THE *CAUDINA* OF ASAMUSHI, THE SO-CALLED *CAUDINA CHILENSIS* (JOHS. MÜLLER).

BY

S. G. HEDING.

Zoological Museum, Copenhagen.

(With Pls. V–VIII and 2 text-figs.)

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Of the many intricate problems concerning Molpadid-classification that of the specific limitation within the genus *Paracaudina* is one of the most interesting and for the present one of the most confused, a confusion which has led to a very deplorable wrong determination of the Japanese species so much used for studies in the anatomy, physiology, and biology of Molpadids.

In 1925 Dr. MORTENSEN showed (Echinoderms of New-Zealand and the Auckland-Campbell Islands IV. pp. 363–367)[1] that the three species *chilensis* JOHS. MÜLLER, *coriacea* HUTTON, and *australis* SEMPER are well limited species, rather easily distinguishable, and he furthermore pointed out that the Japanese form *ransonetii* v. MARENZELLER could not be the same species as *chilensis* as maintained by H. L. CLARK in "The Apodous Holothurians"[2]. In 1928 HÔZAWA published his beautiful study of the anatomy of *ransonetii* v. MARENZELLER[3], using the name *chilensis* JOHS. MÜLLER for the species, evidently without knowing MORTENSEN's paper. On Dr. MORTENSEN's calling his attention to the fact that the name he had used could not rightly be used for the Japanese form, Prof. HÔZAWA handed Dr. MORTENSEN's letter to Prof. OHSHIMA, who then in a pamphlet named "The *Caudina* of Asamushi"[4] pointed out that neither the systematic characters used by MORTENSEN nor the way in which he used them were able to change the standpoint reached by Prof. CLARK and adopted by OHSHIMA, BENHAM, and JOSHUA & CREED.

During the studies of the large collections of Molpadids from the

[1] Papers from Dr. MORTENSEN's Pacific Expedition, XXIX, Vid. Med. Dansk Naturh. Forening, Bd. 79, 1925.

[2] Smithsonian Contributions to Knowledge, Vol. XXXV, 1908.

[3] Science Rep. of the Tôhoku Imperial University, Fourth Series, Biol., Vol. III, No 3, Fasc. 2, 1928.

[4] Annot. Zool. Japonenses, Vol. 12, No. 1, 1929.

Danish "Ingolf"-Expedition, from Dr. MORTENSEN's collections, and from the German "Valdivia"-Expedition the present author has come to the conviction that MORTENSEN is right in using the calcareous deposits and the calcareous ring in the way he has done it in the named paper, and I wanted then to undertake an examination of the Japanese Molpadids and form my own opinion of the question whether the Japanese species is really identical with *chilensis*, as maintained by CLARK and OHSHIMA against the opinion of MORTENSEN. By the great kindness of Prof. HÔZAWA I received an exceedingly fine material of *ransonetii* from Japan and Prof. ARNDT, Berlin, gave me the opportunity of reexamining the type specimens of JOHS. MÜLLER's *Molpadia chilensis*. I beg here to express my sincerest thanks to these two gentlemen. Unfortunately some Australian specimens promised me more than a year ago, have not arrived, but as the problem mainly concerns the Japanese and the South-American forms I think it better not to await the problematic arrival of the Australian material and not to put off publishing the results of my studies any longer.

I.

Some Critical Remarks to our Present Knowledge of "*Caudina*" *chilensis* (JOHS. MÜLLER).

In "The *Caudina* of Asamushi" (Annot. Zool. Jap., 12, 1929) OHSHIMA first points out how important this "*Caudina*" is, being the only Molpadid which is rather easily collected and thus the only one which may be used regularly for scientific researches and experiments. And so it is, indeed, used; more than ten memoirs are published dealing with the physiology, biochemistry, development, anatomy, and ecology of this Holothurian. In all these memoirs the species is named *Caudina chilensis* (JOHS. MÜLLER), based as OHSHIMA states "upon my (his) identification of the specimens".

Thereupon the taxonomical difficulties of the species *chilensis* are shortly mentioned and then, where the reader expects that OHSHIMA is going to settle these problems he shortly states that he "has no intention to settle the problem now in this short note, but some critique of MORTENSEN's paper may be of no little use". He states further that this critique is not based upon own studies, but are "chiefly based on HÔZAWA's recent work ("Calcareous deposits of *Caudina chilensis*" 1928) which is a result of careful examination on a great number of specimens, and thus well to be trusted". HÔZAWA's work is indeed exceedingly fine, and having examined the specimens sent by Prof. HÔZAWA himself the present author

is able to state that it is anatomically seen quite correct. In spite of this it is quite evident that HÔZAWA, having his attention devoted particularly to the "Changes occurring with advancing age in the calcareous deposits" of this species, and apparently not having any thorough knowledge of the classification of the group, has not clearly seen what is classificatorily characteristic of the species examined. He describes the different shape of the calcareous ring within the four developmental stages, but he does not point out which characteristics show that it is in all the four stages a ring of that special species and not of any other, and he gives numerous figures of calcareous deposits but without pointing out clearly which shape is the really characteristic one and may be found in all the different stages. In Pl. XIV, fig. 4 HÔZAWA figures how low and broad the interradials may be in small specimens and in Pl. XVII, fig. 22 how narrow and high they may be in old specimens, and the comparing of these two figures led OHSHIMA to the supposition that it is wrong to use the calcareous ring as a systematic character. However, the examination of the specimens at hand does not show so great a variation, the smallest specimens having a narrower and the largest specimens (being larger than that figured by HÔZAWA) having a wider interradial than shown in HÔZAWA's figure. And as to the deposits HÔZAWA usually does not figure the normal ones, only the much modified, though normal ones may be found also in these large specimens.

In criticising MORTENSEN, OHSHIMA states that "one must note that it is by no means safe to decide the species distinction by simply examining a few illustrations of calcareous deposits;—MORTENSEN gives four figures of calcareous deposits for *coriacea* and three for each of *chilensis* and *australis*, among them one for each species is in side-view". To this it must be said that one has little reason to suppose that MORTENSEN has decided from his few figures and not from his examination of the numerous deposits in the preparations. The comparison of the specimens of the different species at hand has convinced me that MORTENSEN is right in using the shape of the deposits as specific characters, though they may be rather alike and often difficult to separate for an untrained eye.

As OHSHIMA remarks (p. 42) that the size of MORTENSEN's specimens is not given, I may here state that the size of MORTENSEN's specimens is: *australis*–6.5 cm., *coriacea*–10.5 cm., and *chilensis*–16.0 cm. OHSHIMA suggests that "judging from the types of those deposits (i.e. those figured by MORTENSEN) we may infer from HÔZAWA's result that the *coriacea*-type represents the youngest, the *chilensis*-type the medium sized, while the

australis-type represents the oldest stage; if we suppose that the three species are really but one and the same species". This suggestion accordingly does not hold very well.

As to the calcareous ring OHSHIMA states: "MORTENSEN tries to take the shape of the calcareous ring *as one of the characteristics to distinguish Holothurian species*. So marked a structure, and so diversely formed, this organ is apt to lead one to regard it as of too much importance in taxonomy. My impression is that *the form and structure of the calcareous ring do show characteristics of each species*, but are not in accordance with natural affinity of groups, being rather variable, due to adaptation to the modes of life". Contrary to OHSHIMA I must however maintain that in any case within the Molpadids the shape of the calcareous ring gives, in spite of changes due to age, the best base for separating genera and families. In this connection it does not help to take examples from the other families of Holothurians e.g. from the *Cucumaria* and *Phyllophorus*, as done by OHSHIMA. Further, though I am not able to state much about the value of the ring within these groups, I suppose that a closer study of the anatomy of the species belonging to these groups will result in a division of them corresponding to differences in the shape of the calcareous ring.

On page 430 OHSHIMA states that: "MORTENSEN seems to attach importance to the shape of the anterior margin of the radial segments of the calcareous ring. It is a general rule among the Holothurians that possesses 15 tentacles, irrespective of whether they be *Molpadiidae* or *Cucumariidae*, that the radial segment of *the calcareous ring has its anterior margin divided by a projection into two unequal indentations*. . . . The position of the median projection, whether it shifts to either extreme or remains not far from the middle, and the relative size of the two identations thus formed, are not so constant as MORTENSEN appears to consider. One can see that it is quite a variable feature even in HÔZAWA's illustrations (figs. 4, 9, 15, 22)".

To this I am obliged to say that OHSHIMA appears to have not quite understood the building up of the radials within the Molpadids. They do not have their anterior margin "divided by a projection into two unequal indentations", but they have two projections, normally separated by a medial indentation, and the one of the projections, the muscular projection (i.e. that to which the longitudinal muscles are fastened) has usually a passage for the nerve, either a perforation (e.g. in the genus *Molpadia*) or a notch (e.g. most species of *Paracaudina*). Such a passage may be lacking (e.g. in *coriacea* as stated by MORTENSEN; he has not overlooked

any notch as OHSHIMA supposes).

The building up of the calcareous ring in the Molpadids is the most easily understood when one goes out from the ring in a Synaptid with 15 tentacles (e.g. *Pendecaplectana*). In such a specimen there are 5 radials and 10 interradials placed in such a way that a tentacle may be inserted between each two pieces. When in such a ring each of the radials coalesces with one interradial, we get a ring with five interradials and with five radials, each of which latter consists of two parts of different origin, which is indicated by the presence of two anterior projections, or perhaps better by the presence of insertions for one whole and two half tentacles, (cf. Pl. VIII, fig. 1) i.e. a normal Molpadid-ring, and when instead of the hole in the radials there is only a notch for the passage of the nerve and the radial canal, we have a normal ring of a *Paracaudina* e.g. of *P. ransonetii* (v. MARENZELLER). That such an alteration may really take place is seen within the Chiridotids and the Myriotrochids. All the Chiridotids with 12 tentacles have 12 pieces in the calcareous ring, and some species have some or all the radials notched and not perforated (e.g. *Chiridota pisanii* LUDWIG). In the Myriotrochids with 12 tentacles there are only 10 pieces, but the two dorsal radials are obviously composed of two pieces, one of radial and one of interradial origin. From the diagrammatical figures (Pl. VI, fig. 14–18) it is easily seen how the shape of the calcareous ring is to be understood, and how the tentacles are placed between the anterior tips of the pieces, indicated by the arrows in fig. 18.

As to the so-called *Cuvierian organs* found by JOHS. MÜLLER and refound by MORTENSEN, the present author may only state that they exist, without being able to say what they are. OHSHIMA states that "it is not very clear from his (MORTENSEN's) statement whether he did find such in MÜLLER's type specimens", but as he uses these organs as characters usable for classification and denies their presence in the two other species it seems evident that he has seen them in the type of *chilensis*.

From what is stated above it would seem evident that the reasons given by MORTENSEN are at any rate so much more weighty than those of OHSHIMA, especially as MORTENSEN has decided from the examination of specimens, and a well understood examination too, whereas OHSHIMA has only decided from the rather few figures given by MORTENSEN and HÔZAWA; which he himself states is "by no means safe".

As it will appear from the following description of the characters usable in the classification of this genus, MORTENSEN is quite right in his supposition that *chilensis* MÜLLER, *australis* SEMPER, *coriacea* HUTTON, and *ran-*

sonetii v. MARENZELLER are separate species, and thus the problem of "*Caudina chilensis* (JOHS. MÜLLER)" is—I think—definitely settled, and that in the way pointed out by MORTENSEN in 1925.

II.

Description and Comparison of the Systematical Characters of "*Caudina*" *chilensis* and Allied Species.

When dealing with the classification of Molpadids, one of the greatest problems is, which characters are usable for separating genera and species. The different apprehensions hereof are nearly as many as are the students of the group. Naturally the only safe way is to take all characters, macro- and micro-anatomical as well as eidonomical, into consideration, but even in doing so the great variation of the characters and the fact that often only few specimens are available afford great difficulties.

As the appearance of the specimens is usually dependent on the way of preservation and the degree of contraction, and the greater part of the anatomy is often quite spoiled by the strong contraction, the main character used is the shape of the calcareous deposits; beside this, several authors have used the shape of the calcareous ring. As a matter of fact the combination of these two characters may in nearly all cases serve to distinguish the species with a rather high degree of certainty, and when further a few other characters are taken into consideration, the determination of a specimen may be nearly quite certain.

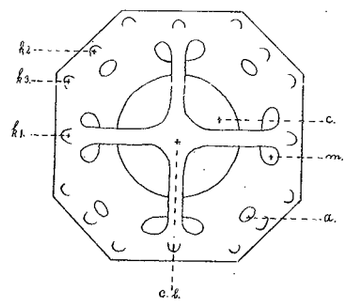
In the case of "*Caudina*" *chilensis* OHSHIMA, of course, admits that the shape of the calcareous deposits serve as a good systematical character, but according to HÔZAWA's work he does not suppose that the differences pointed out by MORTENSEN in 1925 are sufficiently clear to allow a distinction between different forms (species?); the use of the calcareous ring for specific distinction he will not admit. A closer examination and especially a careful comparison of the deposits and of the calcareous ring, the retractor muscles and the genital papilla, definitely show that MORTENSEN is right in his distinction between the species. For showing this clearly a description and a discussion of the named characters are necessary.

a) *Calcareous Deposits.* In "The calcareous deposits of *Caudina chilensis*[1]" HÔZAWA states that the fully developed spicules are "rings which enclose a cross on the one face and a square on the other, the cross

[1] This title is an abreviation of: On the Changes occurring with Advancing Age in the Calcareous Deposits of *Caudina chilensis* (Y. MÜLLER), proposed by HÔZAWA himself.

and square being scarcely separated from each other". This description of the deposits is seemingly quite correct, but a closer examination with a high magnification (×1800), as well as a comparison with other Holothurians shows that it leads to a wrong apprehension of the deposit, which further has occasioned OHSHIMA's difficulties in distinguishing between the different forms.

The normal fully developed deposit or "button" (Text-fig. 1) consists of a little octogonal plate, the basal plate, with five perforations, a large usually circular central-hole (*c.*) and four oblong marginal holes (*m.*). Over this plate and, as HÔZAWA states, always on the exterior surface is a low "spire" in the shape of a cross-bridge (*c.b.*), placed with the four stems at the outer margin of the marginal holes. This arrangement of the cross-bridge quite agrees with the way in which the bridge is placed over the side holes in the anchor-plates of the Synaptids (*e.g.* of *Synaptula*). (As the cross-bridge is developed directly of the primary cross or better *is* the primary cross, it is not at all homologous with the bridge in the Synaptid plate, only its arrangement according to the marginal holes is the same as that of the Synaptid bridge to the side holes of the anchor-plates). When compared with the deposits of other Holothurians the "buttons" of *Paracaudina* thus quite resemble the tables of some aspidochirote forms as these are drawn by EKMAN in 1925 (Systematisch- phylogenetische Studien über Elasipoden und Aspidochiroten) p. 436, Fig. C. b; only the crown is totally lacking.



Text-fig. 1. Diagrammatical figure of a calcareous deposit from the body-wall of a *Paracaudina* (*ransonetii*).
a.—additional hole.
c.—central hole.
c.b.—cross-bridge.
k_1.–k_3.—knobs of 1st to third order.
m.—marginal hole.

In normal plates we thus do not find twelve holes as stated by HÔZAWA, but only five, the large number being only found when in abnormal plates the cross bridge is more closely united with the basal plate, being then placed in the same plane and not over it. Besides the mentioned five perforations some few additional holes (*a.*) may be found, even in quite normally developed plates, but the appearance of such holes is usually combined with anomalies in the shape of the basal plate.

The margin of the basal plate is more or less regularly undulating

and the exterior surface of it is often supplied with knobs (*k.*). These knobs are rather regularly placed and may according to their place and occurrence be named knobs of first, second or third order (k_1., k_2., k_3.), and in this way that the knobs opposite the stems of the cross bridge are of the first order, those opposite the additional holes of the second and those between the marginal and the additional holes are of the third order.

Such normal deposits are figured by HÔZAWA in his different plates, but besides those he has shown a large number of more or less deviating ones, without clearly pointing out which is the real typical shape. In Pl. V, fig. 1–2 I have drawn two quite typical deposits from a little specimen belonging to HÔZAWA's "first stage", and in the figures 3–18 are shown deposits from gradually larger specimens. It is obvious that the deposits are different in the different specimens, and a joint correlation with the size of the specimens may be found, but this is not quite so striking as figured by HÔZAWA. In the largest specimens in which according to HÔZAWA the deposits are all typically diverging from those of the smaller specimens, deposits may easily be found which, except for the surrounding yellow substance, quite agree with those found in quite small ones (cf. fig. 1–2 and fig. 17-18). That the larger part of the deposits in old specimens are abnormal in shape and furthermore are surrounded by the interesting clear yellow stuff, is, seen from a classificatory point of view, of no great importance as the typical and for the species quite characteristic shape of deposits may be found in all specimens, the smallest as well as the largest.

When we now compare the deposits of the other species of the genus with what is found in the Japanese one (*ransonetii* (V. MARENZELLER)), it is evident that they are distinctly different. The deposits of *coriacea* (HUTTON) are very regular (incomplete and thus irregular ones are naturally found, but I only speak of the typical and for the species characteristic ones) and exceedingly uniform (Pl. VI, figs. 8–13). In the one specimen (that from New Brighton) the deposits (Pl. VI, figs. 10–13) are all thick and "fat" and without knobs, but in the specimens from Tiri-Tiri the deposits (Pl. VI, figs. 8-9) are more slender and with large "fat" knobs which distinctly differ from the knobs found in *ransonetii* and *chilensis* (Pl. VI, figs. 1–4). It is true that some deposits from *ransonetii* may be rather like those in *coriacea* (cf. HÔZAWA Pl. XIV, fig. 2 c and Pl. XVI, fig. 11 c), but when a larger number of deposits are compared the differences are quite clear. As it also appears from the figures in Pl. V, the deposits of the specimens from Tiri-Tiri rather definitely differ from those of the specimens from New Brighton, and probably the specimens really

belong to two different forms of *Paracaudina*. The scanty material at hand does however not allow a clearing up of this problem, and as to the problem dealt with in this paper it is really sufficient to show that *coriacea* (this species being composed of two varieties or not) is at any rate clearly different from *ransonetii*, *australis*, and *chilensis*.

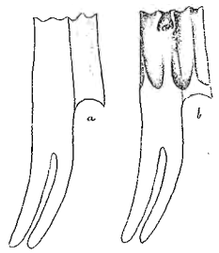
The deposits of *chilensis* (JOHS. MÜLLER) (Pl. VI, figs. 1–4) are as those of *coriacea* rather thick, but they have not the "fat" appearance, and when they have knobs these are more conspicuous.

The deposits of *australis* (SEMPER) (Pl. VI, figs. 5–7) differ distinctly from those of *coriacea* and *chilensis* as also shown by MORTENSEN in 1925, as the cross bridge is not developed, and the deposits themselves are rather irregular and supplied with a varying number of holes and knobs. They are to some degree like some of the abnormal deposits found in *ransonetii* (cf. HÔZAWA Pl. XIV, fig. 2 b) but also here the typical appearance of the deposits is very different, and moreover deposits with well developed cross-bridge do not seem to occur in *australis*.

As it appears from this description a careful comparison of deposits from the four species concerned allows a clear distinction between them, and the few deposits in one species which may strikingly resemble some of the deposits in another species may only be regarded as indicators of the common genus to which they all belong. Such cases of resemblance are indeed found within most genera of apodous Holothurians.

b) *Calcareous Ring.* As shown by HÔZAWA the appearance of the calcareous ring may alter during the life of the specimen, but in spite of this the real, characteristic shape is strikingly constant. It appears that HÔZAWA has cleaned the calcareous pieces too much before drawing, in that the insertions of the tentacular muscles and the tentacle ampullae are removed. In spite of this it is evident also from HÔZAWA's figures that the radials have two anterior projections one of which is distinctly notched for the passage of the nerves and radial canals. This process, to which the retractor is fastened, we may designate as the *muscular process*, the other accordingly the *non-muscular process*. The impressions for the insertions of the tentacle muscles are rather large, but not so deep as those of *chilensis* and *coriacea*. The insertions for the retractor muscles are rather deep and in the largest specimens there may be found a faint furrow from the insertion of the retractor muscle to the anterior notch (Pl. VII, fig. 3). In *chilensis* (Pl. VII, fig. 5) the insertion for the retractor muscle is large and deep, which nicely conforms with the long and well developed retractors; a real notch is absent, as the furrow from the

muscular insertion to the top of the projection is broad and deep. All the muscular impressions in the surface of the ring are very deep and more conspicuous than those in the ring of *ransonetii*. On comparing my figure (Pl. VII, fig. 5) with that given in fig. 47, c of Dr. MORTENSEN's paper it would seem that the latter must be incorrect. This is, however, not the case; the differences are mainly due to the fact that in the said figure no attention has been paid to the sculpture of the calcareous ring, only to the differences in the anterior outline found in the various species. I am reproducing here (Text-fig. 2) the said figure from Dr. MORTENSEN's paper and together with it the same figure with addition of the sculptural impressions. These two figures clearly show that the figure from MORTENSEN's paper (Fig. 47, c) in reality corresponds very well with mine (Pl. VII, fig. 5).



Text-fig. 2. Radial and interradial piece of the calcareous ring in *Paracaudina chilensis*.
a. The figure given by MORTENSEN in "The Echinoderms of New Zealand etc." p. 366 c, showing only the outlines of the pieces.
b. Quite the same figure with addition of the characteristic sculpture.

The calcareous ring of *australis* (Pl. VII, figs. 8–9) differs distinctly from that of the two named species (as also from that of *coriacea*) in having very faint impressions for the tentacular muscles, and in having a very sharp and narrow, deep notch in the muscular processes. Furthermore it differs in a curious way from the other rings in the top of the interradial and the radial non-muscular processes being free of the fascias for the tentacle muscles.

In *coriacea* Pl. VII, figs. 6–7 the radials have no notch in their muscular process, as also stated by MORTENSEN in 1925. OHSHIMA states "that MORTENSEN found in *coriacea* only two lateral projections leaving a wide concavity between, leaves room for a suspicion that he overlooked the presence on top of one of the projections of a minute notch to receive the radial canal". I have very carefully examined MORTENSEN's preparation, and must declare that he is right in his statement, and that the muscular process prepared free by him is nicely rounded on the top, leaving not the faintest trace of a notch. However, in order to be quite certain in this question I prepared the other radials free and found that one of the others has, not a faint notch, but a faintly flattened part on the tip of the muscular process (Pl. VII, fig. 7). Thus it is seen that the calcareous ring in *coriacea* really differs from that in the other species in having no notch, but in some cases a faint trace of the passage of the radial nerve may be present. The sculpture in the surface of the ring is very deep and distinct.

As it appears from what is stated above the calcareous ring of the four species concerned differs in a way which is clearly beyond the degree of specific variation and thus affords the strongest character for separating the species, and, as it nicely corresponds with the differences in the shape of the calcareous deposits, clearly shows that both characters ars to be trusted within this genus.

c) *Retractor Muscles.* As to retractor muscles of Molpadids, CLARK in 1908 states (p. 144) that "the formation of such retractors appears to be very uncommon, if not an altogether exceptional event, possibly only occurring in certain individuals, perhaps very old ones, and the presence or absence of such retractors cannot be considered as having any value in taxonomy". CLARK is thus far right in what he states, as the presence of retractors is altogether exceptional within the Molpadids. They were first found by JOHS. MÜLLER in *chilensis*, and by him, LUDWIG and others used as one of the characteristics of the genus *Molpadia* (=*Paracaudina*, as this genus was understood for many years). In reality I have never found retractors in specimens belonging to other genera than JOHS. MÜLLER's *Molpadia* (=*Paracaudina*), but all the four species here dealt with have distinct retractors, though developed in a different degree. The retractors are in *ransonetii*, in small as well as in large (old) specimens only faint, being developed from the longitudinal muscles which have their outer edges turned up and coalescing so as to form like a small funnel (Pl. VIII, fig. 2). In *coriacea* (Pl. VIII, fig. 3) they are very distinct though short, (in a 6 cm long specimen not more than 0.5 cm) and as in *ransonetii* united with the longitudinal muscles by a rather solid web, which, however, does not contain muscles. The two retractors from each pair of longitudinal muscles join before they reach the calcareous ring (Pl. VIII, fig. 3). In *australis* the retractors of a 6.5 cm long specimen are 1.5 cm long. They are united with the longitudinal muscle by a very thin membrane which contains some few fine, but distinct muscles. The two retractors do not join, but are attached each to a limited place on the calcareous ring (Pl. VIII, fig. 6). In *chilensis* the retractors (Pl. VIII, figs. 4–5) are in a 16 cm. long specimen 1.2 cm. long. They are by a thin web, which does not contain muscles, attached to the exterior margin of the longitudinal muscles (Pl. VIII, fig. 5). The two retractors unite as

they reach the calcareous ring.

d) *Genital Papilla.* It is obvious that marked differences in the genitalia have to be regarded as some of the strongest indicators for systematic difference, but it must be admitted that only through careful studies of the state of the genital papilla in living, mature specimens from the different seasons of the year, can we form a definite judgment of the classificatory value of this organ. Thus one is not allowed to use differences found in the genitalia exteriora of a few poorly preserved specimens as characters of much value, though they ought to be mentioned. In all the specimens of *ransonetii* there is a long genital papilla, which now and then is somewhat contracted, but always quite distinct. This papilla is also mentioned as a character of the species by MITSUKURI in his Studies of Actinopodous Holothurioidea. In the specimens of *chilensis* there is but a short and not much contracted papilla, and in *coriacea* a papilla is lacking. In *australis* the preservation of the specimens does not allow any statement concerning the presence or absence of a genital papilla.

e) *Cuvierian Organs.* So-called Cuvierian organs are found by JOHS. MÜLLER in the type of *chilensis*, and they are refound by both MORTENSEN and the present author. What they really are I cannot tell, but they are rather distinct. There is nothing to support the suggestion by OHSHIMA (p. 44) that they might be gregarines. Such organs do not appear to occur in the other species. However, further investigations on fresh material of *chilensis* is needed before we shall be able to use these organs as a systematic character.

III.

Discussion of the Systematic Position of the four Forms *chilensis* JOHS. MÜLLER, *coriacea* HUTTON, *ransonetii* MARENZELLER, and *australis* SEMPER.

From the above description it definitely appears that we have four different forms of Molpadids, previously described under the names *chilensis*, *coriacea*, *ransonetii*, and *australis* and in modern time confused under the common name *chilensis*. Neither CLARK nor OHSHIMA are willing to see any differences between these four forms and only Dr. DEICHMANN (cfr. OHSHIMA 1929, p. 45) suggests that there is a difference, at least between the Japanese and the South-American forms, and therefore suggests that the Japanese form reasonably may be called *chilensis* var. *ransonetii*.

Naturally it may be a matter of personal taste, whether the four forms

should be regarded as distinct species or only as distinct varieties of one large species. Distinct they are at any rate and to my mind there can be no question but that they should be regarded as distinct species. Besides the morphological differences, zoogeographical reasons speak decidedly against regarding them all as varieties only of *chilensis*. The distribution from Japan to Australia–New Zealand could offer no serious objection. But the fact that no form, which could be referred to *chilensis* is known to occur along the West coast of North-America and Central America would be quite unintelligible, were the Chilenian form really identical with the Japanese–Australian–New Zealand forms. No reasonable explanation can be given of such a "zoogeographical paradox".

As to the question where among the other Molpadid species these four are to be placed, there can be no doubt that they form their own genus within the family *Caudinidae*. This is no new conception of mine, as several authors have distinguished between this genus, naming it *Molpadia* (as done by JOHS. MÜLLER) and STIMPSON's genus *Caudina*, and it was first CLARK who in 1908 united them under the name *Caudina*. As the name *Molpadia* obviously was wrongly used by JOHS. MÜLLER, LUDWIG and others for this genus, I in 1931 proposed the name *Paracaudina* for it (first using the name *Pseudocaudina* which, however, was preoccupied).

The genus *Paracaudina* differs distinctly from *Caudina* in the shape of the calcareous deposits, in the presence of retractor muscles and perhaps also in the arrangement of the mesenteries.

The species may be distinguished thus:

1. Calcareous deposits in medium sized specimens very varying, normally without a well developed cross-bridge. Radials of calcareous ring with very sharp and deep incision, and the anterior processes of the ring with free tips. ..... *australis.*
   In spite of great variation, calcareous deposits with a cross-bridge never quite lacking. Incisions of radial pieces not so sharp and deep, and anterior processes of calcareous ring not with their tips free. 2
2. Muscular process of radials without notch, and without furrow between muscular insertion and tip of projection. Deposits very regular, usually "fat", with or without thick, rounded projections. Genital papilla absent. ..... *coriacea*
   Muscular process of radials notched, or with a deep furrow from the insertion of the retractors to the tip of the projection. Deposits not "fat" and rounded. Genital papilla present. 3

3. Retractor muscles well developed, long. ..... *chilensis*
   Retractor muscles funnel-shaped, very short. ..... *ransonetii*

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EXPLANATION OF LETTERS.

a.l.m.	Anteriormost part of longitudinal muscle.
c.m.	Coalesced part of retractor muscle.
f.p.r.	Bifurcate posterior prolongation of radial pieces.
f.t.m.	Fascias of tentacle muscles.
i.p.	Inserting part of retractor muscle.
i.r.	Interradial piece of calcareous ring.
i.r.m.	Insertion mark of retractor muscle.
i.r.p.	Interradial process of anterior margin of calcareous ring.
i.t.m.	Insertion mark of tentacle muscle.
l.m.	Longitudinal muscle.
l.v.i.a.	Left ventral interambulacrum.
m.d.i.a.	Mid-dorsal interambulacrum.
m.p.	Muscular process.
n.m.p.	Non-muscular process.
n.v.	Notch in anterior margin of muscular process.
r.	Radial piece of calcareous ring.
r.m.	Retractor muscle.

t.a.	Tentacle ampulla
t.m.	Tentacle muscle.
u.w.	Web uniting retractor muscle with longitudinal muscle.

Pl. V.

Deposits of *Paracaudina ransonetii* (JOHS. MÜLLER).

Figs. 1–2 from a specimen measuring 1.5 cm. (lst stage)
,, 3–4 ,, ,, ,, ,, 4.0 ,, (2d ,,)
,, 5–6 ,, ,, ,, ,, 7.5 ,, (3d ,,)
,, 7–10 ,, ,, ,, ,, 9.5 ,, (3d ,,)
,, 11–13 ,, ,, ,, ,, 22 ,, (4th ,,)
,, 14–18 ,, ,, ,, ,, 27 ,, (4th ,,)

The deposits Fig. 12 and Figs. 14-18 are surrounded by the yellow stuff mentioned by HÔZAWA.

Pl. VI.

Figs. 1–4 *Diposits of Paracaudina chilensis;* type specimen.
,, 5–7 ,, ,, ,, *australis.*
,, 8–9 ,, ,, ,, *coriacea,* specimen from Tiri Tiri.
,, 10–13 ,, ,, ,, ,, ,, ,, New Brighton.
,, 14–17 Diagrammatical figures of calcareous rings in
Fig. 14 *Molpadia*
,, 15 *Paracaudina*
,, 16 *Pendecaplectana*
,, 17 *Myriotrochus.*

The punctured part of the radials in figs. 14-15, and 17 as well as in fig. 18 is that which may be regarded as an interradial coalesced with a true radial. The punctured interradial in fig. 16 is that which in a Synaptid may be regarded as corresponding with the non-muscular part (the punctured) of a Molpadid (and a Myriotrochid).

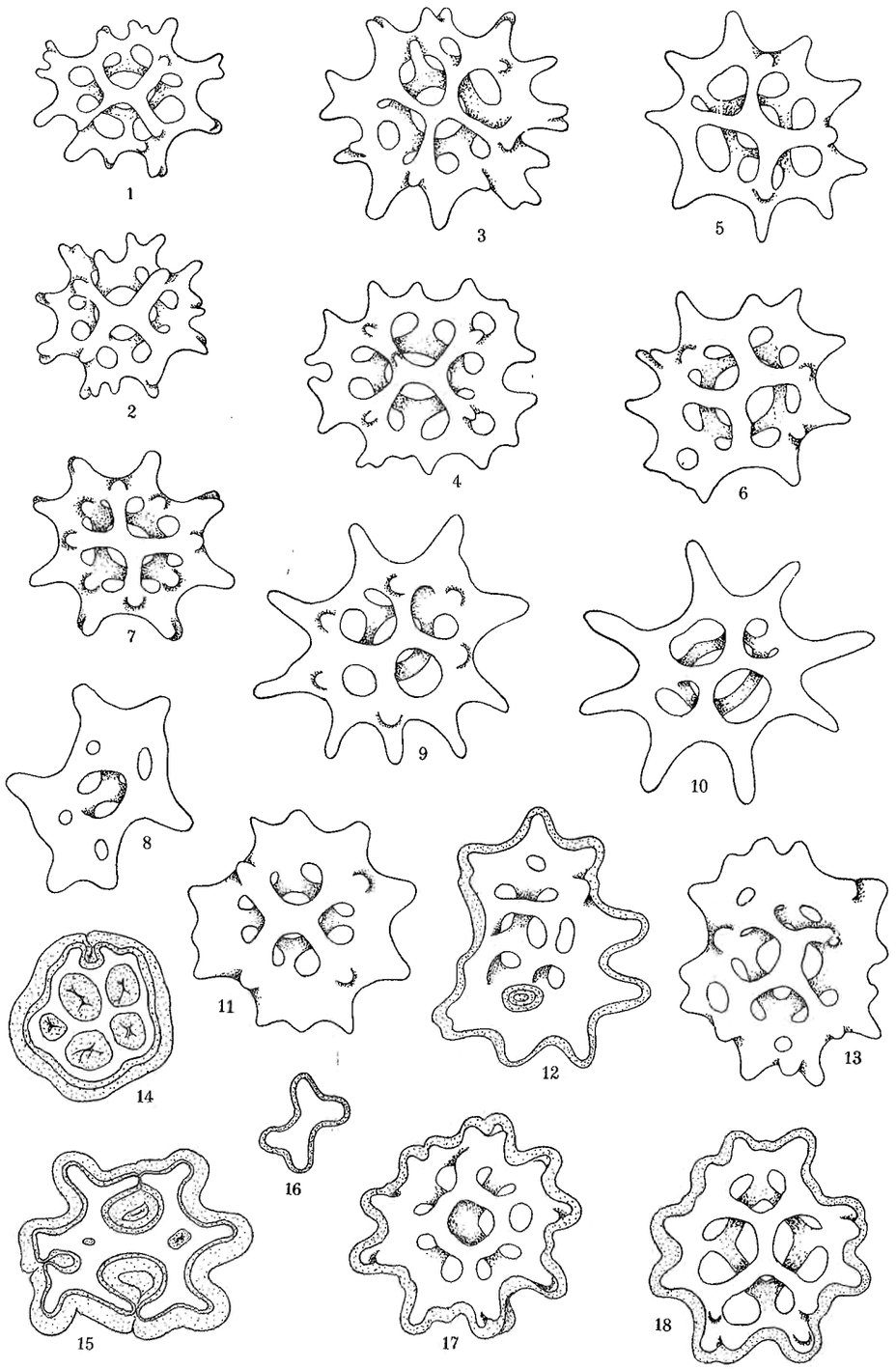
Fig. 18 Diagrammatical figure showing the arrangement of the pieces in the calcareous ring of a Molpadid; the shading is the same as in Figs. 14-17. As the tentacles are always placed *between* the anterior tips of pieces (See the arrows in fig.), it is seen from the figure that there are four tentacles in the middorsal interambulacrum, two in the left ventral and three in each of the others.

Pl. VII.

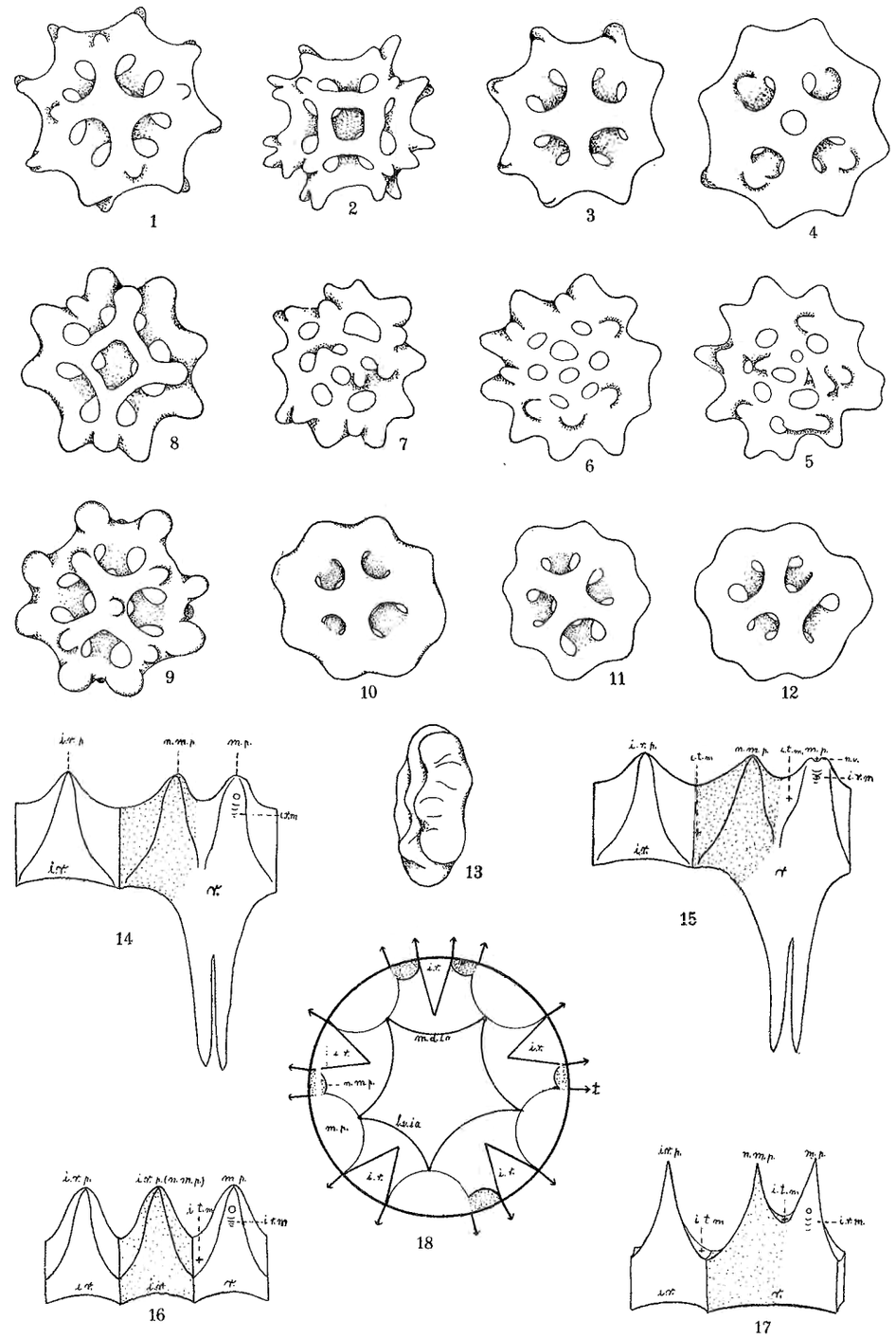
Radial and interradial pieces of calcareous rings in
Figs. 1-3 *Paracaudina ransonetii*
Fig. 1 from a 1.5 cm. long specimen
,, 2 ,, ,. 9.5 ,, ,, ,,
,, 3 ,, ,, 27.0 ,, ,, ,,
Figs. 3-5 *Paracaudina chilensis*
,, 6-7 ,, *coriacea*
,, 8-9 ,, *australis*

Pl. VIII.

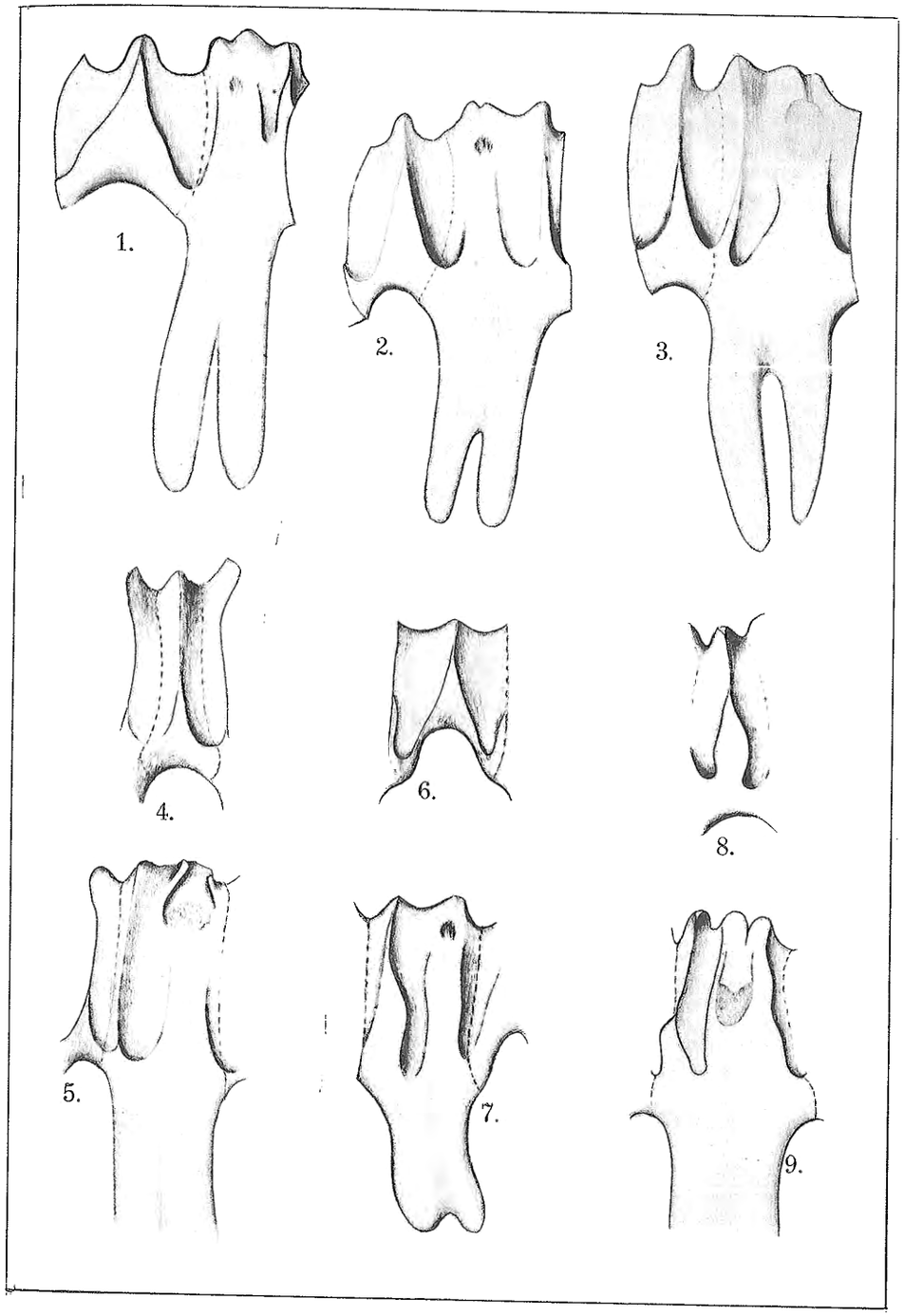
Fig. 1 *Paracaudina ransonetii*, a radial and an interradial piece of the calcareous ring showing the arrangement of the tentacles.
„ 2 *Paracaudina ransonetii*, anterior part of longitudinal muscle with retractor
„ 3 *Paracaudina coriacea*, „ „ „ „ „ „ „
„ 4 „ *chilensis* „ „ „ „ „ „ „
„ 5 „ „ Diagrammatical section of half part showing arrangement of longitudinal muscle and retractor.
„ 6 „ *australis* anterior part of longitudinal muscle with retractor.



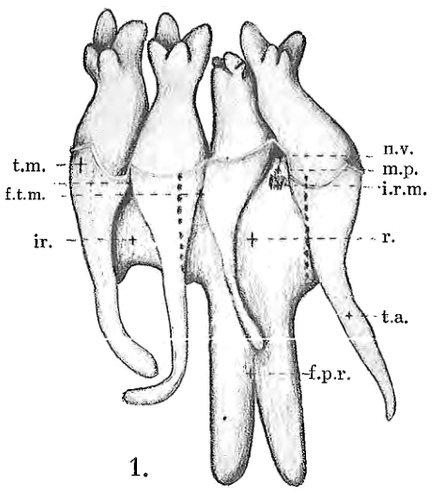
S. G. HEDING: *Caudina* of Asamushi.



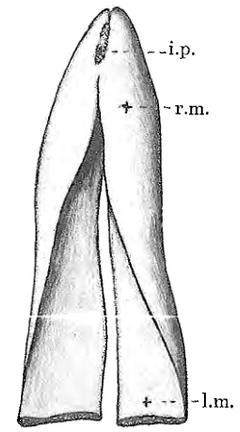
S. G. HEDING: *Caudina* of Asamushi.



S. G. HEDING: *Caudina* of Asamushi.


t.m.
f.t.m.
ir.
n.v.
m.p.
i.r.m.
r.
t.a.
f.p.r.

1.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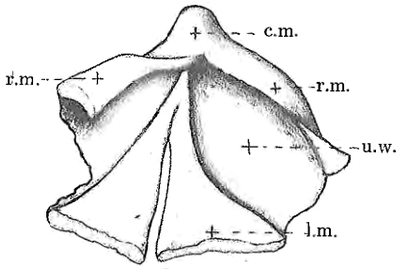
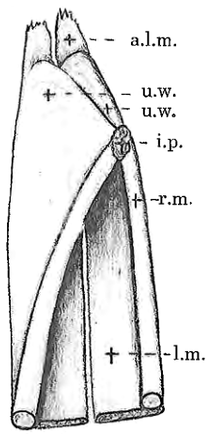
r.m.
l.m.

2.


c.m.
r.m.
r.m.
u.w.
l.m.

3.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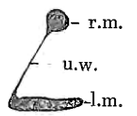
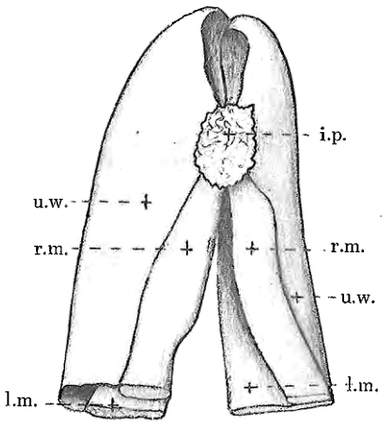
u.w.
u.w.
i.p.
r.m.
l.m.

4.


r.m.
u.w.
l.m.

5.


i.p.
u.w.
r.m.
r.m.
u.w.
l.m.
l.m.

6.