A New Disease of Elm, Caused by *Gnomonia Oharana* n. sp.

By

Yosikazu Nisikado and Hiroyoshi Matsumoto.

[August 28th, 1929]

I. Introduction.

One of the present writers, Y. NISIKADO, found a black spot disease of *Ulmus parvifolia* JACQ. on November 7., 1917, for the first time. Since that time he has observed the disease every year. In 1921, L. E. MILES (1921) published a paper on "Leaf Spots of the Elm" in the Botanical Gazette (71 : 161—196), and he ascribed the causal fungus to *Gnomonia ulmea* (SCHW.) THUEM. About that time the writer sent his specimen to L. E. MILES, as the MILES' fungus resembled the Japanese elm-fungus. Although the writer found some differences between the American and the Japanese fungus at that time, his result was left alone to the present time.

The disease under consideration is a very common disease and prevalent in almost all parts of Japan. However, there seem to be no description regarding the causal fungus in Japan, except brief descriptions given by P. HENNINGS upon the imperfect stage of this fungus, according to the specimens sent by T. YOSHINAGA.

Recently the writers' attention was attracted to the fungus, as it completes the ascigerous stage on the living leaves of the host plants. Therefore they started some experiments on this fungus, hoping to contribute to the knowledge of the life history of the parasitic fungi. The present paper is only a preliminary note upon the occurrence of this fungus in Japan.

The results of the writers' comparative study between the specimens of his fungus and those of the MILES' fungus, which were kindly sent by him to the writers, showed that the ascigerous stage of the writers' fungus is clearly different from that of *Gnomonia ulmea* (SCHW.) THUEM. As it seems to have no previous records, the writer wishes to apply a new name, *Gnomonia Oharana* n. sp. in this paper.

The writers wish to express their indebtedness for supplying materials and necessary informations, to Prof. Dr. S. KUSANO, Prof. Dr. G. YAMADA, Prof. Dr. S. ITO, Prof. Dr. T. HEMMI, Dr. L. E. MILES, Messrs. T. YOSHINAGA, K. HARA, T. FUDIOKA, T. ABE, and S. KATO.

II. Symptoms.

The present disease breaks out after the openning of the new leaves in the early spring, and then continues till the late autumn. At first small yellowish spots are produced on the host leaves, then the spots enlarge gradually. About the central parts of the spots, some densely scattered small black stromata are produced. The stromata are 0.5–1 mm in size, sometimes two or three of them coalesce but do not produce large stromata. The stromata are arranged in regular radial direction from a center of a spot. At or near the margin of a spot many small black stromata are produce in an almost regular circle. Generally the spots are about 10 mm in size. Several spots are produced on a single leaf, and sometimes even more than 10 spots are produced. In severe cases of outbreak, the leaves dropped off before season. (Plate XXIV.)

III. Morphology of the Causal Fungus.

1. Perithecia. (Fig. 5) Under the stromata in the center of the spots, the perithecia are produced. The perithecia are mingled with the conidial acervuli, and are spherical, depressed spherical or elliptical in shape. Each of them is provided with a comparatively large, well-developed beak, at the center or at the excentric part of the main bodies. The beaks are cylindrical, elliptical or obovate, and provided with many periphysis. As shown in Table I, the writers' measurements of 100 perithecia show that the main bodies of them are 180—380 μ (mean 251.40 $\pm$ 0.276 μ) in diameter, 120—280 μ (mean 188.0 $\pm$ 0.173 μ) in height. The beaks are 20—180 μ (mean 90.60 $\pm$ 0.200 μ) in diameter and 20—200 μ (mean 105.20 $\pm$ 0.143 μ) in length.

Table I.

Variations and Means in Size of the main Bodies of the Perithecia.

Size (μ)	120	140	160	180	200	220	240	260	280	300	320	340	360	380	Total
Diameter	—	—	—	3	13	15	24	16	12	10	2	2	2	1	100
Height	1	3	24	30	20	16	4	1	1	—	—	—	—	—	100

	Mean	Standard deviation	Variation coefficient
Diameter (μ)	251.40±0.276	40.915±0.195	16.275±0.795
Height 〃	188.00±0.173	25.690±0.122	13.665±0.637

Table II.

Variations and Means in Size of the Beaks of the Perithecia.

Size (μ)	20	40	60	80	100	120	140	160	180	200	Total
Diameter	1	9	11	27	33	10	6	1	2	—	100
Length	3	6	9	11	24	19	23	2	1	2	100

	Mean	Standard deviation	Variation coefficient
Diameter (μ)	90.60±0.200	29.795±0.142	32.847±1.729
Length 〃	105.20±0.143	21.189±0.101	20.141±0.100

2. Asci. (Fig. 10) Asci are produced in bush at the bottom of the perithecia, hyaline and club-shaped, and each is provided with a thread-like thin stipe. They are straight or slightly curved to one side. The apex is round, thick-walled, provided with a pore at the central part. The pores may be stained to blue color when they are treated with iod-iod-kali. As the walls of the asci are hyaline and easily dissolve in water, the precise measurements of the asci are impossible. However, the results of 200 measurements of the asci are given in Table III. The asci 40—60 μ (mean 50.51 ± 0.171 μ) in length and 10—20 μ (mean 13.125 ± 0.09 μ) in width. They contain 8 ascospores in 2 rows.

Table III.

Variations and Means in Size of the Asci.

Length (μ)	40	42	44	46	48	50	52	54	56	58	60	Total
Frequency	1	5	5	22	36	35	44	32	15	4	1	200

Width (μ)	10	11	12	13	14	15	16	17	18	19	20	Total
Frequency	25	9	51	19	59	9	24	2	1	0	1	200

	Mean	Standard deviation	Variation coefficient
Length (μ)	50.510±0.171	3.580±0.121	7.088±0.239
Width 〃	13.125±0.091	1.905±0.064	14.514±0.450

3. Ascospores. (Fig. 10 and 11) Ascospores are hyaline, obovate, and 2-celled, the basal cells of the ascospores are much smaller than the apical cells. The apical cells each contain a large nucleus, which may be easily stained with eosin. The germination of the ascospores takes place only from

the upper cells, and never from the basal small cells. As shown in the Table IV, ascospores are 10—16 μ (mean 13.13 $\pm$ 0.03 μ) in length, 3.6—6.0 μ (mean 5.28 $\pm$ 0.02 μ) in width. The basal cells are 3.0—3.5 μ in length, the width being similar to the length.

Table IV.

Variations and Means in Size of the Ascospores.

Length (μ)	10	11	12	13	14	15	16	Total
Frequency I	8	13	113	33	29	4	—	200
" II	2	2	41	66	156	21	12	300
Total	10	15	154	99	185	25	12	500

	Mean	Standard deviation	Variation coefficient
Length I (μ)	12.370±0.047	0.978±0.033	7.905±0.133
" II "	13.643±0.039	1.019±0.028	7.468±0.206
Total "	13.134±0.030	0.998±0.021	7.600±0.162

Width (μ)	3.6	4.0	4.4	4.8	5.0	5.2	5.6	6.0	Total
Frequency I	1	82	45	22	—	3	22	15	200
" II	—	4	—	—	58	—	—	238	300
Total	1	86	45	22	58	3	22	253	500

	Mean	Standard deviation	Variation coefficient
Width I (μ)	4.520±0.029	0.623±0.020	13.340±0.457
" II "	5.780±0.017	0.445±0.012	7.877±0.217
Total "	5.276±0.016	0.524±0.011	9.930±0.212

4. Germination of the Ascospores. (Fig. 11) According to L. E. MILES, the ascospores of *Gnomonia ulmea* germinate only on the host leaves, and never on theother various nutrient solutions. On the contrary, the ascospores of the writers' elm fungus germinate comparatively easily in distilled water, in sugar solution or in decoction of the host leaves. The germ-tubes are hyaline slender, and 3.6—6 μ in diameter. The germ-tubes have never continued the growth in distilled water or in sugar solution.

5. Conidia. (Fig. 8, 9 and 12) The conidial layers, or acervuli, are produced in the black stromata. The conidial layers are flat in shape. The conidiophores are produced side by side at the bottom of the layers. They

bear the small conidia at their tip. The conidia are long elliptical or fusiform and non-septate, and are dispersed by the breaking of the upper layers of the stromata. So far the germination of the conidia was not observed by the writers in distilled water or in sugar solution. The conidia are very small in size and measured 3.2 —6 μ (mean 4.231 $\pm$ 0.02 μ) in length and 1.6—2.4 μ (mean 2.01 $\pm$ 0.03 μ) in width.

Table V.

Variations and Means in Size of Conidia.

Length (μ)	3.2	3.6	4.0	4.4	4.8	5.2	5.6	6.0	Total
Frequency	1	24	129	109	26	7	3	1	300

Width (μ)	1.6	1.8	2.0	2.2	2.4	Total
Frequency	1	20	246	31	2	300

	Mean	Standard deviation	Variation coefficient
Length (μ)	4.231±0.015	0.397±0.011	9.290±0.256
Width "	2.009±0.026	0.091±0.025	4.560±0.126

IV. Taxonomical Consideration on the Causal Fungus.

Accordings to the above described characteristics, the complete stage of the fungus under consideration may be supposed that it must belong to the genus Gnomonia. As to the incomplete or the conidial stage of this fungus, however, P. HENNINGS (1905) applied the name, *Asteroma Ulmi* (KLOTZSCH.) COOKE, to this fungus on the specimens sent by NAMBU and YOSHINAGA, who collected them in the Province of Tokyo and Tosa, Japan, respecively. The HENNINGS' description given in Bot. Jahrbücher (36 ; 603) runs as follows : " *Asteroma Ulmi* (KLOTZSCH.) COOK., Handb. n. 1369, Tokyo : auf Blättern von *Ulmus parvifolia* JACQ. (NAMBU n. 280, Sept. 1902); Prov. Tosa, Iokimura ; ebenso (YOSHINAGA n. 34, Nov. 1903). Die Konidien sind oblong, stumpf. 4—5 × 1½ μ hyalin, an stäbchen-förmigen Trägern. ". In the next volume of the same journal he gave a revision of the previous description on the elm fungus. His revised description runs as follows : *Placosphaeria Ulmi* P. HENNINGS n. sp. ; maculis flavido-fuscidulis, rotundato-angulatis vel effusis ; stromatibus ephyllis, innato-superficialibus, rotundato angulatis vel radiantibus, atrocrustaceis, verrucoso-rugulosis, 2—5 mm diam., saepe confluentibus ; conidiophoris hyalinis, breve filiformibus ; conidiis oblonga ellipsoideis vel fusoideis, hyalinis, 3½—5 × 1—1½ μ.....

Der Pilz dürfte sicher zu *Phyllachora Ulmi* gehören, ich habe denselben früher zu *Asteroma Ulmi* (KL.) gestellt.. Regarding to the similarity of the fungus under consideration to the HENNINGS' *Placosphaeria Ulmi*, the present writers are not able to give any decision, as they have no precise data regarding it. There is no room for doubt, however, about the coincidence of the writers' material of the fungus and those sent by NAMBU and YOSHINAGA to P. HENNINGS, as YOSHINAGA has kindly informed me.

Besides this specific name, *Melasmia ulmicola* B. et C. has been known as occurring on *Ulmus parvifolia*. In Japan this specific name was first recorded by I. MIYAKE (1913). He described *Melasmia ulmicola* B. et C. on Ulmus sp. collected in Honan, China, in his studies on Chinese fungi in the Tokyo Bot. Magazine (27 : 51). Then this specific name has been recorded in the List of Japanese Fungi by SHIRAI and HARA (1927). M. MIURA (1928) described this fungus occurring on *Ulmus pumila*, in Manchuria, China. Although the writers have not yet had a chance to inspect the specimens personally, except a specimen of the black spot disease of *Ulmus pumila* collected by G. YAMADA in Harbin, Manchuria, they seem to be the same ones with the fungus under consideration. Indeed a result of the writers' examination of the species preserved with the name of *Melasmia ulmicola* B. et C., which were received through the courtesy of S. KUSANO, showed that those specimens were similar to the writers' fungus. As the writers' elm fungus resembles the fungi of the genus Melasmia, in the symptoms and in the shape of conidia and conidial layer, the former may be confused with the latter. The genus Melasmia, however, is generally thought to be a conidial stage of the genus Rhytisma. Indeed *Melasmia ulmicola* B. et C. was reported by COOKE (1915) as the conidial stage of *Rhytisma Ulmi* FR. The genus Rhytisma has the asci produced in apothecia, and the filiform or linear ascospores, and quite differs from the writers' elm fungus.

The present species seems to be assumed also to *Systremma Ulmi* (SCHLEICH) THEISS. et SYD. by some authors. Both the genus Gnomonia and Systremma have the ascospores of two unequal cells. But the former genus differs from the latter by the well-developed beaks, and the perithecial bodies immersed in the leaf tissues, while the latter genus has the protruded stromata, within which the perithecia are formed. According to the above given morphological descriptions, the present fungus seems to belong to the genus Gnomonia and not Systremma.

The species *Systremma Ulmi* was described by THEISSEN et SYDOW (1915) in Annales Mycologici (13 : 334—5). It occurs on decayed leaves of Ulmus in Northern Europe. This species has been known under various names. The synonyms are as follows:

Sphaeria Ulmi SCHLEICH. (1805)
Sphaeria xylomoides DE CANDOLLE. (1805)
Sphaeria Ulmi DUVAL. (1809)
Xyloma sticticum MARTIUS. (1817)

Sphaeria ulmaria SOWERBY.
Polystigma Ulmi LINK.
Dothidea Ulmi FRIES. (1823)
Phyllachora Ulmi FUCKEL. (1883)
Dothidiella Ulmi (DUV.) WINTER. (1887)
Euryachora Ulmi SCHROETER.
Piggotia astroidea B. et BR. (Conidial stage) BERKELEY et BROOME.

According to a specimen of this fungus with the label of *Dothidiella Ulmi* (DUV.) WINT. on the leaves of *Ulmus suberosa* in Krieger: Fungi Saxonici, Nr. 1514, the fungus has the stromata developed between the palisade tissues and the epidermal layers of the host leaves. Within the stromata, dothideal perithecia are produced. (Fig. 7) These characteristics coincide with the descriptions of THEISSEN and SYDOW, but not with the present writers' fungus.

The writers' fungus very closely resembles *Gnomonia ulmea* (SCHW.) THUEM. The latter species was described as *Xyloma ulmea* FR. by L. D. SCHWEINITZ (1822) in Systematica Mycologicum (2 : 466), and later revised by THUEMEN (1878) in the descriptions on the North American Fungi in the Flora (61 : 178) as *Gnomonia ulmea* (SCHW.) THUEM. As to this species L. E. MILES gave a precise description. For the sakes of convenience for the comparisons of the species, measurements of the ascigerous stage of the both are given in tabular form as follows:

		Measurements of L. E. MILES (Gnomonia ulmea Thuem.)	Measurements of the writers (Black spot fungus of elm)
Perithecia (Main bodies)	Diameter	250—300 (μ)	180—380 (251.4±0.28) (μ)
	Height	150—200	120—260 (188.0±0.17)
Beaks of the Perithecia	Length	100	20—200 (105.2±0.14)
	Width	75	20—180 (90.60±0.20)
Asci	Length	45—55	40—60 (50.51±0.17)
	Width	9—11	10—20 (13.13±0.09)
Ascospores	Length	5—10	10—16 (13.13±0 03)
	Width	3—3.5	3.6—6 (5.280±0.02)

In regard to the numerical comparison, both species are very similar. However, the beaks of the perithecia of the writers' elm fungus open through the stromata at the upper side of the leaves, and the beaks situate usually at the excentric part of the main bodies of the perithecia and rarely at the center. While in *Gnomonia ulmea* (SCHW.) THUEM. the beaks open through the underside of the leaves, and usually situate at the center part of the main bodies. (Fig. 6) Not only in the ascigerous stages, but also in the conidial stages both species are clearly different in the size of the conidia. According to the MILES' description, the conidia of *Gnomonia ulmea* are 8—10 μ long, 2—2.5 μ wide, while those of the writers' fungus are 3.2—6.2 μ (4.23±0.03 μ) long, 1.6—2.4 μ (mean 2.01±0.04 μ) wide. Thus the writers' fungus is quite different from *Gnomonia ulmea* (SCHW.) THUEM. There are no other Gnomonia coinciding with

the writers' fungus.

According to the above given reviews of the previous descriptions regarding the elm spot fungi, the ascigerous stage of the elm fungus under consideration seems to be new to science, although the imperfect stage of the fungus seems to be *Asteroma Ulmi* (KLOTZSCH.) COOKE. Therefore a new name *Gnomonia Oharana* has been applied to the fungus. The specific name has been preferred in commemoration of the Ohara Institute, which held the Fifteenth Anniversary Celebration on the sixth of July, 1929. The diagnosis of this species are as follows:

Gnomonia Oharana n. sp.

Attacking the living leaf-blades. Spots epiphyllous, at first small yellowish, later becoming larger and to 10 mm. and producing black stromata within. Stroamta arranging radially from the center, the marginal ones in a regular circles, 0.5—1 mm in size, in dense group.

Perithecia spherical, depressed spherical or elliptical, immersed in the leaf tissues under the stromata, openning with a well-defined beak. The main bodies of the perithecia being 180—380 μ (mean 251.40$\pm$0.276 μ) in diameter, and 120—280 μ (mean 188.0$\pm$0.173 μ); the beaks 20—180 μ (mean 90.60$\pm$0.200 μ) in diameter, and 20—200 μ (mean 105.20$\pm$0.143 μ) in length.

Asci produced at the bottoms of the perithecia, hyaline, club-shaped, straight or slightly curved to one side, provided with a thread-like stipe; apex being thick-walled, round in shape, with a small pore; 40—60 μ (mean 50.51$\pm$0.17 μ) in length and 10—20 μ (mean 13.135$\pm$0.09 μ) in width, with 8 ascospores in 2 rows; ascospores hyaline, long-elliptical, 2 unequal celled, the basal cell being much smaller than the apical cell, which contains a large nucleus easily stained with eosin; 10—16 μ (mean 13.13$\pm$0.03 μ) long, 3.6—6.0 μ (mean 5.28$\pm$0.02 μ) wide; germinating only from the apical cells; the basal cells being 3.0—3.5 μ in length and width.

Acervuli epiphyllous, gregarious, subcutaneous, covered by the persistent blackened cuticle which finally ruptured irregularly; conidiophores in a closely packed layer, hyaline, cylindrical; conidia hyaline, one-celled, straight, long-elliptical or fusiform; 3.6—6 μ (mean 5.28$\pm$0.02 μ) long, 1.6—2.4 μ (mean 2.01 $\pm$0.04 μ) wide.

Habitat. On *Ulmus parvifolia* JACQ. " Aki-nire ".

Honsyû.–Prov. Okayama: Kurasiki (7/11/15 Y. NISIKADO) (7/11/19 C. MIYAKE) (3/7/21 Y. NISIKADO) (22/6/27 Y. NISIKADO) (20/6/29 H. MATSUMOTO); Prov. Kyoto: Simogamo (3/10/24 K. TOGASHI) (3/10/24 T. NOJIMA) (3/11/24 T. HEMMI) (23/10/28 T. ABE); Prov. Osaka: Sumiyosi (1/11/27 S. KATO) Isibasi (1/7/28 S. KATO); Prov. Siga: Nagaoka (17/10/25 T. HEMMI & K. TOGASHI); Prov. Hyogo: Mukogawa (2/9/28 S. KATO) Kobe (17/10/28 T. FUDIOKA); Prov. Simane: Hamada (6/8/01 S. KUSANO).

On *Ulmus japonica* SARG. " Haru-nire ".

Hokkaido. -Prov. Isikari : Sapporo (19/10/20 K. TOGASHI) (12/9/22 N. HIRATSUKA) (28/9/22 N. HIRATSUKA) Mt. Moiwa (10/9/22 N. HIRATSUKA).

On *Ulmus pumila* L. " No-nire ".

China. -Manchuria : Harbin (5/9/25 G. YAMADA),

On *Ulmus laciniata* MAYER. " Ohiyo ".

Hokkaido. -Prov. Isikari : Sapporo (23/9/23 N. HIRATSUKA).

Remarks : The conidial stage of this species may be *Placosphaeria Ulmi* P. HENN. (*Asteroma Ulmi* (KLOTZSCH.) COOKE.).

Resume.

1) In the present paper a new black spot disease of the leaves of *Ulmus parvifolia* JACQ. caused by *Gnomonia Oharana* n. sp. is reported.

2) Morphological descriptions of the perithecium, ascus, ascospore and conidium of the fungus under consideration are given at some length.

3) In Japan the present fungus is very common, and it attacks *Ulmus parvifolia* JACQ., *U. japonica* SARG., *U. pumila* L. and *U. laciniata* MAYER, and occurs in Honsyû, Hokkaido and Manchuria.

4) The fungus was observed in this country long before, but it has been erroneously known under the names *Melasmia ulmicola* B. et C. or *Systremma Ulmi* (SCHL.) THEISSEN et SYDOW.

5) The writers' elm fungus closely resembles to *Gnomonia ulmea* (SCHW.) THUEM. The differences between them, however, are pointed out in the present paper.

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PLATE XXIV.

Explanation of Plate XXIV.

Fig. 1. Leaves of *Ulmus parvifolia* JACQ., affected by *Gnomonia Oharana* NISIKADO et MATSUMOTO, collected in Kurasiki on July 6. 1928. Showing the characteristic lesions. (Magn. ca. 1.1×)

Fig. 2. Ditto. (Magn. ca. 1.8×)

Fig. 3. (A) Portion of a leaf of *Ulmus laciniata* MAYER. affected by *Gnomonia Oharana* NISIKADO et MATSUMOTO. Collected in Sapporo, Hokkaido by N. HIRATSUKA.

(B) A leaf of *Ulmus japonica* SARG. affected by *Gnomonia Oharana* NISIKADO et MATSUMOTO. Collected in Sapporo, Hokkaido by K. TOGASHI.

Fig. 4. (A) A leaf of *Ulmus pumila* L. affected by *Gnomonia Oharana* NISIKADO et MATSUMOTO. Collected in Harbin, Manchuria by G. YAMADA.

(B) Two leaves of *Ulmus parvifolia* JACQ. affected by *Gnomonia Oharana* NISIKADO et MATSUMOTO. Collected in Kurasiki.

PLATE XXIV.

Fig. 1.

Fig. 2.

Fig. 3.

A B

Fig. 4.

A B

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PLATE XXV.

Explanation of Plate XXV.

Fig. 5. Perithecia and conidial layers of *Gnomonia Oharana* NISIKADO et MATSUMOTO on *Ulmus parvifolia* JACQ. Asci and conidia discharged.

Fig. 6. Perithecium of *Gnomonia ulmea* (SCHW.) THUEM. on a leaf of *Ulmus americana*. Collected by L. E. MILES at Princeton Indiana, July 7. 1919. Showing the beak of the perithecium on the underside of the leaf. (Magn. ca. 200×)

Fig. 7. Perithecia of *Dothidiella Ulmi* (DUV.) WINT. on *Ulmus suberosa*. Nr. 1514 of the herbarium of Krieger: Fungi Saxonici. Showing dothideal perithecia. (Magn. ca. 200×)

Fig. 8. Conidial layers of *Gnomonia Oharana* NISIKADO et MATSUMOTO. Collected at Kurasiki, June 20. 1928. Showing the abundant conidia. (Magn. ca. 250×)

PLATE XXV.

Fig. 5.

Fig. 6.

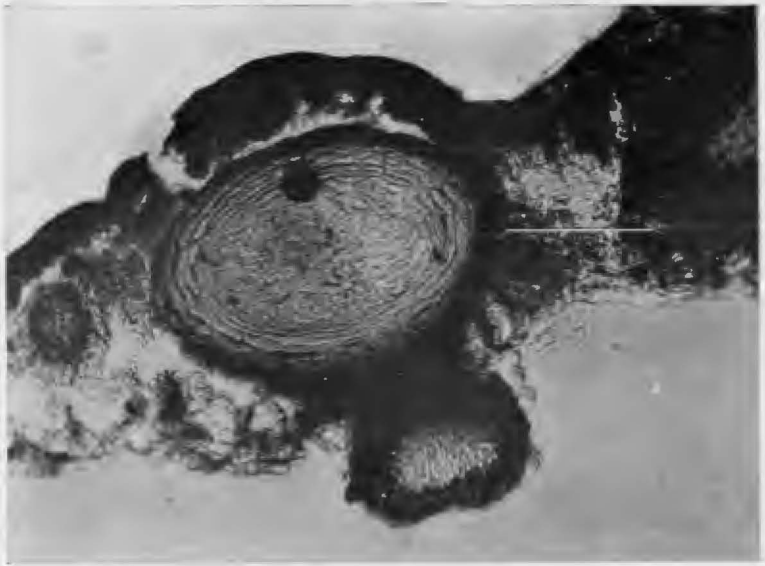

Fig. 7.

Fig. 8.

PLATE XXVI.

Explanation of Plate XXVI.

Fig. 9. Ditto. More magnified. Showing the layer of the conidiophores. (Magn. ca. 700×)

Fig. 10. Three asci of *Gnomonia Oharana* NISIKADO et MATSUMOTO. Collected at Kurasiki, June 22. 1928. Stained with eosin. Showing the 2-unequal-celled ascospores. (Magn. ca. 650×)

Fig. 11. Germinations of the ascospores of *Gnomonia Oharana* NISIKADO et MATSUMOTO. (Magn. ca. 1,000×)

Fig. 12. Conidia of *Gnomonia Oharana* NISIKADO et MATSUMOTO. (Magn. ca. 1,100×)

PLATE XXVI.

Fig. 9.

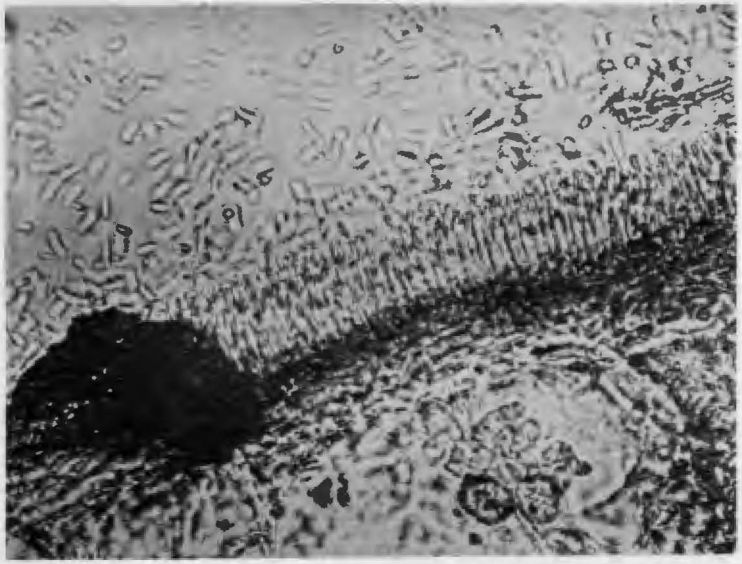

Fig. 10.

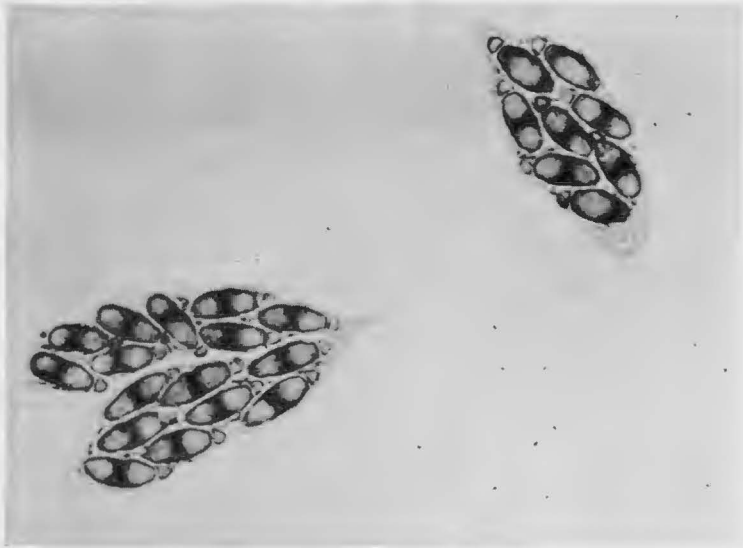

Fig. 11.

Fig. 12.