

Revision of Genus *Vicarya* (Gastropoda) from the Indo-Pacific Region

by
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ABSTRACT

The well-known fossil species of genus *Vicarya* from the Indo-Pacific region are revised from the ontogenetic standpoint of view. The known six species of Miocene *Vicarya* and three species of Eocene *Vicarya* are revised. The writer pointed out that most differences of the surface ornamentation and the strength of tubercles among the known Miocene species are explained by the differences of the state of preservation after buried, though most previous workers have been accepted as the result of the ontogenetic differences due to the geographic isolation.

The differences between the Japanese species of genus *Vicarya* and *V. verneuili* (d'Archiac) as well as *V. callosa* Jenkins from Java and Philippines are merely the strength of callous deposits of the inner lip.

Miocene species of *V. callosa* and *V. formosa* Oostingh are lumped to *V. verneuili*, and the Japanese species of *V. japonica* and *V. yatsuensis* are lumped to *V. yokoyamai*. Eocene species seem to be transferred to genus *Vicaryella* Yabe and Hatai, 1938, though *Vicarya* from Miyakojima in Okinawa is still remaining as the future problem.

KEY WORDS

Revision, *Vicarya*, Indo-Pacific, Region

Introduction

Genus *Vicarya* was established by d'Archiac and M. Haime (1854) based on *Nerinea? verneuili* d'Archiac (1851 not in 1850), collected from the gray limestone with iron hydroxide grains of the topmost bed of Gaj Series (Miocene) in the Hala Range, Sind, Soutwestern Pakistan.

Since genus *Vicarya* established by d'Archiac and Heime, many species of the genus were discriminated by the previous authors from the Indo-Pacific region as J. M. Jenkins (1864), K. Martin (1880, 1896, 1899, 1914 and 1931), W. D. Smith (1906), M. Cossmann (1909 and 1912), M. Yokoyama (1926), L. R. Cox (1931), T. Takeyama (1933), C. H. Oostingh (1935), H. Yabe and K. Hatai (1938), N. Ikebe (1939 and 1952), W. Wentz (1940), K. Oyama and K. Saka (1944), K. Oyama (1950), K. Kamada (1960 and 1967), S. Uozumi and T. Fujie (1966),

S. Hayasaka (1969), M. Goto (1971), J. Itoigawa et al. (1974 and 1982), W. P. Popenoe and R. M. Kleimpell (1978), K. Masuda (1980), S. Kanno et al. (1980), W. Hashimoto et al. (1983), and T. Kotaka and H. Noda (1982).

According to the previous workers' results, the following species have been treated as valid species:

Miocene species:

Vicarya verneuili (d' Archiac, 1851)

V. callosa Jenkins, 1864

V. yokoyamai Takeyama, 1933

V. japonica Yabe and Hatai, 1938

V. yatuoensis Yabe and Hatai, 1938

V. formosa Oostingh, 1935

Eocene species:

Vicarya eocenica Cox, 1931

V. jogjacartensis (Martin, 1914)

V. yabei Kamada, 1967

The genus *Vicarya* has been paid attention by the stratigraphers and paleontologists with keen interests, because all discriminated species of the genus are accepted as the dwellers of the warm shallow brackish-water of estuaries, particularly closed inlets or in lagoons, and the genus is restricted in Miocene and Eocene ages only.

The present writer has been engaged in the geological field work in Southeast Asian countries as Taiwan, Philippines, Indonesia including Japan from the standpoint of biostratigraphy of Tertiary mollusks. On the course of his study, the writer revised the known species of genus *Vicarya* including the "type specimens" of the genus.

According to his results, it becomes clear that there are much confusion for the identification among the respective species and generic diagnosis of the genus.

The purpose of the present paper is to revise the generic diagnosis of the genus *Vicarya* and specific discrimination of the known species in the Indo-Pacific region.

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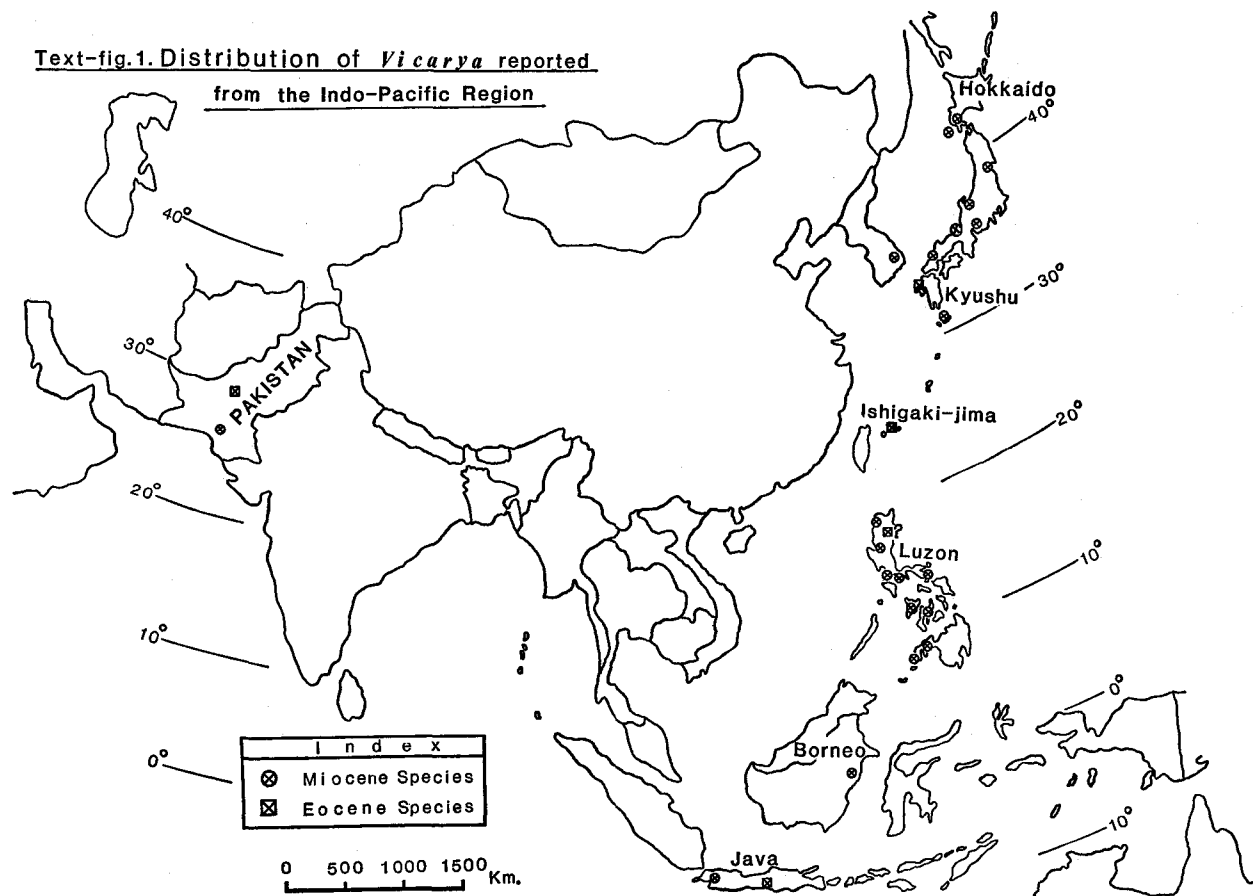


Fig. 1.

pine National Oil Corporation, for the cooperative field work of the northern Luzon in the Philippines. The writer wishes to express his gratitude to Prof. Shoji Fujii of Toyama University, Prof. Kazuo Okamoto and Mr. Eiji Taguchi of Hiroshima University, Mr. Hiroya Kaneda, Nissei High School, Maizuru in Kyoto Prefecture, for their offering the *Vicarya* specimens. Thanks are also due to Dr. Junji Itoigawa of Nagoya University, Mr. Yoshitsugu Okumura of the Mizunami Fossil Museum, for the permission of access to the preserved specimens of *Vicarya* at the Museum. Much of this work are suggested by Profs. Tamio Kotaka, Tohoku University, Karyu Tsuda of Niigata University, Hiroshi Noda of the University of Tsukuba, Masatoshi Tanai of Hokkaido University, and Dr. Kuniteru Matsumaru, Saitama University, for the valuable advice on the course of his study.

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Generic diagnosis of genus *Vicarya* d'Archiac and Haime

Genus *Vicarya* was established by d'Archiac and Haime in 1854 based on *Nerinea? verneuili* d'Archiac which described originally in 1851 (not 1850) from the topmost bed of Gaj Series in Sind, southern Pakistan. Cossmann (1909) treated it under the subgenus *Morgania* Cossmann, 1906. However, after the investigation of Indonesian *Vicarya*, he (1912) concluded that subgenus *Vicarya* could not include to genus *Morgania* and ranked up it to the genus and it transferred under the subfamily Fauninae because of no canal in *Vicarya*.

K. Martin (1917) revised the known species of genus *Vicarya*, and he emphasized the similarity of *V. verneuili* and *V. callosa* Jenkins from Java in Indonesia. He (1917) recognized the variation of sculptures of *Vicarya* based on the specimens from Borneo, Philippine, and Java islands. Moreover, he pointed out that *Vicarya* provides short anterior canal like as *Telescopium*. So, he treated the genus under Potamidinae.

On the occasion of revision of Japanese *Vicarya* by Takeyama (1933), he treated it under subfamily Potaminae, because of the presence of short anterior canal and columellar fold. W. Wenz (1940) also treated this genus under subfamily Potaminae and he includes these subgenera as *Vicarya* s. str. and *Morgania* Cossmann, 1906, under the genus *Vicarya*.

H. Yabe and K. Hatai (1938) revised the Japanese species of *Vicarya* and they recognized followings as valid species, namely,

V. callosa yokoyamai Takeyama

V. callosa martini Yabe and Hatai

V. callosa japonica Yabe and Hatai

V. yatuoensis Yabe and Hatai

They also proposed a new genus *Vicaryella* which is somewhat similar to genus *Vicarya*, but it distinguished therefrom by having double sinus in the outer lip, strong columellar fold, denticles of the inside of outer lip, and more precise sculpture on the whorls.

Y. Kamada (1960) proposed a new subgenus *Shoshiroia* based on *V. callosa* Jenkins, 1864, and this subgenus includes *V. callosa*, *V. callosa japonica* Yabe and Hatai, 1938, and *V. yabei* Kamada, 1960. This subgenus distinguished from *Vicarya* s. str. by having invariably nine or ten tubercles on all whorls, while it varies from a large number of small beads to eight tubercles with their growth stages in *Vicarya* s. str. The subgenus *Vicarya* s. str. includes *V. verneuili*, *V. eocenica* Cox, 1931, *V. yokoyamai*, and *V. yatuensis* Yabe and Hatai.

Y. Kamada (1960) also reported the occurrence of Eocene *Vicarya yabei* from the Hashima Formation (Middle Eocene) in northwestern Kyushu. However, revising the original diagnosis of the genus, the following characteristics of the genus should be paid attention for the classification of the genus:

- 1) Shell is turriculated or conoid, having 12 or 14 flattened whorls which are separated by one simple almost indistinct linear suture.
- 2) The first whorl is ornamented with a row of closed pearls which are bigger, more distant in the following whorls, and are becoming conical or pyramidal tubercles; the last whorl provides more projecting 8 tubercles.
- 3) There is a second row of smaller pearls under the first one on the sixth or seventh whorls, and it is always present until the last whorl.
- 4) A third row adjacent to the second is a little more projecting and it limits the upper (abapical side of concave ribbon, slit band), which shows clearly growth lines concave backward.
- 5) The base of the last whorl is slightly convex, no umbilicus, showing 3 or 4 little granulated threads which crossed by obliquely curved growth lines.
- 6) Aperture is small, rounded and subcanaliculated at the both ends of upper and base, with thin outer lip curved forward, showing a deep sinus in the middle. Inner lip is covered by one big and thick callus which spreads on the major part of the base and joins the extremity of the columella to 2 big rounded tubercles. Of which one is located in the axis plane and the other is against the ribbon (slit band) of the preceding whorl.
- 7) There is no fold on columella.

Although, d'Archiac and Haime described that there is no fold on columella, but their original figure in 1854, plate 28, fig. 4b shows the vertical cross section of the columella which shows faint columellar fold.

Type specimens of genus *Vicarya*

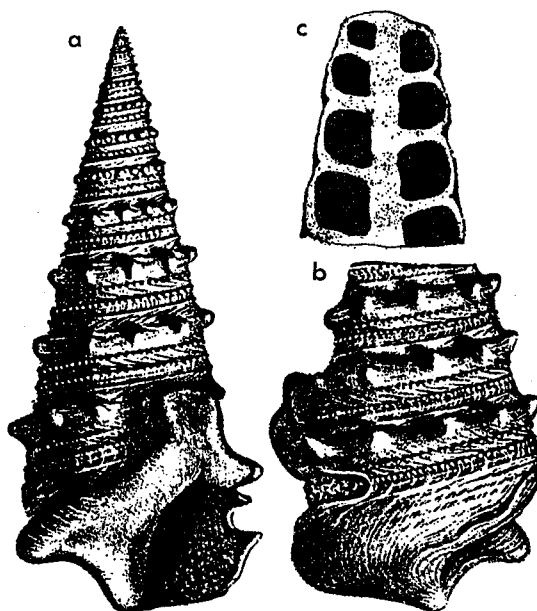
d'Archiac (1851) reported the Nummulitique fauna, in which he described *Nerinea? verneuili* collected from the gray limestone with iron hydroxide grains of the topmost bed of Gaj Series (Miocene) in Hala Range, Sind, southern Pakistan. Although he reported without any plate and figure, his original description is as follow: "We temporarily place this very interesting conoid shell in the genus *Nerinea*, because it shows only one deep sinus at the left side, along the suture and a very thick callosity which covers right side; we don't see any fold and axis is not perforated. The position of the sinus, the callus of the base and the lack of canal make it also far from *Murchisonia*" (translated by D. M. Petitbois).

According to C. P. Nuttall of British Museum, the type specimens of the genus were removed from the Geological Society of London to the British Museum in 1911. He wrote the writer the following letter "The figures of many of species are not particularly accurate. In some cases the specific characters are not clearly shown and

in most cases it is difficult to identify the actual specimens as the drawings are partly reconstructions and traces of damage are not shown."

Three syntypes of *V. verneuili* are preserved in the British Museum, which registered as Reg. nos. GG24195-7. The illustrations 4a-b by Archiac and Haime (1854) appear to be based on BMPE Reg. no. GG24195 (ex. Geological Society of London, no. 9802). The callus pat on the inner lip is slightly reminiscent of GG24196 (ex. Geol. Soc. London, no. 9803). "The spire is illustrated as being complete, but is missing from both specimens. We will never know whether this is because of subsequent damage or because the drawing is a reconstruction" (by P. C. Nuttall's letter).

W. Wenz (1940) introduced the holotype of *Vicarya verneuili* (d'Archiac) which was originally illustrated by d'Archiac and Haime (1854, pl. 28, figs. 4 and 4a). However, no one knows such illustrated specimen preserved in the British Museum at the present. Possibly, this reason is whether this is because of subsequent damage or because the



Text-figs. 2. *Vicarya verneuili* (d'Archiac, 1851)

Reproduced from d'Archiac and Haime (1854);

figs. a-b were introduced as "holotype" by W. Wenz (1940)

drawing is a reconstruction. At any rate, no one identify such illustrated specimen among the preserved type specimens in the Museum. Accordingly, the holotype introduced by Wenz (1940) cannot accept, because there are more than one specimen in the type-series, and there is no specimen identified as the Wenz's holotype among the type-series.

The writer designates the specimen registered no. 9802 as the lectotype of the genus. This specimen was originally registered by the Geological Society of London as no. 9802, but reregistered by the British Museum as GG24195 in 1984 (pl. I, figs. 1a-b). The other specimens among the three are designated as paratype which reregistered by the Museum as GG24196 and GG24197.

The development of tubercles on the subsutural band of the type specimens of genus *Vicarya* is shown in the following table as well as Plate I, figures 1a-b (by P. C. Nuttall):

Whorls* Specimens	bw	pw	3rd w.	4th w.	5th w.	6th w.
G G 24195	T (8+1**)	T (9)	T (8)	db (31)	db (34)	db (36)
G G 24196	T (10+1**)	T (9)	T (8)	—	—	—

*The respective whorl is counted from the base.

**Showing the estimated number of tubercles hidden by the callus surrounding posterior notch of the aperture. Numbers in bracket show the number of tubercles or beads on the respective whorl.

T... tubercles; db... distinct beads; bw... body whorl; pw... penultimate whorl

Type specimens of *Vicarya callosa* Jenkins

Vicarya callosa was originally reported by Jenkins as *Vicarya? callosa* in 1864 (not 1863,) collected by M. de Groot (ca. 1863) from Mt. Séla in Java, Indonesia. This species closely similar to *V. verneuili* (d'Archiac, 1851), but Jenkins stated that "differences merely those of detail in the ornamentation, and of form and size in the callosity" (Jenkins, 1864, p. 58). Moreover, he described as follow: "M. de Groot's collection contains two specimens of this species, but, as both of them have lost their epidermis and much of the outer shelly layer, and are moreover in a condition very much resembling chalk, and consequently very fragile, they do not exhibit the ornamentation so well as could be wished; it is, therefore, very probable that better-preserved specimens would render necessary some alternation in the above description" (Jenkins, 1864, p. 57-58).

Two Java specimens of *V. callosa* have still preserved in the British Museum, of which one figured by Jenkins in 1864 as registered BM Reg. no. G. 76775 and the other non-figured one G. 76776 (Pl. II, figs. 1, 2).

In 1976, the writer examined the topotype specimens preserved in the Museum of the Geological Survey of Indonesia in Bandung, where two topotype specimens are preserved. Of which one is almost complete one with about 16 whorls having complete

aperture as well as thick callus in the inner lip. However, the callus of this specimen does not extend over the subsutural tubercular band, but just reaches to the row of tubercles of the body whorl (pl II, fig. 7).

The surface ornamentation of both topotypes are so eroded that hardly observed their beadal threads, which are scarcely represented by the indistinct two rows of spiral ridges. The number* of tubercles of these specimens is estimated as follow:

Whorls**	bw	pw	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
1	9	9	9	8	n	n	n	r	r	r	r	r
2	9	9	9	8	n	n	n	r	r	r	r	r

*These specimens are fixed in the plastic materials, so that it could not count their exact number of tubercles and nodes of the hidden side of respective whorl.

**Whorls are counted from the base. bw... body whorl; pw... penultimate whorl; n... nodes; r... ridge

Vicarya formosa Oostingh, 1935

C. H. Oostingh (1935, p. 81, figs. 2a-b) reported a peculiar form of *Vicarya*, *V. formosa*, (Pl, VI, figs. 12a-b), from the Mittel-Bodjongmanik Formation in Tjimaeli of west Java. This species is characterized by having the subsutural band which provides only beadal thread or a row of nodes, and without any tubercles, though it reaches to about 76 mm in its height of shell.

Judging from the original description and figures, the patterns of development of spiral beads on the subsutural band and the surface ornamentation of the respective whorl seem to indicate that this species possibly belongs to genus *Vicaryella* Yaba and Hatai, 1938.

According to the Stratigraphi Lexicon of Indonesia (1957), Bodjongmanik Formation yields the following molluscan fossils: *Vicarya callosa* Jenkins, *Siphocypraea caput-vipere* (Martin), *Paphia neglecta* Martin, *Apolymenis grimensi elongata* (Haanstra and Spiker), *Cultellus delatatus* Martin.

Philippine *Vicarya*

Since *Vicarya callosa* var. *semperi* was reported from the northern Luzon by K. Martin in 1896, many workers listed up the Vicaryan species from the various regions in Philippines, namely, W. E. Smith (1906 and 1913), R. E. Dickerson (1921 and 1922), W. P. Popenoe and R. M. Kleimpell (1978), and W. Hashimoto et al. (1984) were described its occurrences with figures. S. Kanno et al. (1980) revised the fossil localities of *Vicarya* in Philippines reported by the previous workers, and discussed their geologic horizons so far as with recent stratigraphic and biostratigraphic data.

Most specimens of *Vicarya* in Philippines have been indentified as *V. callosa* Jenkins by the previous workers, though K. Martin (1896) described *V. callosa* var. *semperei* collected from Minanga, northern Luzon. However, he (1917) lumped it under *V. callosa* considering its variability of local character. T. Takeyama (1933) also agreed with Martin's opinion.

The difference between *V. callosa* and its variety *semperei* is only the ornamentation of spiral threads on the respective whorl, namely, the former provides distinct tubercles on the subsutural band as well as two rows of ridges on the respective whorl, while the latter one ornamented with three rows of beadal threads besides the tubercles.

Although the present writer could not approach to the type locality of *V. callosa semperei* in northern Luzon in 1981 the writer collected *Vicarya*-bearing molluscan fossils from the roadside cutting near Nayon, Ifugao, northern Luzon, with Y. Makino of Ibaraki University and N. L. Caagusan, Philippine National Oil Corporation. The writer could collect some *Vicarya* specimens from the calcareous concretion buried in silty sandstone. Some of which show just the same surface sculptures as *V. callosa semperei* Martin reported from northern Luzon. However, other specimens buried in the sandstone provide no beadal threads just the same ornamentation as *V. callosa* Jenkins. Then, it may be regarded that whether the beadal threads have being clear or not is due to the state of preservation of fossils, though K. Martin (1917) and T. Takeyama (1933) considered that such differences are due to the variability among the species. Moreover, judging from the size of Martin's type specimen of *semperei* shows 74 mm in length, but the largest specimen collected from Nayon in Ifugao, northern Luzon, attains about 90 mm in length which provides very large and thick callus just the same as that of *V. callosa* (pl. III, fig. 6).

From the above mentioned reason, the writer would like to emphasize that such differences between *V. callosa* and its subspecies *semperei* may be due to the state of preservation as well as the characters of growth stages of the respective specimen rather than the variation among the specimens.

The development of tubercles and spiral ornamentation of the specimens from Nayon in Ifugao, northern Luzon, is shown in the following tables:

1) Young specimen: Protoconch is missing, with 9 whorls. Length, 19.4 mm; maximum diameter, 9.5 mm (pl. III, fig. 1).

Whorls	P	N	2nd	3rd	4th	5th	6th	7th	8th	9th
Ssb	mis.	sm.	r	fb	b	b	db	db (37)	db (26)	n (20)
s									fr	r
p				fr	r	fb	b	b	db	db
per.		r	R	R	R	R	R	R	R	R

The above table is the results of the development of tubercles and auxiliary spiral ornamentation on the respective whorl. Abbreviations used to designate the develop-

The respective granule on the subsutural band becomes larger and decreases its number of respective whorl toward 8th whorl from the younger whorls, and turns into small node at 9th whorl, where it may be about 10–11 in number. These nodes also grow in the later whorl, and turns to tubercles at the 10th and later whorls.

The primary auxiliary spiral fine beadal thread appears on the 4th whorl and it becomes more distinct toward later whorl, where it consists of about 48 beads at 9th whorl. Around 9th whorl, the secondary fine spiral thread appears between the subsutural nodes and the primary fine spiral beadal thread. This secondary spiral thread turns gradually into beadal thread at the last four whorls. Moreover, another fine spiral thread appears along the center and the apices of the tubercles.

3) Adult specimens (pl. III, fig. 6):

A full grown specimen having about 17 whorls of which younger 5 whorls seem to be missing. Length, 80.8 mm (ca. 86.0 mm in total), maximum diameter, 31.4 mm.

The surface sculpture of the younger whorls of 6th through 10th from the protoconch are almost same as above mentioned immature one; namely, respective whorl of these younger part provides the same distinct beadal threads on the subsutural band and somewhat weak beadal thread and auxiliary fine beadal threads (primary and secondary ones). However, the tertiary fine spiral thread is hardly observed between the primary and secondary spiral thread.

The distinct beadal thread on the subsutural band turns to about 9 nodes at 11th whorl, and it changes to tubercles at 12th through 17th where 7 tubercles are counted as shown in the following table:

Whorls	P	N	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th
Ssb							b	db	db	db	fn	dn (9)	T (9)	T (7)	T (7)	T (7)	T (7)	T (7)
s							fr	fr	fr	fr	r	r	tr	tr	—	—	—	—
p							b	b	b	b	db	r	tr	tr	—	—	—	—
per.							R	R	R	R	R	r	fr	—	—	—	—	—

tr... trace

The number of tubercles of the respective whorl is rather variable, for instance, one specimen provides 8 tubercles in each whorl from the base, but other specimen has 9 or more tubercles as shown in the next page.

The characteristic features of the adult specimens in Philippine Islands are the inner lip which furnishes with very large and very thick callosity which extends forwards as a semicircular, and upward in shape of tongue as far as row of tubercles of the penultimate whorl (pl. III, fig. 6).

Number of tubercles of the specimens collected from northern Luzon

Whorls specimens	bw	pw	3rd	4th	5th	6th	max. diam.	Length
1	10	10	9	9	—	—	37.8 mm	ca. 86.8 mm
2	9	9	8	8	7	n(8)	37.0	ca. 83.0
3	13	11	10	10	n(9)	n(8)	25.3	ca. 62.0
4	9	8	7	—	—	n(8)	28.0	ca. 55.0+
5	7	7	7(?)	7	6	n(6)	32.8	ca. 81.0+
6	8	8	7	6	n(7)	n(9)	32.8	ca. 68.1+

1-4. Specimens collected from Baguio; 5-6. Specimens collected from Nayan, Ifugao Province.

Vicarya verneuili (d'Archiac) and *V. callosa* Jenkins

According to Jenkins (1864), *V. callosa* distinguished from *V. verneuili* by having raised nodiferous subsutural band which becomes gradually obsolete in the upper whorls and one or two parallel ridges, whereas *V. verneuili* provides distinct tubercular band and rows of beadal threads between the subsutural band and the anterior suture.

On the occasion of the revision of genus *Vicarya* based on the specimens collected from Java, Borneo, and Philippines, K. Martin (1917) expressed that *V. callosa* and its variety *semperi* are lumped to a single species with remarkable variety. However, T. Takeyama (1933) disagreed with Martin's opinion, though agreed with Martin in placing the variety *semperi* in the conspecific of *V. callosa*. He pointed out that the differences between *V. verneuili* and *V. callosa* are that of the characters of spiral ornamentation, namely, 1) the lower whorls of *verneuili* always provide 8 tubercles in the respective whorl, and these tubercles are gradually increasing in number toward younger ones becoming smaller size as granules. While *callosa* is always ornamented with 9 larger tubercles on the subsutural band; 2) the narrow spiral band between the upper two spiral striae of *callosa* is little elevated, while it is not elevated in *verneuili*.

Yabe and Hatai (1938) was against Martin's interpretation, and they pointed out the differences between *verneuili* and *callosa*, namely, "the differences between *verneuili* and *callosa* lie chiefly in the spiral sculpture, strength of the spine-like tubercles, and in the degree of callosity." Moreover, they stated that such differences can not interpret as within a variation.

However, it is noteworthy that the original description of *V. callosa* by Jenkins (1864) was done based on the poorly preserved specimens as remarked by Jenkins himself as introduced in the preceding lines (p. 37).

Actually, the number of tubercles on the respective whorl of the type specimens of *V. verneuili* and *V. callosa* as well as *V. callosa* from Java and Philippines are shown in the following table.

Whorls specimens	bw	pw	3rd	4th	5th	6th	7th	8th
1	8(?+1)	9	8	b (31)	b (34)	b (36)	—	—
2	10(?+1)	9	8	—	—	—	—	—
3	9	9	9	8	—	—	—	—
4	9	9	9	8	b (?)	—	—	—
5	7	7	7 (?)	7	6	n (6)	b (?)	b (?)
6	8	8	7	6	n (7)	n (9)	n (10)	b (?)
7	10	10	9	9	—	—	—	—
8	9	9	8	8	7	n (8)	—	—
9	9	8	7	—	—	—	—	—
10	13	11	10	10	n (9)	n (8)	b (?)	—

1-2. Type specimens of *V. verneuili*; 3-4, "topotype" specimens of *V. "callosa"*; 5-6, *V. "callosa"* from Nayan, Ifugao, northern Luzon; 7-10, *V. "callosa"* from Baguio, northern Luzon.

Taking a glance at the above table, there is no distinct differences in the number of tubercles between *V. verneuili* and *V. callosa* as stated by the previous workers, but there are rather broad variation in its number of tubercles on the respective specimen.

In addition to the above, there is no differences for the ontogenetic development of spinose tubercles on the subsutural band and spiral beadal threads between *V. verneuili* and *V. callosa* as shown in the foregoing pages. Moreover, the strength of tubercles of both species of *verneuili* and *callosa* are no difference in the well-preserved specimens as shown in plate III, figs. 1, 7.

From the above mentioned reason it may be said that the *V. callosa* is to conspecific to *V. verneuili*, though there are distinct differences between the type specimens of *V. verneuili* and poorly preserved most specimens of *V. callosa*.

Japanese *Vicarya*

Since M. Yokoyama (1926) described *V. baculum* from Tsukiyoshi Miocene in Gifu Prefecture, T. Takeyama (1933), Y. Otuka (1938), H. Yabe and K. Hatai (1938), N. Ikebe (1939 and 1952), K. Otatume (1943), K. Oyama and K. Saka (1944), K. Oyama (1950), H. Matsuo (1960), Y. Kamada (1960 and 1967), M. Goto (1971), J. Itoigawa et al. (1974), K. Masuda (1980) and, Tsuda et al. (1981) studied the Japanese *Vicarya* from the standpoint of taxonomy, paleoecological significance and paleozoogeography.

Most previous workers recognized the following species as valid species in Japan, namely; *V. yokoyamai* Takeda, 1933, *V. japonica* Yabe and Hatai, 1938, *V. yatuoensis* Yabe and Hatai, 1938, and *V. yabei* Kamada, 1960.

Excepting for the Eocene species of *V. yabei*, all known species occur from the various localities from southern Kyushu in south through southwestern Hokkaido in north, and they are restricted in Middle Miocene strata and represent a brackish dwellers such

as mangrove swamps (Oyama, 1950; Tsuda et al, 1981).

1. *Vicarya yokoyamai* Takeyama, 1933

Takeyama (1933) classified the Japanese *Vicarya* into *V. callosa* Jenkins and *V. verneuili yokoyamai* Takeyama. He described the latter species based on *Cerithium baculum* Yokoyama, 1925 (= *V. baculum* (Yokoyama)) which collected from the Tsukiyoshi Miocene in Gifu Prefecture. He described it as the subspecies of *V. verneuili* (d'Archiac, 1851), and distinguish it from the species based on the following respects:

1) The lowest spiral cord is beaded; 2) narrow band between the upper two spiral striae is elevated; 3) the callus deposit is smaller than the species.

The difference between the species and this subspecies is so small that Takeyama recognized it as a subspecies of *V. verneuili*.

Yabe and Hatai (1938) studied Japanese *Vicarya* and they treated Tsukiyoshi *Vicarya* as subspecies of *V. callosa* Jenkins, and they descriminated an another new subspecies *V. callosa martini*.

N. Ikebe (1939) described *V. verneuili yokoyamai* collected from Tsukiyoshi Miocene, but he includes *V. callosa martini* Yabe and Hatai, 1938, into *V. verneuili yokoyamai*, because Yabe and Hatai's subspecies is regarded as a varietal form of *V. verneuili yokoyamai*. Based on the results of his study, he concluded that Japanese *Vicarya* is to classified into two types; namely, Tsukiyoshi type as *V. verneuili yokoyamai*, and Tsuyama type as *V. callosa japonica*.

In 1944, K. Oyama and K. Saka studied the molluscan fossils from the Tsukiyoshi Miocene, and they stated that the characteristics of *Vicarya* from Tsukiyoshi are so different from *V. verneuili* that they recognized it as specific rank. In later, J. Itoigawa and et al. (1974) followed after Oyama and Saka's view.

The writer examined the development of tubercles on the subsutural band, primary and secondary spiral threads, and tertiary intercalations based on the topotype specimens preserved in the Mizunami Fossil Museum in Mizunami City, Gifu Prefecture. The following tables are the results of the development of tubercles and auxiliary spiral ornamentation on the respective whorl. Abbreviations used to designate the development of surface ornamentation are the same as the foregoing lines (p. 40).

1) Young specimen A (pl. V. fig. 6):

Length, 9.1 mm; Maximum diameter, 4.4 mm. Protoconch and nepinonic whorl are missing.

Whorls	P	N	2nd	3rd	4th	5th	6th	7th
Ssb	missing		sm	sm	fr	fb	b	db (32)
p								fr
per.			R	R	R	R	R	R

2) Young specimen B (pl. V. fig. 5):

Length, 9.9 mm; maximum diameter, 5.2 mm. Protoconch and nepionic whorl are missing.

Whorls	P	N	2nd	3rd	4th	5th	6th	7th	8th
Ssb	missing		?	sm	fr	fb	fb	b	db(32)
p							fr	fb	fb
per.			R	R	R	R	R	R	R

3) Young specimen C (pl. IV fig. 4):

Length, 27.0 mm; maximum diameter, 11.0 mm. Protoconch is missing, with 13 whorls.

Whorls	P	N	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th
Ssb	missing		sm	sm	fr	fb	b	db	fn	n	n (22)	n (22)	n (18)	n (10)
s										fr	fr	fr	fr	fr
p								fr	b	db	db	db	db	db
s													fr	fr
per.		R	R	R	R	R	R	R	R	R	R	R	R	R

4) Young specimen D (pl. IV, fig. 5):

Length, 27.0 mm; maximum diameter, 13.0 mm. Protoconch through 2nd whorls are missing, possibly with 13 whorls.

Whorls	P	N	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th
Ssb	missing			sm	sm	fr	fr	fb	b	fn	n (28)	n (26)	n (24)	n (17)
s									fr	fr	fb	fb	fb	fb
p									fb	fb	b	b	b	b
s												fr	fr	fr
per.				R	R	R	R	R	P	R	R	R	R	R

This specimen seems to be missing its younger part of one or more whorls but it is uncertain how many numbers of whorls are missing. Then, the whorls of the above table are tentatively counted.

5) Almost adult specimen (pl. IV, fig. 3):

Length, 78.9 mm; maximum diameter, 23.3 mm. The number of whorls are 15 with protoconch, without thick callosity.

W.	P	N	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
Ssb	—	br	sm	fr	fr	fr	b	b	db	db	n (25)	n (25)	T (10)	T (10)	T (11)	T (11)
s								fr	fr	b	b	b	b	b	b	b
t															fr	fr
s													fr	fr	fr	fr
p						fr	b	b	b	b	b	b	db	db	db	db
s													fr	fb	fb	fb
per.			R	R	R	R	R	R	R	R	R	R	R	r	r	r

br... broken

From the above listed tables, it may be clear that the development of tubercles on the subsutural band and the auxiliary spiral ornamentations is as follow:

1) The nepionic whorl through 3rd or 4th whorls have almost no distinct spiral ornamentation on the respective whorl.

2) A fine spiral thread appears on the subsutural area close to the adapical whorl in 3rd through 5th whorls.

3) The spiral thread turns to the fine beadal thread in 5th to 7th whorl, which becomes gradually distinct one. As a result of growth of size of respective bead, the beads in the later whorl decrease in its number, and change gradually to nodes and tubercles as shown in the above tables; namely, from 9th or 10th whorl beads on the subsutural band growup to nodes and it finally turns to tubercles.

4) Tubercles appear on the body whorl through 4th or 5th whorls from the base, where 9 to 11 tubercles are counted, though more less number of tubercles such as 5 one are observed in some specimens.

5) The inclination of tubercles to the axis of shell has been stated that the inclinations to above and below of a tubercle are no difference in *V. yokoyamai*, but actually, some specimens of *yokoyamai* collected from the type locality provide the tubercles just same as that of *V. japonica* as shown in plate IV, figs. 1, 3, 6 and 8.

From the above observation, there is no difference between *V. verneuili* and *V. yokoyamai* excepting for the strength of the callosity as pointed out in the foregoing lines.

2. *Vicarya japonica* Yabe and Hatai, 1938

Vicarya japonica was described by Yabe and Hatai in 1938 as a subspecies of *V. callosa* Jenkins, 1864, based on *V. callosa* var. *japonica* Saga (MS) collected from the Uetsuki Miocene in the Tsuyama Basin, Okayama Prefecture. They distinguished it from the species by having the tubercles which are flat above and gently sloping below, while the tubercles of *V. callosa* show gently sloping both above and below. Moreover, they

Number of tubercles of the Mizunami specimens:

Specimens	bw	pw	3rd	4th	Nw	Length
1	11	11	n (32?)	?	15	70.8 mm
2	11	11	10	10?	?	78.9 "
3	9	9	12	13	16?	82.0 "
4	5	9	15	n (20)	15	79.3 "

bw... body whorl; pw... penultimate whorl;

Nw... number of whorls;

pointed out that the present subspecies differs from *V. verneuili* in the absence of auxiliary rows of delicate beads or knots. They also stated that the tubercles appear on the whorls from about the fourth from the largest whorl, and number 9-11 tubercles on the body whorl. The auxiliary spiral ridges are generally two, but there may be three on younger whorls and they don't become beadal threads.

Recently, the writer observed well-preserved some excellent specimens of *V. japonica* Yabe and Hatai collected from the type locality of Tsuyama, Okayama Prefecture and the Kouno Formation in Takahama-cho, Fukui Prefecture. These specimens show somewhat different characters from that of the original description by Yabe and Hatai in 1938 on the development of tubercles and spiral ornamentation of the respective whorl. The development of tubercles and auxiliary spiral threads on the respective whorl are shown in the following table:

1) Young specimen A (pl. V, fig. 1):

Length, 13.2 mm; maximum diameter, 7.0 mm. Protoconch is missing, with 9 whorls.

Whorls	P	N	2nd	3rd	4th	5th	6th	7th	8th
Ssb	miss	sm	fr	fb	fb	b	db (38)	db (33)	db (24)
p						fr	fr	fr	fr
per.			fr	r	R	R	R	R	R

2) Young specimen B (pl. V, fig. 2):

Length, 19.8 mm; maximum diameter, 9.5 mm. Protoconch and nepionic whorl are missing, with 9 whorls.

Whorls	P	N	2nd	3rd	4th	5th	6th	7th	8th	9th
Ssb	missing		fb	fb	b	b	db (35)	db (34)	db (22)	db (25)
s					fr	fb	fb	fb	fb	fb
p			fb	fb	fb	b	b	b	b	b
per.			R	R	R	R	R	R	R	R

3) Specimen C:

Length, 19.4 mm; maximum diameter (average width), 9.5 mm. Protoconch through 2nd whorls are missing, more or less compressed specimen, with 9 whorls.

Whorls	P	N	2nd	3rd	4th	5th	6th	7th	8th	9th
Ssb	missing			fb	b	db (44)	db (34)	db (34)	fn (12)	n (11)
s							fr	fr	fb	fb
p				fr	r	r	fb	b	b	db
per.				R	R	R	R	R	R	R

4) Specimen D (pl. V, fig. 3):

Length, 22.0 mm; maximum diameter, 10.6 mm. Protoconch through almost 2nd whorls are missing, with 10 whorls.

[illegible]

The number of tubercles on the adult stages of *V. japonica* are shown in the following table:

Specimens	bw	pw	3rd	4th	Nw	Length (mm)	
1	9	8	11	10	15	67.1	1-6, Tsuyama specimens; 7-9, Kouno specimens from Takahama-shi, Fukui Prefecture; 10, Ayukawa specimen, Fukui City, collected by T. Yasuno
2	11	9	8	7	ca. 16	ca. 77.0	
3	11	8	—	—	ca. 15	ca. 75.0	
4	10	10	10	11	ca. 16	ca. 84.0	
5	10	9	10	13	ca. 15	ca. 72.0	
6	9	8	7	—	ca. 14	ca. 52.0	
7	10	10	9	8	18	77.0	
8	9	8	8	8	ca. 14	ca. 74.0	
9	7	6	7	—	ca. 13	ca. 42.0	
10	8	9	8	10	ca. 16	ca. 83.0	

The inclination of tubercles to the axis of the whorls

Yabe and Hatai (1938) distinguished *V. japonica* from the Indonesian species *V. callosa* by the shape of the tubercles which are flat above and sloping below. This characteristic feature of *V. "japonica"* has been accepted as to distinguish it from *V. yokoyamai* Takeyama.

N. Ikebe (1939) reported on certain species of *Vicarya* collected from the Miocene Tsuyama and Tsukiyoshi formations. He concluded that Tsuyama form of *Vicarya* is *V. callosa japonica* Yabe and Hatai and *V. verneuili yokoyamai* may not be regarded as local variation within a species. He pointed out that the development of tubercles of respective species differs ontogenetically, namely, *V. verneuili* and *V. verneuili yokoyamai* have no tubercles in the nepionic whorl but numerous granules, some of which develop into spinose tubercles in the adult stage. This characteristic feature is never seen in *V. callosa* and *V. callosa japonica*.

N. Ikebe (1952) investigated Indonesian *V. callosa* collected from the type locality of Java. Among more than 500 specimens, he could find more than 100 specimens with tubercles just same as Japanese *V. callosa japonica* which characterized by having the tubercles of flat above and sloping below. As the result of his study he seems to be inclined that Japanese subspecies *V. callosa japonica* is an identical form of Indonesian *V. callosa*.

Yabe and Hatai (1938) and N. Ikebe (1939) pointed out that the characteristic feature of *V. callosa* and *V. callosa japonica* have no auxiliary rows of delicate beads or knots. However, *V. callosa* from Luzon and the well preserved specimens of *V. japonica* from the type locality of the species and the Kouno Formation of Takahama-cho in Fukui Prefecture provide two rows of beadal threads besides tubercles on the subsutural band as shown in the foregoing tables and many figures in plates (pl. V, figs. 1-4, 7-10; pl. VI, figs. 2-6).

In addition, though Yabe and Hatai stated that *V. callosa* provides distinct grove

which extends over the tips of the tubercles, however, such groove is actually not a real groove, but a fine ridge which is running through the tip of tubercles connecting the respective tubercles in the well preserved specimens (pl. VI, figs. 4, 6; text-fig. 3).

The differences between the results of Yabe and Hatai (1938) as well as N. Ikebe (1939) and the present writer's seem to be due to the state of preservation of specimens used for their study. Actually, well preserved specimens at hand from the type locality of *V. japonica* and the Kouno Formation of Fukui Prefecture, provide primary, secondary and tertiary spiral threads, besides the tubercles on the subsutural band. Among the auxiliary spiral threads, primary and secondary ones are distinct beadal threads but the tertiary one is mostly represented by a fine weak thread. Moreover, the latest one is missing in some cases. However, these surface ornamentations of the respective whorl seem to be easily eroded, then, the auxiliary surface ornamentation of the most specimens is so poorly preserved that neither the beads nor tubercles can be seen properly.

Moreover, the inclination of the tubercles to the axis of whorls is not always serving to distinguish between *V. yokoyamai* and *V. japonica* as pointed out in the preceding lines (p. 46). From the above data the writer concludes that *V. japonica* is to lumped to *V. yokoyamai* Takeyama.

3. *Vicarya yatuoensis* Yabe and Hatai, 1938

Yabe and Hatai (1938) reported a new species of *Vicarya* from the Yatsuo Miocene in Kakebata, Yatsuo-machi, Neigun, Toyama Prefecture. They distinguished the present species from the known species by the following characters. Namely, the species differs from *V. japonica* by having the different surface sculpture of the whorls, less extensive tubercles, and the shouldered whorl of the last one; from *V. yokoyamai* by having different character of shape and sculpture of the whorls.

However, rather well-preserved specimens from the type locality of *V. yatuoensis* show the same characteristic features as *V. japonica*, and hardly distinguish it from the latter as shown in plate VII, figures 5, 6 and 8 as well as following table. For example, the development of surface sculptures of Yatsuo specimen (pl. VII, fig. 5) which is somewhat compressed, provided 83.5 mm in length and 29.8 mm in average width, is as follow;

Whorls	bw	pw	3rd	4th	5th	6th	7th	8th
Ssb	T (10)	T (8)	T (8)	T (9)	n (9)	n	dr	dr
s	r	r	r	r	r	r	r	r
p	dr	dr	dr	dr	dr	dr	dr	dr
per.	R	R	R	R	R	R	R	R

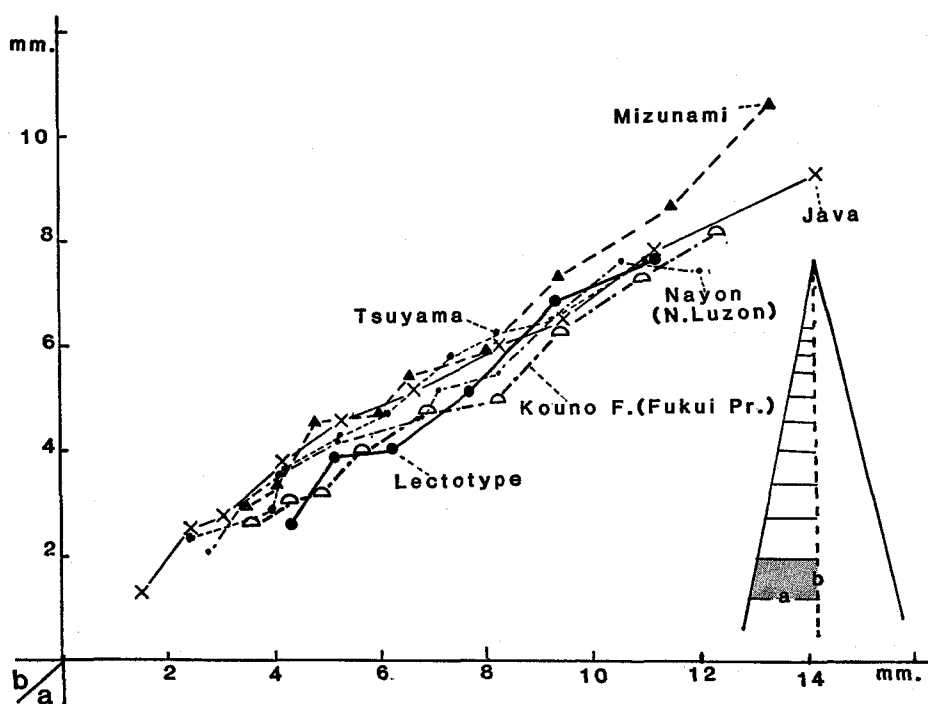
Though the topotype specimens at hand are so poorly preserved, but they provide distinct tubercles on the 4 whorls from the base, two spiral ridges between the subsutural band and peripheral ridge just same as *V. japonica* and *V. yokoyamai* abovementioned.

Moreover, somewhat well-preserved whorls show two spiral beadal threads instead of spiral ridges between the subsutural band and peripheral one, and a fine ridge just beneath the tubercular band as shown in plate VII, fig. 6.

According to Yabe and Hatai (1938), the tubercles of the present species are rather weaker than that of *V. japonica*, but the topotype specimens at hand provide the same strong tubercles in the four whorls from the base as that of *V. japonica* and have flat whorls in stead of shouldered one. From the abovementioned reason, the Yatsuo specimens are surely conspecific of *V. japonica*.

Growth ratios of Miocene *Vicarya*

The growth ratio of respective species is measured as the series of height (b) and radius (a) of respective whorl as shown in Text-figure 4. According to the result of the growth ratios of respective species, there are almost no difference in the growth ratios among the known species, and it is represented by a simple linear equation (Text-fig. 4).



Text-fig. 4. The growth ratios of the known species of *Vicarya*.

Eocene species of genus *Vicarya*

Since L. R. Cox (1931) and K. Martin (1931) reported the Eocene *Vicarya* from Pakistan and Java in 1931, M. Kamada (1960) and K. Masuda (1980) reported it from the western Kyushu and Ishigakijima in Okinawa Prefecture, Japan.

1) Eocene species from Pakistan

Vicarya eocenica was described by Cox (1931) from the Lower Ghazij Shale (Middle Laki) of Harnai, Barkistan, Pakistan. According to the original description, *V. eocenica* provides the following characters; (1) shell is much smaller than *V. verneuili*; height, ca. 36 mm; diameter, 13.2 mm; (2) ornamentation consists of three rows of granules, separated on the later whorls by a few fine obscurely granulated threads of periphery which turns into a narrow ungranulated ridge near the anterior suture in the later whorls; (3) the granular subsutural band becomes more conspicuous than the other two, but does not growup into a tubercular band.

The development of surface ornamentation of the respective whorl of the type specimens is shown in the right table.

The ornamentation of the younger whorls show a conspicuous beadal thread on the subsutural band, rather weak primary beadal one, and rather conspicuous spiral ridge of periphery. But in later whorl, secondary, tertiary and quaternary spiral threads appear as hown in the right table.

It is clear that the development of the surface ornamentation of Cox's *V. eocenica* is fundamentally different from the generic diagnosis of the genus *Vicarya* as shown in the preceding page (p. 35). Moreover, this species provides no tubercle on the subsutural band, but only provides a granular beadal thread. In addition, the size and shape of granules on the respective whorl hardly change into tubercles in later whorls, and hardly decrease their number towards to the later whorls. These characteristics are strongly against to the original diagnosis of the genus *Vicarya* d'Archiac and Haime in 1854.

Cox described that the outer lip of *V. eocenica* provides with deep sinus lying between the second and third rows of granules (counting from the posterior suture), but the degree of curvature of growth lines of *V. eocenica* is distinctly more broader than that of *V. verneuili* and other Miocene species of *Vicarya*.

Judging from the abovementioned reasons, Cox's species *V. eocenica* should be ex-

Whorls	bw	pw	3rd	4th	5th	6th
Ssb	db	db	db	db	db	db
t	fr	fr	fr	fr	fr	fr
q	fr	fr	fr	fr	fr	fr
s	b	b	b	b	b	b
t	fb	fb	fb	fb	fb	fb
q	fr	fr				
p	b	b	b	b	b	b
q	fr					
per.	R	R	R	R	R	R

Abbreviations cited above table besides foregoing page (p. 40) are:

q...quaternary spiral thread

cluded from the genus *Vicarya* and it seems to be under the genus *Vicaryella* Yaba and Hatai, 1938.

2) Eocene species from Java

K. Martin (1931) reported the Eocene species of *Vicarya*, *V. jogjacartensis* (Martin, 1914), which was originally described from the Nanggulan Formation (Upper Eocene) by Martin as *Potamides* (*Tympanotonus*)? *jogjacartensis* in 1914.

Martin's type specimen (K. Martin, 1914, pl. 5, fig. 131) seems to be represent a younger part of adult specimen (or younger one) of waterworn specimen. He (1931, p. 40, pl. 6, figs. 1-3) also reported this species from the same locality as that of Nanggulan Formation in 1914, but these specimens are also poorly preserved ones. So, it is very hard to identify their characteristic features.

The writer examined *V. jogjacartensis* preserved in the Museum of the Geological Survey of Indonesia in Bandung in 1976. These specimens are collected from the Nanggulan Formation in Nanggulan, but these are so waterworn out and the sculpture is mostly damaged by erosion in whole whorls, that the accurate identification of Nanggulan specimens is impossible at the present as shown in plates II, fig. 3 and pl. VI, figs. 8-11.

3) Eocene species from Japan

Y. Kamada (1960) reported the Eocene species of *Vicarya* (pl. IV, figs. 9 and 10) from the Hashima Formation (Middle Eocene). According to the original description by Kamada, this species is characterized by having a smaller shell than *V. verneuili* and the other species of Miocene *Vicarya* in their adult stage, well-developed subsutural spinous tubercles, deep sinuous growth lines on the inner lip, and *Vicarya*-like whorl sculpture. However, the development of tubercles of Kamada's specimens is not variable among the respective whorls, while the tubercles on the subsutural band in the respective whorl become gradually conspicuous from nodes to distinct tubercles in the specimens of genus *Vicarya* as stated in the original diagnosis of d'Archiac and Haime in 1854. In addition, the size of this specimens are too small compared with the type of the genus, and the degree of curvature of sinuous growth lines is rather broader than that of genus *Vicarya*. So far as judging from the original description and given figures, the writer is wondering that this species seems to belong to the genus *Vicaryella* Yabe and Hatai (1938).

K. Masuda (1980) also reported the Eocene species *V. yabei* Kamada from the Eocene Miyara Formation of Ishigaki-jima, Okinawa Prefecture (Text-fig. 5). He identified the Miyara specimens as *V. yabei*, and he stated the supplementary to the Kamada's original descri-



Text-fig. 5. *Vicarya yabei* Kamada
×1. Reproduced from Masuda
(1980)

ption that the shell consists of 12 whorls with distinct tubercles which are gently sloping both above and below, and has about 30° or a little less apical angle. So far as Masuda's figures are concerned, the Miyara specimens seem to be so poorly preserved that it is impossible to discuss the precise characters of these specimens.

From the abovementioned reasons, the Japanese Eocene "*Vicarya*" is to classify under the genus *Vicaryella* Yabe and Hatai (1938), though some doubtful specimens still remain for the taxonomical position such as Masuda's "*Vicarya yabei*" from the Miyara Formation. Such suspended problem may be pending until the more well-preserved specimens are examined in future. Accordingly, the genus *Vicarya* from the Indo-Pacific region seems to be restricted in Mioocene (mostly Middle Miocene), and most of Eocene species of the genus is to transfer under the genus *Vicaryella* Yabe and Hatai. This results seem to suggest the reason that nothing Oligocene *Vicarya* has been reported from the Indo-Pacific region.

The relationship between the both genera of *Vicarya* and *Vicaryella* will be discussed in the other article.

Conclusion

1. Among the three syntypes of *Vicarya verneuili* preserved in the British Museum, Reg. no. GG24195 is designated as lectotype, and the other two specimens of GG24196 and GG24197 are designated as paratype.

2. *Vicarya callosa* Jenkins (1864) collected from west Java is simply an eroded specimen of *V. verneuili* (d'Archiac, 1851). The specific name *V. callosa* is cancelled.

3. Japanese *Vicarya japonica* Yabe and Hatai, 1938, is no differences ontogenetically to *V. yokoyamai* Takeyama, 1933, and their surface ornamentation is also same between the both species from Tsuyama and Tsukiyoshi.

4. The inclination of tubercles to the axis of whorls shows rather wide variation, so that some specimens of *V. yokoyamai* from Tsukiyoshi show the inclination of tubercles just same as that of *V. japonica* from Tsuyama.

5. *V. yatuoensis* Yabe and Hatai, 1938, is merely a varietal form or immature form of *V. "japonica."*

6. The well-preserved specimens of Japanese *Vicarya* provide the same surface ornamentation as *V. verneuili*, but the size of callosity is smaller than that of *V. verneuili*.

7. The known species of Miocene *Vicarya* in Japan are included to *V. yokoyamai* Takeyama.

8. The number of tubercles on the respective whorl shows rather broad variation among the individuals of the same species, so, it is impossible to distinguish the respective specimen based on the number of tubercles of those whorls.

9. *Vicarya formosa* Oostingh is to transfer to the genus *Vicaryella* Yabe and Hatai,

1938.

10. Eocene species *Vicarya eocenica* Cox, 1931, is transferred under the genus *Vicaryella* Yabe and Hatai, 1938.

11. Indonesian specimens *V. jogjartensis* (Martine, 1914) reported by Martin are so poorly preserved that could not identify taxonomically.

12. Japanese Eocene *V. yabei* Kamada, 1960, seems to be included under the genus *Vicaryella* Yabe and Hatai, 1938.

13. Eocene specimens of *V. yabei* Kamada from Ishigaki-jima by Masuda (1980) are so poorly preserved that could not refer to the precise comparison to the known species of genus *Vicarya*. This problem may be suspended until more well-preserved specimens are examined.

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Plate I

Explanation of plate I

Figs. 1a-b. *Vicarya verneuili* (d'Archiac) $\times 2$

Lectotype, BMPD. Reg. no. GG24195 (ex. Geol. Soc. London, Reg. no. 9802)

fig. 1a, showing the apertural view.

fig. 1b, side view of fig. 1a.

Figs. 2-3. *Vicaryella eocenica* (Cox, 1931) $\times 2.5$

figs. 2a-b, holotype. BMPD. Reg. no. G50108 (=Cox, 1931, pl. 1, figs. 7a-b).

fig. 3, paratype. BMPD. Reg. no. G50109 (Cox, 1931, pl. 1, fig. 8)

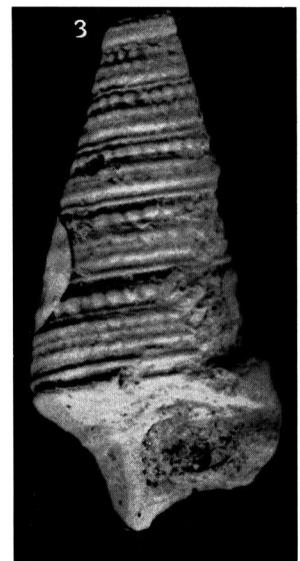
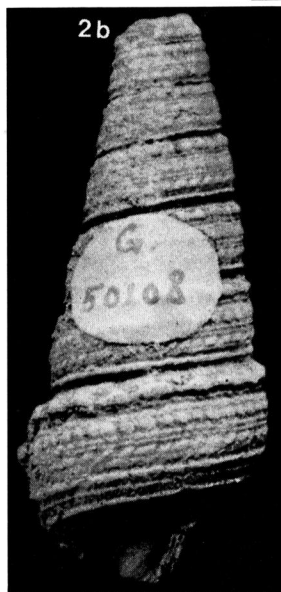
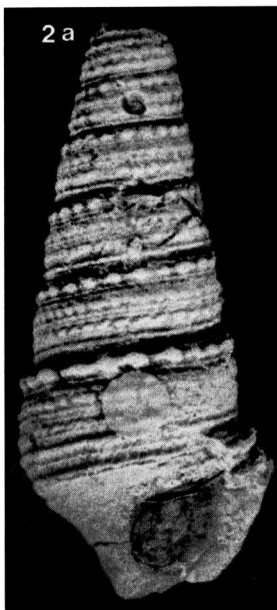
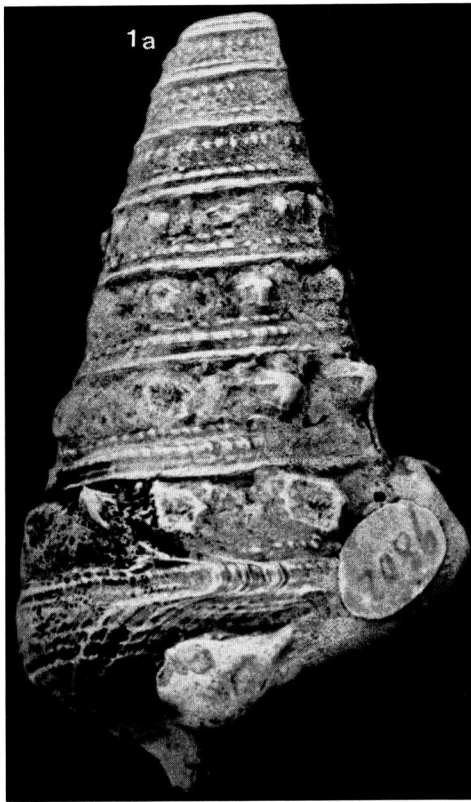


Plate II

Explanation of Plate II

Figs. 1-2. *Vicarya verneuili* (d'Archiac)

fig. 1, eroded specimen. BMPD. Reg. no. G676776 $\times 2$ (= *V. callosa*, paratype specimen by Jenkins, 1864)

fig. 2, the original drawn specimen by Jenkins as *V. (?) callosa* in 1864. $\times 1$
BMPD. Reg. no. G76775 (= *V. callosa*, holotype specimen by Jenkins, 1864)

Fig. 3. *Vicaryella jogjacartensis* (Martin, 1914) $\times 1$

Specimen preserved in the Museum, Geological Survey of Indonesia, Bandung.

Fig. 4. *Vicaryella eocenica* (Cox, 1931) $\times 2.5$

Back view of the fig. 3 in plate I (=Cox, 1931, pl. 1, fig. 8)

Figs. 5 and 7. *Vicarya verneuili* (d'Archiac) $\times 1$

Specimens preserved in the Museum of Geological Survey of Indonesia, Bandung, collected from Njalindung, west Java.

Fig. 6. *Vicarya verneuili* (d'Archiac) $\times 1$

Specimens collected from the Danao Coal-field, Cebu Is., Philippines. Reg. no. JUE 10066

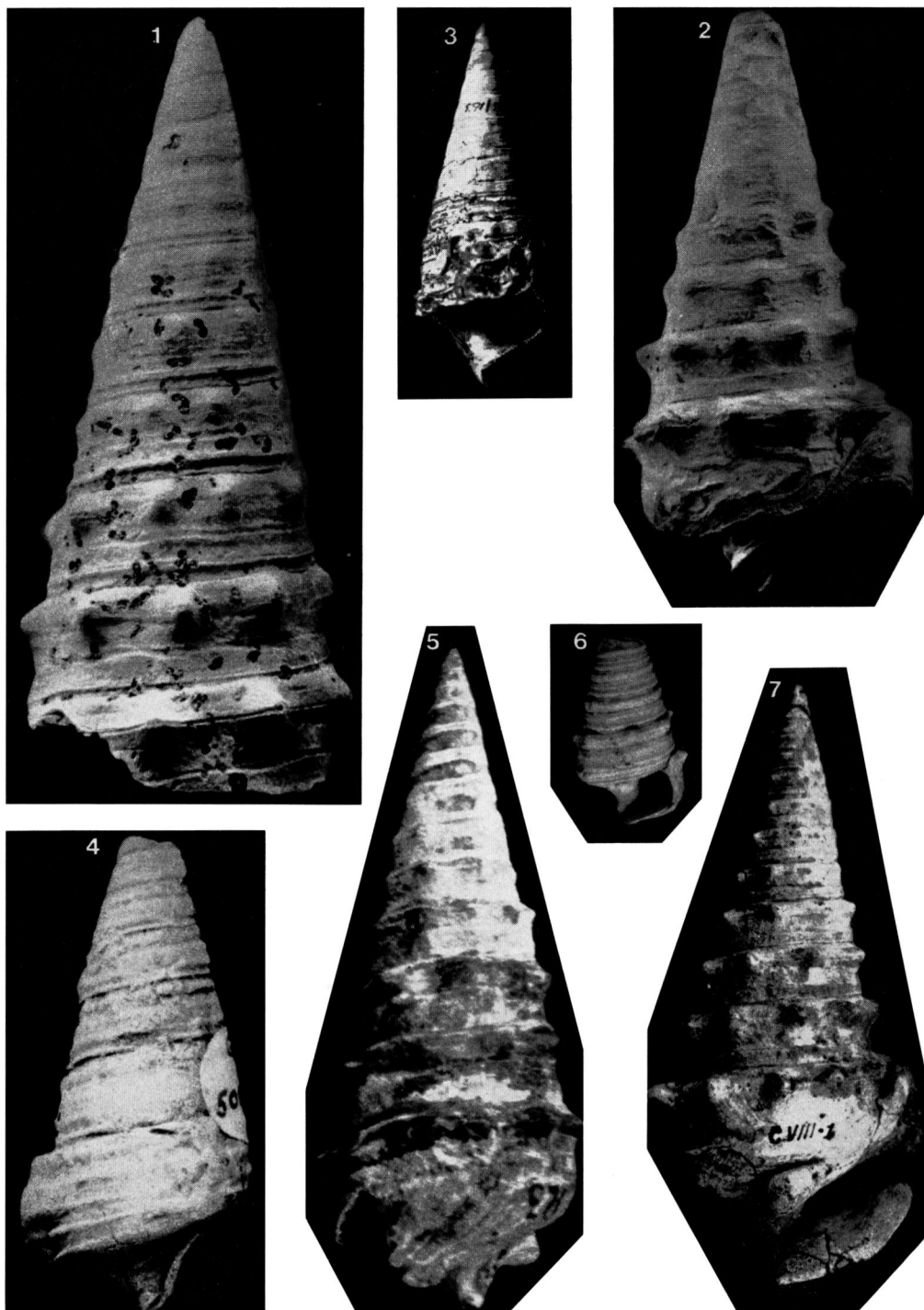


Plate III

Explanation of Plate III

Figs. 1-7. *Vicarya verneuili* (d'Archiac)

All figured specimens are from Philippines.

fig. 1, very young specimen collected from Nayon, Ifugao, northern Luzon, showing the development of subsutural band and auxiliary spiral threads. $\times 3.3$

Reg. no. JUE 10067

figs. 2 and 6, adult specimens $\times 0.9$ Reg. no. JUE 10067 fig. 6, specimen with complete aperture, showing the callosity which extends over the row of tubercles of the preceding whorl; outer lip of aperture is more or less deformed, collected from Nayon, Ifugao, northern Luzon.

figs. 3a-b, collected from Baguio, northern Luzon. fig. 3a, showing the callosity which extends over the tubercles of body whorl and reaches to the row of tubercles of the penultimate whorl. $\times 0.9$ Reg. no. JUE 10068

fig. 3b, back view of fig. 3a $\times 1.1$

figs. 4-5, specimens collected from the Danao Coal-field, Cebu Is., Philippines, showing the surface ornamentation and the inclination of tubercles to the axis of the whorls. $\times 1$ Reg. no. JUE 10069

fig. 7, immature specimen, buried in a calcareous concretion, which shows the development of tubercles and auxiliary spiral beadal threads just same as *V. verneuili*.

$\times 1.4$ Reg. no. JUE 10067

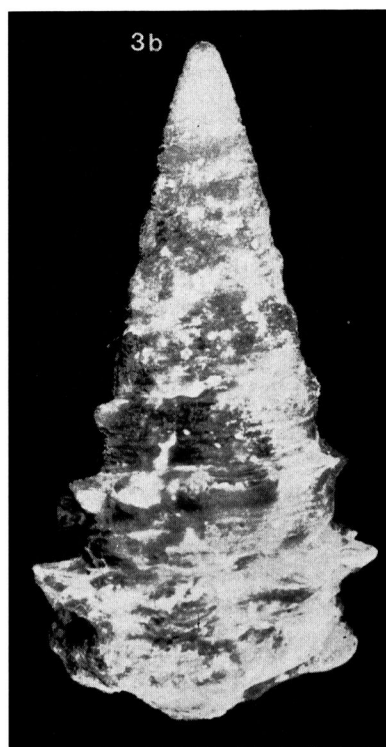
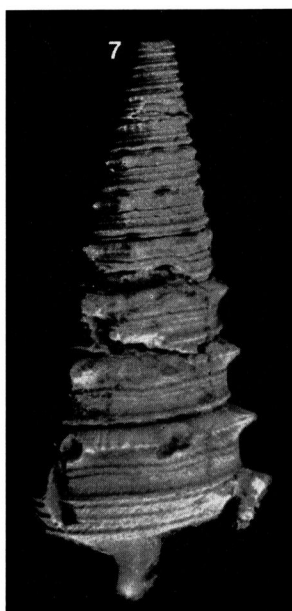
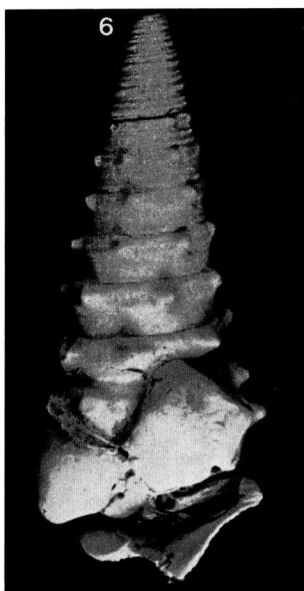
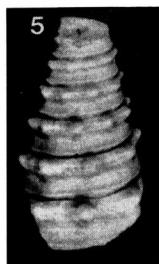
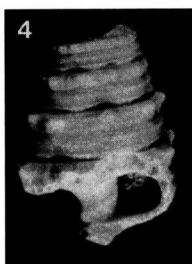
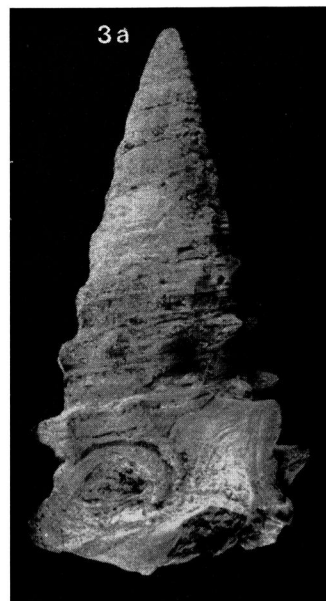
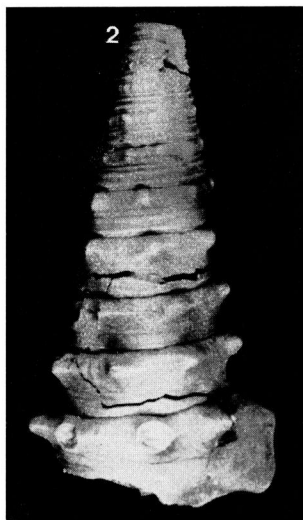
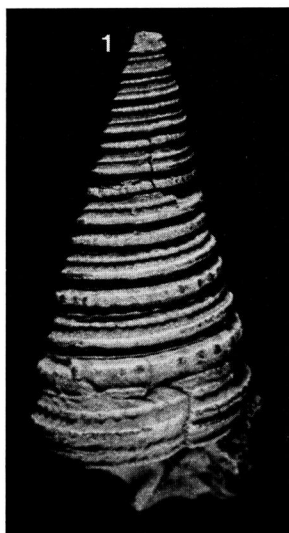


Plate IV

Explanation of Plate IV

Figs. 1-8. *Vicarya yokoyamai* Takeyama

All specimens collected from Shimizu-matsubora, Akeyo-machi, Mizunami City, preserved in the Mizunami Fossil Museum.

figs. 1, 3, 6 and 8, showing the inclination of tubercles which are flat above and gently sloping below to the axis of whorls, while the tubercles of whorls in figs. 2 and 7 are rather gently sloping both above and below fig. 1 $\times 0.94$ fig. 3 $\times 0.9$; figs. 6 and 8 $\times 1$; fig. 7 $\times 0.72$

figs. 4 and 5, immature specimens showing the development of tubercles and auxiliary spiral threads on the respective whorl. $\times 2$

Figs. 9 and 10. *Vicaryella yabei* (Kamada) $\times 1$

Reproduced from the original report of Kamada (1960)

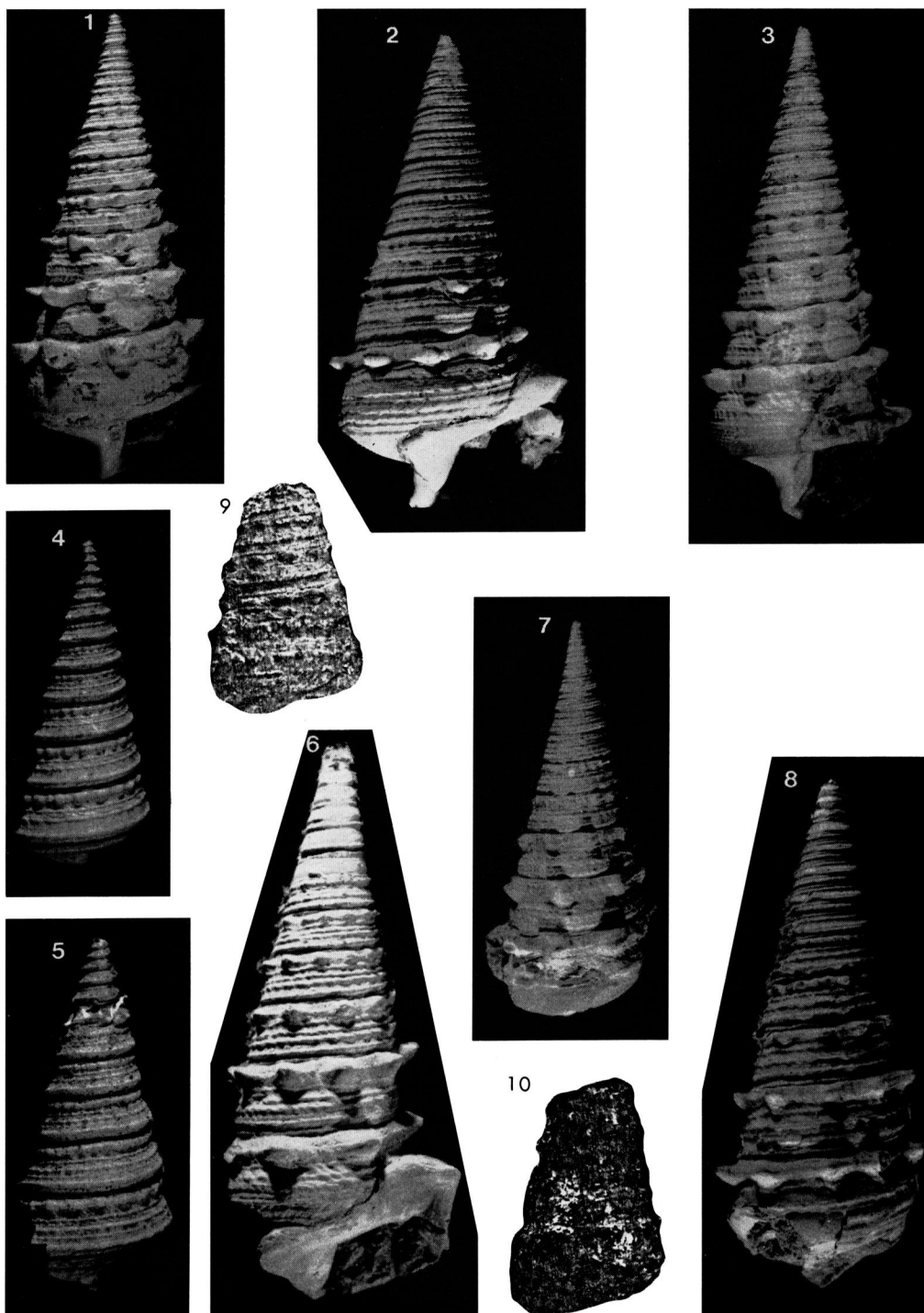


Plate V

Explanation of Plate V

Excepting for figs. 5 and 6, all figured specimens in the plate were collected from Takao, Tsuyama City in Okayama Prefecture by Mr. Eiji Taguchi.

Figs. 1-4, and 7-11. *Vicarya yokoyamai* Takeyama, 1933

(= topotype specimens of *V. japonica* Yabe and Hatai, 1938)

figs. 1-3, very young specimens showing the development of tubercles and auxiliary spiral threads; fig. 1 $\times 5$; fig. 2 $\times 3.0$; fig. 3 $\times 3$

figs. 4, 7, 8 and 10, immature specimens, showing the development of tubercles and the spiral beadal threads as well as the inclination of tubercles which are flat above and gently sloping below.

fig. 9, adult specimen $\times 1.07$

Figs. 5 and 6. *Vicarya yokoyamai* Takeyama

Showing the first appearance of beads on the subsutural area which grow on tubercles in later whorls collected from Shimizu-matsubora, Mizunami City. fig. 5 $\times 4.6$; fig. 6 $\times 4.4$

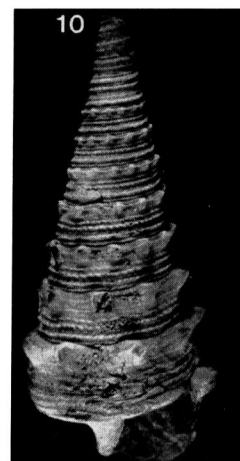
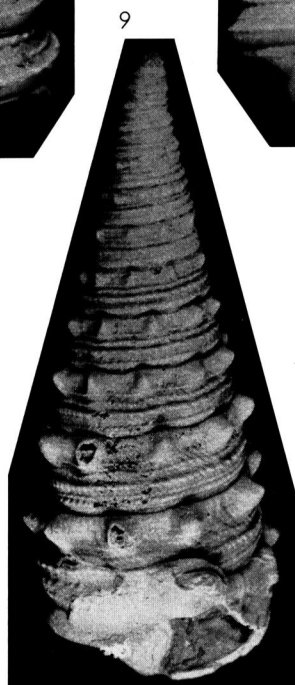
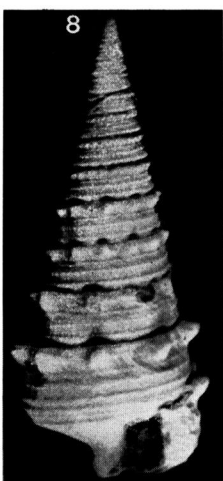
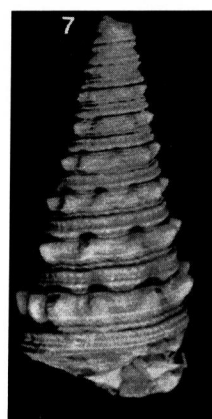
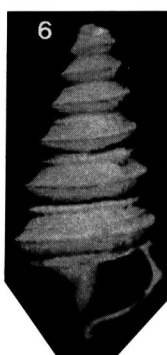
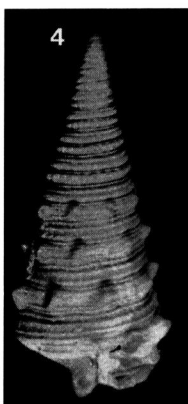
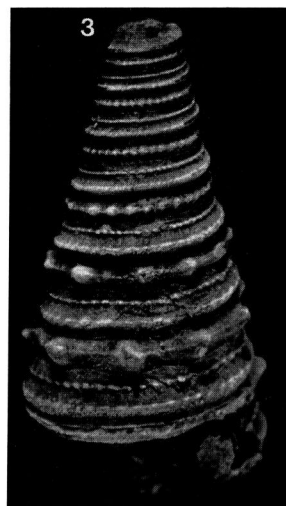
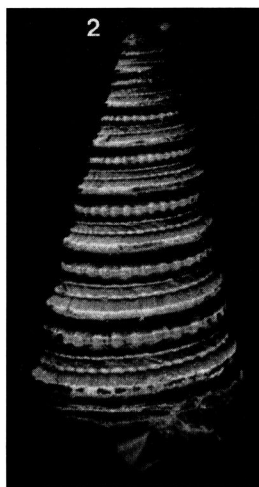
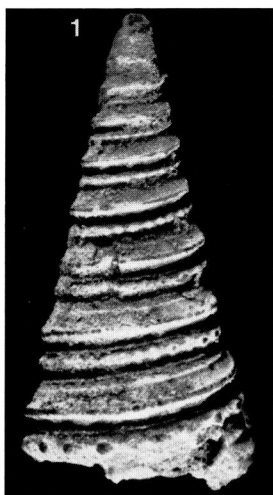


Plate VI

Explanation of Plate VI

Fig. 1. *Vicarya yokoyamai* Takeyama $\times 0.94$

Specimen preserved in the Mizunami Fossil Museum collected from Shimizu-matsubora, Akeyo-machi, Mizunami City, showing the callosity which extends upward, but does not reach to the row of tubercles of the preceding whorl; the inclination of tubercles to the axis of whorls of this specimen is also more or less flat above and gently sloping below.

Figs. 2 through 6. *Vicarya yokoyamai* Takeyama

All collected from the Kouno Formation in Takaham-cho, Fukui Prefecture by the co-operation of Mr. H. Kaneda. Reg no. JUE 10069

fig. 2, youngest part of the whorls showing the development of spiral thread; the primary spiral thread appears on the 5th whorl, and the secondary spirals slightly appears on the last whorl, though subsutural spiral threads appear on the 2nd whorl. $\times 5$

figs. 3, 4 and 6, immature specimens showing the development of tubercles and beadal threads as to their growth stages; periphery of respective whorl also becomes granulate toward later whorl. fig. 3 $\times 1$; fig. 4 $\times 2$; fig. 6 $\times 1.7$

figs. 5a-b, adult specimen $\times 0.95$

fig. 5a, apertural view, showing the almost complete aperture.

fig. 5b, side view of fig. 5a, showing the sinus of the outer lip and the callosity which does not extend to the row of tubercles of the preceding whorl.

Figs. 8, 9 and 10. *Vicaryella jogjacartensis* (Martin, 1914)

Reproduced from Martin, 1931, pl. 6, figs. 1-3.

Fig. 11. *Vicaryella jogjacartensis* (Martin, 1914)

(= *Potamides* (*Tympanotonus*)? *jogjacartensis* Maring, 1914)

Reproduced from Martin (1914, pl. 5, fig. 131), which transferred to genus *Vicarya* in 1931.

Figs. 12a-b. *Vicaryella formosa* (Oostingh)

Reproduced from Oostingh (1935, p. 31, figs. 2a-b).

fig. 12a, apertural view, and fig. 12b showing the surface ornamentation and growth lines on the body whorl of fig. 12a. fig. 12a $\times 1$; fig. 12b $\times 1.4$

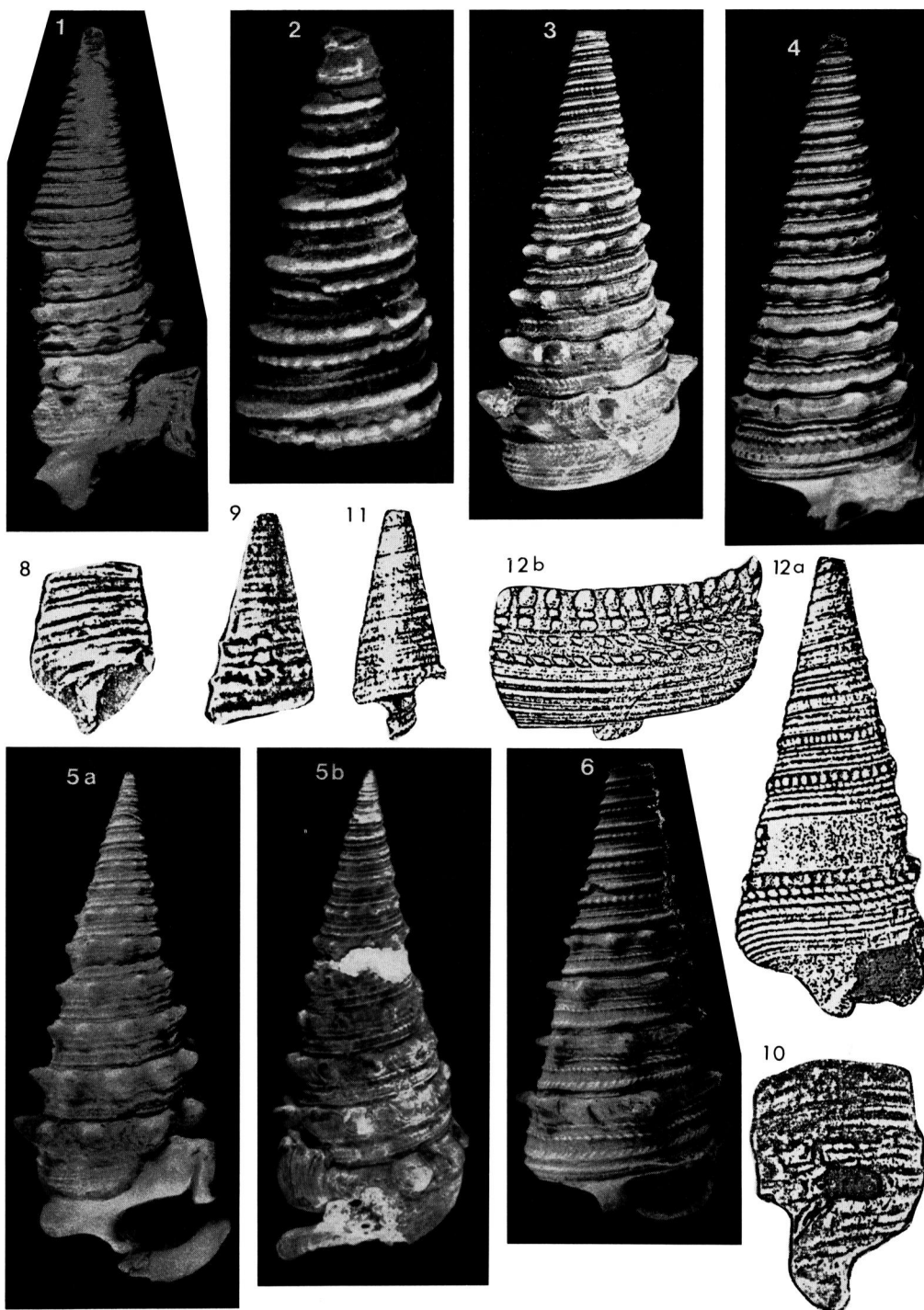


Plate VII

Explanation of Plate VII

Figs. 1-4. *Vicarya yokoyamai* Takeyama \times ca. 1

Locality: Kouno Formation in Takahama-cho, Fukui Prefecture.

figs. 1-2, showing the inclination of tubercles; most tubercles on the body whorl show almost the same inclination to the axis of whorls, but tubercles on the most younger whorls show that their inclination are fiat above and gently sloping below.

fig. 4, the cross section showing a weak fold of columella, but it rather distinct in the younger part, while gradually becomes obscure toward the later whorl.

Figs. 5, 6 and 8. *Vicarya yokoyamai* Takeyama \times 1

The topotype specimens of *V. yatuoensis* Yabe and Hatai, 1938, collected from Kakebata, Yatsuo-machi, Toyama Prefecture by Dr. Shoji Fujii.

fig. 5, showing the rows of tubercles which are distinct in the almlost four whorls from the base.

figs. 6 and 8, fragmental specimens which show rather clear surface ornamentation just same as that of *V. "japonica"*

Fig. 7. *V. verneuili* (d'Archiac) \times 1

Specimen collected from Baguio City, northern Luzon, which provides 13 tubercles on the body whorl. Reg. no. JUE 10007

