On the Pleistocene Flora in Prov. Yamashiro with the Descriptions of 3 New Species and 1 New Variety.

(With Plate 1 and 5 Text-figures)

by

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In spite of the fact that the tertiary fossil flora of Japan is fairly well known, that of Pleistocene is rather little studied. Last year I had an opportunity to collect some fossil flora of Older Pleistocene in the suburb of Kyoto, Prov. Yamashiro. There have been found 23 different species satisfactory identified. Some of them are quite extinct or only their allied species are found in remote districts, while the other are still living.

From these facts, as well as from the habitats of the flora it might also be possible to consider the climatic and topographical changes that have taken place during the course of the era in the region under consideration, the geological age of which is identical with that of Naganuma bed in South Kwanto.

I wish to express here many sincere thanks to Prof. K. Koriba, under whose direction this study was undertaken. Further I am deeply indebted to Prof. S. Nakamura and Prof. J. Makiyama for their most valuable suggestions upon geological questions and also to Prof. Y. Okada who kindly determined for me the remains of marine animals. I wish to thank Prof. Y. Yamamoto, of Taihoku Imp. University, Mr. Y. Yoshinaga of Kochi Prefecture and Mr. Y. Tanaka of Fukuoka Imp. University, who have so kindly sent materials for the writer’s use.

The Sites of the Fossil Beds

The fossil beds are found both in the eastern and western parts of Yamashiro basin; Ohbakusan, Kobata and Taniguti in the east, and Iwami-kamisato in the west. In the former two, three fossil beds are distinguished while in the latter only two of them are found.

The fossil beds are laid between thick sand and gravel layers, which show some variation in the thickness and the kind of fossil according to
the localities, though they all contain the seed of *Sapium*, and fruit and twig of *Paliurus* as shown in the following table.

<table>
<thead>
<tr>
<th>Name of fossil plant</th>
<th>Ohbakusan</th>
<th>Taniguti</th>
<th>Iwami-kamisato</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Alnus japonica</em></td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><em>Carex vesicaria</em></td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><em>Ceratophyllum demersum</em></td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Euryale ferox</em></td>
<td>+</td>
<td></td>
<td></td>
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<tr>
<td><em>Fagus ferruginea</em> var.</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><em>Fagus microcarpa</em></td>
<td>+</td>
<td></td>
<td></td>
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<tr>
<td><em>Loropetalum chinense?</em></td>
<td>+</td>
<td></td>
<td></td>
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<tr>
<td><em>Magnolia hypoleuca</em></td>
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<td></td>
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<tr>
<td><em>Netumbo nucifera</em></td>
<td>+</td>
<td></td>
<td></td>
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<tr>
<td><em>Osmanthus Aquifolium</em></td>
<td></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><em>Paliurus nipponicus</em></td>
<td>+</td>
<td></td>
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<tr>
<td><em>Phragmites communis</em></td>
<td></td>
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<td></td>
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<tr>
<td><em>Quercus serrata</em></td>
<td>+</td>
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<tr>
<td><em>Quercus acutissima</em></td>
<td>+</td>
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<td></td>
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<tr>
<td><em>Salix amygdalina</em> var.</td>
<td>+</td>
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<tr>
<td><em>Sapium sebiferum</em> var.</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Scirpus macronatus</em></td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><em>Syrax japonicum</em></td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Tetraena macrocoda</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Ternstroemia japonica</em></td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Tsuga Sieboldii</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Vitia rotundifolia</em></td>
<td>+</td>
<td></td>
<td></td>
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<tr>
<td><em>Zelkova sp.</em></td>
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</table>

**Description of Fossil Plants**

The fossil leaves were first separated from inorganic sediments, then boiled with dilute Soda to remove the dark humous substance and after adequate procedures imbedded in Canada balsam. The fruits were examined in section.

**Coniferae**

1 **Tsuga Sieboldii** Carr. (Fig. 1 D).

Only one leaf has been found from Ohkamedani near Taniguti, but the bifid leaf-apex and narrow petiole show clearly the characteristics of
the species; leaf length 1.5 cm., breadth 3 mm.

Salicaceae

2 *Salix amygdalina* L. var. *nipponica* SCHNEID. ([Pl. I, Fig. 4 H])

Leaves are found abundantly at Iwami-kamisato and also a few leaves in the cliff a at Ohbakusan. These fossil leaves are referred to the recent form by the size and many little serrations of the leaf.

Betulaceae

3 *Alnus japonica* S. et Z. (Pl. L)

One cone has been obtained from Kobata. It is identified by their characteristic scales which are short, broad and destitute of the central lobe.

Fagaceae

4 *Fagus microcarpa* MIKI n. sp. ([Pl. F-G, Fig. 1 I-M])

Cupula and leaves are abundant at Ohbakusan and Taniguti, together with a few nuts.

Leaf ovate, tapered, not pointed; 3-4 cm. wide, 4-6.5 cm. long and 7-8 pairs of lateral veins, spreading at ca. 40° to the midrib. Fruit 1 cm. long with a short peduncle. Involucre of the fruit covered with spine and 7 mm. wide. Seed as long as the fruit.

This species can be distinguished from the living one by the following characters:

<table>
<thead>
<tr>
<th>Fruit and seed</th>
<th>Leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Fagus ferruginea</em></td>
<td>Wing of the seed extends down to the base</td>
</tr>
<tr>
<td><em>Fagus Hayatae</em></td>
<td>?</td>
</tr>
<tr>
<td><em>Fagus japonica</em></td>
<td>Length of seed and fruit is different</td>
</tr>
<tr>
<td><em>Fagus crenata</em></td>
<td>Fruit and seed are large</td>
</tr>
</tbody>
</table>

Further this species can be distinguished from other fossil beeches in Japan, which have no serration; *Fagus plioceana* SAP., which NATHORST (5) described as a form of *Fagus crenata*, and *Fagus intermedia* NATHORST which ENDO (2) described as a variety of *Fagus crenata* are both large and with many lateral veins as compared with *Fagus microcarpa*. So the fossil beech here described is closest to *Fagus crenata*.

5 *Fagus ferruginea* Art. var. ([Pl. H, Fig. 1 N-P])

Two leaves have been obtained from Ohbakusan. This specimen resembles to *Fagus ferruginea* by the serration of margin and angle of lateral veins to the midrib, though it differs by its small size and shape
A-C. Quercus acutissima Carr. (Found at cliff c at Ohbakusan). A. Serration of B. ×7.5.

D. Tsuga Sieboldii Carr. (Found at Ohkamedani near Taniguti). ×1.


N-O. Fagus ferruginea A. It. var. N. ×1. O. Apical portion ×7.5. P. Marginal portion ×7.5.

of their top; 2.2 cm. wide, 4 cm. long, 7–8 pairs of lateral veins, spreading at ca. 50° to the midrib.

6 Quercus serrata Thunb. (Pl. M, Fig. 1 E-H)

Two cupulas have been found in the cliff c at Ohbakusan, and one leaf in the cliff b. Cupula is a little compressed, otherwise it is identical with the living one. Leaf not well preserved, but the serration and nerves are clearly recognisable as in fig. 1 E and F.

7 Quercus acutissima Carr. (Fig. 1 A-C)

Cupula, seeds and leaves have been found in cliff c at Ohbakusan, and also one leaf in cliff b. This species is determined by the size and marginal nerves of the leaf and by short hairs on the under side of veins. The fruit and seeds correspond in size exactly with the recent one.

Ulmaceae

8 Zelkowa sp. (Pl. J, Fig. 4 A-B)

A few leaves occur in cliff a at Ohbakusan and Iwami-kamisato. At a glance they look like the leaves of Ulmus parvifolia, but differ from them by the shape of serration and undivided lateral veins, so that it is clear that they belong to Zelkowa. It is however difficult to determine whether it is a variety of Zelkowa Keaki or allied to Zelkowa Ungeri.

Nymphaeaceae

9 Nelumbo nucifera Gaertn. (Pl. N-O)

Peltate leaves and abundant petiole, rhizome and one fragmentary torus have been obtained from cliff a at Ohbakusan and from Toge of Taniguti.

Leaf with 21 nerves radiating from the center, compressed petiole, 17 mm. wide with recurved spines. The width of rhizome is variable according to the node and internode; the former ca. 3 cm., the latter ca. 1.5 cm. with radiated root cluster.

The dimension of leaves of Nelumbo is usually variable according to the site of the shoot and growing season, but the number of radiating nerves is nearly constant. Berry (1) described a Nelumbo of Japan in Pleistocene as Nelumbo minimum Reid., but the fossil here mentioned seems by their character more probable to be referred to the present Nelumbo nucifera than to Nelumbo minimum.
10 **Euryale ferox** Salisb. (Pl. P)

Many well preserved seeds occur in cliff a and b at Ohbakusan. They are exactly the same with one little form of the recent species.

Ceratophyllaceae

11 **Ceratophyllum demersum** L. (Pl. V)

Many seeds occur in cliff a at Ohbakusan. It is 4 mm. long, 3 mm. wide and with spine of 1 cm. length upon each corner. The central part of the seed is a little depressed and 0.5 mm. wider than the recent one but this may be attributed to compression it has undergone.

Magnoliaceae

12 **Magnolia hypoleuca** S. et Z. (Pl. C)

One fruit has been found at Taniguti. Fruit axis 9 mm. wide, with traces of spirally arranged petals, many stamens and few remains of carpels. These characters, especially the size, shape and many stamens agree exactly with the recent one.

Hamamelidaceae

13 **Loropetalum chinense** Oliv. ? (Pl. A-B, Fig. 4 C-E)

One leaf has been obtained from cliff a at Ohbakusan. It is entire, 1.5 cm. wide, ca. 3 cm. long and with stellate hairs on the underside.

This leaf agrees closely in size, shape and stellate hairs with the recent one, though the form of stellate hairs differs distinctly.

Euphorbiaceae

14 **Sapium sebiferum** Roxb. var. pleistoceaca MIKI nov. (Pl. K, Fig. 4 T-V)

Many seeds are found in every locality. The seed agrees in shape with the recent one, but differs by its smallness: 5 mm. long, 5 mm. wide; testa 0.35 mm. thick, consisting only of the remain of the palisade cell layer.

Rhamnaceae

15 **Paliurus nipponicus** MIKI n. sp. (Pl. Q-U, Fig. 2 F-J)

Abundant fruit and twigs are found in every locality and leaves also occur in cliff c at Ohbakusan.

Fruit with entire wing, 3-4 mm. wide, but most of them are partly decayed or reserve only the endocarp through the loss of soft exocarp. Ovary 3-celled with one seed in each cell. Leaf with 3 big veins from the base, 28 mm. wide, ca. 4 cm. long; secondary veins spread distinctly ascending and with many minute serrations; petiole 7-10 mm. long. In each node of the twig with 2 spines of the metamorphosed stipules.

This species differs from the recent one, by the wing of the fruit and the margin of the leaf. Fossil leaf from Kami-kanazawa-mura Prov. Hitati which was designated by Nathorst (5) as *Ziziphus tiliefolius,*
seems by their size and shape to be the same with the species here mentioned.

Theaceae

16 Ternstroemia japonica Thunb. (Pl. D, Fig. 4 N-O)

A few seeds have been found from cliff b at Ohbaku-san and one leaf at Iwami-kamisato. The seed can be well identified by the remains of characteristic septa laid between the accumbent embryo. The leaf has a distinct midrib, lateral veins being all insignificant.

Trapaceae

17 Trapa macropoda MiKi n. sp. (Fig. 3 A-B)

Many fruits have been found in cliff a at Ohbaku-san, at Tōge of Taniguti, in the upper bed of Iwami-kamisato and also in Pleistocene deposits around the Biwa Lake.

Shape of fruit varies according to the direction of compression, but always with four horns; upper horns with large protuberance at the base and inverse spines on the horn apex; the base of the fruit is thicker on account of the development of the basal portion of each horn, 2-3 cm. in height, 6 cm. breadth from apex of the both horns.

This species resembles Trapa amurensis but differs from it by the size and also from Trapa Yokoyamae and Trapa natans by the thick fruit base.

Styracaceae

18 Styrax japonicum S. et Z. (Fig. 4 W)

Many seeds have been found in cliff c at Ohbaku-san and at Taniguti.
Fig. 3. *Trapa macropoda* MiKi n. sp.

A. Differences in the form of fruits produced according to the direction of compression.
B. Fruit, diagrammatic ×1.

Seed 5–6 mm. wide, 7–9 mm. high with a longitudinal groove. It seems identical with the recent one by its size and shape.

Oleaceae

19 **Osmanthus Aquifolium** Sieb. (Fig. 4 J)

One leaf with the characteristic spine has been obtained from Taniguti. It seems just the same as the recent one by their size and spine.

Verbenaceae

20 **Vitex rotundifolia** L. (Pl. E, Fig. 4 R-S)

Abundant seeds occur in cliff b at Ohbakusan. It is identified easily by the characteristic structure of the fruit as in fig. 4 S.
Fig. 4.
C-E. Loropetalum chinense? Same with Pl. B. C. ×1/2. D. Stellate hairs on the underside of leaf ×7.5. E. Stellate hair ×7.5.
F-G. Loropetalum chinense Oliv. Recent. F. ×2. G. Stellate hair ×7.5.
H. Salix amygdalin L. var. nipponica SCHNEID. Margin of Pl. I ×7.5.
T-V. Sapindus sibiferum Roxb. var. pleistoceaca Miki nov. T. Left, side view and right, ventral view ×4. U. Pallisade layer of testa ×75. V. Surface view of pallisade cell ×500.
W. Styrax japonicum S. et Z. ×2.

21 Phragmites communis Trin. (Pl. W, Fig. 5 A-C)
Many fragmentary leaves occur in cliff c at Ohbakusan. Leaf 1.5 cm wide number of main nerves 10-11, with 5 small veins between each of them. It seems just the same with the recent one by its characteristic short silicified cells on one row upon the small veins, and also 3 rows of the same upon the large one (Fig. 5 B-C)

Cyperaceae
22 Carex vesicaria L. (Pl. X, Fig. D-F)
Many seeds and a few fruits have been found in cliff c at Ohbakusan. Seed with a long style, with a few layers of collenchymatic cells in the cross section.
This seems as a form of the recent species.

23 Scirpus macronatus L. (Fig. 5 G)
Many seeds are found in cliff b at Ohbakusan. Seed with black luster and thread like perianth.
Consideration on the Fossil Flora

Among 23 species just enumerated, there are 5 species and 2 varietes which are extinct completely or at least in Japan to day.

The fossil species may be divided into four groups by their habitat 4 littoral, 4 water, 5 marsh and 10 mountain plants.

If we compare the distribution of the fossil plants with that of their nearest living allies at present, the result may be tabularized as follows:

<table>
<thead>
<tr>
<th>Habitat</th>
<th>Name of fossil plants</th>
<th>Distribution of nearest living ally</th>
</tr>
</thead>
<tbody>
<tr>
<td>Littoral</td>
<td><em>Palium nipponicus</em></td>
<td><img src="image" alt="Table Content" /></td>
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<tr>
<td></td>
<td><em>Sapium sebiferum var.</em></td>
<td><img src="image" alt="Table Content" /></td>
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<tr>
<td></td>
<td><em>Ternstroemia japonica</em></td>
<td><img src="image" alt="Table Content" /></td>
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<tr>
<td></td>
<td><em>Vitex rotundifolia</em></td>
<td><img src="image" alt="Table Content" /></td>
</tr>
<tr>
<td>Water</td>
<td><em>Euryale ferox</em></td>
<td><img src="image" alt="Table Content" /></td>
</tr>
<tr>
<td></td>
<td><em>Ceratophyllum demersum</em></td>
<td><img src="image" alt="Table Content" /></td>
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<tr>
<td></td>
<td>* Nelumbo nucifera*</td>
<td><img src="image" alt="Table Content" /></td>
</tr>
<tr>
<td></td>
<td><em>Trapa macropoda</em></td>
<td><img src="image" alt="Table Content" /></td>
</tr>
<tr>
<td>Marsh</td>
<td><em>Alnus japonica</em></td>
<td><img src="image" alt="Table Content" /></td>
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<tr>
<td></td>
<td><em>Carex vesicaria</em></td>
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<tr>
<td></td>
<td><em>Phragmites communis</em></td>
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<tr>
<td></td>
<td><em>Salix amygdalina var.</em></td>
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<tr>
<td></td>
<td><em>Scirpus macrornatus</em></td>
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<tr>
<td>Mountain</td>
<td><em>Fagus ferruginea var.</em></td>
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<tr>
<td></td>
<td><em>Fagus microcarpa</em></td>
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<tr>
<td></td>
<td><em>Loropetalum chínense?</em></td>
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<td></td>
<td><em>Magnolia hypoleuca</em></td>
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<td><em>Osmanthus Aquifolium</em></td>
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<td></td>
<td><em>Quercus acutissima</em></td>
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<td></td>
<td><em>Styrax japonicum</em></td>
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<tr>
<td></td>
<td><em>Tsuga Sieboldii</em></td>
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<tr>
<td></td>
<td><em>Zelkova sp.</em></td>
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<tr>
<td>Total</td>
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<td>%</td>
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<td><img src="image" alt="Table Content" /></td>
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</table>
In order to make clear the topographical and climatic conditions of the era, it is necessary here to note that in the lower beds there are found two littoral plants, *Paliurus* and *Sapium* throughout the districts and also some casts of marine mollusca (Teredo and soil boring Lamellibranchia) at Ohbakusan, while fresh water plants are found only from the upper bed in some localities. Such a mode of occurrence may be attributed to the topographical change of the district from the sea at the beginning to the lake afterwards. The same opinion was already expressed by Prof. Nakamura (4) too as is seen in the table. The greater part of the fossil flora occur from middle Honshu to Kyushu, so that the climatic condition at that time seems to have been a little warmer than at present.

The fossil beds here are laid between the thick gravel and sand layers, similar to Tokyo bed upon Naganuma bed in south Kwanto (Nakamura p. 117). The Tokyo bed has been supposed from the composition of the fossil fauna contained in it to have been formed when the climate was a little colder than at present (Yabe P. 22).

Moreover the gravels and sands are generally regarded to be laid in the fluvial period, the climatic condition of which is supposed to be a little colder than the adjoining period.

From these facts it is therefore conceivable, that the fossil beds in Yamashiro basin were laid in a little warmer period between fluctuating colder ones, just as Naganuma bed under Tokyo bed in South Kwanto.

**Summary**

1. Around Yamashiro basin there are laid two or three fossil beds of Older Pleistocene. There are found, so far as satisfactorily identified, 23 species of fossil plants belonging to 21 genera, 18 families.

2. Among them there are seven extinct species or varieties, namely *Fagus microcarpa* Miki n. sp., *Paliurus nipponicus* Miki n. sp., *Trapa macropoda* Miki n. sp., *Fagus ferruginea* Art. var., *Sapium sebiferum* var. *pleistocene* Miki nov., *Zelkowa* sp. and *Loropetalum chinense*.

3. According to their habitats they may be divided into four groups, which contain following number of species; 4 in littoral, 4 in fresh water, 5 in marsh and 10 in mountain region.

4. In the lower bed at Ohbakusan there has been found some casts of marine mollusca, while the fresh water plants are found only in the upper bed of some localities.

5. The climatic condition of the fossil flora apparently corresponds with the modern condition prevailing in South Honshu and Kyushu, so that it must have been somewhat warmer than at present.
6. These fossil beds probably correspond to Naganuma bed in South Kanto.

Literature


Explanation of the Plate.

C Magnolia hypoleuca S. et Z. Fruit (2nd soil collecting station at Taniguti).
D Ternstroemia japonica THUNB. Seeds (Cliff b at Ohbakusan).
E Vitex rotundifolia L. Fruits (Cliff b at Ohbakusan).
F-G Fagus microcarpa MIKI n. sp. F (Ohkamedani near Taniguti) G (Cliff a at Ohbakusan).
H Fagus ferruginea AIT. var. (Cliff b at Ohbakusan).
I Salix amygdalina L. var. nipponica SCHNEID. (Cliff a at Ohbakusan).
J Zelkowa sp. (Cliff a at Ohbakusan).
K Sapium seWerunt RoxB. var. pleistoceaca MIKI nov. Seeds (Cliff a at Ohbakusan).
L Alnus japonica S. et Z. Scales of cone (Kobuta).
M Quercus serrata THUNB. Cupula (Cliff c at Ohbakusan).
N-O Nelumbo nucifera GAERTN. N Leaf. O Fragmentary torus (Cliff a at Ohbakusan).
P Euryale ferox SALISB. Seeds (Cliff a at Ohbakusan).
Q-T Paliurus nipponicus MIKI n. sp. Q-R. Fruits, Q from above, R from below.
T-U Leaves (Cliff a at Ohbakusan).
V Ceratophyllum demersum L. Seed (Cliff a at Ohbakusan).
W Eleagnus communis THUN. Leaves (Cliff c at Ohbakusan).
X Carex vesicaria L. Fruit and Seeds (Cliff c at Ohbakusan).