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The Effect of Some Antibiotics, Natural and Chemical Compounds on Swarming Motility of *Proteus mirabilis*

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تأثير بعض المضادات الحيوية والمركبات الطبيعية والكيميائية على حركة الانثيال لبكتيريا *Proteus mirabilis*

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ABSTRACT

Background: *Proteus mirabilis* known for its motility, swimming and swarming motility and involvement in various infections, these two types of motility are important for tissue colonization, thus increase the pathogenicity of the bacteria.

Materials and Methods: Twenty-one isolates from different clinical and animal sources belong to P. mirabilis were collected. The isolates identified using biochemical tests and the Vitek-2 compact system. Swimmer and swarmer cells media used to detect the effect of antibiotics, sodium azide and tannic acid.

Results: Sodium azide inhibited swimming more effectively than swarming, with higher concentrations (0.1%) showing the greatest inhibition. Tannic acid also inhibited swimming and swarming, with greater effects on swimming cells, particularly from clinical isolates. Swarming motility, especially in animal-derived isolates, exhibited resistance to tannic acid. Additionally, the isolates showed varying resistance levels to antibiotics.

Conclusions: This study demonstrated that, *P. mirabilis* exhibit different responses to antibiotics, sodium azide and tannic acid according to the type of cells whether it was swimmer or swarmer. Sodium azide and tannic acid inhibit swimming more than swarming cells. Antibiotics resistance patterns was differ according bacterial isolate and type of antibiotic. These finding could be used in future to enhance the activity of antibiotics especially those used to treat gram-negative bacterial infection.

Key words: *Proteus mirabilis*; Tannic acid; Sodium azide; Swarming; Swimming.

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INTRODUCTION

Hauser first discovered Proteus in the year 1885, after isolation from putrefied meat. The genus Proteus includes many species such as mirabilis, vulgaris and zenkeri according the ability to liquefy gelatin [1]. The bacteria *P. mirabilis* belongs to the family enterobacteriaceae are gram negative rods, motile by flagella and gain its energy from fermentation and respiration [2]. P. mirabilis are isolated from variety of sources such as soil, water and clinical samples [3] and they are part of the large intestine of flora of human, also they are present in many animals according their nature of life [4]. P. mirabilis acquire many virulence factors responsible for its pathogenicity [5]. The enzyme urease which is an important virulence factor hydrolyze ammonia leading to increase urine pH leading to the formation of struvite stones [6]. The phenomenon of swarming defined as rapid migration of bacterial cells as a group in order to enhance colonization of rich nutrient environment. Swarming require cellular signaling, a system known as quorum sensing (QS) used by bacterial cells to communicate with each other. This system relies on chemical signaling molecules known as auto-inducers, which are acyl-homoserine lactones (AHL) in gram-negative bacteria, which are passively diffuse through their cell membrane. Additional to chemical signals, physical signals represented by flagella movement rapidly, both lead to differentiation of cells from swimmer to swarmer. Swimmer cells, which are the vegetative cells of P. mirabilis, when they are transported to firm surfaces, they turn to hyper-flagellated elongated rods [5], [7], [8]. Migration of swarmer cells forms concentric zones within few hours, and then they enter to unification state followed by loss of differentiation to swimmer cells. The process continuously repeated to form a centric region in around the agar center [9]. Many studies referred that swarming phenomenon could be eradicated by many substances such n-acetyle cysteine [6], Glycerol [10], Fatty acids [11], purified resveratrol [12] and the use of 1-6% agar [13]. Also the swarming could be enhanced by using amino acids, which serves as source of carbon leading to increase growth rate [14, 15]. The present study aimed to detect effect of sodium azide, Tannis and antibiotics against on swimmer and swarmer cells of different Proteus mirabilis isolates.

Materials and Methods

Isolation and identification of P. mirabilis

Up to Twenty-one of Proteus isolates gathered from different sources. Clinical samples represented by urine, wound swaps and sputum were handled [27] , briefly each sample were cultured on MacConkey and Blood agar and incubated for overnight at 37ºc. animal sources isolates represented by Chicken faeces, Dog Rectal and Cat Rectal were also culture on MacConkey and Blood agar for overnight at 37ºc, after following the methods of handling of each sample [27].Primary identification depends on Morphological and Biochemical tests [15], followed by identification by using Vitek-2 compact system.

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Swimmer and Swarmer Cells Test

A full loop of each tested isolate cultured on swimmer and swarmer cells media as mentioned in [17].

Sodium azide Effect on swimmer and swarmer cells

Three concentrations (0.1, 0.01 and 0.001)% of Sodium azide were added to swimming and swarming media [17] to determine its activity against swimmer and swarmer cells.

Tannic acid effect on swimmer and swarmer cells

Tannic acid added at different concentration 0.001%, 0.01% and 0.1% to swimming and swarming media [17] to estimate their activity against swimming and swarming cells.

Antibiotics effect on swimmer and swarmer cells

Kirby-Baure method as mentioned in [18] carried out to detect the activity of antibiotics on swimming and swarming cells by using swimming and swarming media mentioned in [17].

Up to Twenty-one isolates of Proteus identified according to morphological characterization, followed by many biochemical tests, which include oxidase, catalase, Indole, Methyl red, Vogeus Proskaure and Citrate utilization [19, 20]. The results of Biochemical tests showed that only 18 isolate were P. mirabilis and it was confirmed by using the automated Vitek -2 compact system with accuracy of (93-99)%. The number percentage of isolates distribution shown in figure (1).

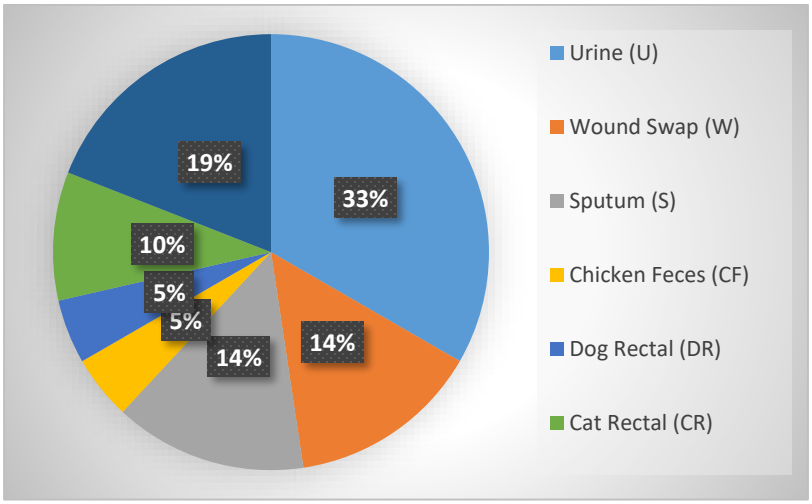

Figure (1) Distribution percentage isolates

Swimmer and Swarmer Cells Test

The result reviled that all swimmer cells were motile, and the calculated diameter was 26 to 80 mm, while the swarmer cells motility diameter ranged from 10 to 35 mm.

Sodium azide effect on swimmer and swarmer cells

The results reviled that Sodium azide eradicate swimmer and swarmer cells. As displayed within figure (2), the lowest concentration (0.001%) was inefficient to inhibit both of clinical and animal sources isolates, while at the concentration of 0.01%, eradication of swimmer cells was differ as isolate source differ. The isolates S1, CF1 and DR1 reaches the highest inhibition ratio

ranged from 85 to 87.5%, while it was 62.5% for W1isolate and 68.5% for CR1 isolate and it was 50% for U1. The highest concentration represented by 0.1% which inhibit swimmer cells and ranged from 81.4 to 88.7%. As shown in Figure (3) sodium azide effect was variable on swarmer cells depending on the source of isolate. All of the tested concentrations inhibit swarmer cells of CF1 isolate; also, none of the tested concentrations inhibits CR1 isolate. The lowest concentration (0.001 %) inhibit swarmer cells of S1 isolate and the inhibition ratio was to 6.5 %, while it was not active against the other isolates. The inhibition ratio ranged from 2.1 to 43.7% at the concentration 0.01 % against U1, W1 and S1, while for DR1 isolate, it was 12.5 %. Also the 0.1 % concentration reaches its maximum effect against CF1 isolate with a ratio of 75.3%, while in U1 , W1 and DR1 the ratio was (50.9,57.5 and 25) %.

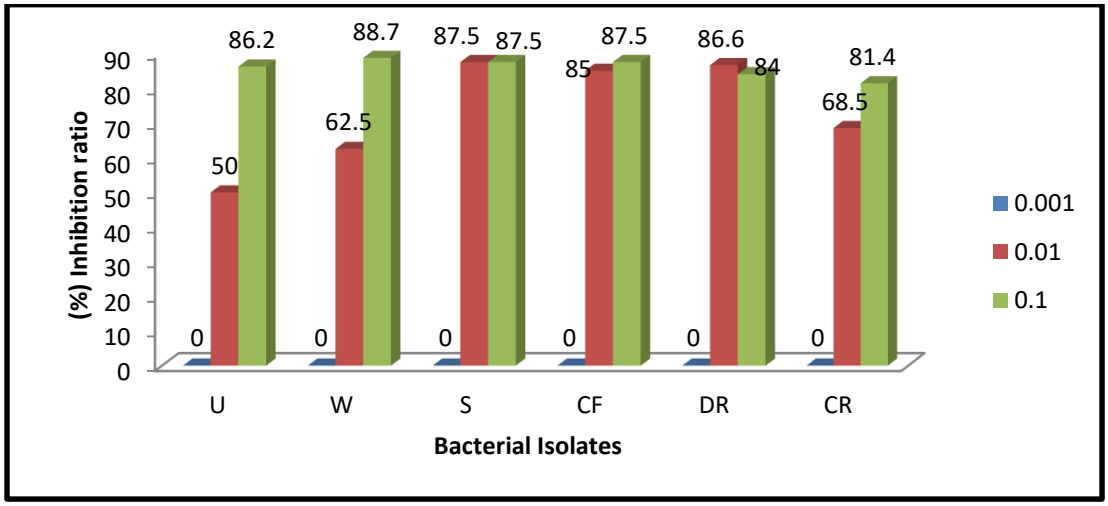

Figure (2) Sodium azide effect on swimmer cells of P. mirabilis clinical isolates Urine (U), Wounds (W) and Sputum (S) and Animal sources isolates Chicken Feaces (CF), Dog Rectal (DR) and Cat Rectal (CR)

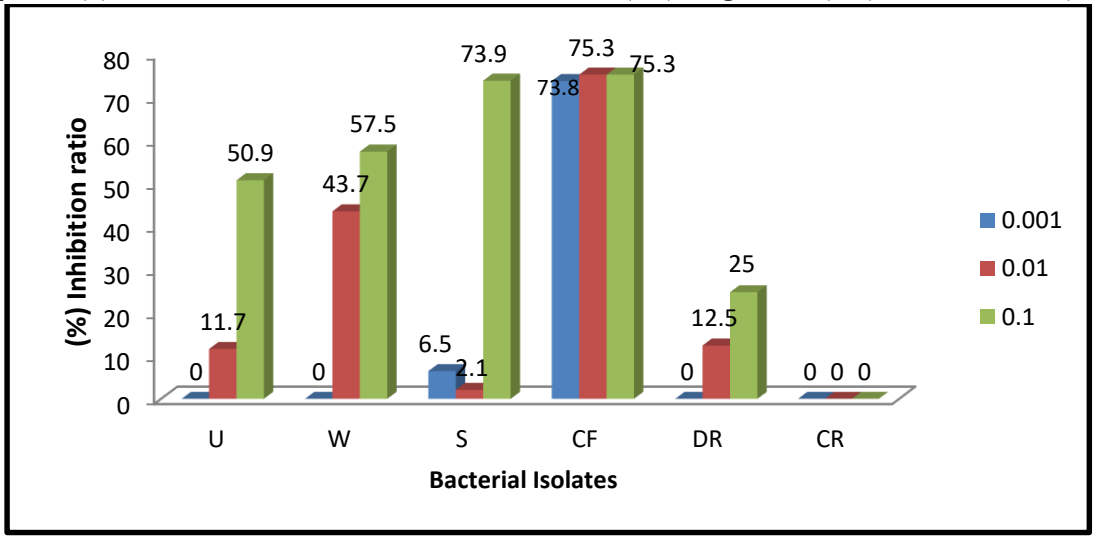

Figure (3) Sodium azide effect on Swarmer cells of P. mirabilis clinical isolates Urine (U), Wounds (W) and Sputum (S) and Animal sources isolates Chicken Feaces (CF), Dog Rectal (DR) and Cat Rectal (CR)

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These results showed that swimmer cells of *P.mirabilis* were inhibited more than swarmer cells by and the inhibition rate depend on isolate source whether it was clinical or from animal source. As referred in [21] study, sodium azide at different concentration blocks *P.mirabilis* swimmer and swarmer cells motility. Also in a different study of [22], pointed that supplementing of the media with sodium azide at 0.005% concentration leads aerobic respiration poisoning as result from its activity on Tri-carboxylic Acid cycle genes. In a another study, [23] conduct that bacterial flagella formation could be blocked by using chemical compounds, which effect on bacterial cells motility, while [24] suggest that the differentiation from swimmer to swarmer cells could be discourage by chemical compounds and thus lead to block swarming phenomenon. These finding give a clear vision of possibility of using sodium azide salt as a supplement for antibiotics to improve their activity against Varity types of infections.

Tannic acid effect on swimmer and swarmer cells

The results exhibited tannic acid ability to eradicate swimmer and swarmer cells. As presented in figure (4), all of the concentrations inhibit swimmer cells. The lowest concentration 0.001% shows an inhibition rates ranged from 56.1 to 75.6% in U1, W1 and S1isolates, while fro the animal sources isolates, it ranged from 41 to 56.3%. The concentration 0.01% inhibition rate was the same in all isolates and ranged from 83.2 to 87.5%. The highest concentration 0.1%, showed the highest inhibition rate 89% against U1 isolate, while it was 83.3 and 78.7% against W1 and S1 isolates, respectively. The animal sources isolates inhibition rate ranged from 81.3 to 86.2%.

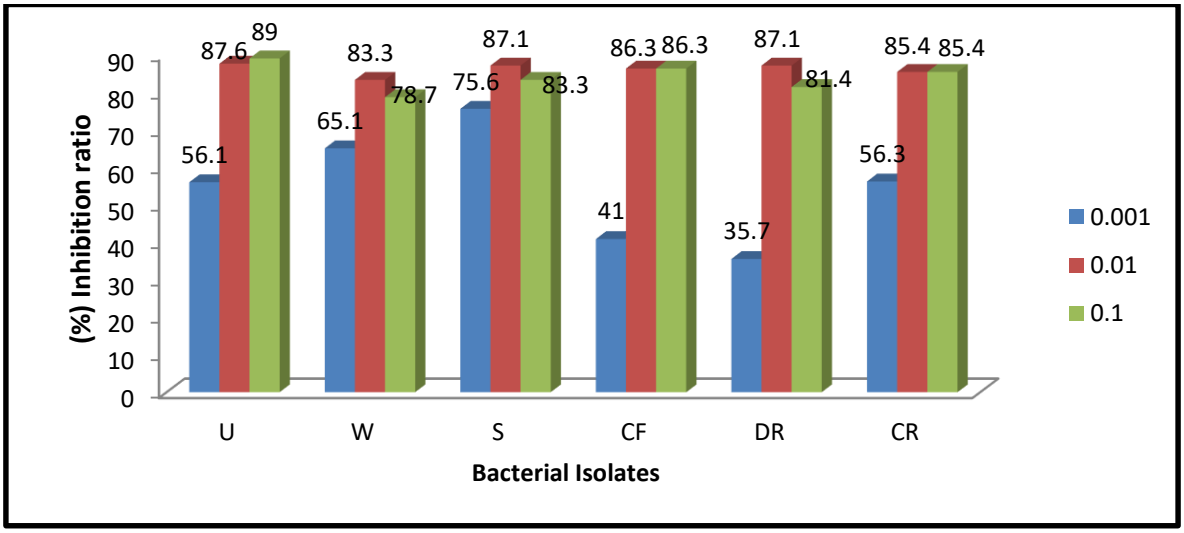

Figure (4) Tannic acid effect on swimmer cells of P. mirabilis clinical isolates (U, W and S) and Animal sources isolates (CF, DR and CR)

As shown in Figure (5) swarmer cells motility inhibited. All concentrations were unsuccessfully effective against CR1 isolate. The lowest concentration 0.001% was incapable to inhibit U1 isolate swarmer cells, while the inhibition ratios ranged from 31.2 to 61.5% for W1, S1, CF1 and DR1 isolates. At 0.01% concentration, the maximum inhibition ratios scored for W1, CF1 isolates, and it was 84 % and 81.4 %, respectively. The inhibition ratio was 68.6% for U1 isolate

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and 73.9% for S1 isolate, while it was 37.5% for DR1isolate. The isolates U1, W1, S1 and CF1 inhibition ratio ranged from 72.4 to 82.4% at the concentration 0.1 %, while it was 18.7% for DR1 isolate. The results of tannic acid effect showed that, it was effective against swimmer cells more than swarmer cell according to source of bacterial isolate and tannic acid concentration. Additionally, P. mirabilis swarmer cells isolated from animal sources were more resistance than the clinical isolates to tannic acid. According to Smith [25] results, the adding of tannic acid to culture media with concentration of 0.00001% to 0.1%, may be responsible for blocking swarming, when it binds with outer membrane phospholipids without any harmful effect on growth or cell signaling system. These results represented by using tannic acid, which is a natural compound at specific concentration, may limits the infection of P. mirabilis. Additionally it may be added also at specific concentration to antibiotics to enhance their activity.

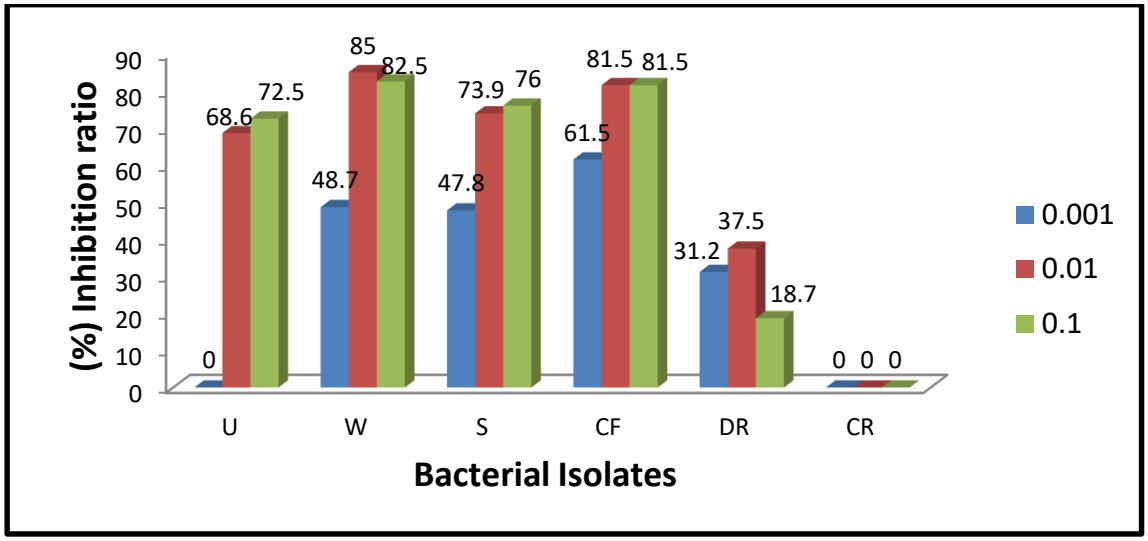

Figure (5) Tannic acid effect on swarmer cells of P. mirabilis clinical isolates (U, W and S) and Animal sources isolates (CF, DR and CR)

Antibiotics effect on swimmer and swarmer cells

The resistance of *P.mirabilis* isolates towards four types of antibiotics (Penicillin, Tetracycline, Nitrofurantoin and Cefoxitin) tested by Kirby-Baure method. The results showed that all swimming and swarming cells were (100) % resistant to the antibiotic Penicillin (P), while the resistance rate of swarming cells was 83.3% for the antibiotic Tetracycline (TE). The resistance of swimming cells to the antibiotic Nitrofurantoin was (100)%, while the resistance rate of swarming cells was 55.5%. As for the antibiotic Cefoxitin (FOX), the resistance rate was 5.5% for both swimming and swarming cells, as shown in Figures (5, 6, 7, 8, 9, 10), it showed variation in the resistance of bacterial isolates to antibiotics.

The results in Figure (6), (7) and (8) show that the swimming cells of the clinical and animal isolates of *P.mirabilis* under study were resistant to Penicillin (P) at a very high rate, except for the isolates U7, DR, S1, S2, W2 and CF, whose inhibition diameters reached (21, 21, 5, 9, 7, 19) mm, respectively. The isolates U1, U2, U3, U5, CR1, DR, H.en1 and H.en3 were highly resistant

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to Tetracycline (TE). The isolates U4, U6 and U7 had TE inhibitory diameters of (8, 7 and 8) mm, respectively. The isolates W1, W2, S1, S2 and CR2 had TE inhibitory diameters of (7, 8, 8, 9 and 8) mm, respectively. The isolates CF and H.en2 had inhibitory diameters of (6 and 9) mm, respectively. The isolates U1, U3, U5, U6, W1, CR1, CR2, DR, CF, H.en1 and H.en3 were highly resistant to Nitrofurantoin (F), while the isolates U2, U4 and U7 had a diameter of inhibition to Nitrofurantoin of (6, 10, 7) mm, respectively, while the isolates W2, S1 and S2 had a diameter of inhibition of (6, 9, 9) mm, respectively, while the isolate H.en2 had a diameter of inhibition of (9) mm. Most of the *P.mirabilis* isolates under study showed sensitivity to Cefoxitin (FOX) as the diameter of inhibition of swimming cells ranged between (19-29) mm, while the diameter of inhibition of isolates U5 and CR1 was (13, 17) mm, respectively.

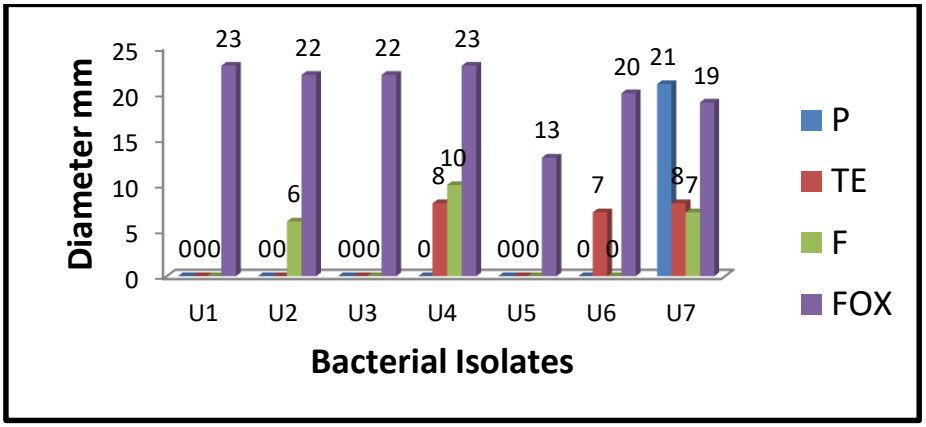

Figure (6) antibiotics Penicillin (P), Tetracycline (TE), Nitrofurantoin (F) and Cefoxitin (FOX) effect on swimmer cells of P. mirabilis Urine (U) isolates

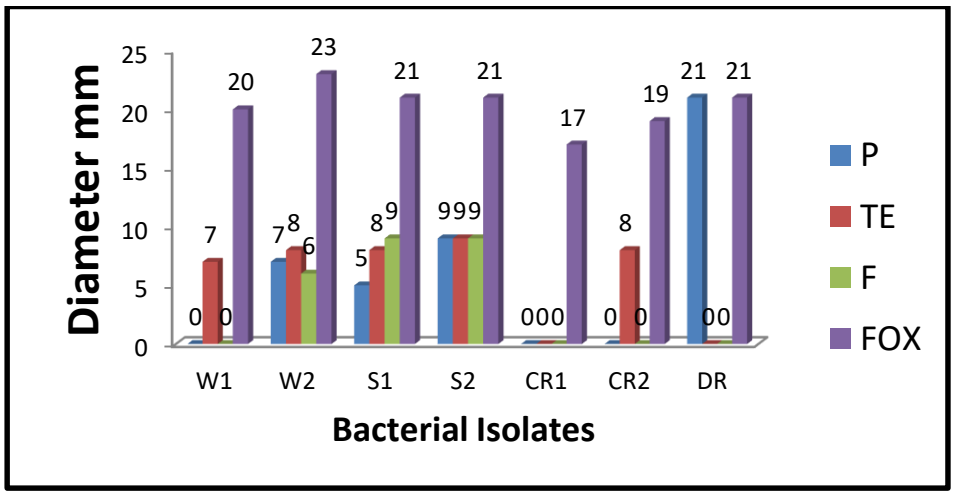

Figure (7) antibiotics Penicillin (P), Tetracycline (TE), Nitrofurantoin (F) and Cefoxitin (FOX) effect on swimmer cells of P. mirabilis clinical isolates Wounds (W), Sputum (S) and animal sources isolates Cat Rectal (CR) and Dog Rectal (DR)

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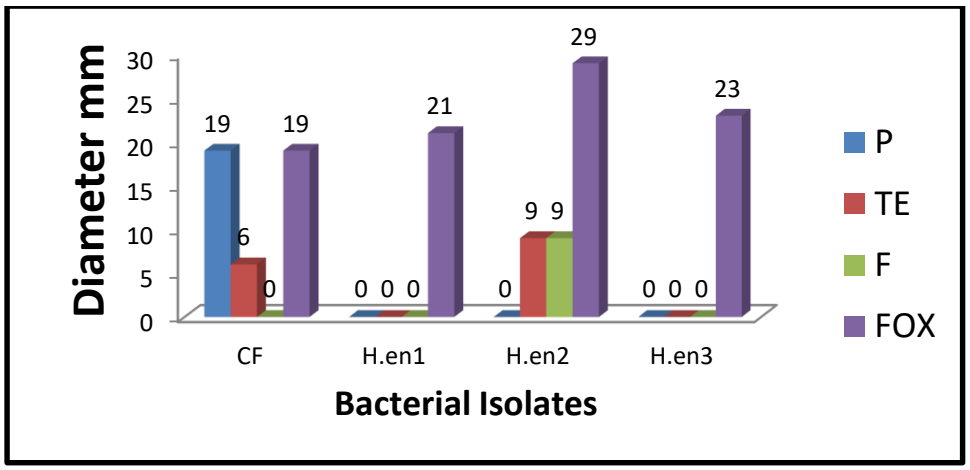

Figure (8) antibiotics Penicillin (P), Tetracycline (TE), Nitrofurantoin (F) and Cefoxitin (FOX) effect on swimmer cells of P. mirabilis animal sources isolate Chicken faeces (CF) and Hospital environment (H.en)

As for the swarming cells, Figures (9, 10, 11), show their resistance to antibiotics. The germ cells of the isolates U1, U2, U3, U4 and H.en3 were highly resistant to the antibiotic Penicillin (P). The inhibition diameters of isolates U5, U6 and U7 reached (7, 9, 23) mm, respectively. As for isolates W1, W2, S1 S2, CR1, CR2, DR, their inhibition diameters reached (12, 15, 9, 9, 15, 11, 23) mm, respectively. While the inhibition diameters of isolates CF, H.en1 and H.en2 reached (20, 7, 11) mm, respectively. The isolates U3, CR1 and CF were highly resistant to Tetracycline (TE), the diameter of resistance of isolates U1 and U2 was (10, 6) mm, respectively, while that of isolates U4, U5, U6, U7 and S2 was 8 mm, the diameter of isolates W1 and S1 was (11) mm, while that of isolates W2, DR, H.en2 and H.en3 was (12, 9, 15, 12) mm, respectively, while that of isolates CR2 and H.en1 was 7 mm. The isolates U1, U2, W1, S2 and DR were highly resistant to the antibiotic Nitrofurantoin (F), the inhibition diameter of isolates U5, U6 and U7 was (18, 15, 14) mm, respectively, while the isolates U3 and U4 were (17) mm, while the isolates W2, S1, CR1 and CR2 were (25, 12, 13, 14) mm, respectively, while the isolates CF, H.en1, H.en2 and H.en3 had an inhibition diameter of (13, 23, 17, 15) mm, respectively. The isolates of *P.mirabilis* bacteria under study showed sensitivity to the antibiotic Cefoxitin, as the inhibition diameter ranged between (22-29) mm, while the inhibition diameter of isolates U5 and W2 was (17, 7) mm, respectively.

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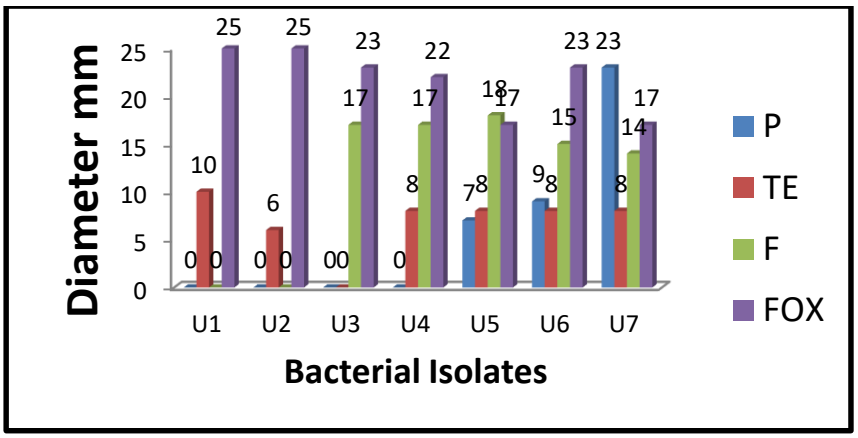

Figure (9) antibiotics Penicillin (P), Tetracycline (TE), Nitrofurantoin (F) and Cefoxitin (FOX) effect on Swarming cells of P. mirabilis Urine (Urine) Isolates

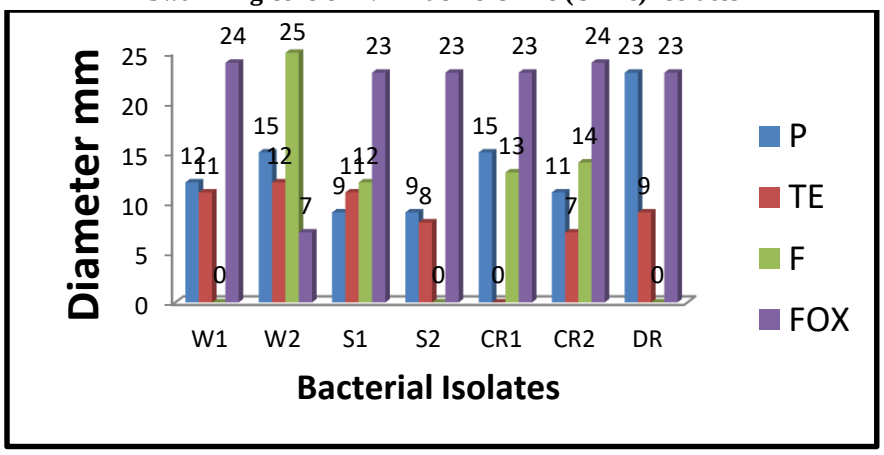

Figure (10)) antibiotics Penicillin (P), Tetracycline (TE), Nitrofurantoin (F) and Cefoxitin (FOX) effect on swarmer cells of P. mirabilis clinical isolates Wounds (W), Sputum (S) and animal sources isolates Cat Rectal (CR) and Dog Rectal (DR)

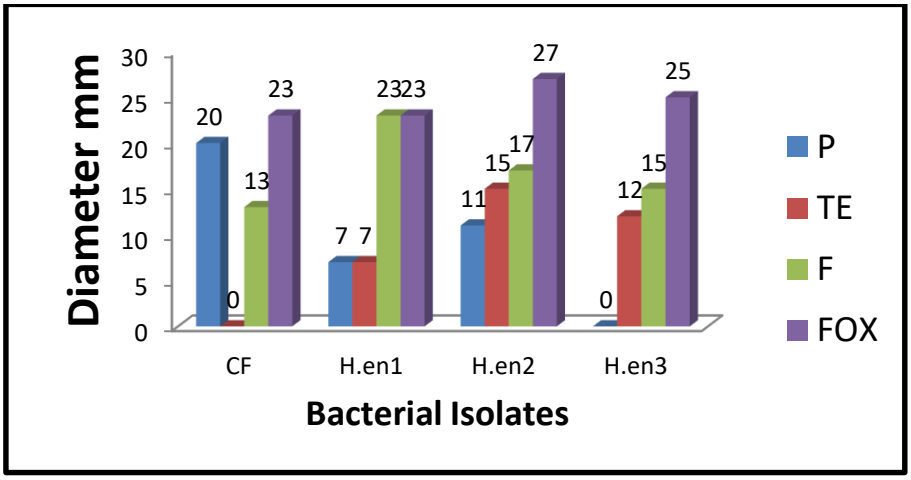

Figure (10) antibiotics Penicillin (P), Tetracycline (TE), Nitrofurantoin (F) and Cefoxitin (FOX) effect on swarmer cells of P. mirabilis animal sources isolate Chicken faeces (CF) and Hospital environment (H.en)

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It is also noted that antibiotics have different effects on swimming cells and swarming cells. This difference may be due to the source of isolation, in addition to the resistance of thalli cells to antibiotics more than swimming cells. The results of the current study agree with [26] who indicated that *P.mirabilis* bacteria isolated from urine, wounds and burns are resistant to the antibiotics Tetracycline and Cefoxiti, Hussein [27] indicated that *P.mirabilis* bacteria isolated from chicken feces, dog rectum and cat rectum were sensitive to the antibiotic Cefoxitin.

Conclusions:

P. mirabilis showed Varity of responses according to the type of cells which was simmer or swarmer to the tested compounds and antibiotics and this differences in cells response was depends on type of cell, type of compound or antibiotics and concentration. Both of swimming and swarming cells were inhibited by Sodium azide and tannic acid. Additionally, the resistance patterns of the tested Antibiotic varied according to the type of antibiotic.

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Conflict of interests.

There is no conflict of interests.

References

[1] U. Behrendt, S. Wende, S. Kolb, and A. Ulrich, “Genome-based phylogeny of the genera *Proteus* and *Cosenzaea* and description of Proteus terrae subsp. terrae subsp. nov. and Proteus terrae subsp. cibarius subsp. nov.,”, *International Journal of Systematic and Evolutionary Microbiology*, vol. 71, no. 3, pp. 1-4, Mar. 2021.

[2] G. M. Garrity, D. J. Brenner, N. R. Krieg, J. T. Staley, D. R. Boone, P. De Vos, M. Goodfellow, F. A. Rainey, and K.-H. Schleifer, *Bergey’s Manual of Systematic Bacteriology, Vol. 2: The Proteobacteria Part B: The Gammaproteobacteria*, 2nd ed. New York: Springer, 2005.

[3] I. Kwill, D. Kazmierczak, and A. Rozalski, “Swarming growth and resistance of Proteus penneri and Proteus vulgaris strains to normal human serum”, *Advances in Clinical and Experimental Medicine*, vol. 22, no. 2, pp. 165-175, Mar. 2013.

[4] D. Drzewiecka, “Significance and roles of Proteus spp. bacteria in natural environments”, *Microbial Ecology*, vol. 72, pp. 741-785, Jan. 2016.

[5] A. Rozalski, A. Torzewska, M. Moryl, I. Kwil, A. Maszewska, K. Ostrowska, D. Drzewiecka, A. Zablotni, A. Palusiak, M. Siwinska, and P. Staczek, “Proteus sp. – an opportunistic bacterial pathogen – classification, swarming growth, clinical significance and virulence factors”, *Folia Biologica et Oecologica*, vol. 8, pp. 1-17, 2012.

[6] R. M. Abdel-Baky, M. A. Ali, G. E. D. A. A. Abuo-Rahma, and N. AbdelAziz, “Inhibition of urease enzyme production and some other virulence factors expression in Proteus mirabilis by N-Acetyl

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Cysteine and Dipropyl Disulphide", *Advances in Microbiology, Infectious Diseases and Public Health*, vol. 973, pp. 99-113, Jan. 2017.

[7] N. Verstraeten, K. Braeken, B. Debkumari, M. Fauvart, J. Fransaer, J. Vermant, and J. Michiels, "Living on a surface: swarming and biofilm formation", *Trends in Microbiology*, vol. 16, no. 10, pp. 496-506, Jan. 2008.

[8] S. Cavalu, S.S. Elbaramawi, A.G. Eissa, M.F. Radwan, T.S. Ibrahim, E.S. Khafagy, B.S. Lopes, M.A. Ali, W.A.H. Hegazy, and M.A. Elfaky, "Characterization of the anti-biofilm and anti-quorum sensing activities of the β-adrenoreceptor antagonist atenolol against gram-negative bacterial pathogens", *International Journal of Molecular Sciences*, vol. 23, no. 21, pp. 13088, Oct. 2022.

[9] R. M. Morgenstein, B. Szostek, and P. N. Rather, "Regulation of gene expression during swarmer cell differentiation in Proteus mirabilis", *FEMS Microbiol. Rev.*, vol. 34, pp. 753-763, Nov. 2010.

[10] S. J. Liaw, H. C. Lai, S. W. Ho, K. T. Luh, and W. B. Wang, "Inhibition of virulence factor expression and swarming differentiation in Proteus mirabilis by p-nitrophenylglycerol", *Journal of Medical Microbiology*, vol. 49, no. 8, pp. 725-731, Aug. 2000.

[11] S. J. Liaw, H. C. Lai, and W. B. Wang, "Modulation of swarming and virulence by fatty acids through the RsbA protein in Proteus mirabilis" *Infection and Immunity*, vol. 72, pp. 6836-6845, Dec. 2004.

[12] W. B. Wang, H. C. Lai, P. R. Hsueh, R. Chiou, Y. Y. Lin, S. B. Liaw, and S. J. Liaw, "Inhibition of swarming and virulence factor expression in *Proteus mirabilis* by Resveratrol", *Journal of Medical Microbiology*, vol. 55, no. 11, pp. 1313-1321, Nov. 2006.

[13] N. J. Hayward, G. M. Incledon, and J. Spragg, "Effect of firm agar on the swarming of *Proteus* and *Clostridium* species and on the colonies of clinically important bacteria", *Journal of Medical Microbiology*, vol. 11, no. 2, pp. 155-164, Feb. 1978.

[14] H. E. Jones and R. W. A. Park, "The influence of medium composition on the growth and swarming of *Proteus*", *Journal of General Microbiology*, vol. 47, no. 3, pp. 369-378, Mar. 1967.

[15] C. Allison, H. C. Lai, D. Gygi, and C. Hughes, "Cell differentiation of *Proteus mirabilis* is initiated by glutamine, a specific chemoattractant for swarming cells", *Molecular Microbiology*, vol. 8, no. 1, pp. 53-60, Jan. 1993.

[16] P. M. Tille, *Baily and Scott's Diagnostic Microbiology*, 12th ed., Mosby Inc.: Elsevier, Inc., 2021.

[17] A. Fusco, L. Coretti, V. Savio, E. Buommino, F. Lembo, and G. Donnarumma, "Biofilm formation and immunomodulatory activity of *Proteus mirabilis* clinically isolated strains", *International Journal of Molecular Science*, vol. 18, no. 2, pp. 1-11, Feb. 2017.

[18] J. Vandepitte, J. Verhaegen, K. Engbaek, P. Rohner, P. Piot, and C. C. Heuck, *Bacteriological Investigations*, 2nd ed., *Basic Laboratory Procedures in Clinical Bacteriology*. Geneva: World Health Organization, 2003.

[19] W. Levinson, *Review of Medical Microbiology and Immunology*, 14th ed., New York: McGraw-Hill Education, Inc., 2016.

[20] C. M. O'Hara, F. W. Brenner, and J. M. Miller, "Classification, identification, and clinical significance of *Proteus*, *Providencia*, and *Morganella*", *Clinical Microbiology Reviews*, vol. 13, no. 4, pp. 534-546, Oct. 2000.

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[21] A. K. Al-Yasseen and A. K. M. Alatrash, "The effect of sodium azide on swimming and swarming phenomenon of *Proteus mirabilis*" , *International Journal of ChemTech Research*, vol. 10, no. 6, pp. 865-872, Nov. 2017.

[22] C. J. Alteri, S. D. Himpsl, M. D. Engstrom, and H. L. T. Mobley, "Anaerobic respiration using a complete oxidative TCA cycle drives multicellular swarming in *Proteus mirabilis*", *Mbio*, vol. 3, no. 6, pp. 1-13, Dec. 2012.

[23] R. Kopp, J. Muller, and R. Lemme, "Inhibition of swarming of *Proteus* by sodium tetradecyl sulfate, beta-phenethyl alcohol, and p-nitrophenylglycerine", *Journal of Applied Microbiology*, vol. 14, no. 6, pp. 873-878, Jun. 1966.

[24] M. Ghaidaa, W. Yanchang, and H. Abdallah, "The effect of p-nitrophenylglycerol on swarming and the production of some virulence factors in *Proteus vulgaris*", *New York Science Journal*, vol. 6, no. 9, pp. 8-14, Sep. 2013.

[25] D. G. Smith, "Inhibition of swarming in *Proteus* spp. by tannic acid", *Journal of Applied Bacteriology*, vol. 38, pp. 29-32, Jan. 1974.

[26] D. A. Ahmed, "Prevalence of *Proteus* spp. in some hospitals in Baghdad city", *Iraqi Journal of Science*, vol. 65, no. 1, pp. 665-672, Jan. 2015.

[27] A. S. K. Hussain, "Bacteriological and molecular study of *Proteus mirabilis* isolated from clinical and animal sources", M.S. thesis, Univ. of Baghdad, Baghdad, Iraq, 2016.

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الخلاصة

المقدمة: تعرف بكتيريا *Proteus mirabilis* بقدرتها على الحركة متمثلة بالخلايا السابحة والخلايا الانثيالية وهي مسؤولة عن أنواع مختلفة من العدوى، اذ تعتبر هذه الحركتين مهمتين في استعمار الانسجة وبالتالي تزاداد امراضية البكتيريا.

طرق العمل: جمعت 21 عزلة بكتيرية من مصادر سريرية وحيوانية مختلفة عائدة لبكتيريا Proteus mirabilis. شخصت جميع العزلات باستخدام الاختبارات الكيموحيوية ونظام الفايتك 2- .استخدم الوسط الزرعي الخاص بالخلايا السابحة والخلايا الانثيالية للكشف عن تأثير المضادات الحيوية، ملح ازايد الصوديوم و حامض التانيك.

الاستنتاجات: أظهرت هذه الدراسة أن البكتيريا *P. mirabilis* تظهر استجابة مختلفة للمضادات الحيوية وأزيد الصوديوم وحمض التانيك وفقًا لنوع الخلايا سواء كانت سباحة أو متكتلة. أزيد الصوديوم وحمض التانيك يثبطان السباحة أكثر من الخلايا المتكتلة. تختلف أنماط مقاومة المضادات الحيوية وفقًا للعزلة البكتيرية ونوع المضاد الحيوي. توصلت الدراسة الى امكانية استخدام هذه المواد في المستقبل لتعزيز نشاط المضادات الحيوية وخاصة تلك المستخدمة لعلاج العدوى البكتيرية السالبة لصبغة كرام.

الكلمات المفتاحية: السباحة، الانثيال، ملح ازايد الصوديوم، حامض التانيك، بكتيريا *Proteus mirabilis*.

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