A NOTE ON PECTEN (FORTIPECTEN, SUBG. NOV.) TAKAHASHII YOKOYAMA AND ITS BEARING ON THE NEOGENE DEPOSITS OF JAPAN

A NOTE ON *PECTEN (FORTIPECTEN, SUBG. NOV.) TAKAHASHII* YOKOYAMA AND ITS BEARING ON THE NEOGENE DEPOSITS OF JAPAN

BY

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With 2 Plates

Since many years it has been known that there are a number of interesting Pectinidae fossils in the Tertiary deposits of the Japanese Islands, but that they have not received the amount of attention they deserve is also well known. Experience shows that many of these Pectinidae fossils are restricted in geological range but have a fairly extensive geographical distribution, while others extend their range to the present seas. With the accumulation of both specimens for study and data on various geological formations, we now wish to present some views on the well known scallop, *Pecten (Patinopecten) takahashii* Yokoyama, and its bearing on the Neogene deposits of Japan.

Before going further, we wish to thank Mr. N. Zinbô, geologists to the Mining Bureau of the Karahuto-Tyô, for kindly presenting to one of us (H. Yabe) a large number of specimens. Acknowledgements are also due to Dr. S. Nomura of the Division of Geology of the Saito Ho-on Kai Museum in Sendai, for permiting us to study the specimens preserved there.

As to the subgeneric position of the specimens of *Pecten takahashii* now before us, there appears to be considerable question. T. Kuroda[1] refers this scallop to *Patinopecten* and this procedure is followed by S. Nomura,[2] while M. Yokoyama[3] once placed it in *Chlamys*. However, whether *P. takahashii* belongs to the subgenus *Patinopecten* or to some other subgenus is a point of debate.

U. S. Grant and H. R. Gale[4] in their large work, defined *Patinopecten* as follows, taking *Pecten caurinus* Gould as the type. Their definition is:

"Shell large, thin, sometimes of a somewhat pearly texture, having a circular outline and very low convexity, valves usually nearly equal, although at times one or the other may become nearly flat; radial sculpture consisting of distinct ribs without minor striation, sometimes with microscopic cross-hatching, ribs of the right valve comparatively broad and squarish, sometimes with a medial sulcus, those of the left valve narrow, often sharp, with intercalaries if the ribs of the right valve are sulcated; hinge line usually short, ears of almost equal length, byssal notch deep in the older species, more shallow in Recent species."

1) T. KURODA Catalogue of Japanese Shells. Venus, Vol. 3, No. 2, appendix p. 101, 1932.

2) S. NOMURA: A Note on Some Fossil Mollusca from the Takikawa Beds of the Northwestern Part of Hokkaidô, Japan. Sci. Rep., Tôhoku Imp. Univ., Ser. 2, Vol. 18, No. 1, p. 33, 1935. S. NOMURA: Molluscan Fossils from the Tatunokuti Shell Bed Exposed at Gôroku Cliff in the Western Border of Sendai. Ibid., Vol. 19, No. 2, p. 249, 1938.

3) M. YOKOYAMA: Tertiary Mollusca from the Coalfield of Uryu, Ishikari. Jour. Fac. Sci., Imp. Univ., Tokyo, Sec. 2, Vol. 3, Pt. 6, p. 288, 1932.

4) U. S. GRANT and H. R. GALE: Catalogue of the Marine Pliocene and Pleistocene Mollusca of California and Adjacent Regions. Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 192, 1931.

In regard to this subgenus, they stated that, "This group of species, although obviously closely related to *Chlamys* and to *Vertipecten,* is, none the less, a rather distinct unit. It represents an evolutionary adaptation starting in the same direction as that taken by *Amusium;* but the external ribs did not become obsolete, and hence the internal lirae did not become sharp. The general shape, however, is the same. The shape of *Placopecten*[1] is also similar. *Patinopecten* developed distinct external ribs, *Placopecten* retained but faint radial riblets on the exterior, while all that is left of the ribs of *Amusium* are the strengthened internal lirae.[2]"

The specimens of *P. takahashii* from South Karahuto are very much inflated and the convexity is not "very low convexity", further the radial sculpture of the specimens from the vicinity of Sendai exhibit distinctly (fig. 5) "minor striation", and the left valve has intercalaries even though the ribs of the right valve are not sulcated. These said features are quite contrary to the subgeneric characters of *Patinopecten* as defined by U. S. Grant and H. R. Gale.

Vertipecten established by U. S. Grant and H. R. Gale[3] also somewhat resembles *Patinopecten,*[4] and the specimens before us are close to it. Their definition of *Vertipecten* is:

"Shell fairly thick, usually large; strengthened with large radial ribs which are somewhat irregular in number and prominence, showing a tendency to bifurcate or multiply by intercalation, often roughened by imbrication; left valve usually strongly convex, right valve nearly flat; ears on large specimens strengthened by riblets and sometimes imbricated, the right ventral ear being elongate and narrow, separated from the ventral sub-margin by a large byssal notch which leaves behind it a scar as wide as the ear, the ventral submargin strongly concave, the dorsal nearly straight; interior of hinge practically smooth, except for a shallow cartilage pit."

Although the present specimens resemble *Pecten nevadanus* Conrad (+*Pecten bowersi* Arnold) the type of the subgenus *Vertipecten,* the chief difference of our specimens to the definition of that subgenus, is that in our specimens the shell has not the "left valve usually strongly convex, right valve nearly flat" as in the type. Therefore, our specimens can not be referred to *Vertipecten,* even though the type of radial sculpture may be somewhat similar.

Lyropecten Conrad, defined by U. S. Grant and H. R. Gale[5] possesses characteristics exhibited by the specimens of *P. takahashii* at our disposal. Their definition of *Lyropecten* is:

"Shell thick, usually large, valves about equally convex; strengthened with large radial ribs upon which and upon the interspaces between which secondary striations are usually developed as on *Pecten maximus;* surface of valves sometimes marked by nodes or concentric constrictions as in *Manupecten* ventral ear somewhat longer than the dorsal, with a moderate or characteristically shallow byssal notch; interior of hinge often marked with strong cardinal grooves."

The present specimens often exhibit on their surface "nodes or concentric constrictions" and also "secondary striations" in the valleys of the ribs, further the shell is thick and usually large. Another feature is the "shallow byssal notch" which makes the present specimens close to the subgenus *Lyropecten* as defined by U. S. Grant and H. R. Gale. However, from *Lyropecten* the present specimens diverge by the valves not being "about equally convex," probably larger and less strongly sculptured ears and weak or almost obsolete "cardinal grooves".

1) "*Placopecten* Verril, Trans. Conn. Acad. Sci., Vol. 10, p. 69, 1897, type (by original designation) *Pecten clintonius* Say, described in the Journ. Acad. Nat. Sci. Phila., Vol. 4, p. 124, pl. 9, fig. 2, 1924, also described and figured by Verril, op. cit., p. 78, pl. 17, figs. 1–7, pl. 20, figs. 7, 8, 8a, pl. 21, figs. 1, 1a, 2, 2a,=? *Pecten magellanicus* Gmelin, Miocene to Recent of the Atlantic coast" (fide U. S. GRANT and H. R. GALE, Op. cit., p. 192, 1931).

2) "*Amusium* is more closely related to *Janira,* and it is probable that its apparent relation to *Patinopecten* is superficial, being a parallel adaptation to a somewhat similar environment" (fide U. S. GRANT and H. R. GALE, Op. cit., p. 192).

3) U. S. GRANT and H. R. GALE: Op. cit., p. 188, 1931.

4) J. THIELE: Handbuch der Systematischen Weichtierkunde, Bd. 2, p. 808, 1931 (type:—*P.* (*P*) *caurinus* GOULD.

5) U. S. GRANT and H. R. GALE: Op. cit., p. 175, 1931.

Thus, in strict sense the present specimens are not referable to the subgenera *Patinopecten* Dall, *Vertipecten* Grant and Gale, and *Lyropecten* Conrad, differing from *Patinopecten* by the strong convexity of right valve, minor striations in the valleys of both right and left valves, and by the left valve possessing intercalaries even though the ribs of right valve are not sulcated, differing from *Vertipecten* by the left valve not being strongly convex and by right valve not being nearly flat, and differing from *Lyropecten* by unequal convexity of the valves, weak cardinal grooves, and the ears less strongly sculptured. And to refer the present specimens to *Patinopecten* as done by previous Japanese workers, makes necessary a redefinition of the subgenus. Such a procedure would, however, not only cause further confusion to the conchologist, but also make more complex the morphological characters of the Pectinidae. Under the circumstances, we here propose a new subgeneric name, *Fortipecten*, with the following description, which takes into account all of the subgeneric characters (type:—Pl. XXXIV (1), Figs. 4–6).

Pecten (*Fortipecten*, subg. nov.) *takahashii* YOKOYAMA, 1930

Pl. XXXIV (1), Figs. 1–9, Pl. XXXV (2), Figs. 1–9.

1930 *Pecten takahashi* YOKOYAMA: Tertiary Mollusca from South Karafuto. Jour. Fac. Sci., Imp. Uni., Tokyo, Sec. 2, Vol. 2, Pt. 10, p. 416, pl. 78, figs. 1, 2; pl. 79. (Type loc. Isos, Higasi-Sakutan, Motodomari-gun, South Karahuto).

1931 *Pecten takahashi* YOKOYAMA: Neogene Shells from Karafuto and the Hokkaido. Ibid., Sec. 2, Vol. 3, Pt. 4, pp. 187, 189.

1932 *Chlamys takahashii* YOKOYAMA: Tertiary Mollusca from the Coalfield of Uryu, Ishikari. Ibid., Sec. 2, Vol. 3, Pt. 6, pp. 228, 230.

1932 *Pecten* (*Patinopecten*) *takahashii* KURODA: Catalogue of Japanese Shells. The Venus, Vol. 3, No. 2, appendix p. 101.

1935 *Pecten takahashii* YABE: The Middle and Lower Mizuho Period. Contr. Inst. Geol. Pal., Tôhoku Imp. Univ., in Japanese Language, No. 12, p. 23.

1935 *Pecten* (*Patinopecten*) *takahashii* NOMURA: A Note on Some Fossil Mollusca from the Takikawa Beds of the Northwestern Part of Hokkaidô, Japan. Sci. Rep., Tôhoku Imp. Univ., Ser. 2, Vol. 18, No. 1, p. 33, pl. 4, figs. 9a, 9b.

1936 *Pecten takahashii* NOMURA and HATAI: A Note Concerning Data on the Bathymetric Range of Certain Marine Animals and Remarks on the Geology of the Neogene Formations in Northeast Honsyû, Japan and Their Depth of Sedimentation as Indicated by the Fossil Fauna. Saito Ho-on Kai Mus., Res. Bull., No. 10, p. 288.

1937 *Pecten takahashii* SASSA and NISIDA: On the Geology of the Northeast Coast of South Karafuto. Jour. Geol. Soc. Jap., Vol. 44, Supplement to No. 530, p. 1072.

1937 *Pecten* (*Patinopecten*) *takahashii* INAI and SEKI: Tertiary Strata of the Tometakagawa and Mountainous Region West of the Otiai-Toyohara District. Ibid., Vol. 44, Supplement to No. 530, pp. 1125, 1126.

1938 *Pecten* (*Patinopecten*) *takahashii* NOMURA: Molluscan Fauna from the Tatunokuti Shell Bed Exposed at Gôroku Cliff in the Western Border of Sendai. Sci. Rep., Tôhoku Imp. Univ., Ser. 2, Vol. 19, No. 2, p. 249, pl. 36, figs. 4a, 4b.

1939 *Pecten takahashii* INAI: Neogene Stratigraphy of Sendai and Its Environs. Jubilee Publ. Commem. Prof. H. YABE's 60th Birthday, p. 368.

1939 *Pecten takahashii* SHIMAKURA and TUTIDA: Cenozoic Strata along the Border of the Kitagami-gawa (River). Contr. Inst. Geol. Pal., Tôhoku Imp. Univ., in Japanese Language, No. 32, p. 19.

1926 *Pecten wadai* YABE: Sendai and Matsushima. Guide-Book Excur. C-3, Pan-Pacific Sci. Congr., Tokyo, p. 5 (Manuscript name of YABE and NAGOYA).

1931 *Pecten piltunensis* KHOMENKO: Materials on the Stratigraphy of the Tertiary Beds of the Eastern Sakhalin Oilfield. I. The Nutovo and Supranutovo Series. II. The Ekhabi Series. Trans. Geol. Prosp. Ser., U.S.S.R., Fasc. 79, p. 53, pl. 1, fig. 6, pl. 2, figs. 1, 2. (Type loc. Between Piltun and Paromay Rivers, about 6 km. from the mouth; Supranutovo series. North Karahuto).

The presence of *Pecten takahashii* was first made public by M. Yokoyama in 1930, but to us, it was known to be a very characteristic mollusc in the Tatunokuti beds developed in Sendai and its environs. Being so characteristic, one of us (H. Yabe) in cooperation with Y. Tomita (formerly Nagoya) named the scallop, *Pecten wadai*, in the honor of the late Dr. T. Wada, ex-Director of the Imperial Goelogical Survey of Japan; however, the description and figures were left in manuscript form. The manuscript description (Pl. XXXIV (1), Figs. 4–6) was written as follows:

"Shell large, attaining about 130–140 mm in length; test thick, heavy; inequivalve, subequilateral; disc subcircular, generally slightly longer than high, straight at sides and evenly rounded along base.

Right valve convex, being 40–50 mm deep; disc carrying 10–13 strong radial ribs and a few submarginal radial riblets. Ribs subequal, low, rather narrow and rounded; intervals rather flat and broader than ribs, being thrice broader along base. Whole surface of disc ornamented by numerous radial striae and fine concentric growth-lines having a number of distant, distinct lines of annual cessation of growth; radial striae somewhat scaly, usually better preserved in intervals of ribs than on their top, developed more prominent on submarginal area than elsewhere. Hinge-line about 100–110 mm long, with large, subequal ears. Anterior ear with a shallow byssal notch and depressed byssal area; surface sculptured by many, obsolete, narrow riblets and rather conspicuous, flexuouse, incremental lines. Posterior ear squarely truncated, sculptured by similar radial riblets and incremental lines like those on anterior. Inside of disc almost smooth, slightly undulated in basal part; adductor scar almost circular. Resial pit triangular, 10 mm high and 15 mm broad, with its lateral margin raised into a tooth-like process.

Left valve almost flat, or but slightly convex. Ribs 10–13, narrow and sharp on umbonal part, intervened there by broader, flat-bottomed interspaces, becoming gradually broader and round-topped toward basal margin, where they are as broad as their intervals. Whole surface of disc covered by radial striae and concentric incremental lines as in right valve. Anterior ear somewhat longer than posterior; both being squarely truncated and marked by numerous radial riblets and fine growth-lines. Resial pit bordered on each side by a conspicuous ridge and obsolete groove, which fits into corresponding process of right valve".

The large number of specimens received from N. Zinbô during one of the writer's (H. Yabe) trip in South Karahuto together with the specimens now in the collection of the Institute of Geology and Palaeontology, Tôhoku Imperial University, and in the collection of the Division of Geology of the Saito Ho-on Kai Museum, both in Sendai were measured in order that some degree of variation may be studied. The specimens measured are given below.

Measurement (in mm)

1. Specimens from the Maruyama sandy shale beds at Horokanai, Siritori-mati, South Karahuto. Reg. No. 63405. Coll. N. ZINRÔ.

A. Right Valve

Length of shell	Width of shell	Depth of shell	Hinge-length	Ribs number	— Ribs — Maximum	Minimum	Muscular impression
138.5	136.5	55	99.5	14	18	13	65.5 × 54.5
101.5	102.0	45	92	12	19.5	10	54 × 38.5
103.0	109.0	44	86	10	23.5	14.2	46 × 41.5
127.5	126	45	97	12	18	12	56.5 × 54.5
116	99	41	92	11	22	10.5	49 × 42.5
117	106	38	86	13	—	—	— —
106	104.5	38	84	12	16.3	9	44 × 35
106+	109	42+	—	11	22	12.5	55 × 46.5
120	112	38	87	13	15.5	11	47.5 × 41
106.5	104	38+	84+	12	12.5	11.5	43.5 × 35
123	131	38+	103	11	18.5	14	55 × 46.5
132.5	123.5	43	109+	12	23.5	19.5	50 × 40
148	139	51	109+	12	22.5	12.5	62 × 58
112.5	102.5	42	86+	14	12.5	9	43.5 × 37.5
112.5	106.5	42	90+	13	16	11	45 × 42

Length of shell	Width of shell	Depth of shell	Hinge-length	Ribs number	— Ribs — Maximum	Minimum	Muscular impression
140+	138	56+	—	12	24.5	13.5	— —
146.5	134	46	107+	12	18	11.5	52 × 52
137+	121+	48	103+	12	28	13	46 × 50.5
119	107	47	93+	12	19.5	12	50 × 44.5
106+	104+	40	79	12	15	11.5	42 × 43
113.5	108+	41	77	10	17	10	37.5 × 37.5
111	105	41	—	11	20	13	42 × 37
109	100	40	—	14	16.5	8	— —
129	125.5	55	106.5	13	20.5	12	56 × 46
114	110	41	88	13	24	10	36 × 43
—	124	—	101	13	18	10.5	— —
109	105+	40	81+	12	16	11	45 × 46.5
—	125+	44+	101+	12	18.5	13	59 × 44.5
—	127	—	103	12	19	10	60 × 45
144	128	42	—	13	27	9	52 × 52
130	122	41	—	12	21	10	44 × 44
—	104	—	—	12	14	7	47 × 40
			B. Left Valve				
126.5	125	24	100.5	8	—	—	56 × 51.5
126	125	16	103+	12	21	21	55.5 × 51
112	107	16	—	8	23	13	46 × 38
116.5	114	17	95+	11	—	—	53.5 × 43
115+	122	15.5	97	10	15	13.5	55 × 47.5
107	105	18	92	7	20	10	46.5 × 37.5
115.5	109.5	25	—	9	24	12	49 × 41
117	114.5	20	97	10	18	12.5	49 × 39.5
98.5	—	11	—	10	10	10	36 × 30.5
103.5	99	22	—	8	27.5	12	47.5 × 33+
115+	114.5	28	—	11	17.5	13	44 × 39
124+	118.5	24	94	7	31	14	50 × 50
—	114	—	—	9	—	—	— —
100	100	20	—	9	18	11	— —
—	116	17	95+	9	19.5	13.5	54 × 45.5
122.5	119	20	95+	10	18	13	52 × 43
127.5	120	17	115+	9	17	13.5	60 × 44
112	117.5	20	98+	10	20.5	15	47 × 40.5
130.5	124.5	20	117+	10	22	13.5	54 × 50
128	125	19	—	11	23	14.5	54 × 44
—	131.5	—	117+	9	39	12.5	57 × —
139	139	15	119+	—	—	—	69 × 55.5
114	97.5	15	—	7	22.5	14.5	— —
115	110	18	—	—	—	—	— —
125	126	25	—	—	—	—	55 × 44
118	97	26	—	—	—	—	43 × 37.5
117	117	10	—	10	—	—	40 × 38

2. Specimens from the Tatunokuti beds in Sendai and its environs, Rikuzen.

a. Tatunokuti gorge, Sendai City. Reg. Nos. 7086, 7086a, 7086b.
b. Mukôyama, Sendai City. Reg. Nos. 7085, 70859.
c. Vicinity of Nenosiroisi, Miyagi-gun. Reg. Nos. 49918, 49919.
d. Vicinity of Sanbongi-mati, Sida-gun. Reg. No. 58579.
e. Gôroku, Hirose-mura, Miyagi-gun. Reg. No. 2170*.
f. Yodomi-basi, Sendai City. Reg. No. 2169*.
g. Nenosiroisi, Miyagi-gun. Reg. No. 2168.

* specimens in the collection of the Saito Ho-on Kai Museum, Sendai.

Valve	Length of shell	Width of shell	Depth of shell	Hinge-length	Ribs numb.	— Ribs — Max.	Min.	Muscular impressions	Reg. No.
Right	131	134	27.5	99+	13	19	9	55 × 52	7086
Left	127+	131	17	—	10	17.5	15	— —	7086
Left	129	133.5	—	111	11	19.5	13	41.5 × 51	7086a
Right	130+	130+	34	—	13	19	15.5	— —	7086a
Intact	148	145	44	—	14	26	14	— —	7086b
Right	148	—	52	—	13	24	14	62.5 × 56.5	7085
Right	136	140	38	—	12	23.5	15	— —	7085
Left	118	119.5	—	—	11	20.5	14	— —	49919
Left	73+	73+	—	—	8	11	11	26 × 18	49919
Right	120+	127.5	—	—	11	21	13	— —	58579
Intact	160	160	56	—	13	24.5	13	— —	2170*
Right	160+	170	48	—	13	24	17	— —	2170*
Right	122	—	40	—	12	17	10	— —	2170*
Right	150+	—	—	—	12	23	15	— —	2170*
Right	128.5	135	35	—	12	20	12.5	— —	2170*
Right	125	131	34	—	13	20.5	12	50 × 54	2169*
Intact	138+	146.5	57	121	10	21.5	16	— —	2169*
Right	135+	142	—	—	13	21.5	12.5	— —	2169*
Right	—	157+	—	—	14	19	13.5	66 × 62.5	2169*
Intact	160	—	54	—	11	31	19.5	— —	2168*
Intact	—	—	43	—	12	22	13	— —	2168*
Left	123.5	119+	—	—	—	—	—	49 × 53	2168*

3. Specimens from several localities in Hokkaidô, whose exact horizons are not known.

a. Tokati (?), Hokkaidô. Reg. No. 7083.

b. Zarigawa, Numata-mura, Uryû-gun. Reg. No. 56487 (labled as Upper Takikawa beds).

c. Morai, Isikari province. Reg. No. 2531.

Valve	Length of shell	Width of shell	Depth of shell	Hinge-length	Ribs numb.	— Ribs — Max.	Min.	Muscular impressions	Reg. No.
Right	124	125	50	—	12	20.5	13.5	52.5 × 52.5	56487
Intact	128.5	139+	59	101	13	16	14	— —	7083
Left	148.5	138.5	13	100	12	20	12	61 × 48	2531

The above given dimensions of the specimens studied includes only those which are in good preservation or in a state permitting measurement; a good many other specimens were also studied but owing to their being considerably fractured they were left from the present consideration.

Comparing the specimens from South Karahuto with those from Sendai and its vicinity, it is at once recognised that the outstanding features lie in the convexity of the right valve, which is greater in those from Karahuto; in the nature of the left valve, which in the specimens from Karahuto frequently have a flat surface or disc-area at the young part of the shell, such a feature is not observed in the specimens from Sendai, in the size of the shell, those from Sendai exceed those from Karahuto in general. Further, in the particulars of the intercalary riblets and the submarginal ones, probably the greater variation lies in the specimens from Sendai and its vicinity.

The maximum dimensions of the specimens from South Karahuto (A), Hokkaidô (B), and Sendai and its vicinity (C), are shown in the following table.

Locality	Length of shell	Width of shell	Depth of shell	Ribs numb.	— Ribs — Max.	Min.	Muscular impression	Valve
(A)	148.0	139.0	56+	14	27.0	7.0	65.5 × 54.5	Right
(A)	139.0	139.0	28	11	39.0	10	69.0 × 55.5	Left
(B)	148.5	139.0	50	13	20.5	12	61.0 × 48.0	Left
(C)	160.0	160.0	56	13	24.5	13	— —	Intact
(C)	160.0	170.0	48	13	24.0	17	— —	Right

The above given maximum dimensions of the specimens from the three different geographically isolated localities seem to point to the assumption that from north to south the size of the shell becomes larger, the convexity of the right valve less, and that the distance (maximum) between the radial riblets decreases. This appears to be the general tendency shown by the specimens measured, or in other words, the tendency shown by the numerals given in the list.

The shell outline in this species varies from nearly circular to subcircular, and the convexity of the right valve varies within the limits of 38–56 mm for specimens in the size-range of 106–146 mm, and the left valve of 10–28 for the specimens in the size-range of 98–139 mm, from South Karahuto; the right valve of specimens from Sendai and its environs is in the limits of 27–52 mm for specimens in the size-range of 120–160 mm, and the left valve is within the limits of 17-to nearly flat in specimens of the size-range of 73–129 mm; while in the specimens from Hokkaidô, the convexity of the right valve is in the limits of 50–59 mm when the size-range is 124–128 mm. The number of radial riblets of the right valve of the specimens studied is in the range of 10–14, and the most common number is 12–13, while for the left valve the general number is 10–11, ~~while~~ the range in their number being 7–12; this is for the specimens from South Karahuto. In the specimens from Sendai and its environs, the number of radial riblets of the right valve is in the range of 11–14, and the most common number is 11–13, while the range in their number for the left valve is 8–11, the most common number being 10–11. In the specimens from Hokkaidô, which are few in number, the general range in the number of the radial ribs is 12–13.

The distance between each of the radial riblets, measured at the ventral margin of the shell shows a range of 8–28 mm for the right valve and 10–39 mm for the left valve of the specimens from South Karahuto, 9–26 mm for the right valve and 11–20.5 mm for the left valve of the specimens from Sendai and its vicinity, and, 12–20.5 mm for the specimens from Hokkaidô. The given figures are the maximum and minimum measurements and do not indicate the commonly observed specimens. In general there is not so much difference or even a general tendency of the radial ribs becoming either closer to or more distant from one another with the increase or decrease of latitude. Detail features of variation are not measureable in terms of numerals, even though they can be detected by the eye.

Pecten (*Fortipecten*) *takahashii* Yokoyama which is characterized by its large size of shell, long ears, straight hinge-line, unequal convexity of the valves of which the right is always twice or more times swollen than the left, weak cardinal grooves, shallow byssal notch, possession of weak radial riblets on both valves, frequent nodose or constricted structure of the ribs, heavy test and simple ribs, can be distinguished from the members of the Japanese *Patinopecten* by the stated features.

Fortipecten is a subgenus related to ~~those of~~ *Patinopecten* and *Lyropecten* and may have branched off from the stock of *Patinopecten* (+ *Lyropecten*) during the closing of the Miocene or opening of the Pliocene, seeing that it is not known to occur in deposits of Miocene age (as now employed by the members of the Institute of Geology and Palaeontology, Tôhoku Imperial University). If this subgenus branched off from the *Patinopecten*-stock, then its relation to such species as *Pecten* (*Patinopecten*) *yessoensis*[1] Jay and *P.* (*Patinopecten*) *yamasakii*[2] Yokoyama (+ *P. tryblium* Yokoyama[3]), may be a key to its line of evolution. Until

1) This is a common species in Japan and our Institute possesses a large number of specimens, both recent and fossil.

2) M. YOKOYAMA: Tertiary Mollusca from Shinano and Echigo. Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. 2, Vol. 1, Pt. 1, p. 17, pl. 5, figs. 1, 2, 4, 5, 1925.

3) M. YOKOYAMA: Ibid., p. 17, pl. 6, figs. 1, 2. pl. 7, fig. 1, 5, 1925.

studies have been advanced on those two species, it may be best to withhold conclusive remarks.

The unusually heavy shell of *Fortipecten* in South Karahuto may have close bearing on its environment, seeing that the specimens from the vicinity of Sendai, which is its southernmost limit in geographical distribution have shells which are much thinner than those from South Karahuto. Shells living in cold waters generally possess a thicker test than those living in warmer waters, and such a feature is best seen in shells which have a geographical distribution ranging from north to south; *Pecten takahashii* is a good example.

From the type locality of *Pecten takahashii*, M. Yokoyama also reported on the occurrence of another scallop, *Pecten agnatus* YOKOYAMA,[1] which is closely allied to the first mentioned. M. Yokoyama described *Pecten agnatus* in the following way.

"A single right valve moderate in size, rather thin, convex, circular, somewhat longer than high, equilateral save for ears, radiately ribbed, with ribs about fifteen in number, equal, straight, narrow, rounded at top, separated by much broader interstices. The ears are unequal with the anterior larger than the posterior. Byssal notch present, shallow. Height 62.5 millim. Length 66 millim. Depth 15.5 millim."

As can be judged from the illustrations and description of *Pecten agnatus*, it appears evident that it is merely a *Pecten takahashii* in which an extreme variation is exhibited, seeing that the number and type of radial ribs as well as shell outline and general features of it are well displayed in the specimens of *P. takahashii* now before us. Consequently, whether *P. agnatus* should be given a specific name or whether it should be thrown into the synonymy of *P. takahashii* may call for personal taste. However, at the present time it appears best to place it with *P. takahashii*.

Pecten piltunensis described by J. P. Khomenko[2] from the Supranutovo series between Piltun and Paromay rivers in North Karahuto, was placed into the synonymy of *Pecten takahashii* Yokoyama by S. Nomura,[3] who failed to state whether all of the figures of that species belong to *P. takahashii*. Judging from the figures of *P. piltunensis* given by J. P. Khomenko, there seems to be no doubt as to figures 1 and 2 of plate 2, and figure 6 on plate 1 belong to *P. takahashii*, but figures 7 and 8 of plate 1 are too fragmentary and poorly figured to give decisive remarks, while figures 3–6 of plate 2 appear to be a different species. Figures 5 and 6 of plate 2 are said to be left valves, but judging from their sculpture, it appears that they are closer to *P. kagamianus* Yokoyama[4] a species with such sculpture. Figure 3 on plate 2 has too many ribs to be a form of *P. takahashii*. Even figure 1 and 2 on plate 2 may not be true forms of *P. takahashii* seeing that the type of radial ribs are somewhat different. *Pecten kimurai* Yokoyama[5] may be a species close to what J. P. Khomenko named *P. piltunensis*, but the latter has a larger number of radial ribs.

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1) M. YOKOYAMA: Tertiary Mollusca from South Karafuto. Jour. Fac. Sci., Imp. Univ., Tokyo, Sec. 2, Vol. 2, Pt. 10, p. 417, pl. 80, fig. 1. (Type locality of *Pecten agnatus* is Isos, Higasi-Sakutan, Motodomari-gun, South Karahuto, collected by Mr. Takahashi). *Pecten agnatus*, according to M. YOKOYAMA's report, occurs together with *P. takahashii;* other fossils occurring in association with *P. agnatus* are, *Mitra* ? sp., *Beringius hanzoganensis* Yok., *Natica janthostoma* Desh., *Cardium groenlandicum* Chem., *Diplodonta usta* Gld., *Venericardia* sp., *Acila insignis* (Gld.), and the two scallops above mentioned.

The type locality for both *Pecten takahashii* and P. agnatus, was spelled "Isos" in M. YOKOYAMA's report, but this should read as "Isousi." This is a typical locality of the Maruyama beds, or the lower part of the Siritori series.

2) J. P. KHOMENKO: Materials on the Stratigraphy of the Tertiary Beds of the Eastern Sakhalin Oilfield. Trans. Geol. Prosp. Ser., U.S.S.R., Fasc. 79, p. 53, 1931.

3) S. NOMURA: Molluscan Fossils from the Tatunokuti Shell Bed Exposed at Gôroku Cliff in the Western Border of Sendai. Sci. Rep., Tôhoku Imp. Univ., Ser. 2, Vol. 19, No. 2, p. 249, 1938.

4) M. YOKOYAMA: On Some Fossil Mollusca from the Neogene of Izumo. Jap..Jour. Geol. Geogr., Vol. 2, No. 1, p. 8, pl. 1, fig. 1, 1923. K. HATAI: A Note on *Pecten kagamianus* Yokoyama. Bull. Biogeogr. Soc. Jap., Vol. 8, No. 6, pp. 103–110, 1938.

5) M. YOKOYAMA: Molluscan Remains from the Uppermost Part of the Jô-Ban Coalfield. Jour. Coll. Sci., Imp. Univ., Tokyo, Vol. 45, Art. 5, p. 27, pl. 4, pl. 2, fig. 4, 1925. K. HATAI and S. NISIYAMA: Palaeontological Notes on Certain Japanese Scallops. Trans. Pal. Soc. Japan, No. 78, pp. 37–46, 1939.

Among the *Pecten* described and figured by U. S. Grant and H. R. Gale[1] from the Neogene deposits of California, *Pecten* (*Vertipecten*) *nevadanus* Conrad, somewhat resembles the varietal forms of *Pecten* (~~*Patino*~~*Fortipecten*) *takahashii* Yokoyama, but the convexity of the valves and type of radial riblets are different.

Pecten (*Patinopecten*) *caurinus* Gould, described and figured by R. Arnold[2] from the Pliocene of San Raphael Hills in Santa Barbara County, California, closely resembles *P. takahashii* in size of shell, general outline, formation of the ribs and in geological age of occurrence. However, the Japanese one can be distinguished from the Californian one by the larger ears, less number of radial ribs on the left valve as well as on the right, and by the right valve being much more convex in the Japanese form.

Although the Japanese form is closely allied to the Californian *caurinus* and *nevadanus* above mentioned, the true relationship existing between the Japanese and Californian species is uncertain. It may also be stated that there are species of *Pecten* common to the Tertiary deposits of both sides of the North Pacific, and a much larger number are very closely similar. Similarly, the number of molluscan species common to the Tertiary deposits of both sides of the Pacific is by no means small, and that this close similarity has close bearing on the problem of migration in Tertiary seas between the two continents can hardly be denied.

Since *Pecten takahashii* was originally described by M. Yokoyama in 1930, upon the specimens collected by Mr. Takahashi to whom the specific name is given, from an unknown horizon at "Isos, Higasi-Sakutan, Motodomari-gun" in South Karahuto, it is now necessary to determine, if possible, the stratigraphic position and geological age as well as geological range of this species in order that its bearing on the Japanese Neogene deposits may be settled. After a brief survey of the stratigraphic horizons in which this scallop is known to occur is undertaken, then it may be possible to determine the geological age of the horizon from which M. Yokoyama's specimens were derived.

In Sendai and its environs are developed Neogene deposits of considerable distribution, and *Pecten* (*Fortipecten*) *takahashii* Yokoyama, occurs, so far as is known at present, only from the Tatunokuti beds, a marine fossiliferous beds which occupy the following stratigraphic position.[2]

Basement complex: Rihu Triassic deposits.

—unconformity—

Siogama agglomerate and Natori-gawa andesite.

—unconformity—

Lower Sawoyama series: Basal conglomerate, impure limestone, sandstone, shale and tuff. Important fossils are, *Pecten kagamianus* Yokoyama, *P. notoensis* Yokoyama, *Cardium shiobarense* Yokoyama, *Dosinia kaneharai* Yokoyama, *Vicarya martini* Yabe & Hatai, *Tanakura tanakura* Hatai, *Terebratalia tenuis* (Hayasaka), *Echinolampas yoshiwarai* P. de Loriol, *Lepidocyclina polygonalis* (Hanzawa), *L. japonica* Yabe, *Aphrocallistes* sp., *Desmostylus japonicus* Iwasaki and Yoshiwara, *Comptoniphyllum naumanni* Nathorst, *Sequoia japonica* Endô, *Liquidambar formosana* Hance, and others.

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1) U. S. GRANT and H. R. GALE: Catalogue of the Marine Pliocene and Pleistocene Mollusca of California and Adjacent Regions. Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 189, pl. 7, fig. 2, 1931.

2) R. ARNOLD: Tertiary and Quarternary Pectens of California. Prof. Paper No. 47, U. S. Geol. Surv., Ser. C, Syst. Geol. Pal., No. 76, p. 101, pl. 38, figs. 1, 1a, 1b; pl. 39, figs. 1, 2, 1906.

3) 磯牛

4) In a paper entitled, Tertiary Stratigraphy of Japan, as presented to the Sixth Pan-Pacific Science Congress, held in California, U.S.A., 1939.

—unconformity—

Upper Sawoyama series: Tuff, sandy tuff, tuffaceous shale and sandy shale. Important fossils are, *Glyptostrobus europaeus* Heer, *Sequoia sempervirens* Endlicher, *Acer pictum* Thunberg, *Betula japonica* Siebold, *Liriodendron honsyuensis* Endô, *Ulmus japonica* Sargent, *Sassafras yabei* Endô & Okutsu, and many others.

—unconformity—

Mitaki basaltic-andesite.

—unconformity—

Lower Sendai series: Sandstone, shale, and lignite with basal conglomerate. Important fossils are, *Arca tatunokutiensis* Nomura & Hatai, *Glycymeris gorokuensis* Nomura, *Ostrea gravitesta* Yokoyama, *Cardium pseudofastosum* Nomura, *Polinices kiritaniana* Yokoyama, var., this is the Tatunokuti shell beds. *Abies balsamea* Millard, *Glyptostrobus europaeus* Heer, *Cinnamomum scheuchzeri* Heer, *Sassafras yabei* Endô & Okutsu, *Taxodioxylon sequoianum* Gothan, *Glyptostroboxylon tenerum* Krausel, *Trilophodon sendaicus* Matsumoto, and a many others.

—unconformity—

Middle Sendai series: Massive tuff, sandstone and shale with basal lignite. Important fossils are *Sequoia japonica* Endô, *Alnus japonica* Siebold & Zuccarini, *Fagus crenata* Blainville, *Taxodioxylon sequoianum* Gothan, *Glyptostrobus tenerum* Krausel, and others.

—unconformity—

Upper Sendai series: Sandstone, sandy shale, shale and basal lignite. Important fossils are, *Mya cuneiformis* (Böhm), *Dosinia japonica* (Reeve), *Arca trilineata* Conrad, *Protocallithaca adamsi* (Reeve), *Fagus crenata* Blainville, and several others.

—unconformity—

Quaternary deposits: Sand, gravel and clay.

From the stratigraphic sequence of the different strata and the fossils they entomb, it is now clear that, according to the standard now employed by us,[1] the Upper Sawoyama series are referable to the Upper Miocene, and in a two fold division of the period. The Mitaki basaltic-andesite may belong to either the Uppermost Miocene, the Lowermost Pliocene, or to an age intermediate between the two mentioned.

The Tatunokuti beds which yield *Pecten takahashii* in profusion at certain places and the underlying lignite beds, with plant fossils belong to an age younger than the Miocene. S. Endô and H. Okutsu[2] in their study of fossil cones of the Balsam Fir from the Lower Sendai series, came to the conclusion that the Lower Pliocene age is to be accepted for the beds. On the other hand S. Nomura[3] from his study of the molluscan fossils from the same series, arrived at the conclusion that the Tatunokuti fauna is Lower Pliocene in age.* Seeing that the fossil molluscan fauna and the fossil plant flora both point to the Lower Pliocene age for the Lower Sendai series, it follows that *Pecten takahashii* in Sendai and its environs is of Lower Pliocene age as it does not occur in beds either younger or older than the Lower Sendai series.

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1) H. Yabe: The Lower and Middle Mizuho Period. Contr. Inst. Geol. Pal., Tôhoku Imp. Univ., in Japanese Language, No. 12, 1935.

2) S. Endô and H. Okutsu: Fossil Cones of Balsam Fir from Sendai. Trans. Pal. Soc. Japan, No. 90, 1939.

3) S. Nomura: Molluscan Fossils from the Tatunokuti Shell Bed Exposed at Gôroku Cliff in the Western Border of Sendai. Sci. Rep., Tôhoku Imp. Univ., Ser. 2, Vol. 19, No. 2, 1938.

* K. M. Hatai: Plio-Pleistocene Versus Lower Pliocene Age for the Tatunokuti Beds Developed in Sendai and Its Environs, Rikuzen Province, Northeast Honsyû, Japan. Jap. Jour. Geol. Geogr., Vol. 16, pp. 239–243, 1939. K. M. Hatai: A Review of the Stratigraphy and Palaeontology of the Tertiary Deposits of the Environs of Sendai, Miyagi-ken, Northeast Honsyû, Japan. Jap. Journ. Geol. Geogr., Vol. 17, pp. 135–157, 1940.

According to M. Shimakura and S. Tutida,[1] *Pecten takahashii* also occurs in the Neogene rocks bordering the Kitakami-gawa (River), and its stratigraphic position is given in the following sequence, which they established during their detail survey there.

Pre-Neogene: Toyoma series, largely consisting of slate.

—unconformity—

Masiba shell beds: Tuffaceous sandstone, shale and tuff. Fossiliferous. This unconformably overlies the Toyoma series in the west, while in the east the Kannari beds are found to overlie the Toyoma series unconformably.

—unconformity—

Arikabe beds: The Kannari basal conglomerate, Arikabe tuff beds and Muyari lignite beds at the top. Important fossils are, *Sequoia sempervirens* Endlicher, *Taxodioxylon sequoianum* Gothan, *Zelkowa serrata* Makino, *Fagus crenata* Blainville, *Cupressinoxylon, Cedroxylon* and *Piceoxylon.*

Yusima beds: Sandy shale and shale. Important fossils are, *Cardium californiense* Deshayes, *Lucina acutilineata* Conrad, *Macoma tokyoensis* Makiyama, *Ostrea gigas* Thunberg, *Pecten takahashii* Yokoyama, besides others.

—unconformity—

Kazawa beds: Iikura basal conglomerate beds and Kazawa lignite beds.

—unconformity—

Mataki lignite beds, which yield *Taxodioxylon sequoianum* Gothan, *Cupressinoxylon, Cedroxylon* (*Abies*), *Gleditschia,* and others.

—unconformity—

Yasaka beds: Kusariba conglomerate beds below and tuffaceous rocks above.

—unconformity—

Quaternary: Sand, gravel and clay.

From the above given stratigraphic position of *Pecten takahashii* Yokoyama together with the general sequence of the entire strata, and their relation to the stratigraphy of Sendai and its environs, it is at once seen that the Yusima beds correspond to the Lower Sendai series. It also appears that the Muyari lignite beds mentioned above are an equivalent of the Lower lignite beds (here included into the Lower Sendai series) developed in Sendai and its environs. Relying upon the general stratigraphy and the fossils derived from the different beds, it can be said that the Yusima beds inclusive of the Muyari beds are an equivalent of the Lower Sendai series, and thus, Lower Pliocene in age.

In South Karahuto the following stratigraphic sequence was recently established.

Cretaceous: Terrestrial and marine sediments.

—unconformity—

Naibuti series: Shales, sandstone and conglomerates with tuffs; coal seams. Important fossils are, *Alnus Kefersteini* Goepp, *Populus arctica* Heer, *P. cuneata* Newberry, *Platanus aceroides* Goepp, *Juglans acuminata* Al. Braun, *Magnolia nordenskioldi* Heer, and others.

Maoka series: Black shale and shaly sandstone; coal seams. Important fossils are, *Yoldia asagaiensis* Makiyama, *Thyasira bisecta* (Conrad), *Cardium harrimani* Dall, *C. asagaiensis* Makiyama, *Colus asagaiensis* Makiyama, *Buccinum matchgarense* Makiyama, and others.

Honto series: Agglomerate, hard-shale, sandstone, shale, coal and shale. Important fossils are, *Yoldia tokunagai* Yokoyama, *Venericardia tokunagai* Yokoyama, *Mya grewingki* Makiyama, *Dentalium tigillum* Yokoyama, *Desmostylus mirabilis* Nagao, and others.

Siritori series: Tinnai sandstone in the upper, and Muruyama beds in the lower, the latter consist of tuffaceous shale and lignite with pebbles at the base in its upper part, and

1) M. SHIMAKURA and S. TUTIDA: Cenozoic Strata of the Border of the Kitakami-gawa (River). Contr. Inst. Geol. Pal., Tôhoku Imp. Univ., in Japanese Language, No. 32, 1939.

its lower part comprises tuffaceous shale more sandy and with *Pecten takahashii* in its uppermost part, *Thyasira bisecta* (Conrad) in its upper, *Mya cuneiformis* (Böhm) in its middle and *Thyasira nipponica* Yabe and Nomura in its lower. It has also *Lucina acutilineata* Conrad, *Mya cuneiformis* (Böhm), *Thyasira* besides a large number of others.

The Siritori series which yields *Pecten takahashii* is the uppermost member of the marine fossil-yielding horizons, and according to Y. Inai of our Institute, who has made geological studies in several parts of South Karahuto, *Pecten takahashii* does not occur in horizons older than the base of the Siritori series (his Maruyama sandy shale beds) or in beds younger than the top of the same. Thus, from his observations as well as from literature, it follows that *Pecten takahashii* in South Karahuto is confined in its geological range to the age indicated by the Siritori series. The Siritori series is, according to present usage of the stratigraphic term, generally regarded as belonging to the Pliocene, and to the Lower part in the standard employed by the members of our Institute.

From the facts concerning the geology of South Karahuto[1] and from the data gained from Y. Inai and T. Koiwai as a result of their stratigraphical studies, it is now definite that the type locality of *Pecten takahashii,* which is stated by M. Yokoyama[2] to be, "Isos, Higashi-Sakutan, Motodomari-gun" (the current reading is Isousi, not Isos), stratigraphically belongs to the Maruyama beds of the Siritori series. The type specimens of both *P. takahashii* and *P. agnatus* were said to be found in association with several molluscs, which according to M. Yokoyama, are, *Mitra* ? sp., *Beringius hanzoganensis* Yokoyama, *Natica janthostoma* Deshayes, *Cardius groenlandicum* Chemnitz, *Diplodonta usta* Gould, *Venericardia* sp., *Pecten subyessoensis* Yokoyama, *Acila insignis* (Gould). That these fossils may be referred to the Lower Pliocene age, probably has no disagreement with their respective geological ranges.

The second locality of *Pecten takahashii* from South Karahuto, mentioned by M. Yokoyama[3] is, "Itatakushunnai, Sakaehama-mura, Sakaehama-gun"; this locality also probably belongs to the Maruyama beds.

In regard to the horizons of this species in Hokkaidô, remarks now follow. The general stratigraphic sequence of the strata in the Isikari coal field, Hokkaidô is as follows.

Cretaceous: Hakobuti sandstone.

—unconformity—

Noborikawa group: Sandstone, shale and sandy shale in alternation; coal seams. Many plant fossils occur.

Horokabets shale: Shale intercalating thin marly layers and rarely with sandstone. Plant fossils occur.

Yûbari group: Sandstone, shale, conglomerate and thin marl in alternation; coal seams. Plant fossils abundant.

Wakkanappe shale; Shale intercalating thin beds of sandstone with many marine shells.

Wakkanappe sandstone: Sandstone intercalating dark shale with many marine shells.

Bibai group: Sandstone, sandy shale and shale in alternation with thin layers of marl and conglomerate; coal seams. Abundant plant fossils.

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1) The Petroleum Geology of South Saghalin. Jour. Geol. Soc. Japan, Vol. 44, Supplement to No. 530, pp. 1025–1173, 1937. K. Uwatoko: Explanatory Text to the Geological Map of South Sakhalin. Publ. Karahuto-tyô, 1939 (Japanese with English Resume).

2) M. Yokoyama: Tertiary Mollusca from South Karahuto. Jour. Fac. Sci., Imp. Univ., Tokyo, Sec. 2, Vol. 2, Pt. 10, p. 412, 1930.

3) M. Yokoyama: Neogene Shells from Karahuto and the Hokkaidô. Jour. Fac. Sci., Imp. Univ., Tokyo, Sec. 2, Vol. 3, Pt. 4, p. 187, 1931.

Lower *Corbicula bed*: Sandstone and shale in alternation; coal seems. *Corbicula* is the predominating fossil.

Woodwardia zone: Sandstone and shale in alternation; coaly shale and coal seams. Fossils of plants common, most outstanding are those of *Woodwardia*.

Ikusyunbets group: Sandstone, shale and sandy shale in alternation with marl layers; coal seams. Plant fossils common.

Upper *Corbicula* bed: Sandstone intercalating with shale. *Corbicula* common.

Asibetu group: Standstone intercalating shale; coal seams. Plant fossils occur.

—unconformity—

Poronai series: Sandy shale intercalating thin layers of marl, rarely with lenticular limestone masses; nodules and Gennoisi common; basal conglomerate with glauconite. Intrusive sheet of augite-andesite in the upper. Marine shells very common in certain horizons.

—unconformity—

Kawabata series: Sandstone, shale, sandy shale, conglomerate and tuff and alternation with thin marly layers. Important fossils are, *Thyasira bisecta* (Conrad), *Ostrea gravitesta* Yokoyama, *Desmostylus japonicus* Iwasaki and Tokunaga, *Callianassa inornata* Nagao & Huzioka, *Nelumbo nipponica* Endô, *Betula brongniarti* Ettinghausen, besides numerous others.

—unconformity—

Oiwake series: Sandstone and sandy shale. Important fossils are, *Solemya tokunagai* Yokoyama, *S. yessoensis* Kanehara, *Japelion tokunagai* Kanehara, *Lucina acutilineata* Conrad, *Thyasira bisecta* (Conrad), *T. nipponica* Yabe & Nomura, *Turritella saishuensis* Yokoyama, *Pecten takahashii* Yokoyama, besides numerous others.

—unconformity—

Takikawa series: Sandstone, shale and conglomerate, more or less tuffaceous and always intercalating loose tuffs. Important fossils are, *Arca trilineata* Conrad, *Macoma tokyoensis* Makiyama, *Venus stimpsoni* Gould, *Nucula divaricata* Hinds, *Yoldia thraciaeformis* Storer, besides numerous others.

In regard to the fossils from the Takikawa beds, it must be stated at this place that the ones listed by S. Nomura[1] upon the collection of S. Endô, are said by S. Oishi (verbal communication) to comprise specimens from both the Oiwake series and the Takikawa series, and therefore, some revision should be made. Consequently, it seems to us that *Pecten takahashii* Yokoyama, and several others are more probably from the Oiwake rather than the Takikawa series.

M. Yokoyama[2] also reports *Pecten takahashii* from the Okada beds in the coalfield of Uryu in Isikari province. The stratigraphic position of the Okada beds, according to M. Yokoyama, is as follows.

Tachibets beds: Greenish gray sandstone, conglomerate, alternation of grey gandstone and dark grey shale intercalating tuffites and coal seams, alternation of black shale and greenish grey sandstone. Fossils occur in the upper part of the beds. Important fossils are, *Yoldia breviscapha* Yokoyama, *Margaritana perdahurica* Yokoyama, *Nodularia pisciformis* Yokoyama, *N. subjapanensis* Yokoyama, *Crassatellites heteroglyptus* (Pilsbry), *Circe tokudai* Yokoyama, *Thiara fiscina* Yokoyama, *Viviparus uryuensis* Yokoyama.

1) S. NOMURA: A Note on Some Fossil Mollusca from the Takikawa Beds of the Northwestern Part of Hokkaidô, Japan. Sci. Rep., Tôhoku Imp. Univ., Ser. 2, Vol. 18, No. 1, pp. 31–39, 1935.

2) M. YOKOYAMA: Tertiary Mollusca from the Coalfield of Uryu, Ishikari. Jour. Fac. Sci., Imp. Univ., Tokyo, Sec. 2, Vol. 3, Pt. 6, pp. 221–247, 1932.

Numata beds: Alternation of sandstone and shale with fossils, green sandstone interbedded with shale and fossils present, shale and sandstone intercalating thin layers of coaly shale and with fossils. Important fossils are, *Ostrea gigas* Thunberg, *Mytilus grayanus* Dunker, *Paphia munroei* Yokoyama, *P. variegata* (Hanley), *Circe* tokudai Yokoyama, *Venus okadana* Yokoyama, *Macrocallista brevisiphonata* (Carpenter), *Dosinia angulosa* (Philippi), *Solen* cf. *krusensterni* Gould, *Mactra sulcataria* Deshayes, *Umbonium ishiianum* Yokoyama, *Natica kiritaniana* Yokoyama, *N. janthostoma* Deshayes, *Thiara fiscina* Yokoyama, *Searlesia japonica* Yokoyama.

Nisei beds: Shale intercalating some layers of sandstone and coaly shale. Fossils present; badly preserved.

Okada beds: Sandstone, conglomerate, sandy shale, sandstone and shale. Fossils present. Important fossils are, *Yoldia sagittaria* Yokoyama, *Ostrea gigas* Thunberg, *Pecten swiftii* Bernardi, *P. takahashii* Yokoyama, *Mytilus grayanus* Dunker, *Venericardia tokunagai* Yokoyama, *Cardium nuttallii* Conrad, *Venus okadana* Yokoyama, *V. stimpsoni* Gould, *Macrocallista brevisiphonata* (Carpenter), *Cyclina sinensis* (Gmelin), *Tellina venulosa* Schrenck, *Macoma tokyoensis* Makiyama, *M. nipponica* (Tokunaga), *Mactra sachalinensis* Schrenck, *M. sulcataria* Deshayes, *Panope japonica* (A. Adams), *Umbonium ishiianum* Yokoyama, *Calliostoma subunicum* Yokoyama, *Sinum neritoideum* (Linne), *Natica janthostoma* Deshayes, *Crepidula jimboana* Yokoyama, *Thiara fiscina* Yokoyama, *Turritella kiiensis* Yokoyama, *Cerithidea ishikariensis* Yokoyama, *Coralliophila tokudai* Yokoyama, *Buccinum undatum* (Linne), *Pleurotoma sadoensis* Yokoyama, and others.

Judging from the figures of the species in M. Yokoyama's article, the poor state of preservation of the majority of the fossils makes it difficult to give accurate specific names. However, from the faunal list given above and from the stratigraphical position of the Okada beds, from which *Pecten takahashii* was found, are probably somewhere in a position close to the Siritori series of South Karahuto and to the Tatunokuti beds or Lower Sendai series in Sendai and its environs. Although without hardly any important elements in common, the Okada beds may belong to a horizon corresponding to either the Oiwake series or to the Takikawa series.

From the foregoing lines showing the stratigraphical position of *Pecten takahashii* Yokoyama and its associated fauna in the various regions from which it is known to occur, it may be said that this particular scallop is confined in its geological range to the Pliocene (Lower to Middle Pliocene) age in the sense now employed by the members of the Institute of Geology and Palaeontology, Tôhoku Imperial University, and that the horizons in which this fossil occurs are either of the Lower or the Middle Pliocene age. Consequently, *Pecten* (*Fortipecten*) *takahashii* Yokoyama, in the Japanese Neogene can be considered to be an important element for age determination on the one hand and for horizon marker on the other; the statement being much strengtherend by surveying its associated fauna.

Explanation of Plate XXXIV (I)

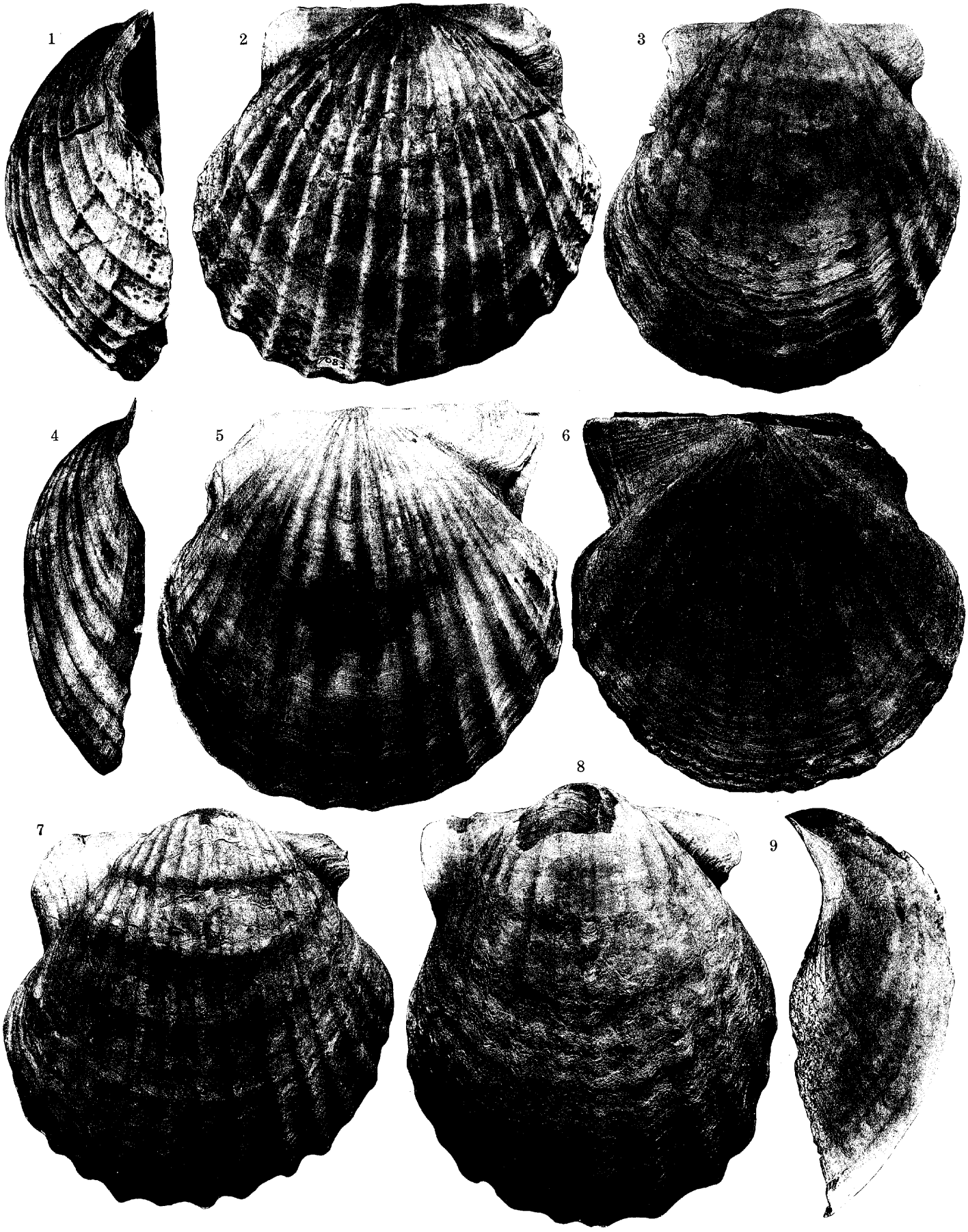
(All figures reduced to 2/3 natural size)

Pecten (*Fortipecten*) *takahashii* Yokoyama

Figs. 1, 2. Lateral and front views of the right valve of a specimen from (?) Tokati province in Hokkaidô (Reg. No. 7083). The convexity of the specimen is remarkable as can be seen when compared to fig. 9 of the same plate and to fig. 1 of plate (2). The umbonal region of this shell is not much inflated compared to those of figs. 3, 7, and 8 of the same plate.

Figs. 4, 5, 6. Lateral, right and left views of the specimen from the Tatunokuti beds at the type locality (Tatunokuti gorge; Reg. No. 7086). In this specimen are seen the radial threads in the valleys of the right valve and on the ears of the left valve. Further, the concentric growth lines and scaly-appearance caused by their crossing the radial ribs is also well seen.

Figs. 3, 7, 8, 9. Specimens of right valves from Horokanai, Siritori-mati in South Karahuto (Reg. No. 63405). In these valves the number of radial ribs and their formation is of interest; further, the much inflated umbonal region and nodose appearance on the surface is of special interest.



Sinozaki Photo.

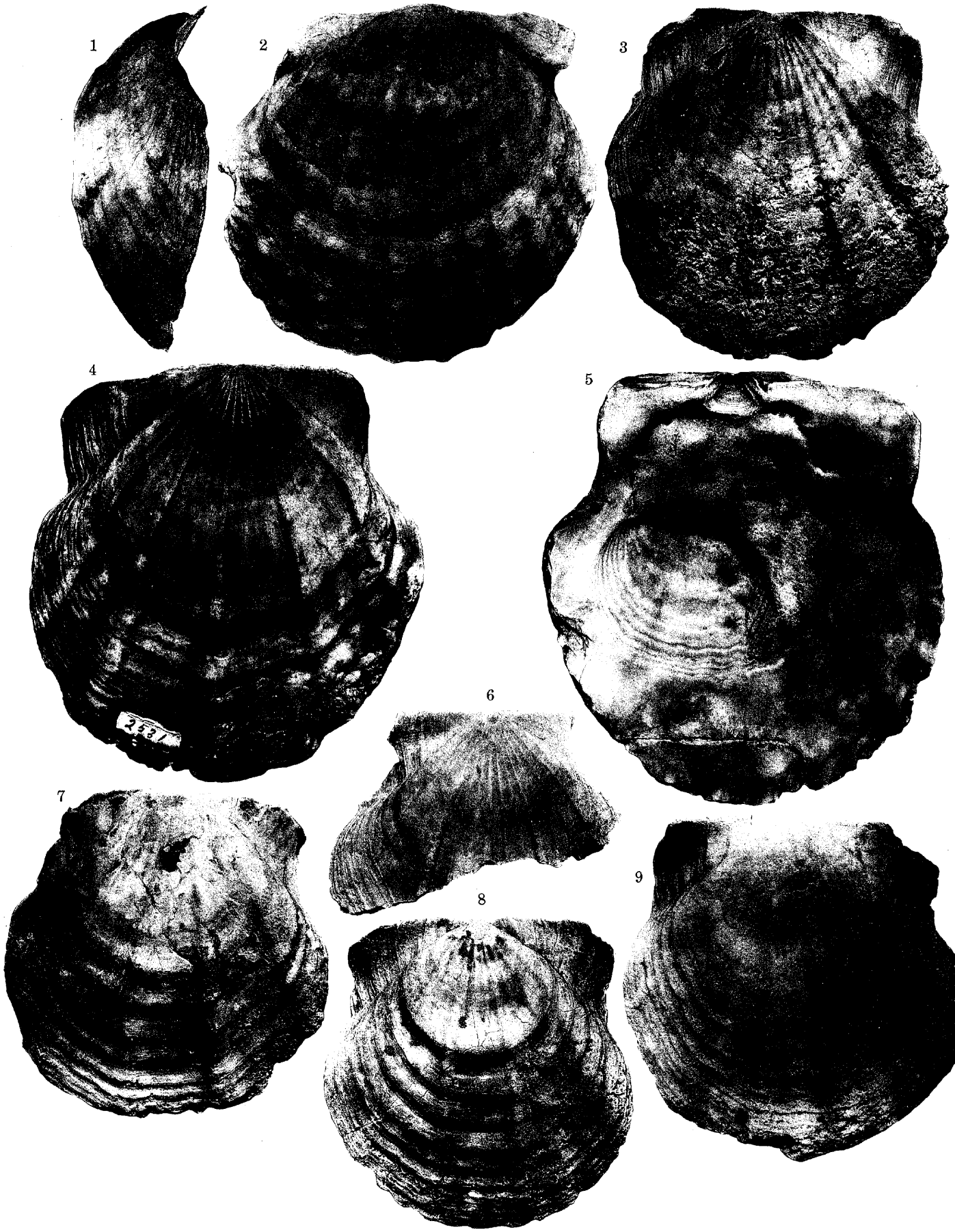
Explanation of Plate XXXV (II)

(All figures reduced to 2/3 natural size)

Pecten (*Fortipecten*) *takahashii* Yokoyama

Figs. 1–3, 6–9. Specimens of the right and left valves from Horokanai, Siritori-mura in South Karahuto (Reg. No. 63405). Peculiar formation of the radial ribs on the left valve can be seen, and it is to be noticed that the umbonal area of the left valve is at times much elevated (fig. 7, 8), or perfectly flat (fig. 3), or even depressed (fig. 9); it may also form sharp boundaries from the rest of the shell (fig. 4). The type of radial ribs in the left valve is variable in both strength, arrangement and number, as can be seen by comparing them with one another. Further, the convexity of the right valve and type of radial ribs is variable (fig. 1, 2).

Figs. 4, 5. A left valve from Môrai in Hokkaidô (Reg. No. 2531), showing the unusually strong muscular impressions (fig. 5), which is provided at its dorsal region with a very heavy and wide-spread covering of additional shelly material. Such a case is not rare, and we have a large number of specimens showing such a feature. The surface of this left valve is of interest in its formation of radial ribs, which is seen from the figure.



Sinozaki Photo.