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# On the Associated Occurrence of *Vicarya* and *Vicaryella* in the Japanese Tertiary, with the first Description of a Paleogene Species of *Vicarya* from Japan

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## INTRODUCTION

During stratigraphical and paleontological studies on the Tertiary deposits in the Joban coal-field, northeast Honshu, Japan, the writer found two *Vicarya*-bearing beds separated from one another by thick marine sediments. From the upper *Vicarya* bed in the Kadono district in the coal-field, Yokoyama (1925) once described the occurrence of *Cerithium baculum* Yokoyama and *Cerithium* sp., these are now referred to *Vicaryella ishiiiana* (Yokoyama) and *Vicarya yokoyamai* Takeyama, respectively. The lower *Vicarya* bed is in the Kunugidaira formation the lowest stratigraphic unit of the Miocene Yunagaya group. That the brackish water *Vicarya*-bearing beds occupy two distinct horizons in a single sedimentary basin is an outstanding feature of the Japanese Tertiary. Further, from the Kunugidaira formation, a new species of *Vicaryella* was found in association with *Vicarya*. In many localities in Japan, *Vicarya* usually occurs associated with *Vicaryella* and such an assemblage is thought to have some paleogeographical, paleoecological and geochronological significances.

Most Japanese geologist believed the Japanese species of *Vicarya* to be restricted to the Miocene deposits for a long time. However, the writer recently discovered a new species of this genus from the Hashima coal-bearing formation in the Takashima coal-field, Nagasaki Prefecture, Kyushu. Nagao (1928) assigned the Hashima formation which includes his "Upper *Orthaulax japonicus* Zone" to Eocene in age. The morphological features of the Hashima specimens are intimately related with *Vicarya callosa* Jenkins of the Javanese Miocene and diverge morphologically from *V. verneuili* (D'Archiac) which is the genotype of *Vicarya*. Thus, the writer introduces a new subgeneric name, *Shoshiroia*, which is based on *Vicarya callosa* Jenkins from Java and includes *Vicarya callosa japonica* Yabe and Hatai and the new Eocene species from the Hashima formation.

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### SOME REMARKS ON THE JAPANESE *VICARYA*

Paleontological studies on the Japanese *Vicarya* were by Yokoyama (1925, 1926), Takeyama (1933), Makiyama (1936), Kanehara (1936, 1937), Yabe and Hatai (1938), Ikebe (1938, 1952), Otatume (1943), Oyama and Saka (1944) and others, and the geographical distribution of this genus in Japan was outlined by Otuka (1938) and Matsuo (1951).

Previous occurrences of this genus in Japan have been restricted to the Miocene formations and two well-known types of *Vicarya* were recognized from various places. One, often called as "Tsuyama type" is *Vicarya callosa japonica* Yabe and Hatai and the other, the "Tsukiyoshi type" is *Vicarya yokoyamai* Takeyama. Besides these two species Yabe and Hatai (1938) described *V. callosa martini* Yabe and Hatai from the Tsukiyoshi formation in Gifu Prefecture and *V. yatuoensis* Yabe and Hatai from the Yatsuo group in Toyama Prefecture.

Yabe and Hatai (1938) emphasized that *V. callosa japonica* is characterized by having the tubercles extending horizontally from the axis of the shell, being flat in its upper part and inclined in its lower. According to Ikebe (1952), *V. callosa* Jenkins, from the Tjilang formation in Tjilang and the Njalindoeng formation in Njalindoeng both in Java, have tuberculous spines with both surfaces sloping and also flat in the upper part and sloping in the lower as in the Japanese *callosa japonica*. Therefore, he concluded that the Japanese *callosa japonica* is conspecific with the Javanese *callosa*.

Aside from the shape of the tubercles as pointed out by Ikebe, the following differences are recognized between the Javanese *callosa* and the Japanese *callosa japonica*. In the shape of whorls, *callosa* is almost cylindrical as indicated in Jenkins' (1864) original description, while *callosa japonica* is conical. The pagoda-shaped whorls of *callosa* are distinct in Martin (1879-80) and Cossmann's (1912) subsequent figures, which were reproduced by Yabe and Hatai (1938), and also in a specimen stored in the Institute of Geology and Paleontology, Tokoku University, Sendai (IGPS Coll. Cat. No. 37156) collected from Njalindoeng, Java. While in the Japanese specimens which were often referred to *callosa* or named as *callosa japonica*, Takeyama (1933) described the whorls as "truncated conic" and Yabe and Hatai in more detail, described as "whorls flat, nearly straightly inclined when tubercles are neglected, regularly increasing in size, each truncated conic". The distinct groove which usually extends over the tips of the tubercles in the Javanese specimens are very obscure and when existing they appear only at the middle part of the shell and do not develop in the adult stage of the shell in the Japanese ones.

The similarity in the shape of the subsutural tubercles between Javanese *callosa* and Japanese *callosa japonica* is one reason referring both forms to the same subgeneric or specific rank. *V. callosa* and its subspecies *japonica* have the subsutural tubercles constant in number in each whorls, while *V. verneuili* (D'Archiac), the genotype of *Vicarya*, has the subsutural cord finely beaded in the younger whorls and they gradually change to spinous tubercles of less number on the later whorls. Accordingly, the writer proposes the new subgeneric name *Shoshiroia*, for the stock of *callosa*.

For the "Tsukiyoshi type", Takeyama (1933) introduced the name of *V. verneuili yokoyamai* based on a specimen collected from Shimizu, Mizumani City, Gifu Prefecture and included *Cerithium* sp. of Yokoyama (1925) from the Joban coal-field and *Vicarya baculum* Yokoyama (1926) (not *Cerithium baculum* Yokoyama, 1923 from Kii Province) from Matsubora, Mizumani City in his new subspecies. Yabe and Hatai (1938) assigned *yokoyamai* to the subspecies of *callosa* and described as "it appears that it is closer to *V. callosa* than to *V. verneuili*". This view was probably taken from the importance of Takeyama's description about a specimen having a complete aperture of *yokoyamai* collected by Ikebe, that was described as "its apertural characters are quite identical with those of *V. callosa*". This specimen was subsequently figured by Ikebe (1939) who supported Takeyama's opinion that in *yokoyamai* the tubercles on the subsutural cords become granular and increase in number towards the younger whorls as in *verneuili* and therefore *yokoyamai* is a subspecies of *verneuili*. Lately, Oyama and Saka (1944) concluded that since *yokoyamai* is characterized by the ill-developed callosity of the inner lip, the shallow sinus of the outer lip and by having no secondary sinus, it is a distinct species which has close relationship to *verneuili*. The sculpture of the whorls of *yokoyamai* are similar to *verneuili* and both species belong to *Vicarya* (s. s.). *V. yokoyamai* is distinguishable from *verneuili* by "the lower spiral cord is beaded, that the narrow band between the upper two striae is elevated" as indicated by Takeyama in his original description.

*V. callosa martini* Yabe and Hatai may fall within the range of variation of *yokoyamai* as already stated by Ikebe (1939), and Oyama and Saka (1944) based on the specimens from the Tsukiyoshi formation where *yokoyamai* occurs. In the many specimens collected from the Kadono district in the Joban coal-field, there are some specimens having the subsutural spinous tubercles only on the body whorl or extending to the penultimate whorl; these become beads on the more younger whorls. In the Joban specimens, it is recognized the variation in the development of the subsutural tubercles is as recognized in the Tsukiyoshi ones.

*Vicarya yatuoensis* Yabe and Hatai was described by Yabe and Hatai (1938) based on two specimens collected by S. Imamura of the Hiroshima University, at Kakehata, Unohana-mura, Nei-gun, Toyama Prefecture. This species is characterized by its having the first or uppermost spiral cord with strong tubercles numbering about 12 on whorl, the second and the third with granular cords, the fourth of smooth cords and the interstitial riblet is found between the third and the fourth. In the body whorl, the third cord forms shoulder and the beads on it become weaker and the beads on the fifth whorl from the last whorl increasing in number, as seen in the reexamination of the holotype. These features of the sculpture of *yatuoensis* are more similar to those of *yokoyamai* than *callosa* or *callosa japonica*.

In the Fukuoka district in northern Iwate Prefecture, there are developed fossiliferous Miocene deposits which have been described by Otuka (1934). Earlier, Yabe (1912) mentioned on the occurrence of *Vicarya* cfr. *callosa* Jenkins and *Desmostylus* from the Yuda group of S. Shimizu (MS). Subsequently, Otatume (1943) figured and described a vicaryan shell collected from Yuda in the same district, under the name of *Vicarya callosa* forma

*japonica* Saga (MS) Yabe and Hatai. Otatume's specimen preserves only the last three whorls and thus there is no mention about spiral cords below the subsutural tuberculous ridge. Recently, K. Hatai and K. Masuda of the Institute of Geology and Paleontology, Tohoku University, collected a specimen of *Vicarya* at Yuda. This specimen is also not well-preserved, however, the tubercles on the subsutural band show that they change into beads in the third whorl from the last. This feature indicates that the Yuda specimen at hand, from the sculpture of the whorls, can be referred to *yatuoensis*.

#### REMARKS ON THE SPECIES OF *VICARYELLA*

Yabe and Hatai established the new genus *Vicaryella* in 1938 and designated the genotype as *Vicaryella tyosenica* Yabe and Hatai from the Miocene Heiroke conglomerate (Makiyama, 1936) at Nanseki, Myonchon (Meisen) District in North Korea. Yabe and Hatai in their article included the following species in this genus :

*Cerithium baculum* Yokoyama, 1923

*Cerithium ishiiianum* Yokoyama, 1926

*Vicaryella tyosenica* Yabe and Hatai, 1938

*Vicaryella nipponica* Yabe and Hatai, 1938

They stated that *Cerithium ishiiianum*, referred to *Vicaryella* with a quotation mark, reserves some doubt and better specimens are needed to clarify the problem. Subsequently, Oyama and Saka (1944) in their paleontological studies on the fossil molluscs from Tsukiyoshi, Mizunomi City, Gifu Prefecture, stated that Yokoyama's *Cerithium ishiiianum* belongs to the named genus. They presented a key to the species of *Vicaryella* and added *Potamides ancisus* Yokoyama, 1929 to this genus.

*Vicaryella ancisa* (Yokoyama) was originally described by Yokoyama (1929) under the generic name of *Potamides* based on the specimens from the Tōgane formation in the environs of Hamada City, Shimane Prefecture. The same species was also reported from the type locality by Otuka (1937) under the generic name of *Cerithium*. *Batillaria atukoae* once described by Otuka (1934) from his "Lower Kadonosawa series" in Iwate Prefecture, was later considered by him (1937) to be a synonym of *ancisa* in his work on the further occurrence of this species from the lower part of the *Operculina* bed at Suketō, Syobara in Hiroshima Prefecture. He referred *ancisa* to the subgenus *Proclava*. Nomura (1935) reported on the occurrence of Otuka's *Batillaria atukoae* from the Miocene deposits in Shiogama City, Miyagi Prefecture. However, Otuka (1937) stated that Nomura's Shiogama specimen is probably conspecific with *ancisa*.

"*Proclava*" aff. *ishiiianum* (Yokoyama) described and figured by Otuka (1934) from his "Lower Kadonosawa series" at Nisatai, Fukuoka-machi, Ninohe-gun, Iwate Prefecture, is based upon a single specimen, apparently more or less worn. Otuka (op. cit.) considered this species to be distinguishable from Yokoyama's original specimen in the type of beaded cords. Subsequently, Nomura (1935) in his description of the molluscan fossils from the Miocene deposits near Shiogama City, Miyagi Prefecture, stated that the Shiogama specimens which consisted only of moulds differs from the "typical *ishiiianum* found in the Miocene of Mino by the revolving cords being finer and entirely beaded on the surface". He con-

sidered the Shiogama specimens to be conspecific with Otuka's "*Proclava*" aff. *ishiianum*, and thus proposed the name of *otukai* for the Nisatai specimen, with the statement that Otuka had already presented a detailed description.

However, whether the Shiogama specimen is identical with Otuka's specimen and different from the original *ishiianum* of Yokoyama (1926) is a problem, and also whether Otuka's aff. *ishiianum* should be compared with Yokoyama's *ishiianum* is also another matter to be considered. So far as the original specimens of Nomura (Saito Ho-on Kai Museum Cat. No. 6338) are concerned, it is evident that the Shiogama and Nisatai specimens are not conspecific, that the sculpture and development of the former specimens are identical with the topotype specimens of Yokoyama's *ishiianum* (IGPS coll. cat. no. 72569, N. Kitamura coll.), that the sculpture and development of the latter specimen except for the degree in strength are conspecific with Yabe and Hatai's *Vicaryella tyosenica*, and that, both generic and specific assignment of Otuka's specimen should be changed. Also since Nomura really based his works upon the Shiogama specimens, referring to Otuka's specimens and employing the description of Otuka for the Shiogama specimens, and considered them to be conspecific, it follows, from ontogenetic development, that the Shiogama specimens should be included into Yokoyama's original *ishiianum*, and Otuka's aff. *ishiianum* into Yabe and Hatai's *Vicaryella tyosenica*, as a geographic form for which the name of *otukai* may be retained.

As already stated by Yabe and Hatai, the type specimens of *Vicaryella tyosenica* (IGPS coll. cat. no. 62419) were collected by S. Endo from Nanseki, Myonchon (Meisen) District, North Korea and a referred specimen (IGPS coll. cat. no. 17715) was collected by the late S. Shimizu at Nisatai, Iwate Prefecture. The latter mentioned specimen is figured in this article and the sculpture of the whorls closely resemble those of Otuka's "*Proclava*" aff. *ishiianum* (Yokoyama). Therefore, the Nisatai specimen collected by Shimizu is easily referred to *Vicaryella tyosenica otukai* (Nomura).

In the Isohara district in the southern part of the Joban coal-field, the Kunugidaira formation unconformably rests on the Oligocene Shirasaka shale and is conformably covered by the Goyasu sandstone of the Yunagaya group. The Kunugidaira formation is an early deposit in the Yunagaya transgressive sea of Miocene age. From this deposits, at about 50 meters up-stream from the Futatsujima mineral-bath, Isohara-machi, Kitaibaragi City, several specimens of *Vicaryella* were discovered in association with *Vicarya*, *Ostrea* and *Trapezium*. The sculpture of the adult shell of the Kunugidaira specimens closely resemble the younger half of the shell of *V. tyosenica*. Thus, from phylogenetic development the Kunugidaira *Vicaryella* is an ancestral form in the stock of *tyosenica*.

The Kunugidaira formation, first discovered by the writer in 1951, was made public in a lecture presented on the occasion of the Tohoku Branch of the Geological Society of Japan, in June 6, 1953. However, the stratigraphic name was published by M. Eguchi and R. Shoji in 1953, in an article submitted to the Journal of the Geological Society of Japan. Subsequently, S. Hanzawa in his book "The Geology of Northeastern Japan" published from the Asakura Book Publishers, Tokyo in 1954. However, Eguchi and Shoji made no mention of Kamada's discovery or naming of the unit, but Hanzawa explained the

situation in detail. Unfortunately, Hanzawa extended the stratigraphic unit in a sense different from that of Kamada, by including the coal beds of the Iwaki formation in the Kadono district into the Kunugidaira. However, the coal beds included by Hanzawa into Kamada's Kunugidaira is Paleogene in age and separable from it by an unconformity. Therefore, the Kunugidaira of Hanzawa is not the same as that of Kamada in areas other than the type locality. For this reason it has become necessary to define the Kunugidaira formation.

The type locality of the Kunugidaira formation is the southern branch of the valley extending west of Futatsujima, Isohara-machi, Kitaibaragi City, from about 600 meters from Futatsujima westwards for about 800 meters along the southern valley. Here the Kunugidaira unconformably overlies the Shirasaka formation of the Paleogene Uchigo group, and its topmost is covered conformably by the basal part of the Goyasu formation of the Miocene Yunagaya group. The Kunugidaira consists of four parts of which the lower comprises ten meters of cobble to boulder conglomerate of well rounded slate, sandstone, hornfels, quartzite, chert and rarely with granitic rocks in a matrix of coarse sandstone. Derived Shirasaka siltstone in the form of pebbles occur in the lower 15 meters of the 32 meters thick lower part. Above this ten meters thick conglomerate comes coarse grained sandstone containing pebbles. The sandstone measures about 12 meters in thickness, and the superjacent ten meters thick medium grained, massive, well-sorted sandstone contains no pebbles, but drift woods are found. These three facies comprise the lower part of the Kunugidaira formation. The middle part of the formation, about 35 meters thick, consists of seven cycles each consisting of pebbly sandstone, medium sandstone, fine sandstone then upwards to siltstone. Each cycle measures about three to six meters in thickness. The medium grained sandstone parts of the respective cycles exhibit cross-lamination, and from the muddy facies there is found abundant carbonaceous matter. The top part of the fourth and fifth cycles are characterized in having pure white, fine compact tuff respectively of 0.8 and 1.0 meters thickness.

The upper part of the formation is about 18 meters thick and comprises from the lower, a two meters thick coarse grained sandstone by which it distinguishes the middle from the lower part; this is overlain with coarse to medium grained sandstone measuring about 16 meters in thickness. Two coal shales of 1.2 and 1.0 meters respectively are intercalated in the middle part, and a 20 centimeters thick coal layer occurs in the basal part of the lower coaly shale layer. From the sandstone immediately underlying the coaly shale and from the one overlying the coaly shale, there occur *Ostrea*, in the former the species accumulated in reef form and in the latter in bank form. *Vicarya* and *Vicaryella* occur only from below the oyster bank.

The uppermost part of the formation, which is about 11 meters thick, comprises in upward sequence, a one meter thick boulder conglomerate of the same kind of rocks as in the lower except for the addition of rhyolite, these are all well rounded and the matrix consists of coarse grained sandstone. Superposed is a five meters thick, massive coarse grained sandstone, overlain with a three meters thick boulder conglomerate as seen in the lower part of the uppermost part of the formation.

The uppermost part of the Kunugidaira formation is conformably overlain by the well water worn boulder conglomerate of the Goyasu formation. This conglomerate has its boulders aligned sporadically in a single row overlain with massive sandstone, and is thus easily distinguished from the uppermost part of the Kunugidaira. And where the Kunugidaira is developed, it is always conformably overlain with the sporadically arranged conglomerate of the Goyasu formation and is always unconformable with the next older units.

This is the lithofacies of the Kunugidaira formation at the type locality, as originally designated by the writer. Concerning the Kunugidaira formation, details as to its distribution, lateral change in lithofacies, and stratigraphical relationship with subjacent and superjacent rock units will be published in a separate article under the title of "The Kunugidaira Formation, its Distribution and Stratigraphical Relationship with Superjacent and Subjacent Rock Units."

From the Nakayama formation in the Kadono district in the Joban coal-field, *Vicaryella ishiiiana* is commonly found in association with *Vicarya yokoyamai*. There is no distinction of the Joban *ishiiiana* from the topotype of Tsukiyoshi, but if more detail comparisons are needed, it can be said that the Joban specimens have rather deeper suture than the Tsukiyoshi ones.

Recently, Masuda (1956) described *Vicaryella notoensis* Masuda from the Higashi-Innai formation at Machino-machi, Fugeshi-gun, Ishikawa Prefecture. *V. notoensis* is characterized by its subsutural cords consisting of constantly 23 or 24 tubercles on each whorls. The sculpture of this species closely resembles *ishiiiana*, but the former is distinguishable from the latter by the greater number of tubercles on the subustural cords.

**ON THE ASSOCIATED OCCURRENCE OF VICARYA AND VICARYELLA**

In the Joban coal-field, the *Vicarya*- and *Vicaryella*-bearing deposits are distributed in the Kadono and the Isohara districts. The stratigraphic positions of these fossil beds are as shown in the following, in descending order :

Group	Formation	Remarks
Taga		
~~~~~		
Shirado	Nakayama . . . . .	<i>Vicarya yokoyamai</i> and <i>Vicaryella ishiiiana</i> occur in the Kadono district.
	~~~~~	
	Kamenoo	
	Mizunoya . . . . .	Deep-water molluscs frequent.
Yunagaya	Goyasu	
	Kunugidaira . . . . .	<i>Vicarya yokoyamai</i> occurs in the Kadono and Isohara districts, <i>Vicaryella jobanica</i> n. sp. occurs in the Isohara district.
	~~~~~	
Uchigo	Shirasaka } . . . . .	These two formations are missing in the Kadono district.
(Oligocene)	Asagai }	
	Iwaki }	
	~~~~~	
	Basement complex	



From the Nakayama formation, which is here called the upper *Vicarya* bed, *Vicarya yokoyamai* occurs in the Kadono district. It is abundantly found from the massive tuffaceous siltstone at Kano, Miyamada, Tōno-machi, Iwaki-gun, Fukushima Prefecture (collected by H. Yabe, F. Ueda and Y. Kamada). In association with it *Vicaryella ishiiiana* is also found from the same siltstone. The lower *Vicarya* bed is in the Kunugidaira formation which is distributed at Shimokawa, Tabito-mura in the Kuroda basin and at Hironosaku, Kami-Yamada, Nakoso City, both in the Kadono district; in a valley west of Minamimae, Sekinami-machi and in environs of the Futatsujima mineral bath, Isohara-machi both in Kitaibaragi City, Ibaragi Prefecture in the Isohara district. The lower *Vicarya* bed yields *Vicaryella jobanica* n. sp. in the Isohara district.

Yabe and Hatai (1938) reported on the occurrence of referred specimens of *Vicarya yokoyamai* from Matsugaya, Kokozura, Iwaki-gun, Iwaki Province. These specimens may have been collected from the calcareous sandstone cropping out on the beach at Matsukawaiso, about 1.5 kilometers south of the Nakoso railroad station on the Joban Line and these fossil-bearing sandstone may belong to the upper *Vicarya* bed of the Nakayama formation.

Takeyama (1933) considered the geological age of *Vicarya* in Japan, and stated that *yokoyamai* represents the upper half of the Miocene and *callosa* the lower Miocene. According to his results, Kanehara (1937) stated that 1) if the Japanese *callosa* and *yokoyamai* are distinct species and belong to different geological ages, it may be interpreted that the early Miocene transgression brought *callosa* and the middle or late Miocene transgression brought *yokoyamai* to Japan, or 2) if two Japanese species are only local variations derived from one stock, it may be said that these two species do not represent different ages. He also emphasized that both species have not yet been found from two successive deposits and *callosa* is distributed in southwestern Japan while *yokoyamai* in the northeast.

All species of *Vicarya* were probably brackish water dwellers in the tidal zone of embayments influenced by warm thermal conditions, like some molluscs belonging to the family Potamididae. The *Vicarya*-bearing deposits may be rapidly covered by the successive accumulation of marine sediments by the transgressive seas and the regressive *Vicarya*-bearing deposits may be easily eroded away by subsequent denudation (Oyama, 1949, 1950). Therefore, it may be difficult to show the successive variation of the species of *Vicarya* in a single stratigraphic column or in a single sedimentary basin. However, the unique example in Japan that the two *Vicarya*-bearing deposits which are separated by thick pure marine sediments were discovered in one district such as the case above-mentioned in the Joban coal-field. Although the two *Vicarya* beds are separated by a considerable distance vertically, the species belong to *yokoyamai*. Different species of *Vicaryella* which are associated with *yokoyamai* in these beds may reflect the differences of their ages if not the ecological conditions.

In the Shiogama district in Shiogama City, Miyagi Prefecture, *Vicarya yokoyamai* and *Vicaryella ishiiiana* were found from the "Upper Shell-Beds (*Cultellus izumoensis* Zone)" of Nomura (1935) or in the middle part of the Ajiri formation of Hanzawa et al. (1953). This assemblage is related to that of the upper *Vicarya* beds in the Joban coal-

field and also in the Tsukiyoshi formation in the north of Mizunami City, Gifu Prefecture where these two characteristic species were first described by Yokoyama (1926).

K. Yoshida collected several specimens of *Vicarya* from the Kurosedani formation (Tsuda, 1953) of the Yatsuo group in the environs of Yatsuo-machi, Nei-gun, Toyama Prefecture; these are stored in the Institute of Geology and Paleontology, Tohoku University, Sendai. Most of them are determined as *V. yatuoensis*. But, a well-preserved specimen collected at Yunoki, Muromaki-mura, west of Yatsuo-machi, is indistinguishable from *V. callosa japonica* from the Tsuyama basin, Okayama Prefecture where the type specimens of the subspecies were collected. Moreover, a medium-sized shell from Kakehata, Kurosedani-mura, south of Yatsuo-machi may be referred to the varietal form of *yokoyamai* which was once named by Yabe and Hatai as *martini*. It is interesting that the three forms of *Vicarya* were found from the same geologic horizon in a single sedimentary basin, however, as already mentioned above, the specific relation between *yatuoensis* and *yokoyamai* is still a problem to be reserved until better specimens are obtained.

Besides the vicaryan shells in Yoshida's collection, several specimens of *Vicaryella notoensis* Masuda were found. *Vicaryella ishiihana* var. of Tsuda (1953) recorded from the Kurosedani formation, is probably identical with *notoensis*. Tsuda noticed the remarkable characters on the molluscan faunas in the Kakehata alternation member of the Kurosedani formation, namely that *Vicarya yokoyamai*, *Vicaryella ishiihana* var., *Anadara kakehataensis* Hatai and Nisiyama and *Cerithidea (Cerithideopsis) yatuoensis* Tsuda occur commonly in association with each other and also in abundance.

The molluscan fossils from the Higashi-Innai formation in Noto Peninsula, Ishikawa Prefecture, were studied by Masuda (1955, 1956) and an excellent specimen of *Vicarya callosa japonica* was figured and *Vicaryella notoensis* n. sp. was described. Masuda (1955) considered the Higashi-Innai fauna to be a correlative of the Yatsuo fauna from the Kurosedani formation just mentioned.

*Vicaryella notoensis* was also found in the collection of K. Masuda from the Orito formation in Sado Island of Niigata Prefecture. Kaseno (1956) figured this species from the Kunimi formation along the coast of Ayukawa in Fukui Prefecture. Kaseno also figured and described a vicaryan shell which was collected from the Ayukawa coast under the name of *V. yokoyamai* Takeyama.

Summarizing the above accounts of the genera *Vicarya* and *Vicaryella* from the various localities in Japan, the following features are recognized.

1) From the Tsukiyoshi formation, the upper *Vicarya* bed in the Joban coal-field and Shiogama, it is found that *Vicarya yokoyamai* and *Vicaryella ishiihana* occur together. *Vicarya yokoyamai* and *Vicaryella bacula* reported by Ikebe (1934) from the Ayukawa formation in Shiga Prefecture form an assemblage which is considered to be inclusive into the aforementioned one. From the lower *Vicarya* bed in the Joban coal-field *Vicarya yokoyamai* occurs in association with *Vicaryella jobanica* Kamada n. sp., a species which has not been reported from elsewhere in Japan.

2) *Vicarya callosa japonica* is distributed in southwest Japan, being known from Okayama and Hiroshima Prefectures and from the Kukinaga formation in Tanegashima,

Kagoshima Prefecture. In the Chugoku District, *Vicaryella ancisa* has been reported from the Shobara Miocene in Hiroshima Prefecture where it occurs in association with *Vicarya callosa japonica*. Our knowledge on the distribution of *Vicaryella* from the said district is meagre and reports bearing on the genus are few.

3) Although there remains more room for study of the *Vicarya* from Niigata (Sado Island), Toyama and Ishikawa Prefectures in the Hokuriku District, the occurrence of *Vicarya yatuoensis* is important. *Vicaryella notoensis* seems to be restricted in distribution to the said district. It is considered that detail examination of the Yatsuo fauna will clarify the relation existing between *Vicarya yokoyamai* and *V. yatuoensis*, and the relation of those species to *V. callosa japonica*.

4) From additional material of the genus *Vicarya* from Otuka's "Lower Kadonosawa series" it has become evident that his *Vicarya* belongs to *V. yatuoensis*. Also it has been verified that the *Vicaryella tyosenica* originally from the Meisen Miocene of North Korea also occurs in association with the said *Vicarya*. *Batillaria atukoae* was first described by Otuka from his "Lower Kanodosawa series" and subsequently referred by him to *Cerithium ancisum* (Yokoyama). However, sufficient material from the type locality of the Kadonosawa area not being at hand, the writer reserves further discussion.

#### PALEOGENE SPECIES OF VICARYA FROM KYUSHU

Fortunately two specimens of *Vicarya* were obtained from the second and third coal-seams of the Hashima formation, about eight meters above its base and about 60 meters below the middle Eocene Upper *Orthaulax* zone of T. Nagao (1928).

According to Woodring (1928), *Orthaulax* ranges from middle Oligocene to late lower Miocene and its distribution is restricted to tropical America and Florida, and the Japanese *Orthaulax japonicus* Nagao (Jap. Jour. Geol. Geogr., Vol. 3, no. 1, pp. 13-18, pl. 1, 1924) from the coal-fields of Kyushu is probably more allied to *Pseudoliva* than to *Orthaulax*. Fortunately, Dr. Myra Keen sent a plastotype of *Pseudoliva plumbea* (Dillwyn), now living in West Africa, to Dr. K. Hatai of the Tohoku University. Comparing this Recent *Pseudoliva* with Nagao's *Orthaulax*, the writer found that Woodring's opinion is quite reasonable. Discussions on the Japanese "*Orthaulax*" *japonicus* Nagao will be given in another article.

The Hashima formation conformably overlies the subjacent Futagojima formation, which succeeds the Koyagi formation, which is unconformably superposed on the basement of schistose rocks. Upwards the Hashima is conformably overlain with the Okinoshima formation, which is succeeded by the Iojima formation. The middle Eocene age of the Hashima formation, according to T. Nagao (1928) is determined by the underlying Futagojima formation containing plants equivalent with the Green River formation of North America, and its correlative the Shiratake sandstone formation of Amakusa Island, well known for its yield of *Nummulites amakusaensis* and *N. amakusaensis subamakusaensis* of early Eocene age. The Okinoshima formation, which conformably succeeds the Hashima is late-middle Eocene from the occurrence of *Athleta* and large *Venericardia*, while the late Eocene age of the next younger Iōjima formation is determined by him from the fossil molluscs. Therefore, it is evident that the *Vicarya*-bearing Hashima formation is middle Eocene in age,

but to what part it belongs may be reserved for another opportunity.

The specimens from the Koyagi coal-mine, here called the Koyagi specimens compared with the Miocene species of *Vicarya*, are smaller in adult stage, provided with well developed subsutural spinous tubercles, deep sinuous growth lines on inner lip, the outer lip although thin is provided with a callous deposit, and the whorl sculpture is that of *Vicarya*. There are about ten constant subsutural tubercles to each whorl. From the said features the present specimens belong to the same stock as *Vicarya callosa* and are distinguishable from both it and *Vicarya eocenica* Cox from the Indian Eocene.

S. Yehara (1921) discovered some vicaryid like specimens from a sandstone developed on the flanks of Mt. Jiromaru in Amakusa-Shimoshima, Kumamoto Prefecture, and thus claimed the age of the sediments to be Tertiary. However, T. Nagao (1922) stated that the fossils recorded by S. Yehara belong either to the genera *Turritella* or *Terebra*, and that the sandstone which yield Yehara's fossils is referable to the Miroku group (of Nagao), and that its age cannot be assigned to the age indicated by *Vicarya callosa*. Although Yehara's original specimens are inaccessible, it is thought quite probable that they may be similar to the *Vicarya* specimens derived from the Hashima formation of the Takashima coal-field.

The specimens (IGPS coll. cat. no. 36083) collected by K. Sawatari from the Namazuta coal-mine in Kaho-gun, Fukuoka Prefecture is labelled as *Cerithium* (*Vicarya*?) in the collection of the Institute of Geology and Paleontology, Tohoku University, and although it is badly preserved, its whorl sculpture quite agrees with the Koyagi specimens. Those specimens are probably from Nagao's Namazuta fossil beds of the Nogata group exposed in the southern part of the Chikuho coal-field.

Recently, a vicaryan specimen collected from a fossiliferous hard, medium grained sandstone by K. Sugai of the Geological Survey of Japan, during his geological survey near Hokonota, Kikuchi-machi, Kikuchi-gun, Kumamoto Prefecture was forwarded to A. Mizuno who sent a plastotype to the writer for study. This specimen is more or less worn, preserves three granular rows, the uppermost subsutural band of the younger whorls is provided with beads which change into tubercles in the later whorls. A faint striae occurs between the upper two granulated rows, and this features resembles more closely the Indian Eocene *Vicarya eocenica* Cox than the Koyagi specimens, and thus may be referred to *Vicarya sensu stricto*. Since the associated fauna of the vicaryid is now being studied by A. Mizuno, its details are expected to be published shortly.

## DESCRIPTION

Genus *Vicarya* D' Archiac and Haime, 1854

Type, *Nerinea* ? *verneuili* D' Archiac, 1850 (by original designation), Miocene, Western India.

Subgenus *Shoshiroia* Kamada, n. subgen.

Type, *Vicarya callosa* Jenkins, 1864, Miocene of Java.

Shell thick, turreted, elongately conical. Whorls almost cylindrical or truncated conic. Subsutural band with nine or ten strong tubercles, nearly constant on all whorls. Tubercles gradually becoming obsolete in upper whorls. Two or three spiral striae below

tuberclous band sometimes with beads.

This new subgenus resembles *Vicarya* s. str. in many respects, but is distinguishable therefrom by the subsutural tubercles being invariably nine or ten on all whorls. *Vicarya* s.s.) *verneuili* has lower whorls with eight subsutural tubercles, which change into a larger number of small beads of its younger whorls.

*Vicarya* (s.s.) includes *V. verneuili* (D' Archiac, 1850), *V. eocenica* Cox, 1931, *V. yokoyamai* Takeyama, 1933 and *V. yatuoensis* Yabe and Hatai, 1938, while *Shoshiroia* includes such species or subspecies as *V. callosa* Jenkins, 1864, *V. callosa japonica* Yabe and Hatai, 1938, and *V. yabei* Kamada, n. sp.,

*Vicarya* (*Shoshiroia*) *yabei* Kamada, n. sp.

Pl. 30, figs. 4, 5.

Shell turreted, elongately conical, medium-sized for genus, but of similar proportions, apical angle about  $25^\circ$ . Whorls almost flat, nearly straightly inclined when neglecting tubercles. Suture linear, indistinct but usually with elevated narrow spiral cord immediately behind. Whorls ornamented by two distinct spiral ridges, upper or subsutural ridge with about ten bluntly pointed compressed, tubercles, lower granular. Two narrow, faint spiral striae connected with lower base of row of subsutural tubercles on younger whorls and two additional spiral striae between the upper row of subsutural tubercles and lower beaded ridge on older. Growth lines visible only near aperture, sigmoidal, deeply incurved backwards, on two interstitial spiral striae and probably corresponding to deep sinus of outer lip. Aperture destroyed. Inner lip covered by rather thin callous deposits. Dimensions :

	Diameter of last whorl	Height
Holotype	25.0 mm.	38.5 mm. +
Paratype	26.0 mm.	39.0 mm. +

Remarks : Although, the Koyagi specimens preserve only the last four to four and half whorls with the aperture destroyed, judging from the preserved about 40 mm. shell height and apical angle of nearly  $25^\circ$ , it is assumed that the original shell attained nearly 60 mm. in height. In this respect the type specimen is of a small type, being much smaller than *callosa* of 84 mm., *verneuili* of 82 mm., *yokoyamai* of about 97 mm. and *callosa japonica* of 70–80 mm. +. The present new species is easily distinguishable from species of *Vicarya* (s.s.), such as *verneuili* and *yokoyamai*, by having a constant number of subsutural tubercles on each whorls. From *V. callosa* and *V. callosa japonica*, this form differs by having smaller size and whorls bearing only one primary beaded cord below the row of subsutural tubercles.

The present specimens were derived from a shale intercalated between two workable coal seams in the Hashima formation. Such a mode of occurrence has been reported for *Vicarya* in the Philippine Islands by Smith (1913). It is also known that *Vicarya* is often associated with coal deposits and therefore, this affords data in the interpretations of the sedimentary environment of the genus and also of coal deposits.

Type locality and horizon : In the pit of the Koyagi coal-mine, Koyagi-mura, Nishi-Sonogigun, Nagasaki Prefecture, Kyushu. Middle Eocene Hashima formation.

Repository: In the collection of the Department of Geology, Nagasaki University, Nagasaki City.

Genus *Vicaryella* Yabe and Hatai, 1938

Type, *Vicaryella tyosencia* Yabe and Hatai, 1938 (by original designation). Miocene, Myonchon (Meisen), North Korea.

*Vicaryella jobanica* Kamada, n. sp.

Pl. 31, figs. 12, 13.

Shell of moderate size, narrowly and highly turreted, 16 whorls preserved, (first fractured). Whorls straightly inclined, ornamented with spiral tuberculous and non-tuberculous threads and striae, former stronger than latter; whorls separated from one another by narrow and rather deep sutures. Spiral sculpture changing with growth.

First three preserved whorls provided with two rows of independent, incipient tubercles connected with longitudinal threads. Fourth whorl with an additional spiral striae between aforementioned two rows of tubercles, becoming granular in fifth whorl, a subsutural weak band below lower row of tubercles. Longitudinal thread connecting tubercles become obscure from fourth whorl to body whorls. Sixth and seventh whorls with upper and lower rows of tubercles becoming stronger, another spiral thread added between uppermost and middle tuberculous rows, lowest subsutural band continues with about equal strength. Eighth whorl with two primary rows of tubercles, becoming stronger and a weak spirial thread is added between uppermost row of tubercles and suture; spiral thread extends to body whorl, its number doubled from 14th whorl and two continue to body whorl. Newly added spiral thread at first, sinuous, parallel with contour of tubercles. Additional interstitial thread appearing on ninth whorl between the lowest row of tubercles and middle granular row; thread becomes granular on 12th to 14th whorls, again becoming smooth therefrom to body whorl. Sculpture on 15th and last whorls consisting of from uppermost part, of two weak spiral threads, one row of very strong subsutural tubercles, one faint striae, one narrow spiral thread, one faint striae, one row of tubercles, and one band-like thread just above suture, making a total of eight spirals, two of which are well tuberculated. Base of last whorl with six or seven spiral cords, much narrower than their broad interspaces. Aperture obliquely pyriform, canal recurved and open. Inner lip covered with thick callous. Columella nearly straight with a single median fold, which extends spirally up into younger whorls. Apical angle slightly exceeding  $20^{\circ}$ . Maximum diameter of shell 13.2 mm., height of preserved whorls 36.4 mm. (holotype). Growth lines best observed in 14th and 15th whorls, broadly concave to left, very weak and unobservable on whorls younger than 14th.

Remarks: This new species resembles *Vicaryella tyosencia* Yabe and Hatai in many respects, but can be distinguished therefrom by the small shell attained in the adult stage, less solid aspect, lack of beaded cord immediately above the suture and the spinuous tubercles of the subsutural bands of *tyosencia* are stronger and higher than this new species.

The adult sculpture of *jobanica* is closely related to the sculpture exhibited by the younger whorls of *tyosenica*, but not to its last two or three whorls which show more advanced features. From the characteristics distinguishing the Korean and Joban specimens and their similarity in development of the younger whorls, it is thought that *tyosenica* was derived from *jobanica*. Yabe and Hatai (1938, p. 168) once expressed the view that *Vicaryella nipponica* Yabe and Hatai from Okayama Prefecture may be an evolutionary descendant or an offspring of the same stock as *tyosenica*. From ontogenetical characteristics, the writer is inclined to believe that the trend of *jobanica-tyosenica-nipponica* represents an evolutionary series, and that the present new species may be the oldest of the line.

Holotype : -IGPS coll. cat. no. 72957. Y. Kamada coll.

Locality and horizon : About 50 mm. upstream of Futatsujima mineral bath, Isohara-machi, Kitaibaragi City, Ibaragi Prefecture. Upper Part of the Kunugidaira formation, Early Miocene.

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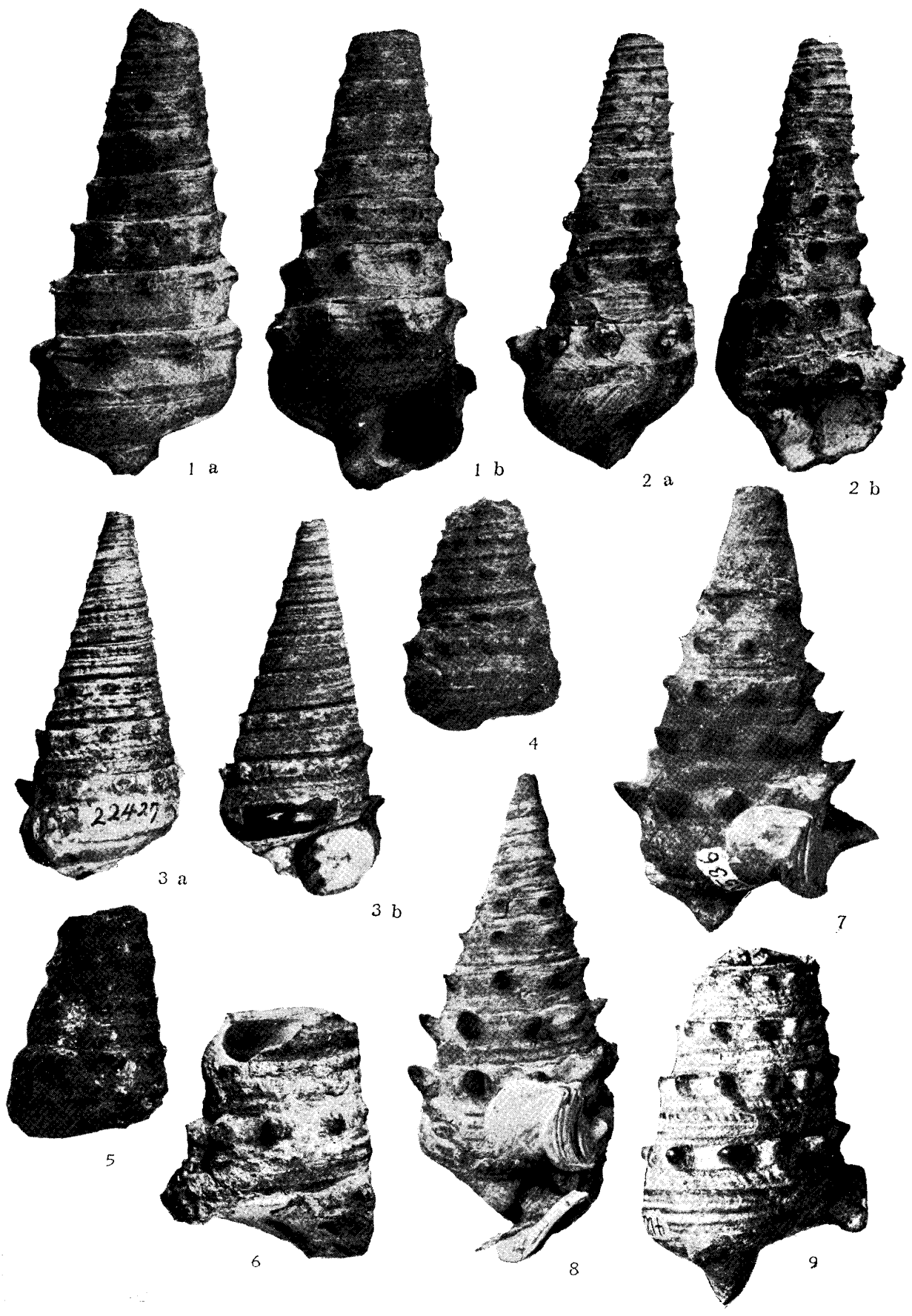


### EXPLANATION TO PLATE 30

- Figs. 1a, 1b-*Vicarya (Shoshiroia) callosa* Jenkins, IGPS\* coll. cat. no. 37156. Loc. Njalindoeng, Java. Coll. Geol surv. Java.
- Figs. 2a, 2b-*Vicarya (Shoshiroia) callosa japonica* Yabe and Hatai, IGPS coll. cat. no. 73266. Loc. Toyota coal-mine, Taira, Toyota-mura, Katta-gun, Okayama Prefecture. Coll. K. Suyari.
- Figs. 3a, 3b-*Vicarya yokoyamai* Takeyama, IGPS. coll. cat. no. 22427. Loc. Shimizu-Matsubora, Toki-gun, Mizunami City, Gifu Prefecture. Coll. Unknown.
- Fig. 4-*Vicarya (Shoshiroia) yabei* Kamada, n. sp., Holotype. Loc. Koyagi coal-mine, Koyagi-mura, Nishi-Sonogi-gun, Nagasaki Prefecture. Coll. Koyagi Coal-mining Co.
- Fig. 5-*Vicarya (Shoshiroia) yabei* Kamada, n. sp., Paratype. Loc. & Coll. Same as Fig. 4.
- Fig. 6-*Vicarya yatuoensis* Yabe and Hatai, DGS\*\* No. 3845. 3845. Loc. Yuda, Kintaichimura, Ninohe-gun, Iwater Prefecture. Coll. K. Hatai and K. Masuda.
- Fig. 7-*Vicarya (Shoshiroia) callosa japonica* Yabe and Hatai, Paratype, IGPS coll. cat. no. 58536. Loc. Dainichizaka, Uetsuki-cho, Uetsuki-mura, Katta-gun, Okayama Prefecture. Coll. I. Saga.
- Fig. 8-*Vicarya (Shoshiroia) callosa japonica* Yabe and Hatai, Topotype, IGPS Coll. cat. no. 78060. Loc. Same as Fig. 7. Coll. S. Hanzawa and K. Suyari.
- Fig. 9-*Vicarya yatuoensis* Yabe and Hatai, Holotype, IGPS coll. cat. no. 41228. Loc. Kakehata, Kurosedani-mura, Nei-gun, Toyama Prefecture. Coll. S. Imamura.  
(All figures in natural size)

\* IGPS: abbreviation for Institute of Geology and Paleontology, Tohoku University, Sendai.

\*\* DGS: abbreviation for Department of Geology, College of Education, Tohoku University, Sendai.



### EXPLANATION TO PLATE 31

- Figs. 1a, 1b-*Vicaryella tyosenica* Yabe and Hatai, Holotype, IGPS coll. cat. no. 62419. Loc. Nanseki, Meisen (Myonchon) District, North Korea. Coll. S. Endo.
- Figs. 2a, 2b-*Vicarya (Shoshiroia) callosa japonica* Yabe and Hatai, IGPS coll. cat. no. 74449. Loc. Tokunari, Machinomachi, Fugehsi-gun, Ishikawa Prefecture. Coll. K. Masuda.
- Figs. 3a, 3b-*Vicaryella tyosenica otukai* (Nomura), Topotype, IGPS coll. cat. no. 17715. Loc. Nisatai, Nisatai-mura, Ninohe-gun, Iwate Prefecture. Coll. S. Shimizu.
- Figs. 4a, 4b-*Vicaryella ishiiiana* (Yokoyama), IGPS coll. cat. no. 72569. Loc. Shimizu-Matsubora, Toki-machi, Mizumani City, Gifu Prefecture. Coll. N. Kitamura.
- Figs. 5a, 5b-*Vicaryella notoensis* Masuda, Holotype, DGS Reg. No. 1410. Loc. & Coll. Same as Fig. 2.
- Figs. 6, 7-*Vicarya yokoyamai* Takeyama, Loc. Kano, Miyamada, Tono-machi, Iwaki-gun, Fukushima Prefecture. Coll. H. Yabe, F. Ueda and Y. Kamada.
- Figs. 8, 9-*Vicaryella ishiiiana* (Yokoyama). Loc. & Coll. Same as above.
- Fig. 10-*Vicarya yokoyamai* Takeyama, IGPS coll. cat. no. 76148. Loc. Upstream of Futatsujima mineral bath, Isohara-machi, Kitaibaragi City, Ibaragi Prefecture. Coll. M. Sogabe.
- Fig. 11-*Vicaryella jobanica* Kamada, n. sp., Holotype, IGPS coll. cat. no. 72957. Loc. Same as Fig. 10, Coll. Y. Kamada.
- Figs. 12, 13-*Vicaryella jobanica* Kamada, n. sp., Paratypes (Fig. 13,  $\times 2$ ). Loc. & Coll. Same as above.
- (All figures in natural size, unless otherwise stated)

