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Short Communication

Rust Disease of Water Willow Intercepted in Import Plant Quarantine in Japan

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Abstract: A rust disease on water willow (*Justicia gendarussa* Burm f.) was found at an import plant quarantine inspection at Nagoya airport, in January, 2002. The causal rust fungus was identified with *Puccinia thwaitesii* Berk., based on it's morphology and the results of inoculation experiments. This is the first report on the interception of rust disease of water willow caused by *P. thwaitesii* at import plant quarantine inspection in Japan.
Key words: rust, water willow, *Justicia gendarussa*, *Puccinia thwaitesii*

Introduction

Water willow (*Justicia gendarussa* Burm f..) is a perennial shrub native to the tropical and subtropical zones of the Asia, and it belongs to Acanthaceae (Editorial Committee of the Flora of Taiwan,1998). In the Southeast Asia, this plant is utilized as a raw material of Chinese medicine, or as a medicine for rheumatism (IWATSUKI *et. al.* ed., 1997). In our country, water willow is introduced and used as an ornamental plant, mainly for indoor.

In January 2002, potted plants of water willow infected with a rust disease were found at an import plant quarantine inspection at Komaki (Nagoya international airport) in Japan. They were plants imported from Thailand for use as the ornamental foliage. Some diseased plants were collected and used for the identification.

Symptoms (Plate I, 1－3)

Pale orange to dark brown sori are arranged irregularly or concentrically, to some extent, in chrolotic to yellow spots on the under surface of the leaf. On the upper surface of the leaf, the sori are rarely formed. As infection progresses, the yellow spots become larger round to ellipsoidal spots (about 25mm or more in sizes). A part of sori in the expanded spots looks cinereous (grayish) on the top part, due to germination without dormacy. In a severe infection, the diseased leaf shows malformation, or part of the leaf, or the whole leaf, becomes yellow and dies, and ultimately the leaf falls.

No symptoms are observed on the stem.

Inoculation experiments

Some leaf pieces with sori (telia of the rust fungus) were cut out from diseased leaves of water willow, and they were placed on the leaves of potted plants of water willow (*Justicia gendarussa* Burm f.) and used as inocula.

Inoculated plants were placed in a moist plastic container in the dark, at about 28℃, for 4 days, and they were moved to a greenhouse (about 26～28℃). Non-inoculated water willow served as control. Results are shown in Table 1.

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Table 1. Pathogenicity of the rust fungus to water willow

Plant	Part inoculated	Pathogenicity [1]
water willow (*Justicia gendarussa* Burm f.)	leaves	9/10 [3]
water willow (*Justicia gendarussa* Burm f.)	leaves	5/12 [4]
control [2] (Mar. and May)	leaves	0/10 [5]

[1] Number of leaves produced telia / number of leaves inoculated

[2] *Justicia gendarussa* Burm f. was used as a control

[3] 1st inoculation test ; three living plants were inoculated at March,2002.

[4] 2nd inoculation test ; two living plant was inoculated at May, 2002.

[5] Total two living plants were used.

At ten to 11 days after inoculation, the symptoms began to appear. Small round light chlorotic to yellow spots (fleck) (about 1mm in size) appeared on the inoculated leaves; eventually they enlarged to be round to ellipsoidal spots (about 25mm or more). About two weeks after inoculation, pale orange to light brown immature sori (telia) were formed in the spots (8 to 10 mm in size) on the under surface of the leaves, and as the sori matured, they became brown to dark chestnut brown, and part of teliospores in the sori, located at the center of the enlarged spots, germinated .

Such sori showed cinereous appearence on their top parts. About one month after inoculation, as the disease progressed, the spots coalesced; heavily infected leaves were malformed or parts of leaves or whole leaf, died, and ultimately fell (**Plate I,6,7and 8**). No symptoms were observed on the non-inoculated plants (control) in these experiments.

Morphological characteristics of the rust fungus (Plate I, 3－5, 9, 10)

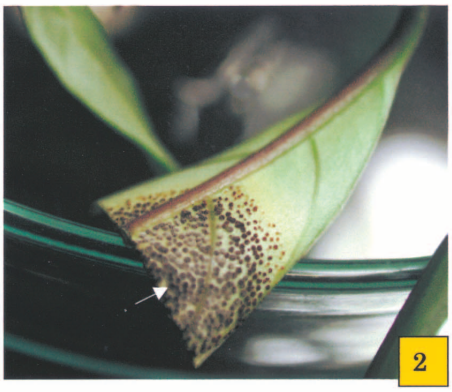
Pycnidia, aecia and uredinia do not occur. Telia are chiefly hypophyllous and are irregularly, concentrically, to some extent, or confluently, arranged in dense groups in chiefly round, clorotic to yellow spots (up to about 25mm or more diameter); at first compact, and then subpulverulent, dark chesnut brown, 0.2～0.3 mm in diameter, not stromatic. Teliospores are mostly two-celled, rarely one-celled or three-celled; irregularly ellipsoidal, oblong, or clavate, and obtuse above; usually slightly constricted at septa, frequently attenuate below; smooth; 32～48 ×19～25 μm in size. Cell walls of teliospores are luteous or sienna; and, the wall thickness is about 2～5 μm at the sides, and about 2～7.5 μm above. Pedicels are basal, persistent, hyaline to pale brown, smooth, mostly up to 105 μm in length. Teliospores germinate without dormacy, but the germ pore on each cell is obscure. Inner wall surface of cell wall of teliospores often shows minutely reticulate under an optical microscope.

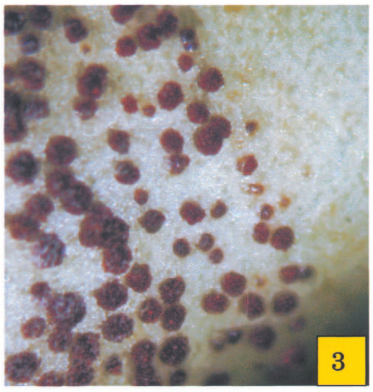
Identification

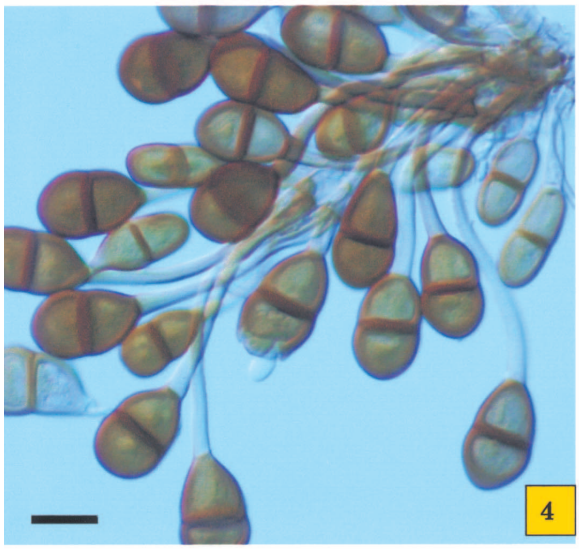
Based on the morphology of the teliospore, our rust fungus was considered to belong to *Puccinia* sp. As the *Puccinia* rust fungi that can infect *Justicia* spp., *Puccinia lantanae* (HIRATSUKA *et. al.*,1992), *Puccinia shiraiana* (Anonymous,1979), *Puccinia elytrariae* (TAI, 1979) and *Puccinia thwaitesii* (LAUNDON, 1963; SYDOW and SYDOW, 1904) were reported mainly from Asia, including southeast Asia, such as Thailand. Also, *Puccinia bonariensis* (LAUNDON, 1963), *Puccinia justiciae* (LAUNDON, 1963), *Puccinia lateripes* (LAUNDON, 1963; STEVENSON, 1975), *Puccinia paranahybae*, (LAUNDON, 1963) *Puccinia fuhrmanni* (KERN, 1933) and *Puccinia ruelliae* (LAUNDON, 1963) were reported on *Justicia* spp., in chiefly, Central or South America. Further, *Puccinia semiloculata* and *Puccinia thunbergiae* (LAUNDON, 1963) were reported from *Justicia* spp. in Africa.

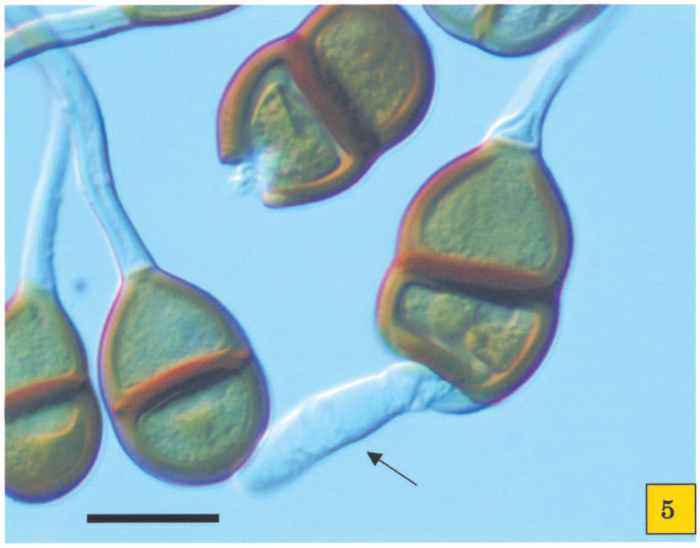
However, LAUNDON (1963) treated *P. fuhrmanni* as a synonym for *P. paranahybae*, and recently

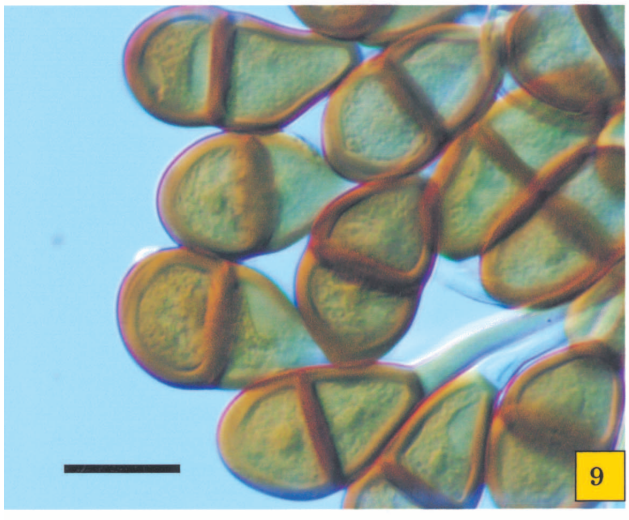
Plate I











Explanation of Plate I

1. Symptom on a leaf of a water willow (*Justicia gendaurussa.*) living plant imported from Thailand.
2. Expansion of the symptom described above (note that part of telia is becoming apparently greyish.)
3. Telia on the symptom described above.
4. Teliospores scraped off the telia on the symptom described above (scale = 20 μm).
5. Expansion of teliospores scraped off the telia on the symptom described above (note that one teliospore is germinating (producing it's basidium)) (scale = 20 μm).
6. Symptoms on a leaf (upper surfaces) of a water willow (*Justicia gendaurussa.*) living plant inoculated with pieces of leaf with telia.
7. Symptom on a leaf (under surface) of a water willow (*Justicia gendaurussa.*) living plant inoculated with pieces of leaf with telia.
8. Yellowing or death of the inoculated leaf, which will soon fall.
9. Teliospores scraped off the telia formed on the symptom of a leaf of a water willow (*Justicia gendaurussa.*) living plant inoculated (cale = 20 μm).
10. Teliospores after germinating, scraped off the telia formed on the symptom of a leaf of a water willow (Justicia gendaurussa.) living plant inoculated (note that the teliospores, after germinating, have the broken upper cell above or they often have old (not fresh) basidia) (scale = 20 μm).

HIRATSUKA *et. al.* (1992) described *P. shiraiana* and *P. elytrariae* as being synonymous with *P. lantanae.*

Therefore, morphological differences in the comparison between our rust fungus and *P. lantanae, P. thwaitesii, P. bonariensis, P. justiciae, P. lateripes, P. paranahybae, P. ruelliae, P. semiloculata, P. thunbergiae* were showed in Table 2 in this paper.

Combining the number of spore states and host－alternating features, eight basic types of life cycles have been recognized within the rust fungus (HIRATSUKA *et. al*, 1992). Among those, it is clear that our rust fungus belongs to Lepto form and has Ⅲ and Ⅳ as the spore states.

Therefore, our rust fungus differs from the Auto-eu form (*P. lateripes, P. bonariensis*, and *P. ruelliae*), with *P. justiciae* having spore stages of Ⅱ, Ⅲ and the Auto- opsis form (*P. semiloculata* and *P. thunbergiae*), by their life cycles.

P. paranahybae differs from our rust fungus in that the former forms cinnamon telia and fulvous or slightly paler teliospore, and it has a thiner teliospore wall.

P. lantanae also differs clearly from our rust fungus, in that the former has lesser dimensions, and also has predominately one-cell teliospores.

On the other hand, morphology of telia and teliospores on the leaves of imported *Justicia* living plants and inoculated leaves were almost similar to that described in *Puccinia thwaitesii* Berk. (SYDOW and SYDOW, 1904; LAUNDON, 1963 and Table 2). The plant infected with our rust fungus was identified as *Justicia gendarussa*, on which, previously *P. thwaitesii* has been reported as a causal agent of rust (BOEDIJN, 1959; LAUNDON,1963). The exporting country (Thailand) of the diseased plants was also one where *P. thwaitesii* is known to occur (LOHSOMBOON *et. al.*, 1986; GJAERUM, H.B. , 1995; and Table 2).

Our inoculation experiment results showed symptoms almost similar to those of imported diseased *Justicia* plants in origin (**Plate I,1, 2, 6, 7**).

Therefore, our rust fungus was identified as *Puccinia thwaitesii* Berk., based on the morphology of mainly the telial stage, and symptomatology, including the results of the inoculation experiments.

A part of the specimen (dead material) was stored as TSH-R1997 in the herbarium of the University of Tsukuba .

Proposal for disease name

Although it is known that *P. thwaitesii* is widely distributed in Asia, especially southeast Asia, including Thailand (LOHSOMBOON *et. al.*, 1986; GJAERUM, H.B., 1995; and Table 2), *P. thwaitesii* is not known to occur on introduced *Acanthaceae* ornamental foliage plants or potted flower plants or

Table 2. Morphological differences between the author's rust fungus and Puccinia spp. previously described

material in origin / characteristic	our rust fungus	*P. lantanae* [2),4)]	*P. thwaitesii* [4)]	*P. thwaitesii* [5)]	*P. paranahybae* [4)]	*P. justiciae* [4)]	*P. lateripes* [4)]	*P. bonariensis* [4)]	*P. ruelliae* [4)]	*P. semiloculata* [4)]	*P. thunbergiae* [4)]
spore stages [1)]	Ⅲ	Ⅲ	Ⅲ	Ⅲ	Ⅲ	Ⅱ, Ⅲ	0, Ⅰ, Ⅱ, Ⅲ appearing in uredinia	0, Ⅰ, Ⅱ, Ⅲ	0, Ⅰ, Ⅱ, Ⅲ arising in the old uredinia	Ⅰ, Ⅲ with paraphyses	Ⅰ, Ⅲ with paraphyses
Telia color	dark chesnut brown	blackish	dark chesnut	dark brown	cinnamon	dark brown～	dark chesnut	pale yellowish	dark brown～black	dark brown	very dark umber
stromatic	not	nd [3)]	not	nd	not	nd	nd	nd	nd	stromatic	stromatic
Teliospore						double layered	double layered		double layered		
shape	irregularly ellipsoidal, oblong or clavate	ellipsoid	ellipsoidal,cylindrical or clavate	irregularly ellipsoidal, oblong or subclavate	cylindrical, clavate or ± ellipsoidal	broadly ellipsoidal, shortly cylindrical	ellipsoidal to shortly cylindrical	shortly cylindrical, ellipsoidal, ± fusiform	broadly ellipsoidal, shortly cylindrical	cylindrical, fusiform, or clavate	cylindrical, fusiform, clavate, or ellipsoidal
sizes(μm)	32～48 ×19～25	24～40 ×15～20	30～50 ×18～25	28～50 ×16～27	30～50 ×16～22	31～44 ×28～33	26～39 ×20～29	42～55 ×17～27	33～43 ×25～34	35～52 ×11～15	35～50 ×13～23
color	luteous or sienna	chesnut brown	luteolus, luteous or sienna	ochraceous brown	fulvous or slightly paler	sienna	sienna	hyaline to pale yellowish	sienna	hyaline to yellowish	luteolus, luteus to ochraceous
No. of cell	2-cell(1or 3-cell rare)	1 cell predominate	2 cell(1 or 3 cell nd)	nd(but, 2 cell as Puccinia)	2 cell(in Fig.)	2 cell(in Fig.)	2 cell(in Fig.)	2 cell(in Fig.)	2 cell (in Fig.)	2 cell(in Fig.)	2 cell (n Fig.)
Thickness of teliospore wall above(μm)	2～7.5	3～5	2～8	not or slightly thickened	1～5	6～8(at the pore), 2～4(caps)	3～5(at the pore)	1～2(not thickened above)	6～9(at the pore), 2～4(caps)	2～6	2～6
at the side(μm)	2～5	1.5～2.5	2～5	nd	0.5～1.5	3～5	2～4	1～2	3～5	1～1.5	1～1.2
surface germination	smooth without dormacy	smooth without dormacy	smooth or very finely reticulate without dormacy	smooth nd	smooth nd	smooth or sparsely verrucose orechinulate nd	verrucose-reticulate, or smooth nd	smooth without dormacy	slightly verrucose-reticulate, or smooth nd	smooth nd	smooth nd
Pedicel location	basal	nd	basal	nd	basal	rough below basal or lateral	rough below lateral	basal	strongly lateral	basal	basal
length(μm)	< 105	24～80	<ca. 100	<150	<70	<40	<80	<50	80-300	<ca. 40	<ca. 50
color	hyaline～ pale brown	colorless	light yellow～light brown	hyaline～yellowish	lightly fulvous	hyaline	hyaline	hyaline	hyaline	hyaline to yellowish	pale yellow to pale ochraceous
Host plants	*Justicia gendarussa* L.	*Justicia procumbens* L.., *J. diffusa* Willd., other *Justicia* spp., *Dicliptera* sp., *Elytraria* spp.,*Hemigraphis* sp., *Hypoestes* sp. *Ruellia* sp., *Peristrophe* sp., *Strobilanthes* sp. [4)]	*Justicia gendarussa* L.., *Asystasia* sp., *Daedalacanthus* sp., *Hemigraphis* sp.,	*Justicia gendarussa* L.	*Justicia secunda* L. and *Ruellia* spp.	*Justicia inaequalis* Benth. & Hook.. and other *Justicia* spp.	*Blechum* spp., *Ruellia* spp. and *Justicia pectoralis* [6)]	*Justicia tweediana* Benth. & Hook.	*Asystasia* spp., *Eranthemum* sp., *Ruellia* spp. and *Justicia* sp. [7)]	*Justicia* sp.	*Asystasia* sp., *Dicliptera* spp., *Monechma* sp., *Thunbergia* spp. and *Justicia* spp. including *Justicia exigua* G Moore.
export country or Distribution	Thailand	Brasil, Honduras, China, Colombia, Costa rica, Taiwan, Guatemala,Mexico, India, Indonesia,Japan[4)]	Burma, Sri lanka, China, India, Indonesia, Malaysia, Papua New Guinea, Philiphines	Sri Lanka, Vietnam, Indonesia, Singapore,Papua New Guinea	Colombia and Brasil	Ecuador, Guatemala, W.indies, USA.	Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, USA	Argentina	Australia, Sri Lanka, Ghana, India, Ivory Coast, Philippines, Costa Rica, Guatemala	Kenya	Ethiopia, Ghana, Nigeria, S. Africa, Tanzania, Uganda, Indonesia, India

1) The Roman numerals, 0, Ⅰ, Ⅱ and Ⅲ respectively indicate the spermogonial, aecial, uredinial, and telial state in the rust fungus life cycle. However, Ⅳ (basidial stage) is omitted because all rust fungus described in here can produce external basidia .
2) HIRATSUKA *et. al.* (1992)
3) not described
4) LAUNDON (1963)
5) SYDOW and SYDOW (1904)
6) STEVENSON (1975)
7) ARTHUR (1918a), ARTHUR (1918b).

Acanthaceae wild plants, as well as on *Justicia* spp., in Japan (The phytopath. Soci. of Japan, 2000).

Therefore, we would like to propose calling newly "Sabi-byô" (in Japanese) for this disease (rust) of water willow caused by *Puccinia thwaitesii* Berk..

This is the first report on rust disease of water willow caused by *P. thwaitesii* intercepted at an import plant quarantine inspection in Japan.

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和 文 摘 要

輸入検疫で発見されたウォーターウィローのさび病

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2002年１月、名古屋国際空港での輸入検疫検査においてタイ王国から輸入されたウォーター・ウィロー（*Justicia gendarussa* Burm f.）苗の葉にさび病が観察され、形態及び病徴等の詳細な調査の結果、我が国では発生未報告の*Puccinia thwaitesii* Berk.による病害であることが判明した。同植物への接種試験の結果、原病徴が再現され、接種菌と同様の菌が観察されたことから、輸入検疫で発見された病害として、*Puccinia thwaitesii* Berk.によるウォーター・ウィローさび病（新称）（英名；rust of water willow）を提案した。