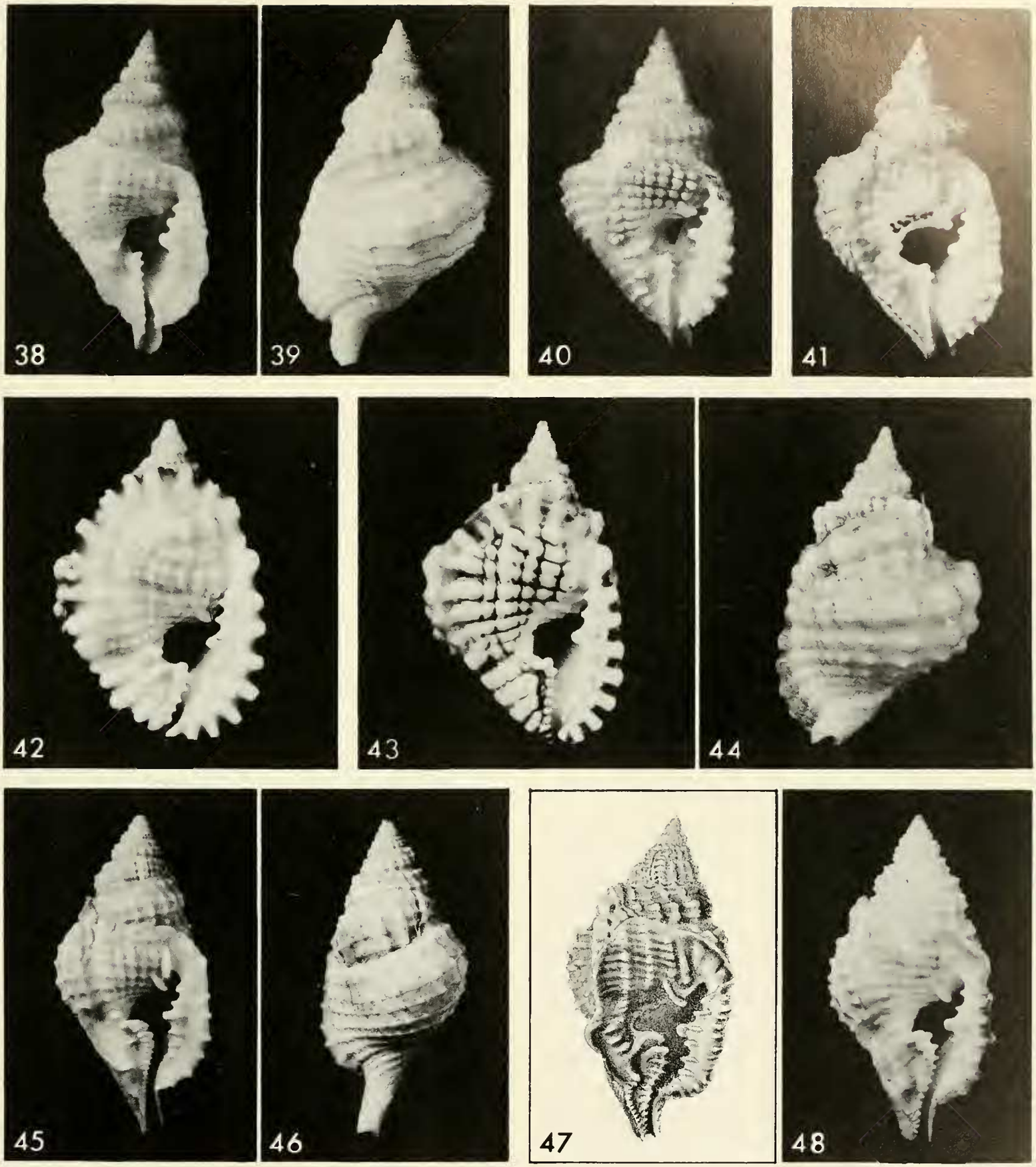

Fig. 38-48. Explanation on opposite page.

torsio simillima with *Distorsio gatunensis* Toula, 1909 (Miocene, Panama). Rutsch, 1930, (pp. 610-611, 614, pl. 17, fig. 6) examined and figured the holotype of *gatunensis* and concluded that this species is actually the fossil form of the recent *decussata.* This was confirmed by Emerson and Puffer, 1953, (p. 100) and Weisbord, 1962, (p. 271). Woodring, 1928, (p. 300, pl. 18, figs. 7 to 9) illustrates two species under the name *"Distorsio decussatus simillimus".* Actually, fig. 9 and fig. 1, pl. 19, are a specimen of *Distorsio simillima,* the ancestor of *constricta.* Figures 7 and 8 are *Distorsio gatunensis* Toula, the ancestor of *decussata.* A possible sequence of evolutionary events indicates that the first true *Distorsio s.s.* was *crassidens* (Conrad, 1848), Vicksburg, Mississippi, Middle Oligocene, which spread throughout the Caribbean developing into *simillima* during the Miocene and eventually into the recent *macgintyi.* Pilsbry, (1922, p. 360,) considered *crassidens* to be a fossil subspecies of *Distorsio constricta.* However, he was unaware of the existence of *macgintyi,* since that species was not reported until 1951, and he was under the impression that *simillima* had died out in the Caribbean without a recent form. Fossil evidence shows that *simillima* existed in the Tertiary Caribbean faunal province from the Lower Miocene to the Pliocene and in the Eastern Pacific from the Middle Miocene to the Pliocene. It must be remembered that the Tertiary Caribbean Province extended into the Eastern Pacific from southern Nicaragua to northern Peru. Woodring, (1966, p. 427) suggests the possibility of transportation of planktonic larvae by the Miocene North Equatorial current along the south border of the Caribbean Sea, through the Atrato Strait (and others) into the Eastern Pacific. It has been reasonably established that this faunal migration was at its height during the Middle Miocene, a time which corresponds with the fossil presence of *simillima* in the Eastern Pacific. Since *simillima* was unknown in the Eastern Pacific during the Lower Miocene, we can assume that it existed in the Caribbean province for approximately 5 million years before migration into the Eastern Pacific. It is likely that *Distorsio macgintyi* was the first recent species to develop from the *crassidens-simillima* stock. *Distorsio simillima,* having migrated to the Eastern Pacific during the Middle Miocene, became isolated at the end of the Tertiary and early Pleistocene after closure of the Central American land bridge, and there was modified into the present-day *constricta.* Eastern migration of ancient *simillima* accounts today for the Japanese subspecies *Distorsio constricta habei.*

Distorsio burgessi *new species,* Lewis

Figs. 43, 44

In August, 1963, an unidentified species of *Distorsio* was illustrated by Dr. C. M. (Pat) Burgess on the first page of vol. 11, no. 10, of the Hawaiian Shell News. The specimen appeared to be closely related to *Distorsio anus* Linné and until recently I have considered it to be a polymorphic form of *D. anus.* Recently sufficient material has come into my possession to show that consistent differences do exist between the two species which suggests that they are sympatric.

Distorsio anus is widespread in its distribution and shows morphological variation within a given population as well as between widely separated populations. However, there is such a great intergrading of form that it would be impossible to tell where a given specimen was taken. In the case of *Distorsio burgessi,* its distribution is limited to Hawaii and though found with *D. anus,* it can readily be separated from it. Though *D. anus* is very common and *D. burgessi* relatively rare, large selections of *anus* examined which were taken in the same general area as *burgessi* fail to show specimens which intergrade with *burgessi.* The first specimen illustrated in Hawaiian Shell News was taken, along with two others, in 14 fathoms, but the holotype and paratypes were found by diving in shallower depths, dispelling the idea that *burgessi* might be a deep water form of *anus*. The differences between the two species are consistent but do require careful observation. If the species were not sympatric it would seem more reasonable to consider *burgessi* as a subspecies of *anus.*

Distorsio burgessi is named in honor of Dr. C. M. Burgess who first published it as an unidentified species.

Description - The largest shell examined reached 60 mm. in length. There are 9 convex whorls which have a flattened plane above the periphery formed between the first and second spiral cords. The periphery is defined by the second and third spiral cords joining to form a double cord. The spire is produced at an angle of approximately 53°. The outer lip is formed by the right edge of the parietal shield which projects slightly past the body whorl. Behind the shield at the point where it meets the body whorl there is a strong axial cord which is separated from the preceding axial

cord by a deep groove. This groove is crossed by the spiral cords and gives the impression of a deep perforated line. The outer edge of the parietal shield is shallowly ruffled by 9 low cords which are separated by 8 dark brown shallow grooves. Larger specimens have a row of sharply formed teeth at the beginning of each dark groove arranged in a line parallel to the outer lip. These teeth are separated from the apertural denticles by a secondary groove which is also parallel to the outer lip and is lightly stained in a dotted line between the teeth. The parietal shield is the most striking character of this species. It is ear-shaped, and the lower left edge of the shield is flattened and conforms to the body whorl behind it. The main mass of the shield is sculptured by 9 strong, regular, spiral cords and 5 or 6 axial ribs which create a checkerboard pattern. This effect is greatly enhanced by the rich dark-brown pigmentation in the grooves between the squares of the pattern. An unusual appearance is created along the left and upper edges of the parietal shield because the ribs stop before the left edge and the spiral cords continue, while the cords stop before the upper edge and the axial ribs continue. The aperture is typically irregular and with 9 denticles. The third, which is the largest, is opposite a deep indentation in the parietal wall. The shell is white, lightly stained with a very pale orange. The columellar plicae and siphonal canal are straight and aligned on the axis of the shell. The siphonal canal is very short and recurves dorsally at an angle of approximately 115°. The sculpture consists of 8 spiral cords on the body whorl and one cord on the dorsal surface of the siphonal canal. There are usually 10 to 12 major axial ribs which cross the cords and form low nodules. The periostracum is yellowish, very flat and thin, formed in a regular pattern of low hairlike processes, with slightly larger processes forming on the axial ribs. It is attached directly to the shell surface, lacking the second layer found in *perdistorta.* I have not examined an animal nor the operculum of this species.

Description of the holotype - The shell measures 39 mm. in length and 25 mm. in width. There are 12 denticles along the columellar edge to the end of the siphonal canal. There are 12 major axial ribs on the body whorl. The specimen has its periostracum intact. Holotype ANSP no. 326470. 2 paratypes in the Hal Lewis collection. 1 paratype Del. Mus. Nat. Hist. 1 paratype in the Clifton S. Weaver collection.

Distribution - All of the specimens examined were taken in Hawaii at approximately 21.18N Long. 158.07 W. Lat. off Oahu Island, Type locality: Barber's Point, S. W. Oahu Island, Hawaii. Collected by E.

Differentiating features - This species differs from *Distorsio anus* primarily on characters relating to the parietal shield and anterior siphonal canal. The parietal shield of *Distorsio anus* is oval to almost round with deep ruffles usually present around the perimeter of the shield. It rises above the body whorl to completely cover the preceding two whorls. In *Distorsio burgessi* the ruffled edge is restricted to the outer lip and the shield covers approximately 1½ preceding whorls. The shield of *anus* is white to diffused orange-tan, lacking the rich dark-brown pigmentation typical of *burgessi.* The sculpture on the shield of both species consists of 9 spiral cords but on *anus* there are usually more numerous axial cords, giving the shield surface a finer beaded and wrinkled look. Even when the sculpture is coarser, it lacks the regular checkerboard pattern of *burgessi.* The anterior canal of *anus* is always angled to the left, often curving slightly, in contrast to the straight axially aligned canal of *burgessi.* The siphonal canal of *anus* is longer and recurves dorsally at an angle of approximately 90°. The groove to the left of the siphonal canal on the lower left parietal shield of *anus* opens into the aperture via a secondary groove which is framed by two large plicae. All of the specimens of *burgessi* which were examined did not have this secondary groove, and the primary groove in the lower left shield was reduced, thinner and shallower than in *anus,* forming a narrow dark-brown passage which follows the edge of the columellar-siphonal denticles. In specimens examined, there were 10 to 12 axial ribs on *burgessi* and 14 to 16 axial ribs on *anus.*

In spite of the rich pigmentation present on the parietal shield of *burgessi,* it is lacking in the rich body whorl pigmentation typical of *Distorsio anus.* This appears once again to be an indication of the specific importance of the position of pigmentation on the shells of *Distorsio.*

Distorsio ridens Reeve, 1844

Figs. 45-48

In the course of my work with the Cymatiidae, I have observed that the species known as *ridens* Reeve is often misidentified in collections. This very uncom-

mon species has had equal mistreatment in the literature. It has been listed as *reticulata* Röding (Maxwell Smith, 1948, p. 23); properly figured but misidentified as *reticulata* (Wagner and Abbott, 1967, p. 85, fig. 13-115); been confused with *Distorsio smithi* von Maltzan, 1884 (Nicklés 1950, p. 86, fig. 133), *perdistorta* Fulton, 1938 (Oyama, 1957, pl. 1, figs. 7-8), and, in many other instances too numerous to mention, improperly synonymized, misidentified and misfigured. The actual species described and figured by Reeve (1844, Triton, pl. 12, sp. 46) has been subsequently figured properly by Tryon (1881, pl. 17, fig. 177) and Webb (1935, pl. 51, fig. 10). Both of these figures are copies of Reeve's original figure, and it is probable that neither author had actually seen specimens of the species. Oddly enough, I have been unable to find a published photograph of *ridens.*

A recent visit to the British Museum of Natural History to study types revealed that none of the syntypes labeled *ridens* matched the actual specimen figured by Reeve. It is important to realize that Reeve's cymatiid drawings are accurate depictions of the specimens which they represent, matching them very well in size, color pattern, details of breakage, etc. All of the syntypes were less colorful, and none matched the figure in size, although they were clearly the same species (fig. 45). However, there is a specimen in the collection of the American Museum of Natural History New York (cat. no. 6369) (fig. 48) which so very closely matches Reeve's figure (our fig. 47) that I feel it is reasonable to designate it as the lectotype. The specimen measures within a millimeter of the figure, matches it exactly in the outline of the shell, shape of the parietal shield, position of color (absent from the syntypes), spire angle, broken siphonal canal, number of denticles on the columellar edge and minor details of breakage. The only differences appear to be artististic exaggerations of a second row of plicae on the lower left parietal shield and the gross manner in which the groove on the lower parietal shield enters into the aperture. Both of these characters are unique to the figure, being absent from the syntypes and all other specimens examined. I have never seen characters such as these on any specimen of any species of *Distorsio.* This specimen is from the Wm. A. Haines collection, the bulk of which was given to the AMNH in 1879. Haines, an American conchologist of the 19th Century, exchanged with many famous conchologists of the day, and could have obtained the specimen through his friend John C. Jay, or even directly from Reeve. While at the British Museum of Natural History, I carefully examined every cymatiid in the collection, including material not separated and distributed. There were no other specimens of *ridens* Reeve that could be considered to match the figured specimen.

The *ridens* situation is further complicated by the similarity of *ridens* to *Distorsio decussata* Valenciennes, 1832. There is a claimed "paratype" of *ridens* in the collection of the Museum of Comparative Zoology at Harvard University (MCZ 186600 C. B. Adams coll.) with Philippine data but which actually is a specimen of *decussata.* This misidentification is common. *Distorsio decussata* can quickly be separated from *ridens* by the fact that *decussata* always has a double spiral cord at the periphery, a character which is consistent in fossil as well as Recent specimens. Myra Keen (1971, p. 508, sp. 962) lists the range of *decussata* from Cape Tepoca and Guaymas, Sonora, Mexico, south to Manta, Ecuador, offshore to depths of 82 m., and she properly considers *Distorsio ridens* of authors, not Reeve, to be a synonym of *decussata.*

It is hoped that the discussion of this matter, publication of photographs of the lectotype, syntype and Reeve's figure will serve to clarify this species and establish it as a valid taxon, separable from *reticulata, perdistorta* and *decussata.*

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BOOK REVIEW

THE KINGDOM OF THE SEASHELL *by R. Tucker Abbott. Crown Publishers, Inc., 419 Park Avenue South, New York, New York. 256 pp., 92 black and white plates, 178 colored plates and 13 drawings. 1972, $14.95.*

This delightful book presents a whole spectrum of topics on marine mollusks from their division into six classes to how and where to find them; their breeding habits, structure, coloration and the ways in which they have been used in the arts, religion and history. Certain families, such as the volutes, cowries, murices, cones and scallops, are selected to portray their importance to man.

Many of the colored plates are among the finest illustrations that have ever been published in this field. These, as well as the black and white photographs, were gleaned from several sources; all are acknowledged at the end of the book. This volume is not a textbook on mollusks, even though it contains much general and basic information, but rather a portrayal of the many facets of this remarkable group of animals. Dr. Abbott has an unusual ability to grasp those facts which are important and interesting about seashells and to combine them all in a lively book which reads like a novel. It is essentially a book for the uniniated, but mollusk enthusiasts, whose efforts have been devoted largely to collecting shells, will find much to broaden their views. Anyone who appreciates a well-written, artistically arranged book will want to own one.

The book is fully indexed and contains a useful, selected bibliography, the titles being grouped under appropriate subject headings.

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