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Pharmacognostical Studies on the *Clematis* Plants and Related Crude Drugs (I) Histological Studies on the Roots of *Clematis terniflora* DC. var. *robusta* (CARR.) TAMURA and "Wei-ling-xian" (威靈仙) from Japan[1)]

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The species of the genus *Clematis* of Ranunculaceae have been known to the world not only as poisonous but also as medicinal plants from antiquity. A series of pharmacognostical studies on the medicinal *Clematis* plants will be presented in turn.

In the case of Chinese crude drug, "Weilingxian" (威靈仙) in Chinese is derived from the underground part of *Clematis* plant, of which botanical origin is rather complicated. To clarify the botanical origin of this "Weilingxian," anatomical fundamental characteristics of the roots of *Clematis terniflora* DC. var. *robusta* (CARR.) TAMURA, as a representative of *Clematis* plants, were studied in this paper. Moreover, comparing with three *Clematis* species from Japan, the botanical origin of "Weilingxian" from Japan, "Ireisen" in Japanese, was examined anatomically.

Our results showed that the anatomical characteristics of the roots of *Clematis* plants vary significantly according as the roots and stocks grow, and "Ireisen" was derived from underground part with short stems of *Clematis terniflora* var. *robusta*.

Keywords——*Clematis terniflora* var. *robusta*; Ranunculaceae; Weilingxian; pharmacognostical study; Chinese crude drug; origin; anatomical study; Ireisen

The genus *Clematis* of Ranunculaceae was first reported by Linnaeus[2)] in 1754. The species *Clematis* have been known from antiquity to the world not only as poisonous[3)] but also as medicinal plants.[4)] In continental China,[5)] Taiwan,[6)] Korea[7)] and Japan,[8)] the roots of the *Clematis* plants are used as a traditional Chinese drug, named "Weilingxian" (威靈仙) in Chinese, "Wiryongseon" in Korean, "Ireisen" in Japanese,[9)] while the leaves and stems are also used commonly as folk medicine.

The first herbological description on the crude drug "Weilingxian" appeared in "Kai-bao-ben-cao" (開宝本草)[10)] written in the Song dynasty in China, and "Weilingxian" has been used mainly as diuretic and antirheumatic remedies.

"Weilingxian" are found in the Chinese, Taiwan, Korean, Hongkong and Japanese markets. The histological study on "Ireisen" has been partly reported by Fujita and Shimomura.[11)] The botanical origin of "Weilingxian" from each country is, however, complicated because many *Clematis* species grow in eastern Asia. To clarify the origin of the crude drug on the present markets, we histologically re-investigated the roots of all the species from eastern Asia, which are anticipated to come into the market as "Weilingxian." In the present paper, we report the anatomical characteristics of *Clematis terniflora* DC. var. *robusta* (CARR.) TAMURA,[12)] as a representative of *Clematis* species having fibrous roots like "Weilingxian," and two similar species to clarify the botanical origin of "Ireisen" from Japan on the present market.

Materials[13)]

The experimental materials were collected at following locations.

***Clematis terniflora* DC. var. *robusta* (CARR.) TAMURA** (Jap. name: Senninsō): Tochigi pref.; Tanuma Asogun. Kanagawa pref.; Oyama Hatano-city (8019, 8030, 8031), Sokozawa Tsukui-gun (8020–8023, 8025–8029). Niigata pref.; Izumozaki Santo-gun. Toyama pref.; Miyazaki Shimoniikawa-gun, Kurikara Oyabe-city, Yabuta Himi-city. Ishikawa pref.; Sanmyo Hakui-gun. Fukui pref.; Mikata Mikata-

gun. Osaka pref.; Mt. Takayasu Yao-city, Mt. Kongo Kawachinagano-city. Wakayama pref.; Nanairodamu Higashimuro-gun Tobichi, Shionomisaki Nishimuro-gun (7777–7778), Yura Hidaka-gun, Mt. Nachi Higashimuro-gun (7736). Kagawa pref.; Mannoike Nakatado-gun (7328–7342). Tokushima pref.; Mikamo Miyoshi-gun. Kochi pref.; Ashizurimisaki Tosashimizu-city, Mt. Yokogura Takaoka-gun (7316). Fukuoka pref.; Sugaonotaki Kitakyūsyū-city (6510, 6511). Kumamoto pref.; Fukuro Minamata-city (7636, 7637, 7640), Nishiki Kuma-gun (7679–7687). Kagoshima pref.; Nijyūban Tanegashima (7701, 7703).

Clematis fujisanensis **Hisauchi et Hara** (Jap. name: Fujisenninsō): Shizuoka pref.; Umegashima Shizuoka-city (7994–7998).

Clematis kyushuensis **Tamura** (Jap. name: Kyūsyūsenninsō): Kumamoto pref.; Nishiki Kuma-gun (7688–7691).

"Ireisen" from Shikoku district and Gunma prefecture on Osaka market were obtained from Tochimoto Tenkaidō in 1975 and 1980, respectively, and "Ireisen" from Miyazaki pref. was obtained from Syūgyō-Eizō Syōten in 1978.

Experimental

About twenty species of wild *Clematis* plants are found in Japan.[14] Through our studies on the root morphology of these *Clematis* plants, *C. terniflora* var. *robusta*, *C. fujisanensis*, *C. kyushuensis*, *C. fusca* Turcz., *C. patens* Morren et Decne., and *C. chinensis* Osbeck were proved to be similar to "Ireisen" on the criteria that they had fibrous roots. As the other species have a few big roots or woody roots, which differ apparently from those of "Ireisen," and are not likely to be found in the market. The first three of the species having fibrous roots are botanically quite similar to each other. Among them, *C. terniflora* var. *robusta* is the most common and has the widest range. The anatomical structures of the roots of *C. terniflora* var. *robusta* and two similar species were, therefore, examined to clarify the botanical origin of "Ireisen."

Clematis terniflora **DC. var. *robusta* (Carr.) Tamura**

Botanical characteristics: The species was placed in sect. *Flammula*, subsect. *Rectae*, ser. *Rectae* of genus *Clematis*.[12] Evergreen climbing vine. When the leaves and caryx are dried, their color changes to yellowish green or yellowish brown, but never to black as observed in the case of *C. chinensis*. The achene is flat oval or somewhat spindle in shape, and has elevated margins.

Macroscopical characteristics of the root: One rootstock has 10 to 100, occasionally more roots. The cylindrical, somewhat fusiform root rarely branches, except the tip portion. The outer surface of the fresh root shows greyish brown or light brown color, and that of the dried root shows dark brown. The dried root can be easily broken, and the broken surface shows white or somewhat brown color.

MICROSCOPICAL CHARACTERISTICS OF THE ROOT

Sampling: Five to twenty roots were arbitrarily chosen as experimental samples from each rootstock.

Observational portion: Each section of 5 mm, 50 mm and 60 mm from the proximal end (rhizome) was observed by Fujita and Shimomura.[11] On the structures of the roots of *Clematis* spp., the diameters of the root and vessels from the section at d.p.=100–150 mm (the section at 100–150 mm from the proximal) are generally larger than those from the sections at more proximal or distal parts. On the other hand, most of "Weilingxian" on the market have broken short roots, less than 100 mm from the proximal. In this study, consequently, transverse sections at d.p.=5 mm and d.p.=50 mm are mainly investigated.

General anatomy (Figs. 1–3): Generally, the transverse section is circular or elliptical in shape. The outermost layer covered with thin dark colored layer[15] is the epidermis consisting of circular or elliptical cells, the outer cell walls of which are slightly thick and light brown in color (3-A). One layer of exodermal cells are 1.2–2 times larger than epidermal cells in diameter, and the cell walls are thin and suberized. The primary cortex consists of parenchyma and no mechanical tissue is observed.[16] A distinctive endodermis is present. The endodermal cells have occasional daughter cells and some of the endodermal cells have suberized cell walls. The central cylinder is cylindrical or elliptically cylindrical. One or two cell layers of the pericycle are present (3-B, C). Xylem, fundamentally diarchal, is present in various forms (1-B, C, D; 2), and consists of simple pit-perforated vessels having bordered pits (3-D_7), tracheids (D_8), wood parenchyma cells having lignified cell walls ($D_{5,6}$), wood fibers and substitute fibers (D_9). Fibers and sclerenchymatous cells in the phloem and sclerenchymatous cells in the pericycle are sometimes found (3-$C_{1\sim4}$).

Cell contents: Starch grains, simple or approximately 2–15 complex, are found in the cortex, but rarely in the exodermal and endodermal cells, as well as in the pericycle, substitute fiber, and wood parenchyma (3-A, C). Oil drops, 5–15 μm in diameter, are present in the parenchyma (3-B, C). In aged roots, some vessels contain a brown resin. Fungal hyphae is recognized in the intercellular spaces of the cortex (3-A).

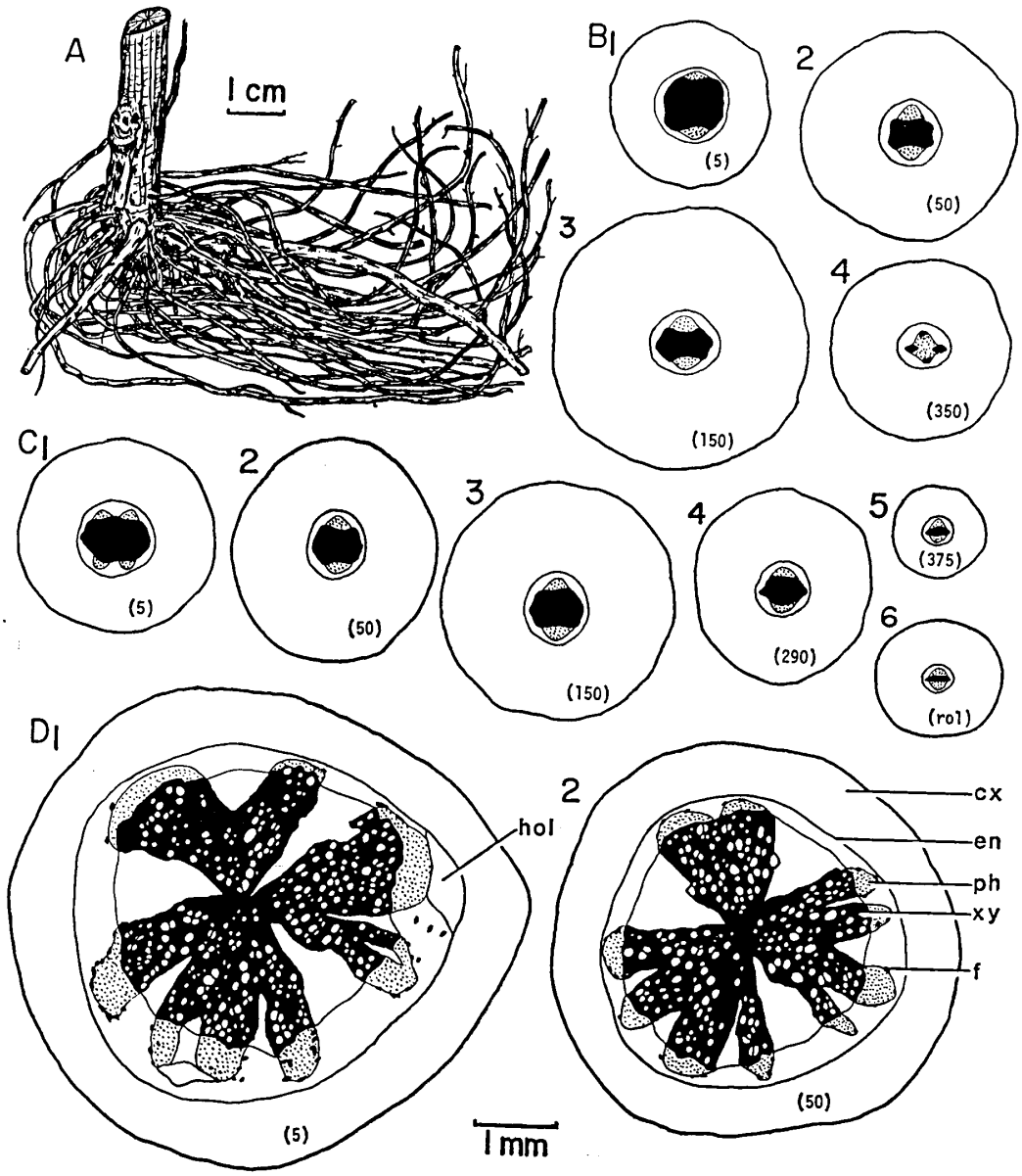

Fig. 1. "Ireisen" and *Clematis terniflora* DC. var. *robusta* (CARR.) TAMURA
A: A sketch of "Ireisen" from Shikoku district. B, C, D: Changes of the vascular bundle shapes in the transverse sections of each root (B, C; Normal roots, D; Large and aged root) from the proximal end to the distal (The parenthesized numeral shows the distance from the promixal end by mm. rol=lateral root).

VARIATION OF THE ANATOMICAL CHARACTERISTICS

Diameter of the root[17]: The root at d.p.=5 mm measures 1,200–6,000 μm, and at d.p.=50 mm, 1,200–5,000 μm (mean 2,720) in diameter. Larger specimens normally have larger roots. The old root is not necessarily large in size.

Diameter of the stele[17]: The stele at d.p.=5 mm measures 330–4,500 μm, and at d.p.=50 mm 210–3,900 μm in diameter. Older roots normally have larger steles.

Percentage of stele in root by diameter at d.p.= 50 mm: 14.9–78.0% (mean 30.4). Older roots generally show higher percentages of steles.

Epidermal cell: Epidermal cells of young roots are somewhat circular and small, and of old roots are tangentially elliptical and large, measuring 40–90 μm in diameter. The outer cell wall is 3–10 μm in thickness.

Parenchyma in the cortex: The cortex consists of 10–20 layers of parenchymatous cells having conspicuous pits. The cells of young roots are circular, while those of old roots elongate tangentially and sometimes show radial divisions, 70–170 μm in diameter, 300–430 μm in length.

Endodermis: The number of endodermal cells in each transverse section are 35–100 or more (mean 67), and they are surely more than 50 in the roots having diameters of over 2,000 μm.[18] Large roots generally have many

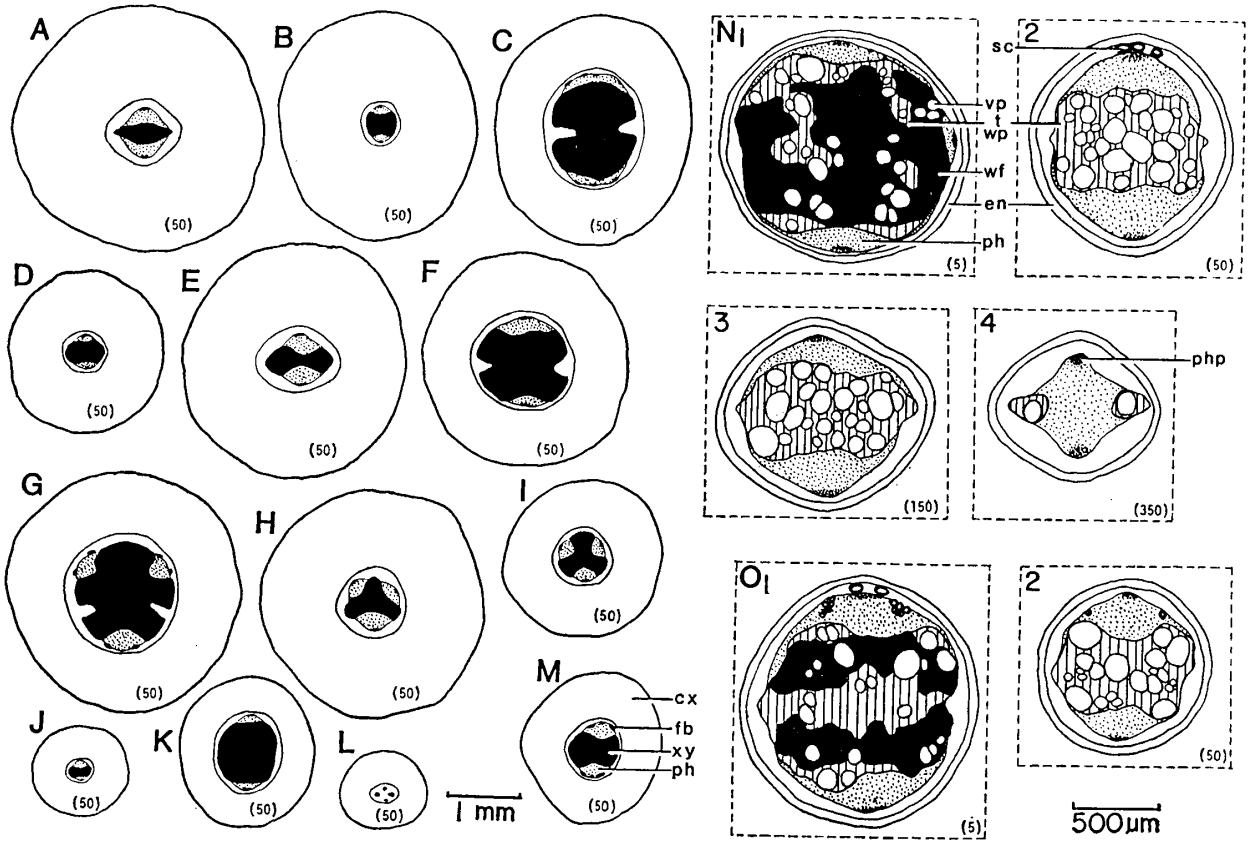

Fig. 2. *Clematis terniflora* var. *robusta*

A–M: Variations of the vascular bundles in the transverse sections of the roots at a distance of 50 mm from the proximal end. N, O: Variations of the vascular bundle elements of each root.

endodermal cells. The cells are circular or somewhat square in young root. As the root grows older, the cell elongates tangentially and adds 2–6 or more daughter cells, while transfusion cells decrease in number.

Form of xylem: Though the radial vascular bundle is fundamentally diarchal, due to secondary thickening growth, xylem exist in various forms in the transverse section. In the tip of the roots and in the early growth-phase roots, the vascular bundles exhibit diarch, *i.e.* consisting of two separate and diametrically opposite xylem (1-B_4, 2-L, N_4). As the root grows older, those two xylem bundles grow in the direction of center, and join together. In this conditions xylem is rod like shaped (1-$C_{5,6}$). Subsequently, xylem grows in the direction of the primary phloem. As the xylem develops, its shape changes in succession from lenticular (1-C_4, 2-A), dumb-bell (1-C_2, 2-E), elliptical, to quadrate (2-N_2, K). In some big roots, triarchal vascular bundles are recognized (2-H, I), and furthermore some secondary xylem may grow big in radial direction (2-G, 1-D). At d.p.=5 mm, xylem generally appears elliptical (1-C_1).

Vessel: The vessels in transverse section (3-C) are circular, elliptical or polygonal in outline, and measure 45–225 μm in diameter,[19] 170–750 μm in length. In the roots more than 2,000 μm in diameter,[18] vessels measure above 55 μm in diameter. Older roots generally have larger vessels in diameter.

Wood fiber and substitute fiber: The wood fiber and substitute fiber appear in the section near the rhizome and the large old roots, and measure 20–23 μm in diameter, 370–600 μm in length. The two fibers can be discriminated from each other by presence or absence of starch grains.

Phloem fiber and sclerenchymatous cell in the phloem and pericycle: Generally, no mechanical tissue is found in the phloem and pericycle of young roots. The frequency of appearance is higher in old roots. Phloem fibers measure 20–40 μm in diameter, and 300–600 μm in length. Sclerenchymatous cells measure 30–50 μm in diameter, and 120–350 μm in length.

Starch grain: A simple grain measures up to 15 μm (normal size is 5–12 μm), and complex grains up to 20 μm (normally 5–15 μm) in diameter. The individual size seems quite arbitrary, and varies regardless of the other characteristics. The size of the starch grain varies with the tissue in which it is included. Generally starch grains near the exodermis and endodermis of the cortex, in the central cylinder, are smaller than those observed in the middle of the cortex.[20] This characteristic seems to be influenced by seasonal variation. Sometimes no starch grain is included in any tissue. Larger roots, those having big steles in diameter, generally have fewer starch grains.

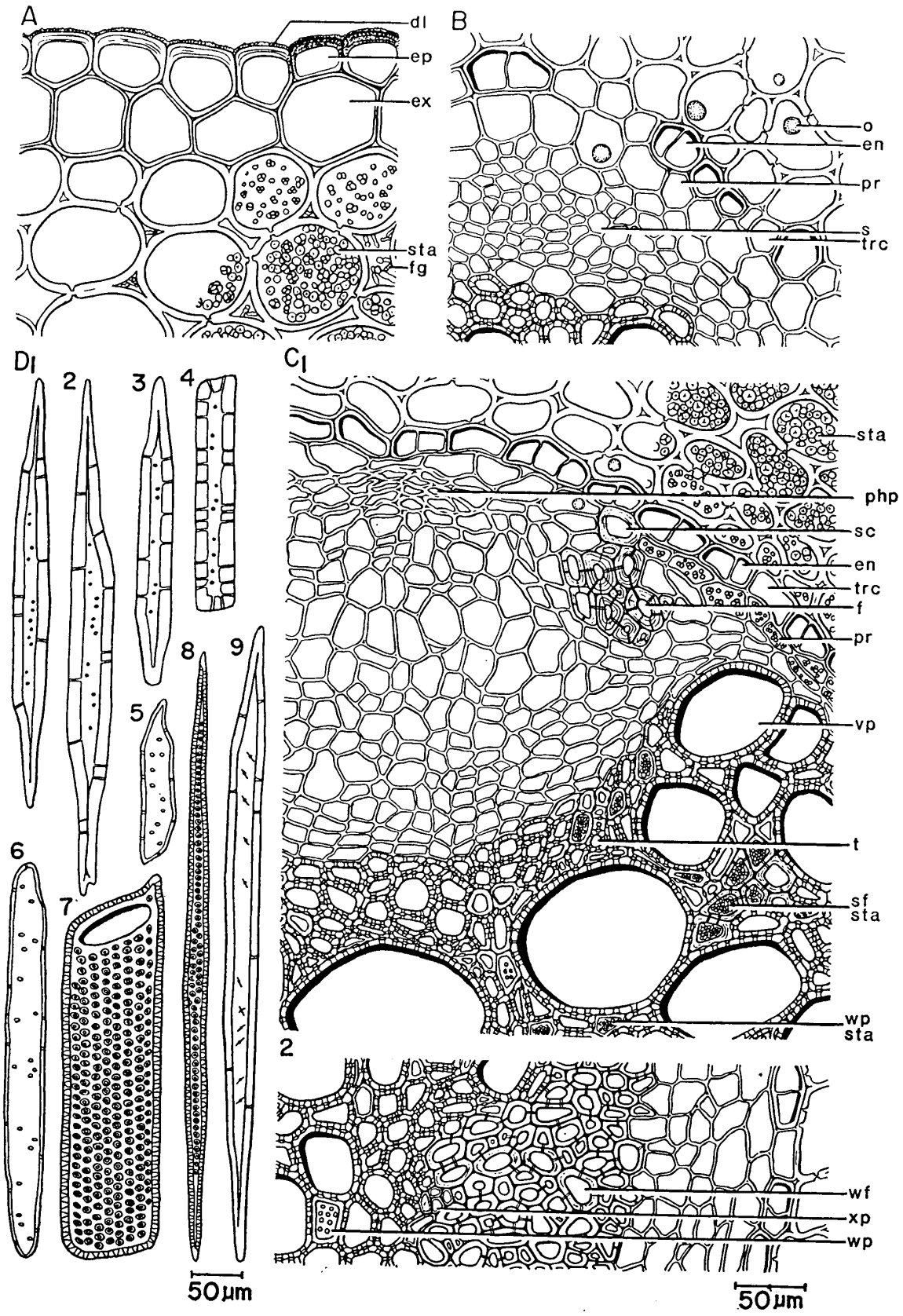

Fig. 3. Detailed Drawing of the Root of *Clematis terniflora* var. *robusta*
A–C: Transverse sections near epidermis (A), endodermis and its surroundings of the young root (B) and parts of standard vascular bundle (C). D: Isolated elements, 1–3, phloem fibers; 4, pericyclic sclerenchyma cell; 5, 6, wood parenchyma cells; 7, pitted vessel; 8, tracheid; 9, wood fiber (substitute fiber).

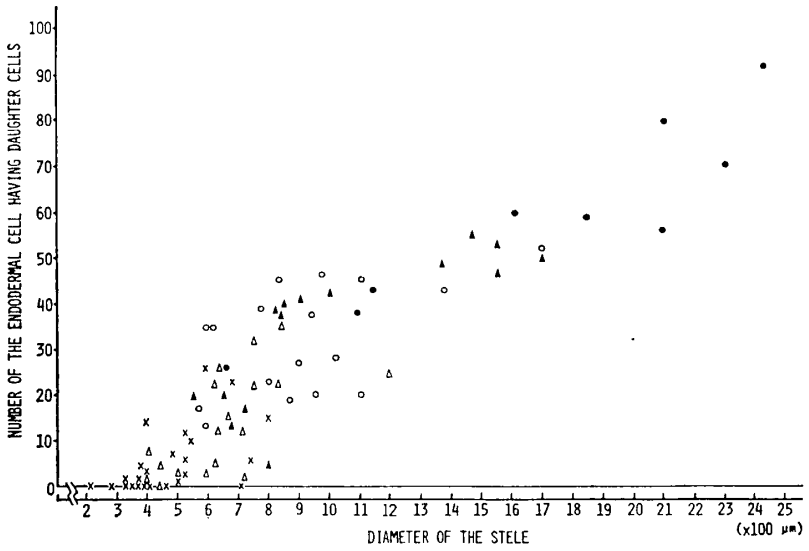

Fig. 4. Correlation among Three Anatomical Characteristics of the Roots of *Clematis terniflora* var. *robusta*

The ordinate shows the number of endodermal cell with daughter cells and the abscissa the diameter of the stele. The stamped mark represents the diameter of the vessel: $\times < 80 \leqq \triangle < 100 \leqq \blacktriangle < 120 \leqq \bigcirc < 150 \leqq \bullet$, μm. (The values from the roots having steles over 2,500 μm in diameter are excluded, because most of the endodermal cells of such aged roots are crashed, and it is difficult to count them correctly. In addition, such roots are uncommon.)

This figure indicates that the three characteristics have a positive correlation with one another as the root grows.

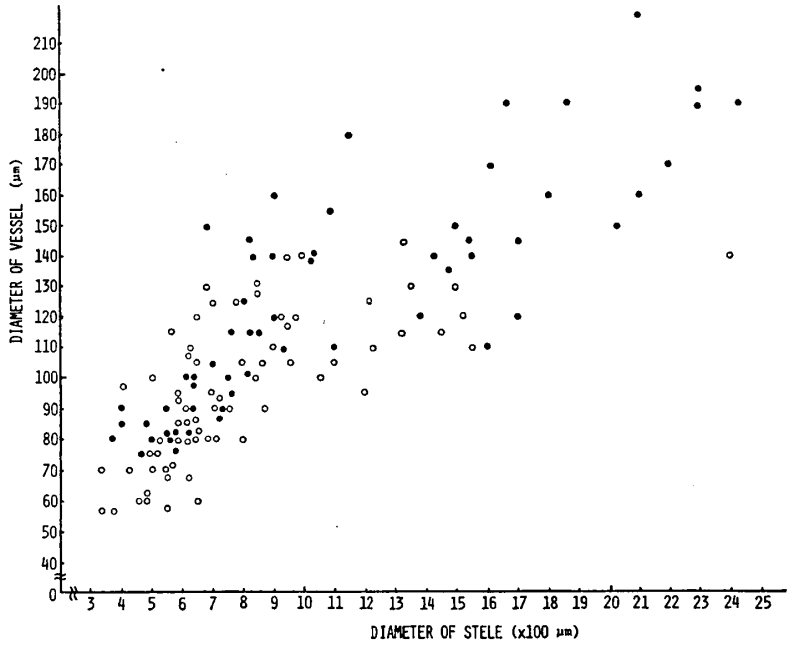

Fig. 5. Two types of *Clematis terniflora* var. *robusta*

The ordinate shows the diameter of the vessel and the abscissa the diameter of the stele. ● = Honshū type, ○ = Shikoku-Kyūshū type. (The roots smaller than 2,000 μm in diameter at a distance of 50 mm from the proximal end are excluded from the figure, because they sometimes shows unnatural values because of their young age. Moreover, the roots with steles over 2,500 μm in diameter are also excluded.)

This figure shows that the roots of Honshū type have a tendency to show larger values in diameter than the Shikoku-Kyūshū type.

TABLE I. Anatomical Characteristics of the Roots of *Clematis* spp. from Japan in the Transverse Sections at a Distance of 50 mm from the Proximal End

	C. terniflora var. *robusta*		*C. fujisanensis*	*C. kyushuensis*
	Honshu Type	Shikoku-Kyūshū Type		
Diameter of the root (μm)	1,200-5,000		1,900-4,000	1,740-2,750
	(2720, 678)		(2830, 513)	(2340, 298)
Diameter of the stele (μm)	210-3,900		270-1750	290-830
	(900, 556)		(744, 452)	(512, 186)
Percentage of stele in root (%)	14.9-78.0		12.5-58.5	16.1-39.5
	(30.4, 11.6)		(26.1, 13.9)	(23.1, 6.0)
Fujiform ratio[a] each root	0.80-1.50		0.96-1.88	1.02-1.49
	(1.16, 0.18)		(1.41, 0.29)	(1.27, 0.30)
average from one stock	1.01-1.30		1.26-1.54	1.25-1.33
Epidermal cell diameter (μm)	40-90		40-65	40-60
thickness of outer cell wall	3-10		3-6	5-12
Cortex diameter of parenchyma cell (μm)	70-170		80-160	80-150
number of cell layers	10-20		12-23	12-17
	(14.8, 2.9)		(17.0, 2.7)	(14.6, 1.6)
Number of endodermal cell*	50-100 or over		44-70	44-64
	(67, 10.7)		(57, 5.9)	(54, 5.6)
Phloem fiber	frequent	somewhat frequent	rare	rare
Diameter of vessel (μm)*	70-225	55-160	44-120	44-120
	(125, 38.0)	(95.8, 26.2)	(78.3, 25.8)	(74.7, 18.0)
Size of starch grain simple grain (μm)	up to 15		up to 18	up to 20
complex grain (μm)	up to 20		up to 21	up to 25

[a] The diameter of the root at a distance of 50 mm from the proximal end, divided by that at 5 mm.

* Unmature roots, smaller than 2mm in diameter, are excluded from the table.

( ) Parenthesized numeral: Former shows mean value and latter standard deviation (though the mean and standard deviation are not so much valuable to distinguish species one another, only in this paper, they are shown in the table to show the extent of variation of each characteristic for reference).

Fusiform ratio[21]: 0.8–1.50 (mean 1.16) on each roots, and average value from one stock of 1.01–1.30.

Correlation among variable characteristics

Our research clarified that the number of endodermal cells with daughter cells, and the diameters of the stele and vessels increase in proportion to the growth degree of the root (Fig. 4). The epidermal cells and cortical parenchyma cells also increase in size. On the other hand the size of starch grains and number of cortical cell layers vary regardless of the growth degree of the root.

Anatomical variation in the roots from one stock

The roots tend to show considerable anatomical variation. Generally, the maximum values of the numerical characteristics lie in d.p.=100 to 150 mm, except that the diameter of the stele increases according as the root closes to the rhizome. There is no constant pattern in the variations of all characteristics.

Local variation

Two anatomical types of *Clematis terniflora* var. *robusta* were recognized from this research. We call them as "Honshū-type" and "Shikoku-Kyūshū type" according to their growing regions (Fig. 5). Specifically, the diameters of the vessels of the root from the northern stock (Honshū type) are large. The appearance of sclereids in the pericycle and phloem area of the northern stock is more frequent than that of the southern stock (TABLE I).

***Clematis fujisanensis* HISAUCHI et HARA**

Botanical characteristics: This species was placed in sect. *Flammula*, subsect. *Rectae*, ser. *Rectae* of the genus. The species is quite similar to *C. terniflora* var. *robusta* except that the leaf and calyx change to black when dried, and the achene is somewhat smaller than that of *C. terniflora* var. *robusta*. Endemic species are found in Tokai district.

Macroscopical characteristics of the root: It is impossible to distinguish the root of *C. fujisanensis* from that of *C. terniflora* var. *robusta* macroscopically.

Microscopical characteristics of the root: Anatomical characteristics are similar to those of *C. terniflora* var.

robusta, but the fusiform ratio is a little large, 0.96–1.88 (mean 1.41). In the roots having diameters of over 2,000 μm, the vessels measure from 40 to 120 μm in diameter, and the sclereid reveals in the phloem and pericyclic areas with low frequency, and the number of endodermal cells in the transverse section is 44–70 (mean 57). The starch grains measure 12–18 μm in simple grains, and up to 21 μm in complex grains.

***Clematis kyushuensis* TAMURA**

Botanical characteristics: This species was placed in sect. *Flammula*, subsect. *Rectae*, ser. *Chinenses* of genus *Clematis*. The plant is quite similar to *C. fujisanensis*, except that the species bears a somewhat elongated achene with a slightly elevated margin. Endemic species exists in Kyūshū district.

Macroscopical characteristics of the root: The shape of the root of this species is the same as that of *C. terniflora* var. *robusta*, but the surface is somewhat brown.

Microscopical characteristics of the root: They are similar to *C. fujisanensis* and Shikoku-Kyūshū type of *C. terniflora* var. *robusta*. In the case of *C. kyushuensis*, the outer cell wall of the epidermis is 5–12 μm in thickness, the vessels measure up to 120 μm in diameter, and the number of endodermal cells in transverse section are 44–64 (mean 54). The fusiform ratio of each root is 1.02–1.49, and average per stock is 1.25–1.33. In addition, with only a few exceptions, the starch grains measure up to 20 μm in simple grains and up to 25 μm in complex ones.

"Ireisen" from Japan

Macroscopical characteristics: In general, "Ireisen" in the market consists of a large rhizome with many fibrous roots and some short stems. Each specimen has 30–100 or more roots. The slender, cylindrical crooked roots measure up to 30 cm, normally 5–15 cm in length, and 0.5–4 mm in diameter, their normal size is 1–2 mm in diameter. Some roots are fusiform to some extent. The outer surface of the root shows dark brown or somewhat black color. The root breaks easily, and on the broken surface, xylem is yellowish white, while the cortex is white or dark brown. The root has almost no taste and no odor, but sometimes smells like Valerianae Radix. Gnarled rhizomes measure 1–2 cm in diameter, dark yellow to dark brown. Sometimes large rhizomes have some stems. The stems with hollowed lines parallel to the axis measure 0.5–1 cm in diameter.

Microscopical characteristics of the roots: Anatomical characteristics of the roots of "Ireisen" from Gunma prefecture correspond to those of Honshū type of *C. terniflora* var. *robusta*, and "Ireisen" from Shikoku district and Miyazaki prefecture correspond to Shikoku-Kyūshū type of the same species.

Results and Discussions

1. Considerable anatomical variations in the root of *Clematis terniflora* DC. var. *robusta* (CARR.) TAMURA were recognized, and they were mainly due to the growth degree of the stock and root. Even from one stock, each root shows different structure. Several roots of each growth degree should be taken as experimental samples for the anatomical characteristics of the *Clematis* species.

2. From the investigation of the correlations between growth degree of the root and the variety of the anatomical characteristics, it was made clear that the growth degree of the root could be estimated by the size of the vessels and the number of endodermal cells with daughter cells. Namely, the size of the vessels and the number of the endodermal cells that have daughter cells increase as the root becomes old. Moreover, in the transverse section, the shape of the xylem changes sequentially from a separated type into a rod like, lenticular, dumb-bell like, elliptical, and quadrete in order as the root grows older. This sequence of change is, however, not clearly correlated with other anatomical features. In addition, the diameter of the vessel seemed to be in proportion to the height of plant.

3. *Clematis terniflora* var. *robusta* has a wide range in Japan. Through the observation of the roots from various places, it was made clear that there were two types of *C. terniflora* var. *robusta* in anatomical characteristics, namely Honshū type and Shikoku-Kyūshū type. The former tend to have larger vessels in diameter than the latter.

4. Though it has been difficult to distinguish the roots of *C. terniflora* var. *robusta* and those of *C. fujisanensis* anatomically, our results show that, as to the matured stocks, the root of those two species can be distinguished clearly each other by the differences of the diameter of the vessel, fusiform ratio, frequency of phloem fiber, size of the starch grains, etc. (TABLE I).

5. According to our recent research on the Japanese market, most of the "Ireisen" (威霊仙) are from the Korean peninsula, and the rest are collected in Shikoku, Kyūshū districts and Gunma prefecture in Japan to meet the demands. All of those from Japan in the present market were confirmed to the underground portions of *C. terniflora* var. *robusta* anatomically. Though the roots from young stocks of this species are considerably similar to those from matured stocks of *C. fujisanensis* and *C. kyushuensis* anatomically, such young root are scarce on the market as "Ireisen." Therefore, as to the botan-

ical origin of "Ireisen" in the market, it can be clarified by root anatomy.

6. *Clematis fusca* TURCZ. and *C. patens* MORR. et DECNE., they have fibrous roots similar to those of "Ireisen," will be reported in another paper. In Japan, as these two species grow within limited regions and are little in quantity, the roots of them are rarely found on the market as "Ireisen."

7. *Clematis fujisanensis* and *C. kyushuensis* are so similar in root anatomy that the two cannot be discriminated clearly each other by root anatomy.

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List of abbreviations: **cx**, cortex; **dl**, dark colored layer; **en**, endodermis; **f**, fiber; **fb**, fiber bundle; **fg**, fungus; **hol**, hollow; **o**, oil drop; **ph**, phloem; **php**, primary phloem; **pr**, pericycle; **s**, sieb tube; **sc**, sclerenchyma cell; **sf**, substitute fiber; **sta**, starch grain; **t**, tracheid; **trc**, transfusions cell; **vp**, pitted vessel; **wf**, wood fiber; **wp**, wood parenchyma; **xp**, primary xylem; **xy**, xylem.

References and Notes

1) A section of this work was presented at the 97th Annual Meeting of Pharmaceutical Society of Japan, Tokyo, April, 1977.
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9) In this paper, we use the term "Weilingxian" in a general name to marketed "威霊仙," and "Ireisen" to "威霊仙" on Japanese market.
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11) N. Fujita, J. Shimomura, *Yakugaku Zasshi*, **63**(2), 1 (1943).
12) M. Tamura, *Acta Phytotax. Geobot.*, **15**(1), 17 (1943).
13) A part of duplicates are stored in the Specimen Rooms of Research Institute for Wakan-yaku, Toyama Medical and Pharmaceutical University, and Kyoto University. The experimental materials were identified by Dr. Michio Tamura, Faculty of Science, Kobe University. The parenthesized numeral shows the collection number by the authors.
14) S. Kitamura and G. Murata, "Coloured illustrations of Herbaceous Plants of Japan," Vol. II, Hoikusha publishing Co., Osaka, 1961, p. 222; J. Ohwi, "Flora of Japan" (Phnerogamae), 2nd ed., Shibundo, Tokyo, 1972, p. 594.
15) Fujita and Shimomura[11] reported the existence of cuticle above the epidermis. After bleaching with Javell's reagent, however, the material covering the epidermis swells partly, and stains slightly with ruthenium red, scarcely with methylen blue and never with sudan III. We would like to call this layer dark colored layer,

in here, from its morphology. This layer is partly covered with granular materials staining easily with methylene blue.

16) Though Li *et al.** has reported fibers in the cortex of the root of *Clematis paniculata* THUNB. (=*C. terniflora* DC. var. *robusta* (CARR.) TAMURA[12], *C. terniflora* DC.**?), we believe their experimental material had taken from another species, because we have recognized no mechanical tissue in the cortex of the root of *Clematis* plants so far, except *C. meyeniana* WALP. and *C. tashiroi* MAXIM. Anatomical characteristics of the root of *C. terniflora* DC. (=*C. mandshurica* RUPR.) will be reported in another paper.

* J.S. Li, P.G. Xiao, Z.Q. Lou, *Acta Pharmaceutica Sinica*, **15**(5), 288 (1980).

** W.C. Wang, "Flora Reipublicae Popularis Sinicae," Vol. 28, 166 (1980).

17) Regardless of the shape, the diameter is taken as the line drawn through the two primary phloem. When the vascular bundle is of a triarchal type, the average value from the extremes was taken.

18) There are some unmature roots in those measuring below 2,000 μm in diameter at d.p.=50 mm.

19) The largest vessel in the section is measured.

20) Fujita and Shimomura[11] observed no starch grains in one cortical layer just under the exodermis. In our research, starch grains are, however, observed sometimes in these areas but a few in number and small in size. In addition, starch grains may be recognized also in the exodermal and endodermal cells.

21) Diameter of the root at 50 mm from the proximal end divided by that at 5 mm.