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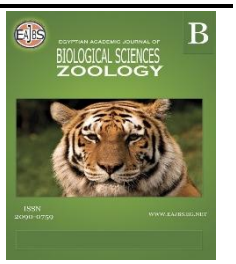

Isolation and Antibiotic Resistance of *Escherichia coli* and *Staphylococcus aureus* from Captive Falcons

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ABSTRACT

The current study aimed to investigate the presence *of Escherichia coli* and *Staphylococcus aureus* in captive falcons and detection of different serotypes of the isolated *Escherichia coli*. In addition to performing antibiotic sensitivity test to the isolated bacteria. Fifty diseased falcons of different species (23 Peregrine falcon, 14 Saker falcon and 13 Gyrfalcon) admitted to specialist hospital and research institute of Fahad bin Sultan falcon center, Riyadh, kingdom of Saudi Arabia and private veterinary clinics in Egypt. Thirty-four fecal samples and 28 oropharyngeal samples were examined bacteriologically for the presence of *Escherichia coli* and *Staphylococcus aureus*, followed by biochemical and antimicrobial sensitivity test. Moreover, the obtained isolates of *Escherichia coli* were subjected to serological tests. Overall, *Escherichia coli* was isolated as (11.77%) and (21.43%) from fecal and oropharyngeal samples respectively while *Staphylococcus aureus* was isolated as (5.88%) and (7.14%) from the same samples. Mixed infection of both *Escherichia coli* and *Staphylococcus aureus* from the fecal and oropharyngeal samples were isolated as (2.94%) and (3.57%) respectively. Six serotypes of *Escherichia coli* were detected; O55: H7, O103: H2, O17: H18, O126: H21, O78, and O159. Isolates of *Escherichia coli* showed complete resistance to Cefepime and highly resistance to Cefazolin, Ampicillin, Amoxycillin, Sulphamethoxazol and sensitive to Gentamicin, Meropenem, Amikacin**,** Imipenem while *Staphylococcus aureus* showed complete resistance to Cefoxitin, Sulphamethoxazol, Penicillin and highly resistance to Cefotaxime, Amoxycillin, Ampicillin-Sulboctam and highly sensitive to Amikacin.

INTRODUCTION

Falcons are rigid birds characterized by their graceful, swift, and predatory skills (Ferguson-lee and Christie, 2001). The most common species of the Genus Falco found in kingdom of Saudi Arabia, United Arab Emirates and Egypt are Saker falcons (*Falco cherrug*), Gyrfalcon (*Falco rusticolus*), Peregrine falcons (*Falco peregrinus*), hybrid of Saker-Gyrfalcon, and hybrid of Peregrine- Gyrfalcon (Al-Ulama and Ismail, 1997). The historical relationship between the Bedouins and falcons is the main cause for the special place given to the falcons by the Arabian people where it is not used only as a sport and entertainment but also, contribute to their traditional societies (Muller, 2009).

Falcons as apex predators play an important role in distribution of the avian and mammalian prey inside the home range (Ims and Andreassen 2000). Furthermore, providing food for other species like scavengers, detritivores animals, and microorganisms (Wang *et al.*,

2017). Loss of apex predator has determinantal effects on terrestrial ecosystem causing instability in herbivore-plant interactions, decline in the biodiversity, reduction in the flexibility of the ecosystem (Loveridge *et al.,* 2016) and considered as a prominent subject for human–wildlife conflicts (Salom *et al.*, 2021).

keeping falcons in captivity is associated with increased stress level and exposure to possible pathogens from industrial, urban, and agricultural environments, including multidrug-resistant bacteria that can be contracted by consuming raw food provided by handlers (Blanco *et al.,* 2023). Moreover, falconers may feed their falcon a game bird which is important reservoir of foodborne pathogens (Sauvala *et al.,* 2021).

Falcons have a potential role as asymptomatic carriers of pathogenic bacteria to other wild birds and zoonotic pathogens to human which in close contact as falconers and the handlers in rehabilitation and raptors rescue centers (Konicek *et al.,* 2016).

Escherichia coli is one of the most prevalent opportunistic enterobacteria in captivity and usually associated with systemic disease in birds (Mattes *et al.,* 2005). Avian pathogenic *E. coli* is the main cause of air saculities which is considered as Extra intestinal pathogenic *E. coli* (Cunha *et al.,* 2014).

Although *staphylococcus* spp. is considered as normal inhabitant microflora of human and animals (França *et al.,* 2021), it can cause wide range of infections (Chin *et al.,* 2021). The *Staphylococcus* genus comprises the coagulase-negative staphylococci and coagulase-positive staphylococci (França *et al.,* 2021). Most pathogenic staphylococci strains are coagulase-positive, whereas coagulase-negative strains are either less pathogenic or rarely cause disease (Becker, 2020). The endogenous infections of staphylococcus usually occur as complications of mold or viral diseases after colonization of the respiratory tract and subsequent septicemia (Mladenov, 2020).

Wild birds have a potential role in spreading antibiotic resistance bacteria due to their ability to move over large distances (Plaza-Rodríguez, 2021). Furthermore, the food preference of predator birds that feed on carcasses and small animals increases the risk of carrying and spreading the antibiotic resistance bacteria (Gambino, 2021).

So, the current study aimed to investigate the presence of *E. coli* and *Staphylococcus aureus* in captive falcons in Saudi Arabia and Egypt, and detection of different serotypes of the isolated *E. coli*. In addition to performing antibiotic sensitivity test to the isolated bacteria.

MATERIALS AND METHODS

Sampling:

The current study was performed on 50 diseased falcons belonged to 3 different species (23 Peregrine falcons (*Falco peregrinus*), 14 Saker falcons (*Falco cherrug*) and 13 Gyrfalcons (*Falco rusticolus*) admitted to specialist hospital and research institute of Fahad bin Sultan falcon center, Riyadh, kingdom of Saudi Arabia and private veterinary clinics in Egypt. A total of 62 samples were collected (34 fresh fecal samples from birds showed clinical signs for digestive disorder and 28 oropharyngeal swabs from birds showed respiratory symptoms).

The falcon's eyes are often hooded with a leather hood-like appliance to reduce the nervousness caused by the surroundings and those that are not trained to accept the hood, were examined in a dimly light room with the aid of a small flashlight. **(**Muller, 2009).

All samples were collected aseptically, were put in 10 ml peptone water and transported to Animal Health Research Institute, Ismailia lab, Egypt in ice box for microbiological examination under complete aseptic conditions.

Bacterial Isolation and Identification:

All samples were enriched overnight onto buffered peptone broth and incubated at 37˚c. Subsequently, the cultures were plated onto Levine's Eosin Methylene Blue (L-EMB) plates and incubated for 24 to 48 hours at 37ºC, for isolation of *E. coli.* Agar slants were used to cultivate suspected *E. coli* colonies, which had a black center and a flat, metallic green luster. Then, colonies were incubated for 18 hours at 35°C before being further identified (Bezerra *et al.,* 2017). Biochemical identification of *E. coli* was carried out according to Quinn *et al.,* (2002)

For isolation of *staphylococcus aureus*, the prepared samples were plated on

Mannitol salt agar and blood agar media. The grown bacterial colonies were subjected to various biochemical tests (Catalase, Oxidase, and Coagulase Tests) to ensure their identity (James and Natalie, 2014).

Serological Identification of *E. coli.*:

The confirmed isolates of *E. coli* were serologically identified according to Kok *et al.*, (1996) by using rapid diagnostic *E. coli* antisera sets (DENKA SEIKEN Co., Japan) in Animal health research institute, Dokki, Giza, Egypt.

Antimicrobial Sensitivity:

The disk diffusion method was used to test antibiotic susceptibility of isolates on Mueller-Hinton agar (Lab M) using different antibiotic discs; for *E. coli* and for *Staphylococcus aureus*. Pure colonies from a 24-hour-old culture were inoculated into 5 mL of Mueller-Hinton broth and incubated for 4–5 hours until turbidity was seen. Then, the bacterial suspension was adjusted to a density equivalent to 0.5 McFarland standard. With a sterile cotton swab containing bacterial suspension, the surfaces of Mueller-Hinton agar plates were streaked, and the plates were left for 30 min at room temperature. Then, by using an antibiotic dispenser and sterile forceps, the antibiotic discs were placed on the surface of the plate (Hudzicki, 2009). The recommended diameter for the inhibition zone of the National Committee for Clinical and Laboratory Standards Institute was used to classify the isolates as resistant, intermediate, or sensitive (CLSI 2017).

RESULTS

A total of 62 samples were collected; 34 fresh fecal samples from birds showed digestive disorder as loss of appetite, greenish watery diarrhea and loss of weight. In addition to, 28 oropharyngeal swabs from birds showed respiratory symptoms as breathing difficulties, coughing and nasal discharges.

Based on cultural characteristics and biochemical reactions, the prevalence of the isolated *E. coli* and *staphylococcus aureus* from fecal samples were 11.77% and 5.88 % respectively and as a mixed infection was 2.94% (Table 1) while their prevalence in the oropharyngeal samples were 21.43% and 7.14% respectively and as a mixed infection was 5.88% (Table 2).

The prevalence of the isolated bacteria from fecal sample showed that saker falcon had the highest infection rate with *E. coli* (16.67%) followed by peregrine falcon (10.53%) while it is not isolated from Gyrfalcon. The infection of *Staph aureus* and the mixed infection of both *E. coli* and *Staph. aureus* was recorded only in peregrine falcon at the rate (10.53%) and (5.26%), respectively (Table 1).

Table 1: Prevalence of *E. coli* and *Staph. aureus* in fecal samples of falcons.

Isolated bacteria	**Fecal samples (n= 34)**							
	Peregrine falcon (n=19)		**Saker falcon (n= 12)**		**Gyrfalcon falcon (n= 3)**		**Total**	
	No.	%	No.	%	No.	%	No.	%
E. coli	2	10.53%	2	16.67%	0	0	4	11.77%
Staph. aureus	2	10.53%	0	0	0	0	2	5.88%
Mixed infection *E. coli* and *Staph. aureus*	1	5.26%	0	0	0	0	1	2.94%

Regarding the oropharyngeal samples, Gyrfalcon showed the highest infection rate *of E. coli* (33.33%) followed by peregrine falcon (25%) while it is not isolated from saker falcon. The infection with *Staph aureus* and the mixed infection of both *E. coli* and *Staph aureus* were recorded only in peregrine falcon at rate (12.5%) and (6.25%), respectively **(**Table 2**)**. The coagulase test for the isolated *staphylococcus aureus* revealed that it was coagulase positive.

Table 2: Prevalence of *E. coli* and *Staph. aureus* in Oropharyngeal samples of falcons.

Isolated bacteria	Oropharyngeal samples (n= 28)							
	Peregrine falcon (n=16)		Saker falcon (n= 6)		Gyrfalcon falcon (n= 6)		Total	
	No.	%	No.	%	No.	%	No.	%
E. coli	4	25%	0	0	2	33.33	6	21.43%
Staph. aureus	2	12.5%	0	0	0	0	2	7.14%
Mixed infection *E. coli* and *Staph. aureus*	1	6.25%	0	0	0	0	1	3.57%

The serological identification of *E. coli* revealed 6 different serotypes; one from fecal samples O55: H7 EHEC in peregrine falcon, three from oropharyngeal samples O103: H2 EHEC, O17: H18 EPEC in peregrine falcon and O159 EIEC in Gyrfalcon and two from both fecal and oropharyngeal samples O78 ETEC and O126: H21 EPEC in peregrine falcon **(**Table 3**)**.

Table 3: Serological identification of *E. coli.*

Type of Samples	**Falcon species**	**Serodiagnosis**	**Strain characterization**
Fecal	Peregrine falcon	O55: H7	EHEC
	Peregrine and Saker falcon	O126: H21	EPEC
Oropharyngeal	Peregrine falcon	O103: H2	EHEC
	Peregrine falcon	O17: H18	EPEC
	Gyrfalcon	O159	EIEC
Fecal and Oropharyngeal	Peregrine falcon	O78	ETEC
	Peregrine falcon	O126: H21	EPEC

Regarding to the antibiotic sensitivity, isolates of *E. coli* showed complete resistance to Cefepime (100%) and highly resistance to Cefazolin (70%), Ampicillin (80%), Amoxycillin (70%) and Sulphamethoxazol (60%) and sensitive to Imipenem (90%), Gentamicin (80%), Meropenem (80%) and Amikacin (70%) **(**Table 4**)** while *Staphylococcus aureus* showed complete resistance to Cefoxitin (100%), Sulphamethoxazol (100%), Penicillin (100%) and highly resistance to Cefotaxime (75%) , Amoxycillin (75%) , Ampicillin-Sulboctam (75%) and highly sensitive to Amikacin (75%) (Table 5).

Table 4: Antimicrobial susceptibility of *E. coli.*

Antimicrobial agent	**Disc potency (µg)**	**Sensitive %**	**Intermediate %**	**Resistance %**
Cefepime (FEP)	30	-	-	100
Cefotaxime (CF)	30	40	10	50
Cefoxitin (FOX)	30	50	-	50
Cefazolin (CZ)	30	10	20	70
Ceftazidime (CE)	30	60	20	20
Ampicillin (AM)	10	-	20	80
Amoxycillin (AMX)	30	30	-	70
Tobramycin (TO)	10	50	10	40
Gentamicin (G)	10	80	10	10
Amikacin (AK)	30	70	-	30
Ciprofloxacin (CP)	5	40	20	40
Levofloxacin (L)	5	60	10	30
Chloramphenicol (C)	30	60	10	30
Sulphamethoxazol (SXT)	25	30	10	60
Tigecycline (T)	30	20	30	50
Meropenem (M)	10	80	-	20
Imipenem (IPM)	10	90	-	10

Table 5: Antimicrobial susceptibility of *Staph. aureus.*

Antimicrobial agent	Disc potency (µg)	Sensitive %	Intermediate %	Resistance %
Cefoxitin (FOX)	30	-	-	100
Sulphamethoxazol (SXT)	25	-	-	100
Penicillin G (P)	10 IU	-	-	100
Cefotaxime (CF)	30	-	25	75
Amoxycillin (AMX)	30	-	25	75
Ampicillin-Sulboctam(AS)	20	25	25	75
Tetracycline (T)	30	25	25	50
Amoxycillin- Clavulanic acid (AMC)	30	-	50	50
Chloramphenicol (C)	30	25	25	50
Clindamycin (CL)	10	25	25	50
Erythromycin (E)	15	50	-	50
Ceftarolin (CT)	30	50	-	50
Gentamicin (G)	10	-	75	25
Levofloxacin (L)	5	25	50	25
Amikacin (AK)	30	75	-	25

DISCUSSION

Wild birds play an important role in the transmission of pathogens to poultry, livestock farms and human water aquifers by contaminating the environment through their fecal matter. Additionally, it may spread infection to other birds when they are admitted to wild rehabilitation centers (Benskin, *et al.*, 2009).

Falcons may be infected with *E. coli* due to poor hygiene and contamination of water sources, food, perches, floors and all environment with feces (Nagi and Raggi, 1972). The affected birds showed lethargy, anorexia, ruffled plumage and diarrhea (Naldo and Samour, 2004).

In the present study, the rate of isolated *E. coli* from fecal samples was 11.76% and *Staph. aureus* was 5.88% and the rate of mixed infection for both was 2.94%. This finding is lower than that recorded by Muller *et al.,* (2009) who isolated *E. coli* at rate 45.5% from falcon spp. and nearly similar to Benskin *et al.,* (2009) who isolated *E. coli* at rate 6.8 % from different wild birds. Also, higher rate of infection with *E. coli* (51.1%) is recorded in birds of prey (Khafagy *et al.,* 2018).

Brittingham *et al.,* (1988) reported that the prevalence of staphylococcus spp. was 15% from wild birds and Latif *et al.,* (2024) isolated *Staphylococcus aureus* at rate of 16% from cloacal samples of wild birds, these results were higher than our finding. Also, Pyzik *et al.,* (2021) isolated pathogenic *Escherichia coli*, and *Staphylococcus* spp. from the fecal samples of urban peregrine falcons.

Although *E. coli* is a natural inhabitant in the intestinal tract of birds, virulent strains of *E. coli* can cause initial infection of the respiratory tract causing systemic infection and disease (Dziva and Stevens, 2008). Also, *Staphylococcus* spp. is considered as normal inhabitant in microflora of human and animals (França *et al.,* 2021) but *Staph. aureus* can cause wide range of infections (Chin *et al.,* 2021).

Oropharyngeal sample is considered as a good choice for detection of infection in upper respiratory tract where Ferdous *et al.,* (2023) reported that the frequency of isolation of an organism from oropharyngeal swab were 10 % higher than that of the same organism from the tracheal swab.

In the current study, the prevalence of *E. coli* and *Staph. aureus* in the oropharyngeal samples was (21.43%) and (7.14%) respectively and (5.88%) as a mixed infection of both. Lower rate is recorded by Medani (2004) who isolated *E. coli* at rate of (17 %) and (3 %) for *Staph. aureus* from zoo birds. Higher rate of *E. coli* infection; 43% and 42 % is recorded by Ferdous *et al.,* (2023) and Mahmoud *et al.,* (2022), respectively. Higher isolation rate of *Staph. aureus* (31%) is reported by Abdullahi *et al.,* (2023) in storks while a nearly similar rate of isolation (8.3%) is reported by Ruiz-Ripa *et al.,* (2020) in different wild birds.

The variation in isolation rates between the current study and the other studies may be related to the type of environment in which the falcons were raised as well as the difference between falcons raised in captivity and those raised in the wild, where Grieves *et al.*, (2022) reported that the microbial diversity in captive birds was higher than that of free-living birds.

Regarding to the difference in the isolation rate of bacteria between the different species of falcon, the current study reported that, Saker falcon had the highest rate of isolation of *E. coli* from the fecal samples while Gyrfalcon had the highest rate from oropharyngeal samples. Peregrine falcon is the only species from the examined falcons that showed infection with *staph aureus* in both the fecal and oropharyngeal samples and, the only species that show mixed infection of *E. coli* and *staph. aureus* in both types of samples.

The wide variety of infection in peregrine falcon in both fecal and oropharyngeal samples may return to its widespread around the world (Pyzik *et al.*, 2021), its close contact to the urbane environment and livestock (Palmgren *et al.*, 2004) and it is considered as the most preferable falcon for falconry (White *et al.*, 2020).

In the current study, 6 different serotypes of *E. coli* belonged to 4 pathogenic strains were detected; 1 from fecal samples O55: H7 EHEC in peregrine falcon, 3 from oropharyngeal samples O103: H2 EHEC, O17: H18 EPEC in peregrine falcon and O159 EIEC in Gyrfalcon and 2 from both fecal and oropharyngeal samples O78 ETEC and O126: H21 EPEC in peregrine falcon.

Caution should be taken for falcon's handler due to the zoonotic nature of *E. coli* where *E. coli* O55:H7 is important pathogenic type causing serious diseases in humans (Nataro and Kaper, 1998), *E. coli* O103:H2 can cause severe diarrheal infections in human (Heinikainen *et al.*, 2007), *E. coli* O17: H18 was recorded as uropathogenic type or associated with meningitis (Johnson and Russo, 2002). *E. coli* O157:H7 was known for their wide range of clinical symptoms in human, including asymptomatic carriage, non-bloody diarrhea, hemorrhagic colitis, the hemolytic-uremic syndrome, and thrombotic thrombocytopenic purpura (Su and Brandt, 1995) and O126 was previously isolated from sporadic and outbreak cases of infantile diarrhea (Yam *et al.*, 1994). Also, *Staph. aureus* causes illness and mortality worldwide as it led to many kinds of diseases, ranging from minor skin infections to fatal sepsis and pneumonia in human (Ghayyib *et al.*, 2022).

Falcons as birds of prey can carry a wide range of different multidrug-resistant bacteria (Ruiz-Ripa, *et al.*, 2020) and the resistance rates were proven to be higher in isolates from captive birds of prey than other zoo birds (Steger *et al.*, 2020) and that may due to the contamination of the food given to these individuals as day-old chicks, rabbits, and mice (Blanco *et al.*, 2023). Other factors may be the frequent shift of birds between enclosures inside the same facility (Nagai *et al.*, 2019)**.**

Isolates of *E. coli* in the present study showed complete resistance to Cefepime (100%), and highly resistance to Cefazolin (70%), Ampicillin (80%), Amoxycillin (70%) and Sulphamethoxazol (60%). Meanwhile, they were sensitive to Imipenem (90%), Gentamicin (80%), Meropenem (80%) and Amikacin (70%) This result disagreed with Nowaczek *et al.*, (2021) who recorded resistance of *E. coli* to tetracycline (50%), ciprofloxacin (46.8%), gentamicin (34.3%) and ampicillin (28.1%) in free wild bird in Poland. Also, Sigirci *et al.*, (2020) found that most of the isolates were resistant to tetracycline (84%) followed by sulfamethoxazole/trimethoprim (46%), streptomycin (34%), and kanamycin (25%) in companion birds. Our result is agreed with Qurat-ul-Ain (2024) who recorded that isolates of *E. coli* strains from falcons were most susceptible to amikacin.

Regarding *Staph. aureus* in the present study, it showed complete resistance to Cefoxitin (100%), Sulphamethoxazol (100%), Penicillin (100%) and highly resistance to Cefotaxime (75%), Amoxycillin (75%), Ampicillin-Sulboctam (75%) and highly sensitive to Amikacin (75%). Silva *et al.*, (2022) recorded the resistance of *Staph. aureus* isolated from nocturnal birds of prey to penicillin, aminoglycosides, clindamycin and tetracycline. Also, Latif *et al.*, (2024) found that, it was resistance to tetracycline (33.33%), erythromycin (16.66%), and gentamicin (10.00%). In addition to, Royal *et al.*, (2024) declared that *Staph. aureus* isolated from budgerigar and cockatiel were resistant to methicillin (100%), vancomycin (71.43%), cotrimoxazole (85.71%), and tetracycline (71.43%).

Conclusion:

Data in the current study emphasizes the zoonotic nature of *E. Coli* and *Staph. aureus*, which can infect captive falcons and endanger handlers who frequently work with these birds.

Additionally, the study identifies antibiotic resistance, which could compromise the effectiveness of treatment for captive falcons.

Declarations:

Ethical Approval: No experimental animals were used in this study, the study was adapted according to the ethical and humane principles of the Scientific Research Ethics Committee at the Faculty of Veterinary Medicine, Suez Canal University, Ismailia, Egypt. (Approval No**.** 2019072**).**

Competing interests: The authors declare that there is no conflict of interest.

Author's Contributions: Ahmed M. Salah-Eldein designing the study and writing the final manuscript; Mohammed A. Elnoubi: collection of sample and analysis; Gamal G. Medani revised the final manuscript; Nada H. Eidaroos: methodology; Nehal M. Elassy data collection and Enas M. Saad; revising the final manuscript and methodology.

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ARABIC SUMMARY

عزل و مقاومة المضادات الحيوية لبكتيريا الإشريكية القولونية والمكورات العنقودية الذهبية من الصقور المرباة في الأسر

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تهدف الدراسة الحالية إلى التحقق من وجود بكتيريا الإشريكية القولونية والمكورات العنقودية الذهبية في الصقور المرباة في الأسر، بالإضافة إلى الكشف عن الأنماط المصلية المختلفة للعزلات البكتيرية من الإشريكية القولونية .كما تم إجراء اختبار الحساسية للمضادات الحيوية على البكتيريا المعزولة.تم فحص خمسين صقرًا مريضًا من أنواع مختلفة (23 صقر شاهين، 14 صقر الحر، و13 صقر الجير) في المستشفى التخصصي ومعهد الأبحاث التابع لمركز فهد بن سلطان للصقور في الرياض، المملكة العربية السعودية، وكذلك في بعض العيادات البيطرية الخاصة في مصر. تم فحص 34عينة برازية و 28عينة من البلعوم الفموي من الناحية البكتريولوجية للكشف عن وجود الإشريكية القولونية والمكورات العنقودية الذهبية، ثم عمل الاختبارات البيوكيميائية واختبار الحساسية للمضادات الحيوية. بالإضافة إلى ذلك، خضعت العزلات المكتشفة من الإشريكية القولونية لاختبارات مصلية. بشكل عام، تم عزل الإشريكية القولونية بنسبة (11.77%) و (21.43%) من العينات البرازية وعينات البلعوم الفموي على التوالي، بينما تم عزل المكورات العنقودية الذهبية بنسبة (5.88%) و (7.14%) من نفس العينات. كما تم عزل العدوى المختلطة من الإشريكية القولونية والمكورات العنقودية الذهبية من العينات البرازية وعينات البلعوم الفموي بنسبة (2.94%) و (3.57%) على التوالي. تم الكشف عن ستة أنماط مصلية من الإشريكية القولونية وهي:O55:H7 ؛ O103:H2، O17:H18، O126:H21، O78، وO159 . أظهرت عزلات الإشريكية القولونية مقاومة تامة للسيفيبيم ومقاومة عالية للسيفازولين، أمبيسيلين، أموكسيسيلين ، وسلفاميثوكسازول ، بينما كانت حساسة تجاه الجنتاميسين ، ميروبينيم ، أميكاسين، وإيميبينيم. أما المكورات العنقودية الذهبية فقد أظهرت مقاومة كاملة لسيفوكسيتين، سلفاميثوكسازول ، والبنسلين، ومقاومة عالية لسيفوتاكسيم ، أموكسيسيلين، وأمبيسيلين-سلباكتام ، بينما كانت حساسة جدًا تجاه الأميكاسين.