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Evolution of the Gastropod Genus Siphonalia with accounts on the Pliocene Species of Tōtōmi and other Examples

The Ketienzian Fauna Series, no. 1

By

Jirō MAKIYAMA

With 4 Plates and 4 Text-figures

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First Words to the Ketienzian Fauna Series

The work on the Tertiary stratigraphy and palaeontology of the areas in Tōtōmi was undertaken by myself from 1919, and its outcome was partly made public, two in English (this Memoirs, B-3, art. 1, B-7, art. 1.) and others in our language. I am still working on the same field as it takes very important place in the geology of this land. In the first English paper, details of the Mollusca of the Dainitian stage or the Lower Kakegawa formation have been given. In comparison with the Dainitian fauna, the Ketienzian or the Upper Kakegawa fauna was seemingly very poor, for the beds were deposited under the sea deeper than that of the Dainitian. From the Hosoya beds which are the representative of the lowest level of the age, some small number of Mollusca was listed in the second English paper. But the number of species became far greater than in this list effected by attempts with care. Some 10 cubic meters of sands which were the greatest possible amount were taken away from a small cutting at loc. 524 in the common of Iida near Ugari, by agreement with the authority helped by young men of the place. In this way I was able to get a great number of fossil samples. I. IMAI made discoveries of new places loc. 534, 424 in Ugari and loc. 431 at Tonbe, where the sands are full of shells. The lower Ketienzian fauna though its number of species is not so much as in the Dainitian is now ready to be worked out in detail. The details, however, are not all the same in their value: some species may be good for guide, some others may be worked by system in biometry and some other groups may be well put into their histories of evolution. Only a list of fossils with accounts and figures in common form is no more interesting in the present day science. It is hardly possible to get out all the works in one complete volume. For this reason, the different outcomes will be made public in separate papers which will be united to a complete series under the head "The Ketienzian Fauna Series". The work was helped by money given from "Tōsyōgū Sanbyakunen-Sai Kinenkwai".

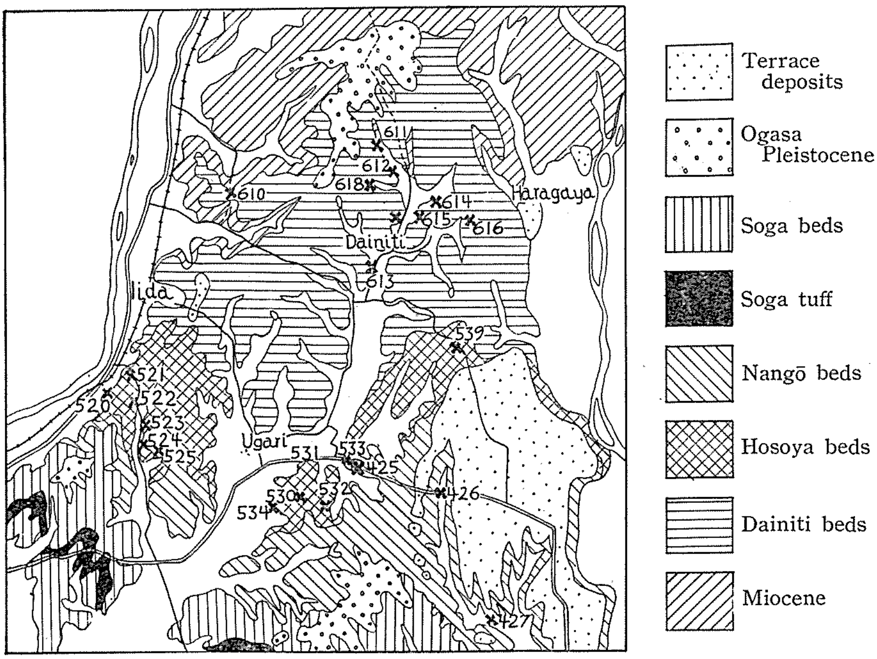

Fig. 1. Fossil localities in Iida-Ugari Area of Sūtigun, Sizuoka-ken. Scale 1: 50,000.

Family Buccinulidae FINLAY, 1928

Subfamily Siphonaliinae FINLAY, 1928

Genus *Siphonalia* A. ADAMS, 1863

Type: *Buccinum cassidariaeforme* REEVE, 1841 (subsequent designation by COSSMANN, 1889, Ess. Coq. Foss. IV, p. 153).

Siphonalia is one of the special marks of the Japonic fauna and though some groups in its nearest relation are made wide distribution in other places of the earth, the genus in narrow sense seems to be limited in the waters of Japan and the nearest countries.

Of a number of species names for the living forms of Japan, the ten coming under are good in law: *Buccinum cassidariaeforme, signum, trochulus, fusoides, modificatum* and *spadiceum* of REEVE, 1846; *S. vanattai* PILSBRY, 1905; *S. mikado* MELVILL, 1909; *S. pfefferi* SOWERBY, 1900; and *S. kikaigashimana* HIRASE, 1908. Other names offered as species may be used for forms of subspecies position under certain species among the ten on the top list, for example: *S. fuscolineata* PEASE, 1860 as a subspecies of *S. spadicea*, *S. hinnulus* ADAMS & REEVE, 1850 of *S. cassidariaeformis* (*fide* KURODA), and *S. longirostris* DUNKER, 1882 of *S. fusoides* (*fide* PILSBRY). A. ADAMS (1863) gave short accounts on a number of new species without giving pictures, of which four have been used as subspecies or race: *S. conspersa*, *concinna* and *ornata* of *S. cassidariaeformis* by PILSBRY *S. filosa* of *spadicea* by KURODA. The others *commoda*, *corrugata*, *ligata*, *grisea*, *colus*, *acuminata*, *pyramis*, *munda* (not *mucida*) and *nodulosa* are not able to be taken well in science being almost names only. It seems to be overnamed by ADAMS as the suggestion given by PILSBRY.

Right names of subspecies are *S. cassidariaeformis tosana* HIRASE, 1908 and *S. c. funera* PILSBRY, 1895. Right fossil species would be *S. declivis* YOKOYAMA, 1926 and *S. dainitiensis* MAKIYAMA, 1927, while *S. longicanalis* NOMURA & ZINBO, 1935 is a synonym of *S. lubrica* DALL, 1918 which would not be a *Siphonolia*. *S. semiplicata* PILSBRY. 1896 was put on one side by PILSBRY himself as a synonym of *S. fusoides*. Probable synonyms are *S. pseudo-buccinum* MELVILL, 1909 (=*modificata*), *S. stearnsi* PILSBRY, 1895 (=*modificata*), *Neptunea aestuosa* GOULD. 1862 (=*cassidariaeformis*) and *S. hyperodon* PILSBRY, 1895 (=*mikado*).

Of the four Javan species of *Siphonalia* by MARTIN, *S. tjbaliungensis* MARTIN, 1895 and *S. bantamensis* MARTIN, 1895 would be true *Siphonalia* or in its very near relation, while *S. dentifilosa* MARTIN, 1895 is a *Penion* and *Fusus varicosus* KIENER, 1840 (non ANTON, 1839) is not a typical *Siphonalia*. A Pliocene fossil of Java *Murex paradoxicus* JENKINS, 1863 was taken in the group of *Siphonalia* by COSSMANN, but it is not right for that form has special lamellate axial plicae.

There are more than ten fossil species put under *Siphonalia* on the west coast of North America. *S. merriami* WAGNER & SCHILLING, 1923 of the San Lorenzo and *S. posoensis* ANDERSONS & MARTIN, 1914 of the Temblor have something like *Kellettia*. Some others, for example *S. andersoni* WAGNER & SCHILLING, 1923 of the San Lorenzo and *S. bicarinata* DICKERSON, 1915 of the Tejon, have two rows of nodes on the whorls which is not a character common to the type *Siphonalia* of Japan and more-over the second example has a clearly marked subsutural band and its canal is wider than in any form of the true *Siphonalia*. Other examples such as *S. sutterensis* DICKERSON, 1913 of the Eocene, *S. dubius* PACKARD, 1922 of the Chico, *S. rodensis* TRASK, 1922 of the Briones, *S. danvillensis* CLARK, 1915 of the San Pablo and *S. gilberti* MOODY, 1916 of the Fernando may seemingly be in the nearest connection of this genus, if they are not possible to be grouped with the Japonic species.

Almost all of the old species of *Siphonalia* of the South Hemisphere have been changed their names of genus. *S. dilatata* QUOY & GAIMARD, 1833 is now the type of the genus *Penion* FISCHER, 1884 (=*Verconella* IREDALE, 1914 for *Penion* not *Penium* PHILIPPI, 1865). There have been offered some other group names such as *Austrosipho*, *Berylsma*, *Glaphyrina*, *Aeneator*, *Pomahakia, Pittela* and *Ellicea* which are covered by the same subfamily as *Siphonalia*. *S. dilatata* was said to be living in this country and YOKOYAMA (1920) gave an account of a fossil specimen from the Pleistocene deposit at Miyata which seems be a different form but not a Penion. We have knowledge now that the distribution of the true *Siphonalia* is limited in the subtropical and temperate waters of Far Fast, and that the Tertiary fossil species from Tasmania and Chile may be moved to certain other groups as well.

On the authority of COSSMANN, there are some number of *Siphonalia* in the Eocene rocks of Europe. Though unhappily I have not seen all the examples, they are not like the type *Siphonalia* of Japan having smaller shell with straight columella ends, little flexed canals, and plicate axials as judged from the accounts and pictures. All these forms of Europe are not seemingly *Siphonalia* but they are *Lyrofusus* DE GREGORIO, 1880, *Coptochetus* COSSMANN, 1889 or some others.

The Japonic fossil and living forms of *Siphonalia* are put in three species groups: *S. cassidariaeformis* group, *S. spadicea* group and *S. mikado* group. Generally saying, the first group has a thick and strong test with wide and low spire; the second has a high and sharply pointed spire and somewhat long and curved canal; while the third is marked by a long bent canal and a sharp edge on the columella. Because the protoconchs of the *S. cassidariaeformis* group are thin and feeble, they are not kept in most of the shells at hand. That of the other two groups which are like those of *Buccinidae* are well kept even in fossil examples. As a rule a protoconch is formed by a globular naticoid head and a cylindrical smooth whorl of about half volution which is limited from the nepionic part by a marked longitudinal rib. The diameter of the top part is a little greater than that of the second volution. The nepionic parts in addition are much the same in all the species under observation. There are four spiral cords as a rule which are running over wide and roundly topped axial ribs.

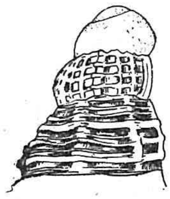

Fig. 2. Young part of *Siphonalia spadicea filosa*.

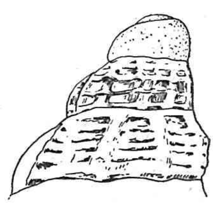

Fig. 3. Young part of *Siphonalia trochulus*.

The top and base edges of the whorl are feebly made thicker with the sutures on later parts and their development into two more spiral cords is a sign that the growth gets to the neanic stage which is in this way ornamented by 6 spirals at first. Length of the nepionic part of the tube is not fixed in different species, for example, it is only half a volution in

S. spadicea and almost one complete volution in *S. mikado*. In the species group of *S. cassidariaeformis*, the topmost one of the four primary spirals is specially feeble giving a look of three-corded nepionic and five-corded early neanic stage.

The six-corded condition is long in the *S. mikado* group by comparison being stretched out over two or three young whorls while it is very shortly put out by the *S. cassidariaeformis* group. The axial ribs are parallel to the growth lines at first, but they become more sloping after the neanic stage. Start of secondary and tertiary spirals in the space between the six primary ones takes place after the neanic stage in almost every species; spirals covered under the top part of the whorl in addition come out on the later whorls as the suture going down from the first position by degree while the shell having growth. On the other hand, the suture is frequently coming up covering the sixth spiral completely or uncompletely giving a look of five-corded condition of the young whorls. Sutures of the gastropoda shells may be ascending, descending, fluctuating or linear. In normal *Siphonalia*, the suture is fixed under the sixth primary spiral though forming low waves. The five-corded whorls of *S. paucilirata* and its Tonna-like look are got up by the higher position of the suture; the up change of the suture level is starting as early as on the nepionic stage.

The secondary and other spirals of later development are anagenetic in some species getting to a multilirate face of the adult whorls, while in some others, they are catagenetic or keep their feeble condtion all through the development. Of the *S. spadicea* group, the spirals are very thick in *S. trochulus*, while on the other hand, they are thin and delicate in *S. spadicea*, specially in *S. spadicea filosa*. Among the *S. cassidariaeformis* group, *S. cassidariaeformis* is an anagenetic form having strong spirals, and *S. signum* is a catagenetic example with its almost smooth body-whorl.

The existence of the axials is one of the most special mark of the genus. There is seen a feeble catagenetic tendency in some forms of the *S. spadicea* group only. The axials on the whorls early in development in all species are ribs stretching from suture to suture, then they become shorter nodes limited upon the angle of the later whorls in normal forms.

Siphonalia is a dioecious animals and the separate sexes have somewhat different tests. IWAO TAKI has pointed out that the female *S. spadicea* takes egg capsules on the front face of the tests and that every one of these egg capsules has kept about ten one year old youngs when he saw the examples in winter. The capsules are so tightly joined to the shell face as to make marks of wound upon it. Such scars are well marked on the female tests in full growth, but sometimes in other sorts they are not very clearly signed, though that parts are made somewhat rough by a little corrosion. In general, a female shell is made of a wider tube with a longer and more curved canal in front than in the other sex. The dimorphism is specially well seen among the species of the *S. cassidariaeformis* group, so that the males even young are possible to be noted by their narrower body-whorls with a nearly straight columella.

The three species groups of *Siphonalia* s. s. are separated by characters given under:

S. mikado group: conservative, spirals catagenetic, outer columella with a sharp sloping lamina limiting from the fasciole in front.

S. spadicea group: Shell high, greater number of volutions in relation with slowly increasing diameter of tube, spirals anagenetic by multiplication. This group is covering a division of *S. trochulus* group in which the tube is quickly increasing in later development and the axials are catagenetic.

S. fusoides is a form coming between the species group s. s. and the group of *S. trochulus*.

S. cassidariaeformis group: shell thick, with quickly increasing tube, spirals anagenetic in strength in one line (type group) or catagenetic but increasing in number in the other line *S. signum* series, sexual dimorphism clearly marked.

The three chief phyletic series were well put up while the Pliocene times. I am not able to make reference to the Miocene forms at present, though we have some small number of doubted ones of that times. Nomura and Zinbō gave two Miocene species of *Siphonalia* named: *S. gravitesta* and *S. prespadicea* which came from the Yanagawa shell-beds near Hukusima. These examples seem to be not representatives of true *Siphonalia* in the limited sense, because they have ornaments quite different in development from that of the type *Siphonalia* given in other lines.

Species Group of *Siphonalia mikado*

Siphonalia tonohamaensis totomiensis n. subsp. Pl. figs, 15-18.

Shell smaller than *S. mikado;* sloping lamina on columella (fasciole edge) not so high and sharp, canal not so long as in *S. mikado.* Type: height 26.1 mm., diameter 13.3 mm., volutions 6.5+protoconch, tube length as measured on suture 78 mm., long diameter of aperture with canal 14.4 mm., short diameter of aperture 7.1 mm., diameter of last volution but one 8.8 mm.; primary spirals 4 on the spire-whorls, a feeble line on the top near the upper suture, suture upon the 4 th primary spiral, 8 primary spirals on the body whorl, two delicate cords between the lowest one and the fasciole edge, no secondary spiral, but for very feeble signs, a very narrow groove line on the periphery at a little over the 4 th spiral; axials 10 on the body whorl, one or two more axials on early whorls. The protoconch is as normal of the genus, but it is much smaller than in *S. mikado* measuring 0.8 mm. in diameter; the young volution are not well marked out from the later part in full growth; only a different effect is that the spirals seem to be a little stronger on the early parts by comparison. In this way this form is very low in evolution with respect to the surface character. The later part of the tube is made narrower on top under the suture forming a short vertical band or a collar which is in addition one of the special marks separating the present species from *S. mikado.* The inner lip is turned out over the fasciole covering its inner part and shutting completely a hollow inside; a feeble tubercle is made on the parietal wall near the back end. The outer lip is thick, about 10 short transverse ridges within, which are starting from a short way inside of the edge. The canal is much shorter than in *S. mikado.*

Distribution: Loc. 530 (type), 430, 524, 431.

The type is a smaller example though in full growth, and it is a little narrower than the most. The material at hand is not small in number, but as the keeping is poor no biometrical method is made use of. The diameter of the shell is somewhat unfixed in relation to the height. It is clear by observation that the wider shells are thick at the same time. Seemingly these changes were effected by outside conditions while in growth.

Generally saying, however, it is true at least that the examples from the upper levels (Nangō Beds material 430, 431) are a little wider and thicker, not only they are greater in size. More-over, the Nangō examples have a stronger secondary spiral in every one space between the spirals on the base.

S. totomiensis is well separated from *S. mikado* though it has the same characters common to this species group. The shell is smaller, shorter and with much shorter canal than that of *S. mikado.* It is in a branch of the same group but not in the same stem line, because there is an older fossil form named *S. mikado tennoensis* which is nearer to the living species.

NOMURA very lately gives a new species *S. tonohamaensis* from the Pliocene of Tosa which seems to be not very different from the present form though his example has a shorter spire, sharper shoulder angle and a greater number of axials. The Ketienzian form of Tōtōmi is naturally not completely equal to the Dainitian form of Tosa, though they may be grouped under the same species for which the name by NOMURA will be given.

Siphonalia mikado tennoensis n. subsp. Pl. fig. 31.

=*S. mikado,* MAKIYAMA, this memoirs, vol. 3, p. 118, pl. 6, figs. 1, 2. 1927.

The shell is wider by comparison than *S. mikado* MELVILL, 1888 measuring 44 mm. by 28 mm. (no. 339). The tube is more quickly increasing and the suture is on a higher level than in the species. The spirals are feeble while the axials are like those of the species. The canal is longer than in *S. totomiensis* but shorter than in *S. mikado.*

Distribution; Loc. 653 (type).

There is only one 653 example from the Tennō Sandstone a little damaged in form by pressure. This subspecies is a form coming between *S. mikado* and *S. tonohamaensis,* though it is nearer in relation to the first which is living in the waters of the south-west parts of this country and is the probable offspring, whereas the second is a form on another branch line of the genetic tree of the species group. As has been noted before, there is a living form of *S. mikado* with a greater diameter in relation to height, but the wide shell is not an only separating mark of the subspecies.

Notes on *Siphonalia mikado: S. mikado* has a higher spire with narrower top angle in comparison with *S. tonohamaensis* and *S. mikado tennoensis*, because the suture in this living species is at a very lower level than in the fossil forms. The nepionic part of the tube is quite like that of *S. tonohamaensis totomiensis*, but after this very young stage the suture goes down from the level of the 4th spiral, and the rate of growth in diameter of the tube is very slow. In this way *S. mikado* is a long-tubed form giving a turreted look of the spire.

The edge of the inner lip is free, being not pushed upon the columella forming an open hollow with the fasciole in front. The canal is long and wide, strongly curved back. There is a marked tubercle within the inner lip near the back angles where a very small canal is made. The transverse ridges within the outer lip is greater in number than in *S. tonohamaensis totomiensis*.

Siphonalia mikado sutiensis n. subsp. Pl. fig. 14, Pl. fig. 34.

Outline like *S. mikado tennoensis* but the spirals anagenetic. In this way it is like *S. cassidariaeformis ornata* in a rough statement. The spire is low, much lower than in the species by comparison, being a little lower than the height of the aperture. The canal is shorter than in the species, though it is well bent. The spirals are wider and stronger than in other forms of the group, giving a look of the surface like that of *S. cassidariaeformis*. The axials are catagenetic, they are only marked on the shoulders of the later whorls, where they are forming low waves of the surface; but the waves have a stronger look than they are by sharp spine-like produces on their tops made by a spiral cord running over them. The fasciole edge is very sharp and lamellate. Dimesion: 40.5 mm. high, 27.5 mm. wide, volutions 6+broken embryo, long diameter of aperture with canal 26.8 mm. (holotype).

Distribution: Loc. 524, 533.

This form seems to be very uncommon; only two examples are under observation. It is far outside the limit of the species in narrow sense with its specially short spire and wide spirals. The ornamenting design is quite like that of the type species when young, while the general outline is nearly equal to that of *S. cassidariaeformis ornata* with which it has something in common in the spirals when in full growth. The present form, however, is not a near relation to the second for they are in differnt genetic series. It is a good example of homoeomorphy.

Species Group of *S. cassidariaeformis*

This species group is covering at least two smaller divisions: *S. signum* group and *S. cassidariaeformis* group s. s., which were well separated while the Pliocene times. The living form *S. signum* is a wide shell of quickly increasing tube ornamented by very feeble minute spirals, while *S. cassidariaeformis* is a somewhat narrow, thick and strong shell with wide and well marked spiral cords. The second is a very variable species, and it has been a belief that the first is only a form of the second. In the same way, it was my opinion that a Dainitian form *S. declivis* is a subspecies of *S. cassidariaeformis*. *S. declivis* is clearly in nearer relation to the type species of the genus, but still it has the special marks of *S. signum* and tendency of evolution to that direction is clearly noted by itself and by its offspring coming after.

Reference has been made on *S. ornata* and the two more species of A. ADAMS (1863) which may be the synonym of *S. cassidariaeformis* or form within the limit of that species. The shell of *S. cassidariaeformis* from Kagosima is the greatest of the group in size, for example, with a dimension 62×32 mm. by a male and 54×31 mm. by a female. The examples from the Inland Sea near Awazi are much smaller than the Kagosima form being about 40 mm. high. This form frequently has a colour marking which was taken to be a special character of *S. ornata* by ADAMS, and by this reason, in addition to other marks, it has been made comparison with that species.

S. vanattai PILSBRY, 1905 is a small form, but is not very different from *S. cassidariaeformis* in its ornamenting design and development in detail. Some examples at hand came from Tosa are making picture of a form coming between *S. vanattai* and *S. cassidariaeformis ornata.* It is quite probable that the two forms are in connection by a series of changes from one to the other.

KURODA gives a name *S. cassidariaeformis hinnulus* (ADAMS & REEVE, 1850) to a specimen came from Kagosima which is a shell with stronger, wider and more regular spirals than in *S. cassidariaeformis* putting out a somewhat different look. Though the aperture of this example is longer than the picture given by ADAMS, it may be a representative of that name, and again this is nothing more than a subspecies of *S. cassidariaeformis*.

S. paucilirata n. sp. a fossil form is well separated from the chief species of the group in its special design of spirals, being a probable branch form which came to its end before the Holocene.

The egg marks are seen on the female shells of all the forms under observation. I have not enough samples to go on with biometrical way of investigation testing if the females have wider tubes than the males. The males of *S. cassidariaeformis* from Kagosima and Husan are in fact a little narrower in the diameters by observation.

The *Siphonalia signum* series

Siphonalia declivis YOKOYAMA, 1926 Pl. figs. 19, 22, 26, 30.

Distribution: Dainiti form at Loc. 610, 611, 612, 614, 615, 616 and 618; Hōnohasi form at Loc. 635, 640, 630 and 679; Tennō-yama form at Loc. 651, 654 and Tōnohama Tosa.

It was my opinion that this form is covered by *S. cassidariaeformis,* simply because the second is very changing species. But as has been given the statement, viewing from the morphogenesis of the series, it has to be separated as a good species. The Dainiti form of this species which was named *S. declivis* by YOKOYAMA is the oldest and most general type of the *S. signum* series so far as be in the knowledge. The out-line is that of *S. cassidariaeformis* and *S. cass. ornata,* but the ornamenting design of the spirals is quite different from those living forms being made of thin threads in place of the wide and strong cords. Such characters as seen in the spirals have sometimes been taken to be not very important, because it was general thought that they are not very regularly handed down to offsprings. But this thought is not true at all times to be put in without giving attention to development of spirals or axials in detail. The strong spiral cords upon the later whorls of *S. cassidariaeformis* are the spirals of the first and second orders though two or three cords of the third order are in development in some wider spaces between them, while the great number of fine spirals of *S. signum* series are of the first to fourth order. These different development of the two lines are starting from the neanic parts making quite unequal effects on the looks.

When *S. declivis* which is the earliest representative of the *S. signum* series was going well in the Dainitian waters of Tōtōmi, there was possibly a form of *S. cassidariaeformis* in existence as well, though no discovery of a form which may be put in that line has been made in the Kakegawa Pliocene. NOMURA gives a picture of an example from the Pliocene of Taiwan (Byōritu beds) and a note that the range of this species is starting from the Miocene in Japan. *S. sikokuana* NOMURA, 1937 is without doubt a Dainitian form of *S. cassidariaeformis* series and it has a different look from *S. declivis,* but not from the living example from Kagosima.

The ornamenting design of the two series has been well separated from the very early times of the group history and seemingly there has been no interbreeding between them.

The type *S. declivis* is a form in the upper levels of the Dainiti sands, and here it is noted as the Hōnohasi form. The spire of the type is a high cone with flat sloping shoulders, while that of the Dainiti form from the lower levels has a more stepped outline with a little in-curving shoulder. Though the first is made a little narrower, it is not very different from the second when young. The sharper and higher slope is seen in full development by the last volution only. The ornamenting designs are quite equal in the two forms.

The change of form from the Dainiti form to that of Hōnohasi was going on after the Dainitian times to the last form named *S. declivis biconica* n. subsp. of the Ketienzian stage. At the same time, there was another line going to the living form *S. signum.* In this second line, the shells were getting wider by degrees opposite the narrower forms of *S. declivis biconica* line. The Ketienzian forms which are steps between the living species and the Dainiti form of *S. declivis* are grouped with *S. signum* in taxnomy.

One more branch of the series is the Tennōyama form which has a wide distribution while the very later times of the Dainitian. This special form is seemingly different from *S. declivis* by a look and frequently it was made reference to *S. cassidariaeformis*, though its ornamenting development is that type of S. *signum* series in detail. The shell substance of this form is not so thick as in the others and the shoulders are high by comparison. It has to be noted that the Tennōyama form was living in the deeper waters of sublittoral zone as the fossil community and the substance of the deposit with it make suggestion, while the other forms were in the more moving waters of littoral zones under which sands were put down. It is most probable that the different characters of the Tennōyama form from the type and *S. declivis biconica* line are the signs of its different conditions of existence. To the last form of this line, a new subspecies name "*tosensis*" will be given.

Siphonalia declivis biconica n. subsp. Pl. figs. 23-25, 27-29.

A variety specially stepped forward. Shell narrow and high, with cone-form spire and base; body whorl of very great size in relation, as high as about three fifths of the shell; spire whorls not very different at first from that of the species type, but later ones with long sloping shoulders, which angles are very low; ornamenting design like the species, but the tubercles on the angle more produced; colour marking as in *S. signum*. Dimensions: height, 38.5 mm.; diameter, 20.4 mm.; long diameter of aperture with canal 25.4 mm.; short diameter of aperture 11.1 mm.; number of volutions 5+x (holotype).

Distribution: Nangō beds at Loc. 431 (type) and 430.

The holotype is a very old individual greater in size than the common examples which are normally 30 mm. high. The outer lips of these 30 mm. individuals are still thin and the growth lines do not make rough edges, though they are adult judging from the egg-prints of the females.

The youngs about 20 mm. high are quite like the Dainiti form of *S. declivis* not only in their outlines but in the details. The tendency of evolution of *S. declivis* to the biconical form is well seen by the Hōnohasi form which is between the old high shouldered Dainiti form and the present subspecies.

S. declivis biconica is very common in a low level of the Nangō beds at the two places on the division line between Tonbe and Hosoya. A great number of examples were got at Loc. 431. The shells of this place are regular and equal in all details to the type. The material from Loc. 430, though small in number, does not give an example different from the type.

Siphonalia declivis var. $\frac{\textbf{S. signum}}{\textbf{S. declivis}}$ Pl. fig. 36.

While *S. declivis biconica* is a well made up subspecies wich is nearly at the top end of a branch in evolution, the chief evolution line of *S. signum* series was in good development in another place seemingly outside the area under observation, as such examples coming between *S. declivis* and *S. signum* do not frequently take places in the Kakegawan rocks The present material under the head name is made of only one example came from the Hosoya beds in Iida (Loc. 524). It is wider than the type *S. declivis* and though its outline is biconical, it is unlike *S. declivis biconica* being much wider but shorter. The outline is nearly that of *S. signum*, but the spire is higher and the shoulder is lower. The shoulder slope is wide and flat. The ornamenting design is in the same way as in *S. declivis* being stronger than in *S. signum*. It is measuring 31 mm. high by 22 mm. wide. The chief evolution line of *S. signum* seems to be in straight connection with the Dainiti form of *S. declivis*. The present form under observation is not on this line, but is between the *S. declivis biconica* branch and the stem. By this reason it may be protested as $\frac{\textit{S. signum}}{\textit{S. declivis}}$ which is not neccessarily a hybrid in palaeontology. A form on the stem line is a mutation and the formula like this will not be made use for such a true mutation.

Siphonalia declivis tosensis n. subsp. Pl. fig. 12.

The type of this subspecies is the form at the farthest end of the Tennōyama branch line of *S. declivis*. An account on the general tendency of the changes in the line has been given under the head of *S. declivis*. The details of the holotype will be given here: Shell thinner, higher but narrower than *S. declivis declivis*, spire turreted and scalariform, made of 8 whorls, protoconch in loss; early 3 to 4 whorls making narrow and sharp top of the spire, with ornamenting design of *S. declivis*, later whorls shouldered at a high level, higher than the middle, surface nearly smooth but with very feeble spirals, shoulder with tubercles, colour marks like *S. signum*, made of brown spiral lines; outer lip smooth within. Dimensions: 34.5 mm. high, 19.3 mm. wide (not true diameter as the shell is broken at the side).

Distribution: See that of *S. declivis;* type at Ikenotani no. 1 in Tōnohama, Kōti-ken (Tosa).

This is a special form with a different look from the mother mutation of Dainiti, but it is clearly in a genetic connection with the second. The new subspecies was nearly at its start as a good branch line, but the change from the mother line was small by comparison,

Siphonalia signum imai n. subsp. Pl. fig. 20.

A form smaller than *S. signum* REEVE, 1846 a living representative of the series; the tubercles on the shoulder are less in number but stronger than in the species. Dimensions: 31.6 mm. high, 22.7 mm. wide.

Distribution: Nangō beds at Tonbe, Loc. 431 (type).

Only one example which is the holotype is at hand. It was made its discovery among the great number of *S. declivis biconica;* its keeping is poor having been damaged on the sea base. It seems, however, not to be a remanie fossil, though it might have come from other place not very far by an act of an animal (hermit crab or something like that) or by a physical agent.

This form may be well covered by the species from which it is different not only in size but in its more sloping and flat upper surface of the shoulder which is at lower level With this respect, it is near to *S. declivis,*

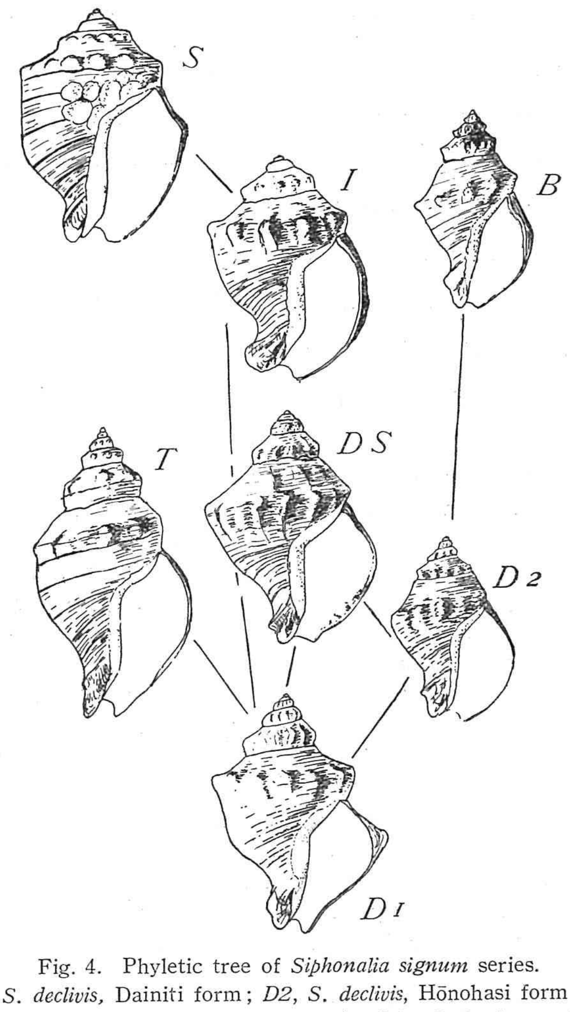

Fig. 4. Phyletic tree of *Siphonalia signum* series.
D1, S. declivis, Dainiti form; *D2, S. declivis,* Hōnohasi form; *B, S. declivis biconica; DS, S. signum/declivis; I, S. signum imai; S, S. signum; T, S. declivis tosensis.*

but the general outline and the regular feeble spirals are completely of the living species. We are able to see, though the material is poor, that the evolution of the stem line has been going on very well by the side of the branch line in the area of Tōtōmi.

The living representatives of *S. signum* are common in the waters near the Kakegawa districts. The shell is much greater in size than any fossil forms of the series. The young part is quite in harmony with the old *S. declivis* in all details.

The fossil shell from the Pliocene of Hyūga in Kyūsyu which was made reference to *S. fusoides* by YOKOYAMA, 1928 is without doubt another form of *S. signum* series and may be the nearest relation to *S. declivis tosensis*, though its shoulder is round unlike the normal form of Tosa. The spirals of this form, however, are very feeble in the same way as in *S. signum*. The genetic tree based upon the fossil materials will be given like this:

Recent.............................*S. signum signum*
Middle Ketienzian...........*S. signum imai*...........*S. declivis biconica*
Lower Ketienzian............................-*S. signum/declivis*
Upper Dainitian......*S. declivis tosensis*
Middle Dainitian..........................*S. declivis declivis*
Lower Dainitian.........*S. declivis* (Dainiti form)

The *S. cassidariaeformis* series

There is none of this group in narrow sense in the Ketienzian levels of Tōtōmi. A new species coming under is not a Ketienzian fossil, but it is a very common form in the shell bed at Sasage in Tiba-ken (Kazusa) which age in geology has been said to be Upper Pliocene by myself, though through very new works by SUZUKI and IKEBE, it will become general thought that it is younger as be Lower Pleistocene. The new species seems to be not on the stem genetic line.

The *S. cassidariaeformis* series is seemingly well separated from the *S. signum* series from the very early times of their history. They may be two species groups not dependent on every other. This opinion, however, has not been supported by any fact before us, and simply for this reason, they will be grouped together in agreement with the general view at present. T. KOBAYASI kindly gave me an example of *S. declivis* in full growth which he has got at Dainiti (Loc. 618). This shell is nothing but very old individual of the Dainiti form common in the same place while it has a look very much like the living examples of *S. cassidariaeformis ornata* making a suggestion about the relation of the two series.

Siphonalia paucilirata n. sp. Pl. figs. 32, 33.

Shell tumid, wide but short; tube quickly increasing in size making a small spire by comparison and a wide and convex body whorl; surface curving out, not well shouldered, but flatly sloping near the top, which ending against the lower vertical part of the back whorl; suture well marked, running upon the fifth spiral; primary spirals normally 11, sometimes up to 14, 2 on the shoulder slope narrow and widely separated, the rest stronger, regular, flat-topped and rib-form; a secondary spiral taking place on the top edge; 2 to 3 less stronger spirals on beak of base; all spaces between the primary spirals with very fine spiral lines; axials node-like, on shoulder only, 10 to 12 in number, catagenetic, the third primary spiral running over the nodes; ornamenting design on early whorls like that of *S. cassidariaeformis*. Dimensions: height, 44.4 mm. (not complete); diameter, 31.0 mm.; long diameter of aperture with canal, 32.4 mm.; short diameter of aperture, 15.7 mm.; shoulder length on outer lip from suture to 3rd spiral, 12.2 mm. (holotype).

Distribution: Sasage at sea-side in Tiba-ken. Kanōzan stage or Lower Pleistocene.

The holotype is a female adult broken at the top. Other examples in full growth are about equal to the type in size. The protoconchs are in loss. A very young example keeps a complete protoconch which is a little wider than the nepionic whorls measuring 1.4 mm. The 5 primary spirals are starting from very feeble threads on the first nepionic part. They are not catagenetic or anagenetic, while the axials are catagenetic as they are stretching from suture to suture on the nepionic and neanic whorls. They become feeble waves on the later whorls.

S. paucilirata is different from *S. cassidariaeformis* in that the shell is wider but shorter; the spire is smaller; the canal is shorter and wider and that the spaces between the primary spirals have no secondary ones in good development but for very fine lines. On the body whorl of the present new species we see a less number of widely separated spiral cords than in *S. cassidariaeformis* which has stronger secondary spirals in all spaces giving a quite different effect on look. In this connection, *S. paucilirata* may be a primitive representative of the species group. We have, however, no more fossil material to put to the test of this idea. As has been given statement, some of *S. signum* series were said to be *S. cassidariaeformis* by error, so that those are no use. Other examples given by some writers have to be tested with care.

The females keep well marked egg prints on the front surface of the body whorl; those in the middle of the area are specially deeply printed on the shell substance. The males are little different in form from the females by observation.

Species Group of *Siphonalia spadicea*

Siphonalia modificata (Reeve, 1846) Pl. figs. 11, 13, 35.

Synonym: *S. stearnsi* Pilsbry, 1895; *S. pseudobuccinum* Melvill, 1909.

Distribution: Tennō sands at Loc. 653, 645; Hosoya beds at Loc. 524, 530; Pliocene of Kwantō. Living; Sagami Bay to Sikoku.

Range of variation is wide in this living species. Types of *S. stearnsi* and *S. pseudobuccinum* may well be covered by the species. It is not frequent in the Kakegawa strata. The form in the Tennō sands was named *S. stearnsi* in comparison with a topotype of that species which, however, is different in having a greater number of the axials. The *S. modificata* of Loc. 524 is smaller form with a shorter canal than in the living representatives of Bungo. The shoulder slope is more flat, sharper and lower than in the other races. One of the examples in full growth is measuring 41 by 22 mm. with protoconch and 7 whorls. This size is normal for some living forms, but it is far smaller than a Bungo example which is measuring 63 by 43 mm.

The material of Loc. 530 gives an interesting example, though it is the nearest relation to that of Loc. 524, to come between the species and *S. trochulus* (Reeve, 1846) respecting its catagenetic axials. A step of change from this form would be enough to make a good *S. trochulus*. By this observation, it is possible to give an opinin that the second is only a branch of the *S. modificata* line. In the same way, other species such as *S. spadicea* and *S. fusoides* may be tightly in connection. We have but very little knowledges of their relation while the Pliocene ages.

S. yabei NOMURA, 1937 is another interesting Pliocene form which will be noted as an early mutation of *S. modificata* while the Dainitian age marked by overdoing sharp shoulder and low spire. The Ketienzian form of Loc. 524 is between the living repesentative and the NOMURA's form.

Siphonalia dainitiensis MAKIYAMA, 1927

Distribution: Dainiti sands at Loc. 613, 640.

Only two examples are at hand for observation. This form is an interesting representative of *S. spadicea* group putting out a relation with *S. cassidariaeformis* group. It is like *S. cassidariaeformis* when very young and then it gets a form of *S. modificata* type. The type though small is in full growth. The axials are narrower but stronger than in *S. modificata*, while the spirals are of the same design to the second. The general outline is like that of *S. vanattai* PILSBRY, 1905, but this fact is not a sign of their genetic relation, because it is a produce of homoeomorphism. The ornamenting design in early development as seen with *S. modificata* of the Tennō sands is in harmony with those of the present species. It is not quite unprobable that *S. dainitiensis* is a representative at the start of the *S. modificata* line.

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Account of Plates

Plate III

Fig. 1. *Siphonalia vanattai* PILSBRY, living, Wakayama-ken, ×2.
2. *S. trochulus* REEVE, living, Wakayama-ken.
3. *S. filosa* A. AEAMS, living, Iwate-ken.
4. *S. fusoides longirostris* DUNKER, living, Awazi.
5. *S. cassidariaeformis* REEVE, living, Awazi.
6. *S. signum* REEVE, living, ♂, Kamakura.
7. *S. signum* REEVE, living, ♀, Kamakura.
7. *S. mikado* MELVILL, living, Wakayama-ken.
9. *S. spadicea* REEVE, living, Wakayama-ken.

Plate IV

Fig. 10. *S. spadicea fuscolineata* PEASE, living, Kanagawa-ken.
11. *S. modificata* REEVE, Loc. 530, p. 89.
12. *S. declivis tosensis* MAKIYAMA, Tōnohama in Kōti-ken, holotype, p. 86.
13. *S. modificata* REEVE, Loc. 524, p. 89.
14. *S. mikado sutiensis* MAKIYAMA, Loc. 524, holotype, p. 82.
15. *S. tonohamaensis totomiensis* MAKIYAMA, Loc. 524, ×2, p. 80.
16. *S. tonohamaensis totomiensis* MAKIYAMA, Loc. 524, ×2, p. 80.
17. *S. tonohamaensis totomiensis* MAKIYAMA, Loc. 530, holotype×2, p. 80.
18. *S. tonohamaensis totomiensis* MAKIYAMA, Loc. 530, ×2, p. 80.

Plate V

Fig. 19. *S. declivis* YOKOYAMA, Dainiti form, Loc. 611, p. 83.
20. *S. signum imai* MAKIYAMA, Loc. 431, holotype, p. 86.
21. *S. fusoidss* REEVE, Pleistocene, Yasiro in Tiba-ken,
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23. *S. declivis biconica* MAKIYAMA, Loc. 431, ♂, p. 85.
24. *S. declivis biconica* MAKIYAMA, Loc. 431, ♀, p. 85.
25. *S. declivis biconica* MAKIYAMA, Loc. 431, ♂, p. 85.
26. *S. declivis* YOKOYAMA, Hōnōhasi form, Loc. 640, ×2, p. 83.
27. *S. declivis biconica* MAKIYAMA, Loc. 431, holotype, p. 85.

28. *S. declivis biconica* MAKIYAMA, Loc. 431, a young ×2, p. 85.
29. *S. declivis biconica* MAKIYAMA, Loc. 431, ×2, colour marking.

Plate VI

Fig. 30. *S. declivis* YOKOYAMA, Hōnohasi form, Loc. 640, p. 83.
31. *S. mikado tennoensis* MAKIYAMA, Loc. 653, holotype, p. 81.
32. *S. paucilirata* MAKIYAMA, Pleistocene, Sasage in Tiba-ken, ♂, p. 88.
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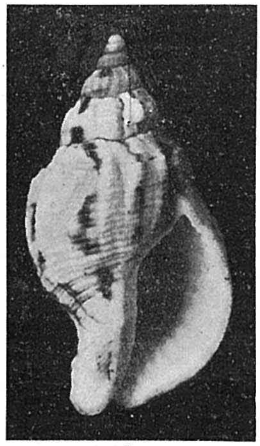
34. *S. mikado sutiensis* MAKIYAMA, Loc. 533, ×2, p. 82.
35. *S. modificata* REEVE, Loc. 653, ×2, p. 89.
36. *S. declivis* var. $\frac{\textit{signum}}{\textit{declivis}}$ Loc. 524, type ×2, p. 86.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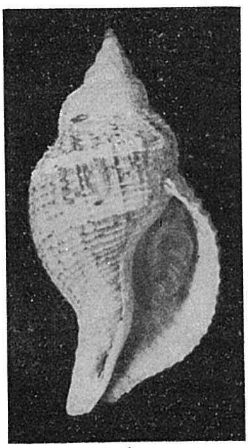
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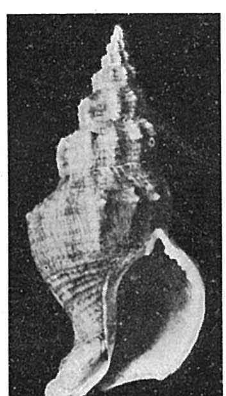
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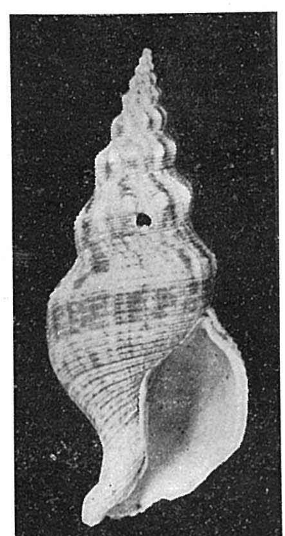
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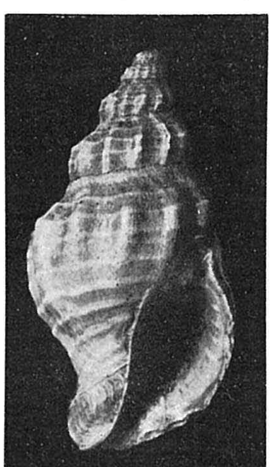
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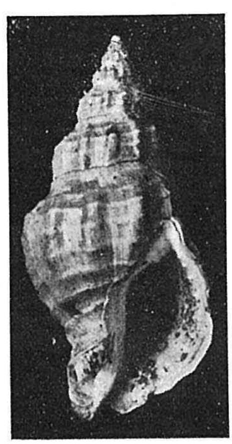
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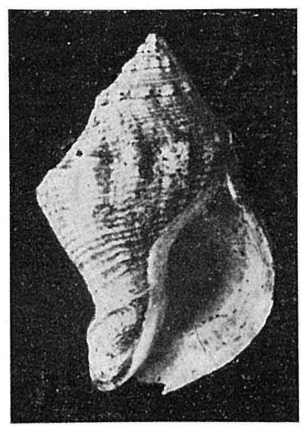
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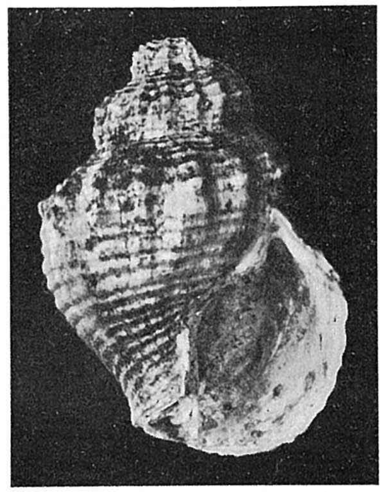

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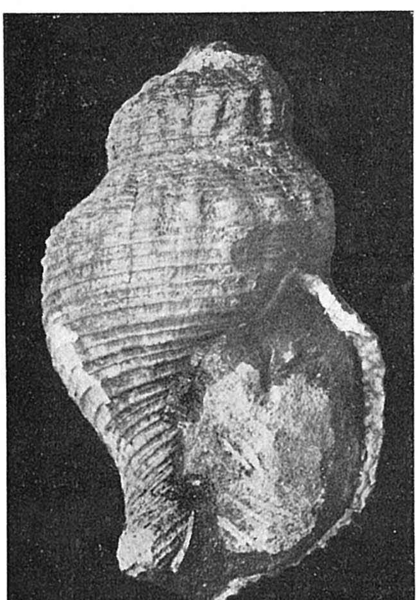

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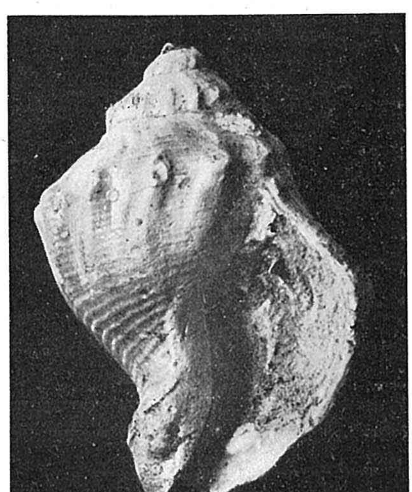

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