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ERRATUM

Emended classification of xanthomonad pathogens on citrus

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In the paper by Schaad et al.\textsuperscript{[24]} on reclassification of several xanthomonads, nomenclatural errors were made. The name \textit{Xanthomonas smithii} subsp. \textit{citr}

\textit{proposed for the former taxon \textit{X. campestris} pv. \textit{citr}

\textit{is illegitimate. Following the reinstatement of \textit{X. citri} \textit{(ex Hasse 1915)} Gabriel et al. \textsuperscript{[9]} as a validly published name, Young et al. \textsuperscript{[34]} wrote that the reinstatement of this epithet was based on a description that was inadequate in terms of modern practice for the purpose of formal classification. This report was subsequently summarized by the International Committee on the Systematics of Bacteria (ICSB) Subcommittee on the Taxonomy of the Genus \textit{Pseudomonas} and Related Organisms \textsuperscript{[32]} as implying rejection of the epithet, which the Subcommittee itself appeared to endorse. As we now understand, in accord with the International Code of Nomenclature of Prokaryotes (‘the Code’—hitherto the International Code of Nomenclature of Bacteria \textsuperscript{[14]}) the Judicial Commission of the ICSB only may reject a name for precisely specified reasons (Rule 56a). We also misinterpreted the subsequent establishment of the pathovar ‘‘\textit{citr}’’ within \textit{Xanthomonas axonopodis} \textsuperscript{[29]} as further evidence for rejection of reinstatement of \textit{X. citri} \textsuperscript{[9]}. Finally, believing that the epithet ‘‘\textit{citr}’’ had been rejected, we followed rule 23a of the Code \textsuperscript{[14]} and proposed an illegitimate specific epithet ‘‘\textit{smithii}’’ (which also required establishing the subspecies epithet ‘‘\textit{smithii}’’ replacing ‘‘\textit{malvacearum}’’; see rule 13a \textsuperscript{[14]}). In fact, \textit{X. citri} Gabriel et al. 1989 was a legitimate, validly published name that was allowed to fall into abeyance because of the inadequacies perceived in its description. Schaad et al. \textsuperscript{[24]} indicated their support for the conclusions of Gabriel et al. \textsuperscript{[9]} but included DNA–D– DNA reassociation data indicated as necessary by for modern classification \textsuperscript{[26,31]}. One purpose of this note is to recognize by effective publication the species related to pathogenic xanthomonads of citrus. The second purpose is to avoid confusion in plant pathological literature by replacing the illegitimate subspecies name \textit{X. smithii} subsp. ‘‘\textit{smithii}’’ with \textit{X. citri} subsp. ‘‘\textit{malvacearum}’’. For that purpose, corrected protologues for those species and subspecies are reported here: \textit{X. citri} subsp. \textit{citr} and \textit{X. citri} subsp. \textit{malvacearum}; \textit{X. fuscans} subsp. \textit{fuscans} and \textit{X. fuscans} subsp. \textit{aurantifoli} and \textit{X. alfalfa} subsp. \textit{alfalfa} and \textit{X. alfalfa} subsp. \textit{citrumel}.

We also present (Table 1) GenBank accession numbers for the intergeneric spacer (ITS) sequences for the type strains proposed in this note \textsuperscript{[24]}. Protologues

Abbreviations for culture collections in which type strains are on deposit: ATCC = American Type Culture Collection, Manassas, VA, USA; CFBP = Collection Francaise de Bacteries Phytopathogenes, Angers, France; ICMP = International Collection of Microorganisms from Plants, Auckland, New Zealand; ICPB = International Collection of Phytopathogenic
Table 1. 16S-23S Ribosomal intergeneric spacer sequences for type strains [24]

<table>
<thead>
<tr>
<th>Proposed name</th>
<th>Strain designation</th>
<th>GenBank accession</th>
</tr>
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<tbody>
<tr>
<td><strong>Xanthomonas citri</strong></td>
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<td>X. citri subsp. citri</td>
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<td>DQ660898</td>
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<td>X. fuscans subsp. fuscans</td>
<td>ATCC 19315</td>
<td>DQ660900</td>
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<tr>
<td>X. fuscans subsp. aurantifoli</td>
<td>NCPPB 3236</td>
<td>DQ660897</td>
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<tr>
<td><strong>Xanthomonas alfalfa</strong></td>
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<tr>
<td>X. alfalfa subsp. alfalfa</td>
<td>ATCC 11765</td>
<td>DQ660896</td>
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<tr>
<td>X. alfalfa subsp. citrumelonis</td>
<td>ATCC 49120</td>
<td>DQ660899</td>
</tr>
</tbody>
</table>

Bacteria, USDA, Ft. Detrick, MD, USA; LMG = Laboratorium Microbiologie Gent, Gent, Belgium; NCPPB = National Collection of Plant Pathogenic Bacteria, York, England.

**Xanthomonas citri** (ex Hasse 1915) Gabriel et al. [9] emend.

**Etymology:** ci’tri. N.L. gen. n. citri of citrus.

**Description:** The description of the species *X. citri* is encompassed within the description of the genus *Xanthomonas* Dowson, 1939 [25] emend. Vauterin et al. [29] and within the description provided by Gabriel et al. [9]. *X. citri* subsp. *citri* causes bacterial canker on *Citrus* spp. and *X. citri* subsp. *malvacearum* causes angular leaf spot and black arm of cotton (*Gossypium* spp.) whereas *X. campestris* and *X. axonopodis* do not affect either host [24]. *X. citri* does not produce a brown water soluble pigment on common media as does *X. fuscans* and *X. campestris* pv. *vignicola* [24]. *X. citri* is differentiated from all other xanthomonads, except *X. campestris* pv. *melonis* and *X. campestris* pv. *viticola*, by fatty acid profiles [33]. Additionally, *X. citri* differs from *X. campestris* and most other pathovars, subspecies, and species of *Xanthomonas* by serology [1,28], SDS-PAGE analysis of membrane proteins [28,30], isozyme analysis [13], DNA-DNA reassociation assays [8,24,29], ITS sequencing [24], RFLP [9,15], and rep-PCR profiles [20].

**Type strain:** ICPB 10518 = ATCC 49118 = LMG 9322.

**Xanthomonas citri** subsp. *citri* (ex Hasse 1915) Gabriel et al. 1989, subsp. nov.

**Etymology:** ci’tri. N.L. gen. n. citri of citrus.

**Description:** *X. citri* subsp. *citri* causes bacterial canker of citrus whereas *X. citri* subsp. *malvacearum* does not [24]. *X. citri* subsp. *citri* may be distinguished from *X. campestris* and most other *Xanthomonas* pathovars, subspecies, and species by DNA-DNA reassociation assays [8,24,29], ITS sequencing [24], rep-PCR profiles [20], and phenotypic traits [24]. Strains of *X. citri* subsp. *citri* produce single colonies on YDC and FS agars [23] after 40–44 and 56–60 h, respectively, at 28–30 °C [24]. In contrast, *X. fuscans* subsp. *fuscans* and *X. fuscans* subsp. *aurantifoli* produce single colonies in 56–60 and 70–76 h, respectively, and *X. alfalfa* subsp. *alfalfa* and *X. alfalfa* subsp. *citrumelonis* grow in 30–34 and 40–44 h, respectively [24]. *X. citri* subsp. *citri* utilizes arabinose and lactose and hydrolyzes pectate whereas *X. citri* subsp. *malvacearum* does not [24]. *X. citri* subsp. *citri* reduces aspartic acid whereas *X. campestris* pv. *campestris* does not [24]. The latter utilizes raffinose and reduces saccharic acid whereas the former does not [24]. Both bacteria are differentiated by host pathogenicity assays and by serology [1–3,5,28] and membrane protein analysis [16,28,30]. Serology differentiates *X. citri* subsp. *citri* from *X. fuscans* subsp. *aurantifoli* [10,11,19]. Strains of *X. citri* subsp. *citri* are susceptible to bacteriophage CP1 and CP2 whereas those of *X. fuscans* subsp. *aurantifoli* are not [18]. *X. citri* subsp. *citri* is differentiated from *X. alfalfa* subsp. *citrumelonis* by isozyme analysis [13]. *X. citri* subsp. *citri* grows on FS and mSX agars, utilizes arabinose, maltose, lactose, mannitol, cellobiose, and asparatic acid; hydrolyzes pectate, liquefies gelatin, and results in an alkaline hydrolysis of litmus milk [24].

**Type strain:** ICPB 10518 = ATCC 49118 = LMG 9322.

**Xanthomonas citri** subsp. *malvacearum* (ex Smith 1901) subsp. nov., nom. rev.

**Etymology:** mal.va.ce.a’rum. N.L. pl. gen. n. malvacearum, of *Malvaceae* (of malvaceous plants of the family *Malvaceae*).

**Description:** *X. citri* subsp. *malvacearum* causes angular leaf spot and black arm of cotton (*Gossypium hirsutum*) whereas *X. citri* subsp. *citri* does not [24]. *X. citri* subsp. *malvacearum* is differentiated from *X. campestris* pv. *campestris* and most other *Xanthomonas* pathovars, subspecies, and species by DNA-DNA reassociation assays [8,24,29], rep-PCR profiles [20], by serology [3], and SDS-PAGE patterns of membrane proteins [30], ITS sequencing [24], and phenotypic characters [24]. Strains of *X. citri* subsp. *malvacearum* produce single colonies on YDC and FS agars [23] after 40–44 and 56–60 h, respectively, at 28–30 °C [24]. In contrast, *X. fuscans* subsp. *fuscans* and *X. fuscans* subsp. *aurantifoli* produce single colonies in 56–60 and 70–76 h, respectively, and *X. alfalfa* subsp. *alfalfa* and *X. alfalfa* subsp. *citrumelonis* grow in 30–34 and 40–44 h, respectively [24]. *X. citri* subsp. *citri* utilizes arabinose and lactose and hydrolyzes pectate whereas *X. citri* subsp. *malvacearum* does not [24]. *X. citri* subsp. *citri* reduces aspartic acid whereas *X. campestris* pv. *campestris* does not [24]. The latter utilizes raffinose and reduces saccharic acid whereas the former does not [24]. Both bacteria are differentiated by host pathogenicity assays and by serology [1–3,5,28] and membrane protein analysis [16,28,30]. Serology differentiates *X. citri* subsp. *citri* from *X. fuscans* subsp. *aurantifoli* [10,11,19]. Strains of *X. citri* subsp. *citri* are susceptible to bacteriophage CP1 and CP2 whereas those of *X. fuscans* subsp. *aurantifoli* are not [18]. *X. citri* subsp. *citri* is differentiated from *X. alfalfa* subsp. *citrumelonis* by isozyme analysis [13]. *X. citri* subsp. *citri* grows on FS and mSX agars, utilizes arabinose, maltose, lactose, mannitol, cellobiose, and asparatic acid; hydrolyzes pectate, liquefies gelatin, and results in an alkaline hydrolysis of litmus milk [24].

**Type strain:** ICPB 10518 = ATCC 49118 = LMG 9322.
aurantifolii produce single colonies in 56–60 and 70–76 h, respectively, and X. alfalfae subsp. alfalfae and X. alfalfae subsp. citrumelonus grows in 30–34 and 40–44 h, respectively [24]. Further, RFLP profiles differentiate X. citri subsp. malvacearum from X. fuscans subsp. fuscans, and X. alfalfae subsp. alfalfae [15]. X. campestris pv. campestris utilizes melizitose and hydrolyzes pectate whereas X. citri subsp. malvacearum does not [24]. X. citri subsp. malvacearum produces an alkaline reaction without hydrolysis in litmus milk whereas X. citri subsp. citri causes an alkaline reaction with hydrolysis [24]. X. citri subsp. malvacearum grows on FS and mSX agars [23], liquefies gelatin, and most strains (60%) utilize maltose [24].

Type strain: ICPB 10520 = ATCC 9924 = ICMP 217 = LMG 785.

The type strain designated here, although identical in pathogenicity [24], is different from strain ICMP 5739 = LMG 761 = NCPPB 633, indicated as the type strain for X. campestris pv. malvacearum (X. axonopodis pv. malvacearum) [7,29].

Xanthomonas fuscans sp. nov.


Description: The description of the species X. fuscans is encompassed within the description of the genus Xanthomonas Dowson 1939 (Approved Lists 1980 [25]) emend. Vauterin et al., 1995 [29]. X. fuscans subsp. fuscans, causes blight of beans (Phaseolus vulgaris) and X. fuscans subsp. aurantifoli is causes cankers on Citrus spp. whereas X. campestris and X. axonopodis do not affect either host [24]. X. fuscans is differentiated from all other xanthomonads, except X. campestris pv. vignicola, by production of a water soluble brown pigment on several common agar media including YDC [4,17,22–24]. Additionally, X. fuscans is differentiated from most other Xanthomonas pathovars and species by DNA–DNA reassociation assays [8,24,29], ITS sequencing [24], and rep-PCR profiles [20].

Type strain: ICPB 10520 = ATCC 19315 = ICMP 239 = LMG 826 = NCPPB 381.

Xanthomonas fuscans subsp. fuscans subsp. nov.


Description: X. fuscans subsp. fuscans, originally described as Phytomonas phaseoli var. fuscans by Burkholder [4], causes fuscos blight of beans (Phaseolus vulgaris) whereas X. fuscans subsp. aurantifoli does not [24]. Fuscos blight may resemble common blight, caused by X. campestris pv. phaseoli. X. fuscans subsp. fuscans is differentiated from X. campestris pv. campestris by serology [27] and membrane protein analysis [16,28]. X. fuscans subsp. fuscans is differentiated from most other Xanthomonas pathovars, subspecies, and species by DNA–DNA reassociation assays [24,29], ITS sequences [24], rep-PCR profiles [20], RFLP profiles [15], and phenotypic traits [24]. Strains of X. fuscans subsp. fuscans produce single colonies on YDC and FS agar after 56–60 and 70–76 h, respectively, at 28–30°C [24]. In contrast, X. citri subsp. citri and X. citri subsp. malvacearum produce single colonies in 40–44 and 56–60 h, respectively, and X. alfalfae subsp. alfalfae and X. alfalfae subsp. citrumelonus grow in 30–34 and 40–44 h, respectively [24]. Strains of X. fuscans subsp. fuscans grow on FS and mSX agars [23], utilize maltose, hydrolyze pectin, and produce an alkaline hydrolysis of litmus milk [24]. X. fuscans subsp. fuscans produces a water soluble brown pigment on several common agar media including YDC [4,17,22–24]. Except for X. fuscans subsp. aurantifoli and X. campestris pv. vignicola, no other xanthomonad produces this brown pigment [24].

Type strain: ICPB 10520 = ATCC 19315 = ICMP 239 = LMG 826 = NCPPB 381.

Xanthomonas fuscans subsp. aurantifoli subsp. nov.

Etymology: au.ran.ti.foli.i. N.L. n. Auran.tium, a genus of citrus plants; N.L. gen. n. foli.i of/from a leaf; N.L. gen. n. aurantiol.foli.of/from a citrus leaf.

Description: X. fuscans subsp. aurantifoli, originally described as a pathovar of X. campestris [9], causes cankers on Mexican lime (Citrus aurantifolia) [18] and occasionally on lemon (C. limon), orange (C. sinensis), and grapefruit (C. paradisi) whereas X. fuscans subsp. fuscans does not affect citrus [24]. X. fuscans subsp. aurantifoli is differentiated from most other Xanthomonas pathovars, subspecies, and species by DNA–DNA reassociation assays [8,24,29], rep-PCR profiles [20], ITS sequences [24], and phenotypic traits [24]. Strains of X. fuscans subsp. aurantifoli produce single colonies on YDC and FS agars [23] after 56–60 and 70–76 h, respectively, at 28–30°C [24]. In contrast, X. citri subsp. citri and X. citri subsp. malvacearum produce single colonies in 40–44 and 56–60 h, respectively, and X. alfalfae subsp. alfalfae and X. alfalfae subsp. citrumelonus grow in 30–34 and 40–44 h, respectively [24]. X. fuscans subsp. aurantifoli is distinguished from X. citri subsp. citri and X. alfalfae subsp. citrumelonus as it precipitates litmus milk and hydrolyses gelatin. X. fuscans subsp. aurantifoli does not utilize maltose or hydrolyze pectate whereas X. citri subsp. citri and X. fuscans subsp. fuscans do not [24]. X. fuscans subsp. aurantifoli precipitates litmus milk, whereas X. fuscans subsp. fuscans does not [24]. X. fuscans subsp. fuscans is distinguished from X. citri subsp. citri and X. campestris pv. campestris by failing to utilize arabinose and lactose [24]. Serology differentiates X. citri subsp. citri from X. fuscans subsp. aurantifoli [10,11,19]. Strains of X. citri subsp. citri are susceptible to bacteriophage CP1 and CP2 whereas those of X. fuscans subsp. aurantifoli are not [18]. Strains of X. fuscans subsp. aurantifoli utilize lactose, mannitol, and cellobiose and precipitate litmus milk [24]. Strains of X. fuscans subsp. aurantifoli
produce a water-soluble brown pigment on several common agar media including YDC [6,22,24]. Except for X. fuscans subsp. fuscans and X. campestris pv. vignicola, no other xanthomonad produces this brown pigment [24].

**Type strain:** ICPB 10470 = NCPPB 3236 = CFBP 2901.

*Xanthomonas alfalfae* (ex Riker et al. 1935) sp. nov., nom. rev.

**Etymology:** al.fal’fae. N.L. gen. n. alfalfa from alfalfa (*Medicago sativa*).

**Description:** The description of the species *X. alfalfa* is encompassed within the description of the genus *Xanthomonas* Dowson 1939 (Approved Lists 1980 [25]) emend. Vauterin et al. 1995 [29]. Strains of *X. alfalfa* subsp. *alfalfa* cause leaf spots on alfalfa (*Medicago sativa*) and strains of *X. alfalfa* subsp. *citrumeloni* cause leaf spots on seedlings of *Citrus* spp. whereas other strains of *X. campestris*, *X. axonopodis*, and any other xanthomonads do not [24]. *X. alfalfa* is differentiated from other *Xanthomonas* pathovars, subspecies, and species by DNA–DNA reassociation assays [8,24,29], rep-PCR profiles [20], RFLP profiles [15], ITS sequences [24] and phenotypic traits [24]. *X. alfalfa* does not produce a brown water soluble pigment on common media as does *X. fuscans* and *X. campestris* pv. *vignicola* [24]. Strains of *X. alfalfa* grow much faster than other xanthomonads on SX and FS agars [23] and utilize a broader range of carbon sources [24]. *X. alfalfa*, and its subspecies, utilize arabinosine, maltose, lactose, mannitol, and cellobiose; liquefy gelatin; and produce an alkaline hydrolysis of litmus milk whereas *X. axonopodis* does not [24].

**Type strain:** ICPB 10701 = ATCC 11765 = LMG 495.

*Xanthomonas alfalfae* subsp. *alfalfa* (ex Riker et al., 1935) subsp. nov.

**Etymology:** al.fal’fae. N.L. gen. n. alfalfa from alfalfa (*Medicago sativa*).


**Type strain:** ICPB 10701 = ATCC 11765 = LMG 495.

*Xanthomonas alfalfae* subsp. *citrumeloni* subsp. nov.

**Etymology:** ci.tru.me’lo.nis. N.L. gen. n. *citrumeloni* of citrumelo (*Citroncirus* sp.; hybrid of *Citrus paradisi* x *Poncirus trifoliata*).

**Description:** *X. alfalfa* subsp. *citrumeloni*, originally described as pathovar “citrumelo” of *X. campestris* [9], causes citrus bacterial spot [12]; *X. alfalfa* subsp *alfalfa* does not [24]. *X. alfalfa* subsp *citrumeloni* is distinguished from *X. campestris* pv. *campestris* and other *Xanthomonas* pathovars, subspecies, and species by DNA–DNA reassociation assays [8,24,29], rep-PCR profiles [20], RFLP profiles [15], ITS sequences [24], and phenotypic traits [24]. Strains of *X. alfalfa* subsp. *citrumeloni* produce single colonies on YDC and FS agars [23] after 30–34 and 40–44 h, respectively, at 28–30 °C [24]. In contrast, *X. citri* subsp. *citri* and *X. citri* subsp. *malvacearum* produce single colonies in 40–44 and 56–60 h, respectively, and *X. fuscans* subsp. *fuscans* and *X. fuscans* subsp. *aurantifoli* grow in 56–60 and 70–76 h, respectively [24]. *X. alfalfa* subsp. *citrumeloni* strains are differentiated from *X. citri* subsp. *citri* and *X. citri* subsp. *malvacearum* and *X. fuscans* subsp. *aurantifoli* by serological assays [2,12,19]. *X. alfalfa* subsp. *citrumeloni* utilizes raffinose whereas *X. alfalfa* subsp. *alfalfa*, *X. citri* subsp. *citri*, and *X. citri* subsp. *malvacearum* strains do not [24]. *X. alfalfa* subsp. *alfalfa* and *X. alfalfa* subsp. *citrumeloni* can be differentiated from *X. fuscans* subsp. *aurantifoli* on their more rapid growth on agar media, liquefaction of gelatin, and utilization of maltose [24]. *X. alfalfa* subsp. *citrumeloni* is distinguished from *X. citri* subsp. *citri* by utilizing raffinose, producing acid from cellobiose and mannitol, and growing faster on YDC and FS agars [24]. All strains of *X. alfalfa* subsp. *citrumeloni* utilize mannitol and raffinose whereas strains of *X. citri* subsp. *malvacearum* do not [24].

**Type strain:** ICPB 10483 = ATCC 49120 = LMG 9325.

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References


