Short Communication

PROPOSAL OF *STREPTOMYCES ATROAURANTIACUS* SP. NOV. AND *STREPTOMYCES KIFUNENSIS* SP. NOV. AND TRANSFERRING *KITASATOSPORIA CYSTARGINEA* KUSAKABE AND ISONO TO THE GENUS *STREPTOMYCES* AS *STREPTOMYCES CYSTARGINEUS* COMB. NOV.

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It has recently been proposed by Wellington et al. that the genus *Kitasatosporia* Ōmura, Takahashi, Iwai and Tanaka (9) is a synonym of the genus *Streptomyces*, and four validly published species, *Kitasatosporia setae* (9), *Kitasatosporia griseola* (12), *Kitasatosporia phosalacinea* (12) and *Kitasatosporia mediocidica* (3), have been transferred to the genus *Streptomyces* as new combinations, *Streptomyces setae*, *Streptomyces griseolosporeus*, *Streptomyces phosalacineus* and *Streptomyces mediocidicus*, respectively (14). These species form no synnema, sporangium, zoospore or sclerotium and contain menaquinones MK-9(H₈) and MK-9(H₆) predominantly. Their phospholipid pattern is type PII, and the guanine-plus-cytosine (G+C) content is around 70 mol%. Moreover, they form submerged spores, and their cell walls contain A₂pm isomer corresponding to the cell forms, i.e. A₂pm isomer of aerial mycelia and vegetative mycelia are LL- and meso-form, respectively. Other species of the genus *Streptomyces* however contain predominantly LL-A₂pm independently of the cell form. Therefore, we showed that the genus *Streptomyces* could be divided into two clusters: a cluster consisting of species previously classified in the genus *Kitasatosporia* (tentatively called the 'setae group') and the other consisting of the original *Streptomyces* species on the basis of the ratio of diaminopimelic acid (A₂pm) isomer in the cell walls, 16S rRNA analysis and phenotypic characteristics (14).

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We proposed three new *Kitasatosporia* species, *Kitasatosporia cochleata*, *Kitasatosporia paracochleata* and *Kitasatosporia azatica* in 1991 (5). However, based on the proposal of Wellington et al. (14), it was suggested that they should be transferred to the genus *Streptomyces* as *Streptomyces cochleatus*, *Streptomyces paracochleatus* and *Streptomyces azaticus*. Therefore, we proposed three new species of the 'setae group' of the genus *Streptomyces*: *S. cochleatus*, *S. paracochleatus* and *S. azaticus* (6). We also reported that '*Kitasatosporia papulosa*' (8) and '*Kitasatosporia grisea*' (8) were synonymous and transferred them to the cluster consisting of the original species of the genus *Streptomyces* and that '*Kitasatosporia brunnea*' (10) and '*Kitasatosporia clausa*' (4) were synonyms of *S. phosalacineus* and *Microtetraspora helvata* (7), respectively (6).

In this paper, we describe the taxonomic position of the remaining species, which are not validly published, '*Kitasatosporia melanogena*' (11) and '*Kitasatosporia kifunense*' (1) and the recently validated species *Kitasatosporia cystarginea* (2, 13). Based on morphological, physiological, chemotaxonomic and DNA-DNA hybridization studies, we propose two new species, *Streptomyces atroaurantiacus* sp. nov. for '*K. melanogena*' and *Streptomyces kifunensis* sp. nov. for '*K. kifunense*,' and also propose to transfer *K. cystarginea* to the genus *Streptomyces* as *Streptomyces cystargineus* comb. nov.

All the experimental conditions for determination of morphological, physiological and chemotaxonomic characteristics and DNA-DNA homology values are based on those given in the previous papers (2, 6).

'*K. melanogena*' IFO 14327^T, '*K. kifunense*' IFO 15206^T and *K. cystarginea* IFO 14836^T have chemotaxonomic characteristics common to all such as the presence of predominant menaquinones MK-9(H₈) and MK-9(H₆), a type II phospholipid pattern, A₂pm isomer in their cell walls corresponding to the cell form and also morphological characteristics which are the same as those of four newly validated *Streptomyces* species including *S. setae* (14). Therefore, these strains can be placed in the 'setae group' of the genus *Streptomyces*. Morphological and physiological characteristics of these three strains were compared with those of already known species of 'setae group.' In the results, strains IFO 14327^T and IFO 15206^T produced melanoid pigments. Aerial mycelia of IFO 15206^T were gray and hooked to spiral, while those of IFO 14327^T were white and rectiflexible. On the other hand, IFO 14836^T did not produce melanoid pigment but formed spiral aerial mycelia. Differential characteristics among these strains and already known species of 'setae group' are shown in Table 1. Furthermore, DNA-DNA homology values among the three strains, and also among the three strains and already known species of 'setae group' of the genus *Streptomyces*, were less than 45% (6). Based on the above properties, strains IFO 14327^T, IFO 15206^T and IFO 14836^T should be placed in the 'setae group' of the genus *Streptomyces* and, in our opinion, warrant new taxa.

Therefore, we formally propose that '*K. melanogena*' and '*K. kifunense*' should be classified in the genus *Streptomyces* as new species, *S. atroaurantiacus* sp. nov., *S.*

Table 1. Differential characteristics among *Streptomyces atroaurantiacus* IFO 14327^T, *Streptomyces cystargineus* IFO 14836^T, *Streptomyces kifunensis* IFO 15206^T and seven species^a of 'setae group' of the genus *Streptomyces*.

Characteristics	<i>S. atroau- rantiacus</i> IFO 14327 ^T	<i>S. cystar- gineus</i> IFO 14836 ^T	<i>S. kifunensis</i> IFO 15206 ^T	<i>S. setae</i>	<i>S. griseolo- sporeus</i>	<i>S. phosala- cineus</i>	<i>S. medio- cidicus</i>	' <i>S. azati- cus</i> '	' <i>S. co- chleatus</i> '	' <i>S. paraco- chleatus</i> '
Form of aerial mycelia	rf ^b	s	hs	rf	rf	rf	rf	rf	hs	s
Color of aerial mycelia	w	gy	gy	w	gy	w	gy	w	gy	gy
Soluble pigment	br	-	-	-	-	-	br	-	yb	yb
Reduction of nitrate	-	-	-	+	-	+	-	+	-	+
Hydrolysis of starch	+	+	-	+	+	+	-	+	+	+
Liquefaction of gelatin	-	-	-	-	+	-	-	-	-	-
Peptonization of milk	+	+	+	+	+	+	-	+	+	+
Formation of melanoid pigment	+	-	+	-	-	-	-	-	+	+
Utilization of carbohydrate										
L-Arabinose	+	-	+	+	+	+	+	+	+	-
D-Fructose	+	-	-	-	-	+	-	+	-	+
D-Mannitol	-	-	+	-	-	-	-	-	-	-
Raffinose	-	-	-	-	+	+	-	-	-	-
L-Rhamnose	-	-	-	-	-	+	-	-	-	-
Sucrose	+	-	+	-	-	+	-	-	-	-
D-Xylose	+	-	+	+	+	+	-	+	-	-

^a Data from Nakagaito et al. (6).

^b s, spiral; hs, hook to spiral; rf, rectiflexible; gy, gray; w, white; y, yellow; br, brown; yb, yellowish brown; +, positive; -, negative.

kifunensis sp. nov., respectively, and that *K. cystarginea* should be transferred to the genus *Streptomyces* as *S. cystargineus* comb. nov.

As summarized in Table 2, all the species formerly classified as *Kitasatosporia* species or related taxa can be reclassified in the 'setae group' of the genus *Streptomyces* or excluded from the group.

Descriptions for the new species are given below.

Streptomyces atroaurantiacus sp. nov.

Streptomyces atroaurantiacus (atro.aurantiacus. L. adj. *atro*, dark; L. adj. *aurantiacus*, orange; *atroaurantiacus*, dark orange). The color of vegetative mycelia is dark orange to slightly orange. The color of aerial mycelia is white. Aerial mycelia are formed slightly on yeast extract-malt extract agar, oatmeal agar, inorganic salts-starch agar, tyrosine agar, Bennett's agar and water agar. Mature spore chains are long and straight to slightly flexuous. Spores are cylindrical with a smooth surface. Melanoid pigments are produced on tyrosine agar. Brown soluble pigments are produced on yeast extract-malt extract agar and yellow pigments are produced on oatmeal agar. The temperature range for growth is 10 to 37°C. The concentration of NaCl at which growth occurs is less than 2%. Nitrate is not reduced, starch is hydrolyzed, gelatin is not liquefied, and milk is peptonized and coagulated. D-Glucose and D-arabinose, D-fructose, sucrose and D-xylose are utilized, but D-mannitol, L-rhamnose, raffinose and inositol are not utilized or are poorly utilized. The cell wall contains both LL- and meso-A₂pm and glycine. Galactose and a trace of madurose are detected as whole-cell sugars. The phospholipid pattern is type II. MK-9(H₆) and MK-9(H₈) are detected. The G + C content of DNA is 70.2 mol%.

The type strain is IFO 14327.

Streptomyces kifunensis sp. nov.

Streptomyces kifunensis (kifune.nsis. M. L. adj. *kifune*, Mt. Kifune, Kyoto Prefecture, Japan, source of the soil from which the organism was isolated). The description is based on the data given by Iwami et al. (1), which was emended according to the results of the present study. The color of vegetative mycelia is yellowish brown. The color of aerial mycelia is gray. Mature spore chains on aerial mycelia are long, straight, hooked to spiral and simply branched. The spores are cylindrical with a smooth surface. Melanoid pigment is produced. Light brown soluble pigment is produced on glycerol-asparagine agar. The temperature range for growth is 9 to 31°C. The concentration of NaCl at which growth occurs is less than 4%. Nitrate is not reduced, starch is not hydrolyzed, and gelatin is not liquefied. Milk is barely peptonized but not coagulated. D-Glucose, L-arabinose, D-xylose, sucrose and D-mannitol are utilized, but D-fructose, L-rhamnose, raffinose and inositol are not utilized or are poorly utilized. The cell wall contains LL- and meso-A₂pm and glycine. Galactose is detected as a whole-cell sugar. The phospholipid pattern is type II. MK-9(H₆) and MK-9(H₈) are detected. The G + C content of DNA is 71.3 mol%.

The type strain is IFO 15206.

Table 2. Summary of the classification of 'setae group' of the genus *Streptomyces*.

Formerly classified as	IFO No.	Re-classified as	Reference
<i>Kitasatosporia setae</i>	14216 ^T	<i>Streptomyces setae</i>	14
<i>Kitasatosporia griseola</i>	14371 ^T	<i>Streptomyces griseolosporus</i>	14
<i>Kitasatosporia mediocidica</i>	14789 ^T	<i>Streptomyces mediocidicus</i>	14
<i>Kitasatosporia cystarginea</i>	14836 ^T	<i>Streptomyces cystargineus</i> comb. nov.	This work
<i>Kitasatosporia phosalacinea</i>	14372 ^T	<i>Streptomyces phosalacineus</i>	14
' <i>Kitasatosporia brunnea</i> '	14627 ^T	<i>Streptomyces phosalacineus</i>	6
' <i>Nocardioopsis streptosporus</i> '	14362 ^T	<i>Streptomyces phosalacineus</i>	6
' <i>Kitasatosporia melanogena</i> '	14327 ^T	<i>Streptomyces atroaurantiacus</i> sp. nov.	This work
' <i>Kitasatosporia kifunense</i> '	15206 ^T	<i>Streptomyces kifunensis</i> sp. nov.	This work
' <i>Streptomyces candidus</i> subsp. <i>azaticus</i> '	13803 ^T	<i>Streptomyces azaticus</i>	6
' <i>Kitasatosporia cochleata</i> '	14768 ^T	<i>Streptomyces cochleatus</i>	5, 6
' <i>Kitasatosporia paracochleata</i> '	14769 ^T	<i>Streptomyces paracochleatus</i>	5, 6
' <i>Kitasatosporia papulosa</i> '	14834 ^T	<i>Streptomyces</i> species out of 'setae group'	6
' <i>Kitasatosporia grisea</i> '	14835 ^T	Synonymous of <i>S. sp.</i> IFO 14834 ^T	6
' <i>Kitasatosporia clausa</i> '	15240 ^T	<i>Microtetraspora helvata</i>	6, 7

Streptomyces cystargineus (Kusakabe and Isono 1992) comb. nov.

Streptomyces cystargineus (cystargin.eus. M. L. N. *cystargin*, antibiotic cystargin; M. L. adj. *cystargineus*, referring to the produced antifungal antibiotic, cystargin). The description is based on the data given by Kusakabe and Isono (2), which was emended according to the results of the present study. The color of vegetative mycelia is light brown. The color of aerial mycelia is gray. Mature spore chains on aerial mycelium are long and spiral. The spores are cylindrical with a smooth surface. Neither melanoid pigment nor soluble pigment is produced. The temperature range for growth is 17 to 40°C. Nitrate is not reduced, starch is hydrolyzed, and gelatin is not liquefied. Milk is peptonized but not coagulated. D-Glucose is utilized, but D-fructose, D-xylose, L-arabinose, L-rhamnose, raffinose, sucrose, D-mannitol and inositol are not utilized or are poorly utilized. The cell wall contains LL- and *meso*-A₂pm and glycine. Galactose is detected as a whole-cell sugar. The phospholipid pattern is type II. MK-9(H₆) and MK-9(H₈) are detected. The G + C content of DNA is 70.6 mol%.

The type strain is IFO 14836 (=RK-419=JCM 7356).

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