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TAXONOMICAL STUDIES ON CERTAIN STREPTOMYCETES EXHIBITING ANTIMICROBIAL ACTIVITY ISOLATED FROM EGYPTIAN SOILS

Hala M. Rifaat*, Nadia H. Abd El Naser, Samia M. Helmy and Amal M. Ali

Microbial Chemistry Department, National Research Centre, Cairo, Egypt

*Corresponding author, e-mail: halamohamed6@hotmail.com

Summary

The easy access and appropriate use of antimicrobials led to selection and spread of resistant microorganisms strains. It is imperative to search and screen for new and more effective antimicrobials from microorganisms found in the environment. The objective of this work is to isolate streptomycetes from soil of Kalubiya Governorate in order to screen them for antimicrobial activity against reference Gram-positive, Gram-negative bacteria as well as unicellular and filamentous fungi. A total of 500 strains of streptomycetes were isolated. Sixty strains (12 %) showed antimicrobial activity. The morphological, cultural, physiological and biochemical characters were studied for identification of the isolates at species level. The obtained results revealed that the dominant group was Streptomyces lydicus.

Key words: *agriculture soil, antimicrobial activity, Egypt, Streptomyces sp.*

Introduction

Streptomycetes (order *Actinomycetales*, family *Streptomycetaceae*) are Gram-positive, filamentous bacteria that are ubiquitous in soil and produce more than 70 % of the known antibiotics [28]. Among the streptomycetes, both the quantity and types of antibiotics produced vary widely among individuals of the same species [10, 30]. Antibiotics produced from streptomycetes can inhibit a broad range of soil borne microbes including Gram-positive bacteria and fungi [4, 16, 32].

Actinomycetes having antimicrobial activity in Egyptian soil attracted the attention of some investigators [1, 5, 11, 27]. The present article is an addition to these studies aiming to assess the presence of *Streptomyces* species with antimicrobial activity in the soil of Kalubiya Governorate, Egypt.

Materials and Methods

Soil sample collecting and processing. Ten agriculture soil samples were collected in clean plastic bags at a depth of 15-20 cm, from Kalubiya Governorate Egypt, about 40 km North of Cairo. Ten gram of each sample was transferred into 250 ml flask containing 90 ml of buffered phosphate solution (pH 7.0). The resulting soil suspension was serially diluted and plated onto starch-nitrate agar plates [21]. The latter were incubated at 28 ^{o}C for 7-14 days. Colonies exhibiting convex shaped and rooting growth into the medium, which characterizes the streptomycetes colonies, were selected randomly and subjected to purification.

Antibiotic assay. The streptomycetes isolates were cultivated for 5 days using starch nitrate agar plates at 28 ^{o}C. A disk of 0.4 cm diameter of this agar culture was transferred to 250 ml Erlenmeyer flasks containing 50 ml of starch nitrate liquid medium. The inoculated flasks were kept on a rotary shaker (200 rpm) at 28-30 ^{o}C for 5 days. The broth was filtrated through Whatman filter paper No. 1.

The seeded plates with target organism were cut by sterile cork borer to make holes (8 mm in diameter). The test organisms used were Gram-positive bacteria (*Staphylococcus aureus*, *Streptococcus pyogens, Bacillus cereus* and *B. sublitis*), Gram-negative bacteria (*Escherichia coli*) as well as yeast (*Saccharomyces cerivesiae*, *Candida albicans* and *C. pseudotropicals*) and fungi (*Macrophomina phaseoli*, *Helminthsporium turcicum*, *Asperagillus niger*, *A. flavus*, *A. terrus*, *Fusarium oxysporium* and *Botrytis alli*). Only 0.1 ml of the streptomycetes isolates from the filtrate were transferred into each hole under septic conditions. The incubation period was 2 days in the case of bacteria and 3 days in the case of yeast and fungi, at 28 ^{o}C. The antimicrobial activity of the streptomycetes isolates was detected as a result of clear inhibition zone around holes and it was measured in millimeters.

Identification of streptomycetes. The active streptomycetes isolates were subjected to morphological, physiological, biochemical and chemotaxonomical tests according to a variety of methods [9, 26, 31].

Numerical analysis. The results of the diagnostic tests were coded for cluster analysis. The analysis was carried out using SPSS software. For the calculation of similarities, the simple matching coefficient was chosen. The clusters and dendrogram were generated by the average linkage method obtained by UPGMA algorithm.

Results

Screening of isolated streptomycetes for antimicrobial activities

500 streptomycetes strains were isolated from the studied soils. After screening for inhibitory action against 15 test cultures, 60 strains (12 % of the total strains) showed antimicrobial activity. It was found that these strains affected to a different degree the test microorganisms (Table 1 and 2). Most of them repressed the growth of *S. pyogenes* to a significant extent and were moderate active against *S. aureus*. The isolates manifested a weak activity against *B. cereus* and *B. subtlis*, while none of them inhibited the growth of *E. coli*. Moreover, most of the strains showed moderate and weak activity against fungi and yeast respectively. The inhibitory profiles of the streptomycetes isolates differed substantially. The inhibition action of the active isolates was in the order: 47 isolates (78.3 % from the active 60 isolates) suppressed fungi, 35 isolates (58,3 %) bacteria and 20 isolates (33,3 %) yeasts. Antimicrobial activity against yeasts and fungi possessed 13 isolates (21,7 %) and only 7 isolates (11,7 %) inhibited all groups of the tested organisms – No. 4, 8, 37, 39, 49, 70 and 75.

Table 1. Antibacterial activity of selected streptomycetes strains.

Test bacteria	Number of strains*		
	14-18 mm	19-25 mm	> 25 mm
S. aureus	*0*	*12* 1, 3, 33, 34, 35, 39, 54, 55, 59, 68, 70, 75	*0*
S. pyogenes	*8* 5, 23, 32, 33, 39, 52, 55, 70	*11* 1, 9, 11, 16, 34, 35, 38, 49, 59, 62, 68	*7* 3, 14, 37, 46, 47, 75, 78
B. cereus	*5* 4, 8, 69, 70, 78	*5* 1, 43, 49, 58, 62	*1* 59
B. subtilis	*2* 69, 73	*5* 46, 47, 61, 70, 76	*0*

*Strains are grouped according to the diameter of the inhibition zone.

Table 2. Antifungal activity of selected streptomycetes strains.

Test yeasts and fungi	Number of strains		
	12-18 mm	19-25 mm	> 25 mm
S. cerevisiae	*3* 4, 9, 70	*2* 24, 59	*3* 5, 7, 8
C. albicans	*5* 5, 8, 16, 39, 69	*3* 19, 32, 37	*1* 62
C. pseudotropicalis	*1* 52	*4* 42, 49, 63, 75	*0*
M. phaseoli	*7* 37, 53, 54, 59, 60, 62, 77	*5* 25, 28, 33, 51, 79	*1* 44
H. turcicum	*5* 40, 49, 62, 65, 75	8 37, 44, 50, 54, 58, 64, 70, 79	*2* 21, 61
A. niger	*5* 23, 25, 28, 40, 77	*7* 24, 35, 46, 51, 54, 58, 75	*4* 37, 45, 47, 49
A. flavus	*3* 53, 68, 77	*3* 3, 4, 28	*3* 8, 51, 62
A. terrus	*1* 64	*9* 2, 3, 19, 25, 28, 39, 41, 58, 62	*3* 1, 14, 37
F. oxysporium	*4* 28, 39, 53, 77	*5* 4, 8, 18, 65, 70	*6* 10, 14, 17, 37, 38, 45
B. alli	*6* 25, 40, 41, 55, 60, 63	*9* 23, 39, 42, 44, 47, 54, 64, 74, 75	*4* 37, 58, 62, 77

*Strains are grouped according to the diameter of the inhibition zone.

Characteristics of the strains with antimicrobial activity

Morphological characteristics. The isolates possessed spore-bearing hyphae of types straight (Fig. 1, A), hooks (Fig. 1, B) or extended spirals (Fig. 1, C). Most of the isolates showed smooth spore surface (Fig. 2, A) or less commonly spiny (Fig. 2, B).

The color of aerial and substrate mycelium of the isolates was determined as shown in Table 3. Diffusible pigments were detected with few strains.

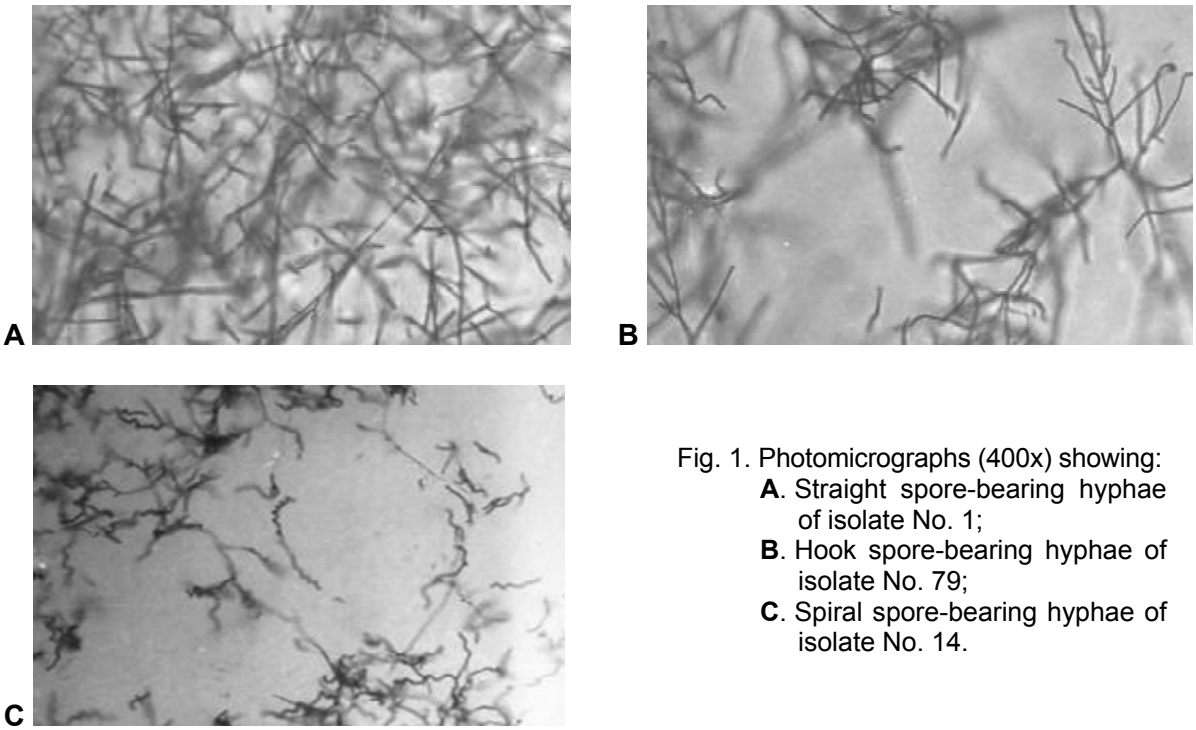

Fig. 1. Photomicrographs (400x) showing:
A. Straight spore-bearing hyphae of isolate No. 1;
B. Hook spore-bearing hyphae of isolate No. 79;
C. Spiral spore-bearing hyphae of isolate No. 14.

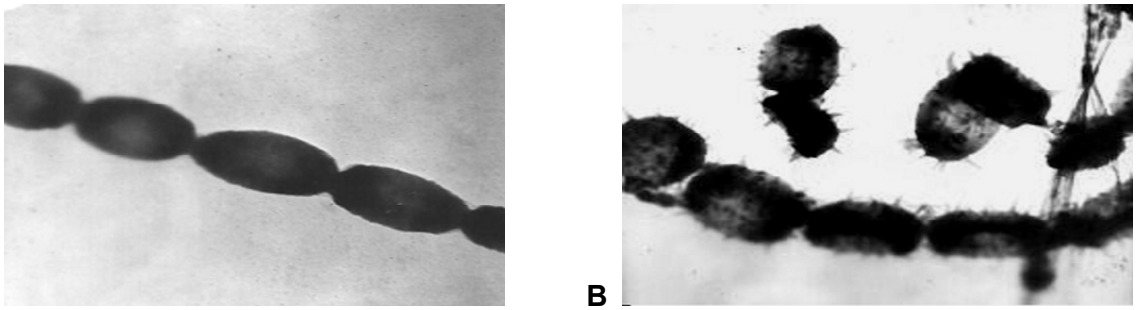

Fig. 2. Scanning electron micrograph (14000x) showing smooth spore surface of isolate No. 8 (**A**) and spiny spore surface of isolate No. 64 (**B**).

Table 3. Morphological and cultural characteristics of streptomycetes isolates.

Characteristics	Number of positive strains	
Spore chain morphology:		
Closed spiral	*10*	2, 10, 14, 24, 33, 43, 47, 58, 75, 76
Open spiral	*30*	5, 7, 9, 11, 17, 18, 23, 25, 32, 35, 38, 39, 42, 45, 46, 50, 52, 53, 54, 55, 59, 60, 61, 62, 63, 64, 65, 73, 77, 78
Spiral hook	*3*	21, 37, 41
Straight	*16*	1, 3, 4, 8, 16, 19, 28, 34, 40, 44, 49, 51, 68, 69, 70, 74
Hook	*1*	79
Spore surface ornamentation:		
Smooth	*48*	1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 14, 16, 17, 18, 21, 23, 24, 25, 28, 32, 33, 35, 37, 38, 40, 41, 42, 44, 49, 50, 51, 52, 53, 54, 55, 58, 59, 60, 61, 62, 63, 69, 70, 74, 76, 77, 78, 79
Spiny	*12*	19, 34, 39, 43, 45, 46, 47, 64, 65, 68, 73, 75
Color of spore mass:		
Light grey	*19*	4, 7, 8, 14, 16, 17, 21, 24, 28, 32, 33, 38, 41, 44, 50, 52, 55, 61, 73
Medium grey	*15*	3, 9, 10, 11, 19, 35, 37, 39, 42, 46, 47, 53, 54, 60, 78
Dark grey	*2*	18, 62
Pinkish grey	*1*	77
Greyish violet	*1*	1
Greyish pink	*9*	43, 45, 49, 51, 58, 59, 63, 74, 79
Greyish green	*1*	68
Yellow	*6*	2, 23, 25, 34, 64, 75
Yellowish grey	*1*	5
Yellowish red	*2*	65, 70
Yellowish green	*1*	69
White	*1*	40
Light red	*1*	76
Color of substrate mycelium:		
Yellow	*5*	3, 8, 10, 11, 35
Light yellow brown	*28*	1, 2, 28, 32, 34, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 50, 51, 52, 53, 54, 55, 58, 60, 62, 70, 75, 78, 79
Medium yellow brown	*10*	25, 33, 49, 59, 61, 64, 68, 69, 74, 77
Dark yellow brown	*3*	37, 63, 73
Yellowish grey	*2*	17, 18
Light brown	*6*	4, 5, 7, 14, 16, 24
Greenish brown	*1*	23
Light violet	*2*	9, 19
Orange	*1*	65
Light red	*1*	76
Grey	*1*	21
Diffusible pigments:		
Yellow	*1*	70
Brown	*4*	37, 46, 68, 73
Light red	*1*	62
Violet	*2*	33, 69
Green	*1*	79

Table 4. Biochemical and physiological characteristics of streptomycetes isolates.

Characteristics	Number of strains			
	Positive		Negative	
Utilization of carbon sources:				
Glucose	*49*	3, 5, 7, 9, 10, 11, 16, 17, 18, 21, 23, 25, 33, 34, 35, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 49, 50, 51, 52, 53, 54, 55, 58, 59, 60, 61, 62, 63, 64, 65, 68, 69, 73, 74, 76, 77, 78, 79	*11*	1, 2, 4, 8, 14, 19, 24, 28, 32, 70, 75
L-Arabinose	*44*	2, 16, 17, 18, 23, 24, 25, 32, 33, 35, 37, 38, 39, 40, 42, 43, 44, 45, 46, 47, 49, 50, 51, 52, 53, 54, 55, 58, 59, 60, 61, 62, 63, 65, 68, 69, 70, 73, 74, 75, 76, 77, 78, 79	*16*	1, 3, 4, 5, 7, 8, 9, 10, 11, 14, 19, 21, 28, 34, 41, 64
D-Fructose	*52*	1, 2, 3, 5, 7, 8, 9, 10, 11, 14, 16, 17, 18, 21, 23, 24, 25, 28, 32, 33, 35, 37, 38, 39, 40, 42, 43, 44, 46, 47, 49, 50, 51, 52, 53, 54, 55, 58, 59, 60, 61, 62, 63, 64, 65, 68, 69, 73, 75, 76, 78, 79	*8*	4, 19, 34, 41, 45, 70, 74, 77
Sucrose	*41*	1, 3, 4, 8, 9, 11, 14, 17, 18, 19, 21, 23, 25, 32, 33, 34, 35, 38, 39, 41, 42, 44, 46, 47, 49, 50, 51, 52, 53, 54, 55, 58, 59, 60, 61, 63, 68, 73, 77, 78, 79	*19*	2, 5, 7, 10, 16, 24, 28, 37, 40, 43, 45, 62, 64, 65, 69, 70, 74, 75, 76
D-Mannitol	*44*	1, 2, 3, 8, 9, 17, 18, 21, 23, 24, 25, 28, 32, 33, 35, 37, 38, 39, 40, 42, 43, 45, 46, 47, 49, 50, 51, 52, 53, 54, 55, 59, 60, 61, 62, 63, 68, 69, 73, 75, 76, 77, 78, 79	*16*	4, 5, 7, 10, 11, 14, 16, 19, 34, 41, 44, 58, 64, 65, 70, 74
D-Xylose	*35*	2, 9, 16, 18, 23, 25, 28, 32, 35, 37, 39, 42, 44, 46, 47, 49, 50, 51, 52, 53, 54, 55, 58, 59, 60, 61, 62, 63, 65, 68, 69, 73, 76, 77, 79	*25*	1, 3, 4, 5, 7, 8, 10, 11, 14, 17, 19, 21, 24, 33, 34, 38, 40, 41, 43, 45, 64, 70, 74, 75, 78
Raffinose	*39*	1, 4, 5, 7, 9, 11, 14, 16, 18, 19, 21, 23, 24, 28, 33, 34, 35, 37, 42, 46, 47, 49, 50, 51, 52, 53, 54, 58, 59, 60, 61, 62, 63, 68, 70, 76, 77, 78, 79	*21*	2, 3, 8, 10, 17, 25, 32, 38, 39, 40, 41, 43, 44, 45, 55, 64, 65, 69, 74, 75, 78
I-Inositol	*40*	1, 4, 5, 7, 8, 9, 10, 11, 14, 17, 18, 19, 21, 23, 24, 28, 32, 33, 34, 35, 37, 38, 42, 46, 49, 50, 51, 52, 53, 54, 55, 58, 59, 60, 61, 62, 63, 76, 78, 79	*20*	2, 3, 16, 25, 39, 40, 41, 43, 44, 45, 47, 64, 65, 68, 69, 70, 73, 74, 75, 77
Galactose	*48*	1, 2, 3, 4, 5, 7, 9, 10, 11, 16, 18, 23, 24, 25, 28, 32, 33, 35, 37, 38, 39, 41, 42, 43, 44, 46, 47, 49, 50, 51, 52, 53, 54, 55, 58, 59, 60, 61, 62, 63, 64, 65, 68, 73, 74, 76, 77, 79	*12*	8, 14, 17, 19, 21, 34, 40, 45, 69, 70, 75, 78
Salicin	*51*	1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 14, 16, 17, 18, 21, 23, 24, 25, 28, 32, 33, 35, 37, 38, 40, 41, 42, 43, 44, 45, 49, 50, 51, 52, 53, 54, 55, 58, 59, 60, 61, 62, 63, 64, 65, 68, 69, 74, 76, 78, 79	*9*	19, 34, 39, 46, 47, 70, 73, 75, 77

Table 4. Continued.

Characteristics	Number of strains	
	Positive	Negative
Degradation of:		
Pectin	*14* 1, 2, 8, 25, 47, 49, 50, 51, 59, 61, 68, 69, 78, 79	*46* 3, 4, 5, 7, 9, 10, 11, 14, 16, 17, 18, 19, 21, 23, 24, 28, 32, 33, 34, 35, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 52, 53, 54, 55, 58, 60, 62, 63, 64, 65, 70, 73, 74, 75, 76, 77
Chitin	*18* 1, 2, 3, 4, 5, 16, 23, 25, 32, 42, 52, 58, 59, 60, 64, 65, 76, 79	*42* 7, 8, 9, 10, 11, 14, 17, 18, 19, 21, 24, 28, 33, 34, 35, 37, 38, 39, 40, 41, 43, 44, 45, 46, 47, 49, 50, 51, 53, 54, 55, 61, 62, 63, 68, 69, 70, 73, 74, 75, 76, 77
Enzyme activity:		
Protease	*21* 5, 7, 18, 21, 24, 39, 45, 47, 51, 55, 59, 60, 61, 62, 63, 64, 65, 68, 69, 74, 79	*39* 1, 2, 3, 4, 8, 9, 10, 11, 14, 16, 17, 19, 23, 24, 25, 28, 32, 34, 35, 37, 38, 40, 41, 42, 43, 44, 46, 49, 50, 52, 53, 54, 58, 70, 73, 75, 76, 77, 78
Lipase	*13* 5, 18, 24, 43, 47, 51, 59, 60, 62, 64, 65, 69, 79	*47* 1, 2, 3, 4, 7, 8, 9, 10, 11, 14, 16, 17, 19, 21, 23, 25, 28, 32, 33, 34, 35, 37, 38, 39, 40, 41, 42, 44, 45, 46, 49, 50, 52, 53, 54, 55, 58, 61, 63, 69, 70, 73, 74, 75, 76, 77, 78
Lecithinase	*12* 5, 18, 24, 43, 51, 59, 60, 62, 64, 65, 69, 79	*48* 1, 2, 3, 4, 7, 8, 9, 10, 11, 14, 16, 17, 19, 21, 23, 25, 28, 32, 33, 34, 35, 37, 38, 39, 40, 41, 42, 44, 45, 46, 47, 49, 50, 52, 53, 54, 55, 58, 61, 63, 68, 70, 73, 74, 75, 76, 77, 78
Melanine production:		
Iron agar	*19* 4, 5, 7, 9, 11, 14, 16, 17, 19, 28, 32, 33, 34, 39, 41, 42, 43, 55, 76	*41* 1, 2, 3, 8, 10, 18, 21, 23, 24 25, 35, 37, 38, 40, 44, 45, 46, 47, 49, 50, 51, 52, 53, 54, 58, 59, 60, 61, 62,63, 64, 65, 68, 69, 70, 73, 74, 75, 77, 78, 79
Tyrosine agar	*16* 3, 4, 10, 14, 28, 32, 41, 42, 43, 47, 54, 62, 70, 76, 77, 79	*44* 1, 2, 5, 7, 8, 9, 11, 16, 17, 18, 19, 21, 23, 24, 25, 33, 34, 35, 37, 38, 39, 40, 44, 45, 46, 49, 50, 51, 52, 53, 55, 58, 59, 60, 61, 63, 64, 65, 68, 69, 73, 74, 75, 78

Physiological and biochemical characteristics. The results presented in Table 4 indicate that the strains showed differences in their ability to assimilate various carbon sources. The strains also differed in the decomposition of chitin and pectin. Slight activity could be detected among the investigated streptomycetes strains for production of lecithinase, lipase and protease. Some differences occurred in melanoid pigments production on both peptone-yeast extract iron agar (ISP6) and tyrosine agar (ISP7).

Chemotaxonomical characteristics. The whole cell walls diaminopimelic acid (DAP) and sugars were analyzed. All strains have LL-DAP acid (e. g. Fig. 3) and no sugars (e. g. Fig. 4) except 5 of them which showed unreliable results (strains No. 25, 46, 70, 73 and 74).

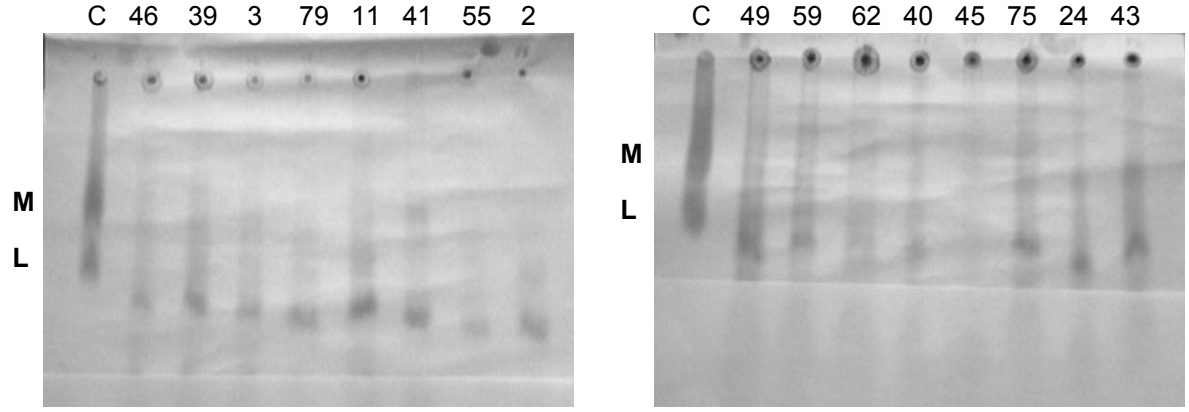

Fig. 3. Photographs showing whole cell wall diaminopimelic acid (DAP) of some streptomycetes strains: LL-DAP (**L**) and meso-DAP (**M**); control (C).

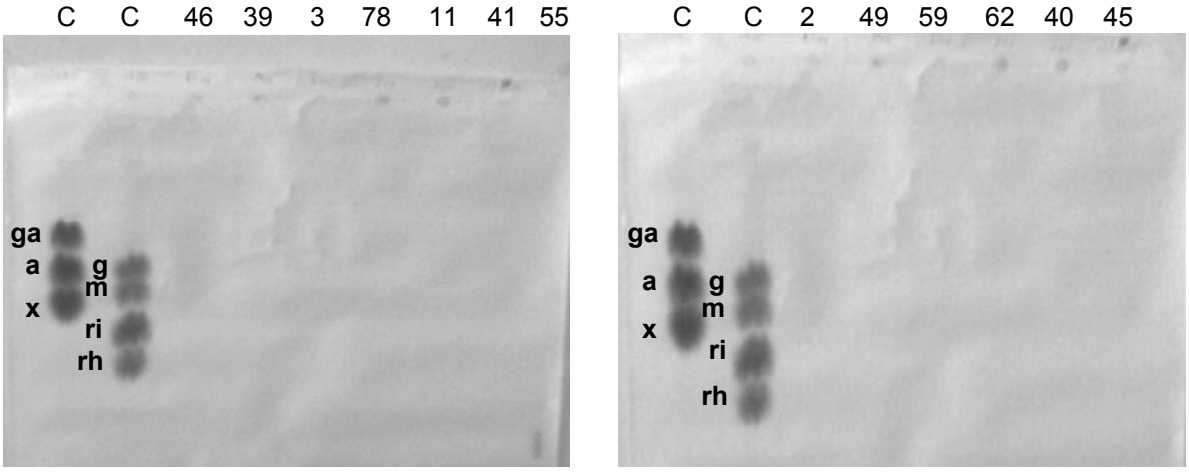

Fig. 4. Photographs showing whole cell sugars of some streptomycetes strains: controls (C), galactose (**ga**), arabinose (**a**), xylose (**x**), glucose (**g**), mannose (**m**), ribose (**ri**) and rhamnose (**rh**).

Identification of streptomycetes strains

On the basis of morphological, physiological, biochemical and chemotaxonomical characteristics the strains were subjected to hierarchical cluster analysis. The obtained results are illustrated as dendrogram (Fig. 5). The first phenon contains 3 strains, all united at 97 % similarity level. Such a phenon was identified as *Streptomyces viridodiastaticus*. This group is connected with a single member phenon of *Str. chromofuscus*. The next phenon united 4 strains which were identified as *Str. anulatus*. The dominant phenon, which is composed of 13 strains united at 94 % similarity matrix, was identified as *Str. lydicus*. Four phenons, each of them uniting 3 strains, were identified as *Str. diastaticus*, *Str. chromofuscus*, *Str. antibioticus* and *Str. albus* respectively. Two single member phenons identified as *Str. diastaticus* and *Str. exfoliatus* were connected with the second group. Another phenon (5 strains) was identified as *Str. capreolus*. A single phenon connected to this group was *Str. microflavus*.

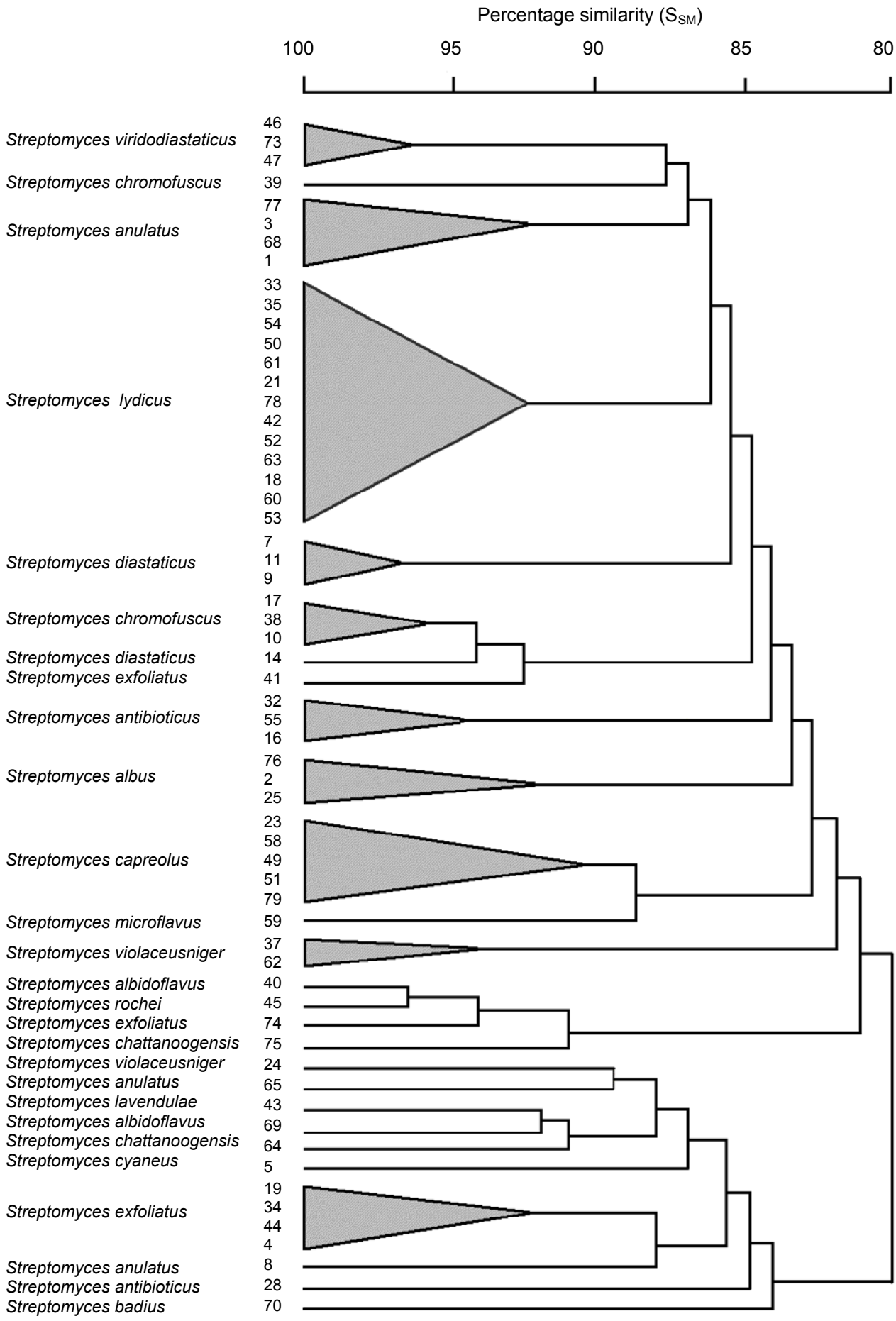

Fig. 5. Dendrogram of active *Streptomyces* species isolated from Kalubiya soil.

10 single member phenons were identified as *Str. albidoflavus*, *Str. rochei*, *Str. violaceusniger*, *Str. exfoliatus*, *Str. chattanoogensis*, *Str. anulatus*, *Str. lavendulae* and *Str. cyaneus*. The last identified phenon containing 4 strains, *Str. exfoliatus,* was connected with three member phenons namely *Str. anulatus*, *Str. antibioticus* and *Str. badius*.

Discussion

The diversity of terrestrial actinomycetes has been of extraordinary significance in several areas of science and medicine. The search for novel drugs from established terrestrial sources has been recommended. The soil represents an environment for microbial discovery. The data presented here provide the first conclusive evidence for the widespread and persistent occurrence of indigenous streptomycetes populations in soil. Analysis of the soil samples from Kalubiya Governorate revealed the presence of streptomycetes population composed of about 500 isolates, from which 60 streptomycetes strains had antimicrobial activity. Most *Streptomyces* were active against more than one organism. The results obtained in the present work reveal the following:

i) Eight species have broad spectrum activity against Gram-positive bacteria, yeast and fungi. These species are *Str. chromofuscus*, *Str. capreolus*, *Str. microflavus*, *Str. violaceusniger*, *Str. chattanoogensis*, *Str. exfoliatus*, *Str.anulatus* and *Str. badius*. Such results are in accordance with those obtained by many researchers [6, 7, 12, 13, 14, 18, 19, 22, 29,].

ii) Four species of *Streptomyces* showed activity against Gram-positive bacteria and fungi namely *Str. viridodiastaticus*, *Str. lydicus*, *Str. diastaticus* and *Str.antibioticus*. This result is in agreement with some investigators [2, 8, 17, 30].

iii) *Str. albidoflavus* and *Str. rochei* displayed activity towards fungi. Such results are in agreement with the findings of Roy and Sen [21] and Kotaka et al. [15].

iv) One species (*Str. lavendulae*) was found to be active against Gram-positive bacteria only. However, Shibata et al. [23] isolated antifungal ilenmycin from culture broth of *Str. lavendulae*.

v) The strains of *Str. albus* were active either against Gram-positive bacteria or fungi. An antibiotic, lysocellin, was isolated from *Str. cacaoi*, a species belonging to *Str. albus*, which has antimicrobial activity against Gram-positive bacteria and some fungi [3].

vi) *Str. cyaneus* showed antimicrobial activity against both Gram-positive bacteria and yeast. This result is compatible with Shimiza and Tamura [24] who isolated an antibiotic from the culture broth of *Str. luteogriseus* (nomen species of *Str. cyaneus*) from soil samples collected in Japan.

As a conclusion, the obtained results indicate that the studied agriculture soil is promising and can be an important source of habitat adapted streptomycetes possessing antimicrobial activity.

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ТАКСОНОМИЧНИ ИЗСЛЕДВАНИЯ НА СТРЕПТОМИЦЕТИ, ИЗОЛИРАНИ ОТ ЕГИПЕТСКИ ПОЧВИ И ПРОЯВЯВАЩИ АНТИМИКРОБНА АКТИВНОСТ

Хала М. Рифаат*, Надя Х. Абд Ел Насер, Самиа М. Хелми, Амал М. Али

Резюме

Лесният достъп и удобната употреба на антимикробни агенти води до селекция и разпространение на резистентни щамове микроорганизми. Наложително е търсенето и проучването на нови и по-ефективни антимикробни вещества от микроорганизми, открити в околната среда. Целта на работата е да се изолират стрептомицети от почви в Kalubiya Governorate, за да се скринират за антимикробна активност срещу референтни Грам-положителни и Грам-отрицателни бактерии, едноклетъчни и нишковидни гъби. Изолирани са общо 500 щама стрептомицети, като 60 от тях (12 %) проявяват антимикробно действие. Проучени са морфологичните, културалните, физиологичните и биохимични свойства на изолатите, за да се идентифицират на видово ниво. Получените резултати показват, че доминиращата група е Streptomyces lydicus.