MOLECULAR IDENTIFICATION OF MICROBIAL CONJUNCTIVITIS OF NEONATAL CAMELS AFTER PARTURITION WITH SPECIAL REFERENCE TO NATURAL ANTI-MICROBIAL ACTIVITY

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ABSTRACT

Camels (*Camelus dromedarius*) are the most valuable desert animals in Egypt, survive and health of camel calves is the main aim of breeders.

The studies on microbial conjunctivitis of newborn camel calves after parturition and their relation to vaginal microbes are rare and important to avoid blindness. Fifty pregnant she-camels were noticed till parturition. Vaginal swabs of mother camels and conjunctival swabs of their newborns were taken after parturition. From microbiological examination, several microbes could be isolated as follow; *E. coli, Pseudomonas aeroginosa, Enterobacter* sp., *Proteus* sp., *Staphylococcus epidermidis, Streptococcus* sp., *Corynebacterium* sp., *Bacillus* sp. and *Candida* sp. From vaginal and conjunctival swabs, *E. coli* was the predominant isolates. Molecular identification by PCR was done on selected 3 *E. coli* isolates from conjunctivitis swabs of newborns camel calves. Antimicrobial resistance was found in *E. coli* isolates to common used antibiotics. The mean results of antibiotic sensitivity were cleared. The *E. coli* isolates showed high resistance against 4 of tested 6 antibiotics with percentage of 66.67% which were Amoxicillin, Ampicillin, Tetracycline and Trimethoprim - Sulfamethoxazole. On the other hand, they were sensitive to only Azthromycin with percentage of 16.66% and intermediate to Streptomycin (16.67 %).

The sensitivity to natural anti-microbial activity of marine microalgae (*Nannocloropsis oculata)* was investigated as trial to overcome antimicrobial resistance. Further studies are recommended to develop new veterinary pharmaceutical agents.

Keywords: Camels, Parturition, conjunctivitis, Antimicrobial resistance and microalgae

INTRODUCTION

As Camels (*Camelus dromedarius*) are the most important desert animals in Egypt, survive and health of camel calves is the main aim of breeders. Healthy and bright camel calves' eyes is one of health signs of them. It is very demand to know the microflora of camel calves' eyes (Ali et al., 2010). Recently, microbial populations of camel in health and disease status have been investigated **(**Ramadan, 1994). The normal microbial flora or normal microbiota introduces a main line of resistance against pathogens, performance a responsibility for toxins decomposition in addition to development of immunity. The anatomical body parts always carry a diversity of microorganisms that can be classified into two groups; (l) the resident or inhabitant microflora which composed of certain types of microorganisms commonly present in a certain area at a certain time, and (2) the transient or temporary microflora contains non pathogenic microorganisms or potentially pathogenic microorganisms that inhabit the body area for short times. The transient microflora is

originated from the surroundings, and it does not evoke a disease. However, if the resident microflora is unstable, transient may inhabit, multiply, and make infection as *E. coli* (Brooks et al., 2013). *E. coli* was recorded as the most prominent recovered microorganism from 78 uterine isolates in camels (Mshelia et al., 2014). The ocular surface is visible to a lot of microorganisms from the surrounding environment as dromedary camel (*Camelus dromedaries*) survives in the tremendously severe desert states including a long dry and dusty hot seasons which reflect on body microflora (Chen et al., 2011). By the way, the occurrence of ocular infections in camel is lower than other desert animals (Fahmy et al., 2003), microbial conjunctivitis was observed in camel calves which may reach to about 10% on the opposite of cattle calves which may reach to about 55% due to the eyes of camels are saving from sand and dust by double eyelashes rows and three eye lids on each of both eyes, in addition to the camel tears have some unique constituents that aids in stabilization of antimicrobial film under sever surrounding conditions (Soliman, 1974 and Chen et al., 2011). Therefore, recognizing the relation between vaginal and conjunctival microflora may be useful in finding spreading mechanisms of bacterial mutations (Meekins et al., 2017). On the other hand, the miss uses of veterinary antibiotics medications leads to the antimicrobial resistance phenomenon which are widely distributed (El-Hawy at al., 2022). Consequently, the microflora of the mother camels which subjected to any changes (as acquiring antimicrobial resistance) may lead to reproductive disorders and microbial transmission to neonate (Tibary et al., 2006 and Ali et al., 2010). The antimicrobial resistance phenomenon give a huge force to use natural economic alternatives as marine algae (*Nannocloropsis oculata)* to solve this serious problem (El-Hawy at al., 2022 and Helmy et al., 2023). This work was done to investigate the probability of microflora transmission and infection from mother camels to their newborn calves, observation of antimicrobial resistance and evaluation of *Nannocloropsis oculata* as natural antimicrobial alternative.

MATERIALS AND METHODS

The present investigation was carried on fifty both Sudan mother camels and their newborn calves after parturition at a camel farm with history of veterinary antibiotics miss using in Aswan governorate Egypt.

1. Clinical Examinations and Microbiological Samples

The clinical examinations were carried out on the just delivered she- camels and their newborn calves. The eyes of newborn calves were examined at day light for presence of ocular discharge, congestion, conjunctiva swellings, conjunctivitis and eye lid lesions. Vaginal and conjunctiva microbiological samples were taken by long and sterile swabs from mothers and their newborn calves respectively. The samples were sent as soon as possible to the veterinary microbiological lab in Desert Research Center, Cairo, Egypt.

2. Microbiological Examinations

The samples were examined microbiologically as they were gathered and brought immediately to the laboratory within ice box and ice bag. For bacterial examination; genital and conjunctival cotton swabs under sterile state were inserted into bacteriological nutrient broth (Oxoid, UK) and kept warm at 37C^{o} for 24 hour and then recaptured onto the another media; 5 % sheep blood agar (Oxoid, UK) and MacConkey agar (Oxoid, UK) at 37C^{o} for 24 hour. The yielded bacterial colonies were identified according to Quinn et al. (2011). Then the purified ones were underwent examination by VITEK system (bioMérieux, Marcy l'Etoile, France) for complete biochemical identification. Trials to isolate mycoplasmas by general cultivation technique using PPLO medium with supplements (Oxoid, UK) described by Tully (2012). For mycological examination; the swabs were cultivated onto duplicate sets of Sabouraud's dextrose agar plates with antibiotics, one plate was kept at room temperature (22-25°C) and another was incubated at 37°C. The plate which had no growth was discarded after 7 days of incubation. The obtained fungal isolates were identified according to Barrow et al. (1993).

3.Molecular Identification by PCR

Extraction of DNA: DNA extractions from selected cultured *E. coli* colonies were performed by QIAamp DNA Mini kit (Qiagen, Germany, GmbH) with adjustments. Concisely, 200 µl of the bacterial sample was kept with 10 µl of Proteinase K and 200 µl of lysis buffer at 56^{O}C for 10 min. After that, 200 µl of 99% concentrated ethanol was added. Then the extracted DNA was washed and centrifuged following the manufacturer's suggestions. DNA was eluted with 100 µl of elution buffer.

Oligonucleotide primers: Primers used were provided by Metabion (Germany) are listed in Table (1) which are species specific to detect the presence of *phoA* gene responsible for Bacterial Alkline Phosphatase (BAP) in all *E. coli*.

Protocol for amplification of PCR: Primers were used in a 25- µl reaction containing 12.5 µl of Emerald Amp Max PCR Master Mix (Takara, Japan), 1 µl of each primer of 20 pmol concentrations, 5.5 µl of purified water for PCR, and 5 µl of DNA template of samples and control positive. The reaction was completed in an Applied biosystems 2720 thermal cycler.

PCR products analysis: The yields of PCR were detached by electrophoresis on 1.5% agarose gel (Applichem, Germany, GmbH) in 1x TBE buffer at room temperature using gradients of 5V/cm. For gel analysis, 15 µl of the yields was filled in each gel slot. A gene ruler 100 bp ladder (Fermentas, Germany). The records were analyzed through computer software. A PCR reaction was considered to be *positive* when a band of correct size at 720 bp.

4. Antimicrobial Susceptibility Test

The antimicrobial susceptibility was done through disk diffusion test, using six standard antimicrobial discs (Oxoid) to investigate the antimicrobial resistance of *E. coli* isolates (6 isolates; 3 from conjunctivitis samples of newborn calves and 3 from their mothers camels), they were Amoxicillin (30 mcg), Streptomycin (10 mcg) , Ampicillin (30 mcg), Azthrothromycin (5 mcg), Co-trimoxazole (25 mcg), Tetracycline (30 mcg), Standard inoculum was prepared with sterile nutrient broth (density 0.5 McFerland), Muller Hinton agar (Oxoid) plate was inoculated with even distribution of the *E. coli* suspension all over the plate. The antimicrobial discs were applied onto the surface of tested plate then kept at 37°C for 24 hours. The average degree of susceptibility was determined and interpreted according to the CLSI standard (CLSI, 2020).

5. Extraction and Antimicrobial Activity of Marine Microalgae (*Nannoclorpsis oculata*)

The natural marine microalgae antimicrobial alternative; *Nannochloropsis oculata* was gained from Algal Biotechnology Unit, National Research Centre, Egypt. Microalgae extraction was prepared by absolute ethanol as 50g of algal powder in 250 ml solvent for 24 hrs. Then the mixture was filtered and concentrated under reduced pressure using rotary evaporator. Dried residue was re- liquefied by DMSO in concentration of 10 mg / ml and preserved at 5 ^{O}C until use. The petri plates containing 20 ml of Muller Hinton Agar medium were cultivated with 24 hour fresh culture of *E. coli* isolates. The wells (6 mm in diameter) were cut from the agar and the extract solution (10 mg/ml) was then added into it. The diameter of the inhibition zone was measured on millimeters (mm). 10 µg/ ml of ampicillin served as control. Also, combination with Amoxicillin disc (30 mcg) was prepared (Alagesaboopathi and Kalaiselvi, 2012).

6. Statistical Analysis

The results were presented as percentages. Percentages were statistically analyzed using the Excel software version 2010.

RESULTS

1. Clinical Findings

From clinical examinations of mother camels under this study with history of veterinary antibiotics misuse and overuse, no inflammation or affection was observed on the genital tract

but there were three bilateral conjunctival swellings, ocular discharge and conjunctivitis in newborn camel calves.

2. Bacteriological Findings

After parturition, mother camels and their offspring (n=50) were sampled All animals were deemed free of disease signs except 3 newborn camel calves suffered from signs of conjunctivitis. From microbiological examination, several microbes could be isolated as follow; *E. coli, Pseudomonas aeroginosa, Enterobacter* sp., *Proteus* spp., *Staphylococcus epidermidis, Streptococcus* sp., *Corynebacterium* sp., *Bacillus* sp. and *Candida* sp. could be isolated as described in Table (2). Not only *E. coli* was the highest recovery rate 36% from both mother camels and their newborn camel calves, but also it was isolated from 3 conjunctivitis samples of newborn camel calves. The lowest recovery rate of vaginal swabs is *Streptococcus* sp. 6% and *Candida* sp. 2% from conjunctival swabs. Although, five bacterial genera (Proteus sp. (vaginal samples only), *Enterobacter* sp. (vaginal samples only), *Corynebacterium* spp (conjunctival samples only) and *Bacillus* sp. (conjunctival samples only) were not present in the both, the statistical analysis indicated isolates could be moderately correlated between mothers' vaginal isolates and their conjunctival isolates of their newborn camel calves. For *Mycoplasma* isolation, it was recovered neither from mothers nor from their offspring.

3. Molecular Identification by PCR.

The three *E. coli* isolated from conjunctivitis were positively confirmed by PCR (Photo (1)) using species specific primer targeted to *phoA* gene which code for Bacterial Alkaline Phosphatase (BAP).

4. In vitro Antimicrobial Susceptibility Test.

With Table (3), the mean results of antibiotic sensitivity were cleared. The *E. coli* isolates showed high resistance against 4 of tested 6 antibiotics with percentage of 66.67% which were Amoxicillin, Ampicillin, Tetracycline and Trimethoprim - Sulfamethoxazole. On the other hand, they were sensitive to only Azthromycin with percentage of 16.66% and intermediate to Streptomycin (16.67 %).

4. Anti Microbial Activity of Natural Marine Microalgae Extract.

The results demonstrated the anti *E. coli* (6 isolates) activity of *Nannochloropsis oculata* algae ethanolic extract as obtained in Table (3), showed the intermediate sensitivity of *E coli* isolates to the ethanolic extract when tested alone but when combination with amoxicillin disc, the sensitivity of isolates increased.

DISCUSSION

Camels are considered the valuable food security animal especially under recent climate change conditions. Hence, many veterinary works are needed as routine diagnosis, control, prevention and treatment of emerging diseases and resistant pathogens with recent techniques and approaches to maintain this animal in good health status (Al Jassim and Veerasamy, 2015).

From clinical examinations of fifty mother camels in a farm which had a history of veterinary antibiotics misuse and overuse. This bad habit of owners is the main driver to development of antimicrobial resistance and spreading of these pathogens through generations (Bengtsson and Greko, 2014). No inflammation or affections was observed on the genital tract during parturitions, but there were three bilateral conjunctival swellings, ocular discharge and conjunctivitis in newborn camel calves.

After parturition, mother camels and their offspring (n=50) were sampled. All animals were deemed free of disease signs except 3 newborn camel calves suffered from signs of conjunctivitis. From microbiological examination, several microbes could be isolated as follow; *E. coli, Pseudomonas aeroginosa, Enterobacter* sp,, *Proteus* sp., *Staphylococcus epidermidis, Streptococcus* sp., *Corynaebacterium* sp., *Bacillus* sp. and *Candida* sp. could be

isolated as described in Table (2). Not only *E. coli* was the highest recovery rate 36% from both mother camels and their newborn camel calves, but also it was isolated from 3 conjunctivitis samples of newborn camel calves. This observation is agree with Peters (2001) who showed that *E. coli* is the most bacterial isolates from genital tract of mother and eye of their newborn.

In this study, *E. coli* was identified as the highest bacteria in the eye swabs of camel calves and vaginal swabs from the same herd. For conjunctival samples, it is agree with Seham and Mohammed (1995), who studied infectious keratoconjunctivitis in dairy calves. As they worked on thirty swabs which were collected from infected eyes of calves and were examined bacteriologically; *E. coli* was the predominant and isolated from 14 cases. About vaginal swabs, the same result was obtained by Mshelia et al. (2014) who reported that *E. coli* was the most prominent recovered microorganism from 78 uterine isolates in camels**.** Recently *E. coli* was isolated from one humped camels with uterine purulent secretions (Arthur et al., 2000 and Ali et al., 2010). The vaginal isolates observed in the present study are similar to those observed by Yagoub (2005) who reported that, *E. coli, S. aureus, Klebsiella* sp., *Proteus* sp., *Corynebacterium* sp. and *Streptococcus* sp. are the main bacterial isolates from genital tract in she-camels. The highest isolation rate of the current findings was *E. coli* which indicates the role of this microorganism in inducing disease under stress conditions. Mostly the pre-breeding and peri-parturient phases are recognized as the furthermost serious for bacterial infection of the genital tract. This is because of the hormonal fluctuations that causing the genital tract vulnerable for ascending infections with local bacteria inhabiting the vagina (Singh et al., 2008). Throughout these times, the vagina is constantly being polluted with bacteria from the surroundings especially from fecal matter that spread the vagina during breeding periods. Also, other male genital microbiota is presented into the vagina which can lead to genital tract infection (Singh et al., 2008; Tibary and Anouassi 2001). In addition to, the immediate time post partum the cervix is dilated which allows bacteria to ascend into the female genital tract post partum (Sheldon and Dobson 2004 and Sheldon et al., 2006). The conjunctival microbiological results were nearly the same obtained by Fahmy et al. (2003). Dystocia is predisposing factor to genital tract infection and mastitis which reflect on eye infection of neonates (Qureshi et al., 2002 and Purohit et al., 2011). The three *E. coli* isolated from conjunctivitis were positively confirmed by PCR (Photo (1)) using species specific primer targeted to *phoA* gene which code for Bacterial Alkaline Phosphatase (BAP). All *E. coli* strains have been shown to produce BAP, which can be used as a marker for the detection of these strains (Denamur, 2021). The lowest recovery rates were *Streptococcus* sp. 6% of vaginal swabs and *Candida* sp. 2% from conjunctival swabs but occurrence of the yeast *Candida* sp. was common in vaginal site with recovery rate of 24% which nearly the same result obtained by Fayez et al.(2022) who mentioned that Candida is common in female genital tract and less common in eyes.

Although, five bacterial genera (*Proteus* sp. (vaginal samples only), *Enterobacter* sp. (vaginal samples only), *Corynebacterium* sp. (conjunctival samples only) and *Bacillus* sp. (conjunctival samples only) were not present in the both, the statistical analysis indicated isolates could be moderately correlated between mothers' vaginal isolates and conjunctival isolates of their newborn camel calves. the same findings were recorded by Meekins et al. (2017) but they recorded that the highest recovery rates were *Staphylococcus* and *Streptococcus* sp. On the opposite of this study which may differ due to differences in geographical locations, seasons, animal breeds and sampling performance.

For *Mycoplasma* isolation, it was recovered neither from mothers nor from their offspring which go hand to hand with observations of Mahmoud et al. (2019) who stated that the prevalence of mycoplasmosis in camel was higher in old male camel.

The mean results of antibiotic sensitivity were cleared. The *E. coli* isolates showed high resistance against 4 of tested 6 antibiotics with percentage of 66.67% which were Amoxicillin, Ampicillin, Tetracycline and Trimethoprim - Sulfamethoxazole. On the other hand, they were sensitive to only Azthromycin with percentage of 16.66% and intermediate to Streptomycin (16.67 %) which is in agreement with WHO (2017) which considered *E. coli* is the third type of bacterial rank that easily acquires antimicrobial resistance (AMR).

The significant increase of *E. coli* isolates which show some resistance to common antibiotic especially Tetracycline has great important finding as this indicates introduction to inflammation either in genital tract or conjunctival infection of their offspring (Golińska *et al.*, 2021). The resistant Enterobacteriaecae were recorded recently under desert conditions in Egypt (Wassif and El Kattan, 2015). Seeking for natural alternatives is mandatory. Consequently, sensitivity test was done to investigate the role natural algeal extract (*Nannocloropsis oculata*) as natural antibacterial agent against resistant camel *E. coli* isolates. The obtained results agree with that obtained by Kokou et al. (2011) as *Nannocloropsis oculata* has advantages of keep bacterial flora healthy which can be used as local applicant in the future after further studies. Although *Nannocloropsis oculata* as micro algae is considered intermediat natural inhibitor in this study to camel isolates *E. coli*, but it was proven to has synergistic action when mixed with Amoxacilline disc (In vitro)and the isolates became sensitive to this combination. Further studies are recommended to develop new veterinary pharmaceutical agents.

CONCLUSION

From obtained results, it was clear the role of microflora transmitting antimicrobial resistant bacteria as *E. coli* from mothers' camels' vagina to newborn calves and inducing disease. Also, using natural alternatives marine microalgae *Nannocloropsis oculata* as antimicrobial has a great promise to over come antimicrobial resistance (AMR). These findings need further investigation to confirm these results.

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Table (1). Primers sequences and detailed PCR conditions.

Target agent	Target gene	Primers sequences	Amplified segment (bp)	Amplification (35 cycles)					Final exten.	Ref.
				Prim Den.	Sec den	An	Ext.			
E. coli	*phoA*	CGATTCTGGAAATGGCAAAAG CGTGATCAGCGGTGACTATGAC	720	94˚C 5 min	94˚C 30 sec.	55˚C 40 sec.	72˚C 45 sec.		72˚C 10 min.	Hu et al., 2011

Table (2). Recovery rate of microbial isolated from vaginal swabs of mother camels and Conjunctival swabs of newborn camel calves after parturition either mixed or single microorganisms.

Isolated microorgnisms	Vaginal swabs of mother camels (50)		Conjunctival swabs of newborn camel calves after parturition (50)	
	No	%	No	%
E. coli	18	36	18	36
Pseudomonas aeroginosa	14	28	12	24
Enterobacter sp,	8	16	-	-
Proteus sp.	5	10	-	-
Staphylococcus epidermidis	7	14	5	10

Streptococcus sp.	3	6	3	6
Corynaebacterium sp.	-	-	5	10
Bacillus sp.	-	-	6	12
Mycoplasma spp.	-	-	-	-
Candida spp	12	24	1	2

Recovery rate is calculated according to total number of vaginal and conjunctival samples (50 samples for each).

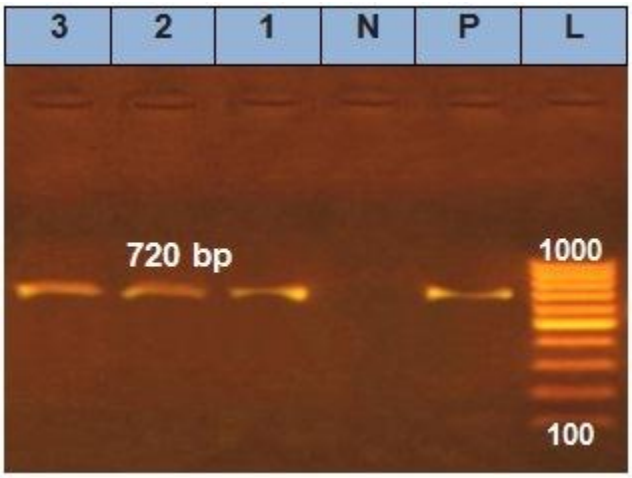

Photo (1). PCR confirmation of three neonate conjunctival isolates.

Table (3). The zone of inhibition (mm) of *E. coli* against antimicrobial agent.

Antimicrobial agent	Concentration in the disk (mcg)	Mean zone of inhibition (mm)	Interpretation of results (CLSI standard)			Interpret.
			Resistant	Intermediate	Susceptible	
Amoxicillin	30	15.00 ± 0.894	≤13	14-17	≥18	R
Streptomycin	10	13.83 ± 0.753	≤12	13-14	≥15	I
Ampicillin	30	12.33 ± 0.816	≤13	14-16	≥17	R
Azthromycin	5	13.50 ± 0.837	≤12	--	≥13	S
Trimethoprim+ Sulfamethoxazole	1.25/ 23.75	7.00 ± 0.632	≤10	11-15	≥16	R
Tetracycline	30	4.83 ± 0.753	≤11	12-14	≥15	R
Nannocloropsis extract	10 mg/ ml	12.33 ± 1.033	≤11	12-14	≥15	I
Nannocloropsis extract + Amoxacillin	10 mg /ml + 30mcg	19.50 ± 1.049	≤16	17-18	≥19	S

R = resistant I= Intermediate S = sensitive

التصنيف الجزيئي لميكروبات التهاب الملتحمة لمواليد الابل بعد الولادة مع الإشارة لنشاط المضادات الميكروبية الطبيعية

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الملخص العربي

تعتبر الإبل وحيدة السنام من أهم الحيوانات الصحراوية في مصر وثروة مهمة لقاطني المناطق الصحراوية والهدف الرئيسي لمربي الإبل هو الحفاظ على هذه الابل من الامراض التي تؤثر على كفاءتها الانتاجية. وتعتبر الحيران الوليدة هي الثمرة التي ينتظرها المربي بعد مرور عام من الحمل والحفاظ عليها من اي ضر يؤثر عليها وخصوصا العيون لما لها من دور مهم جدا في حياة الابل وعند الاصابة باحد المسببات المرضية فى العين واهمل في علاجها قد يصل المرض الى احداث العمى وفقدان البصر وبالتالي فانه من المهم جدًا معرفة التجمعات الميكروبية في عيون مواليد الإبل وعلاقتها بالميكروبات المهبلية للامهات حيث إن الدراسات حول التهاب الملتحمة الجرثومي لحيران الابل بعد الولادة نادرة.

وقد تم متابعة خمسون ناقة حامل حتى الولادة. تم أخذ مسحات من المهبل من الامهات بعد الولادة ومسحات ملتحمة العين لحديثي الولادة. من خلال الفحص الميكروبيولوجي ، امكن عزل العديد من الميكروبات على *النحو التالي ؛ E. coli ،Pseudomonas aeroginosa ،Enterobacter* sp. ،*Proteus* sp. ،*Staphylococcus epidermidis ،Streptococcus spp. ،Corynebacterium sp. ،Bacillus* sp. *Candida* sp

واتضح من خلال النتائج ان البكتريا الإشريكية القولونية هي السائدة. تم التعرف الجزيئي بواسطة تفاعل البلمرة المنسلسل على 3 عزلات من الإشريكية القولونية المأخوذة من مسحات التهاب الملتحمة لقعدان الإبل حديثي الولادة. كما وجدت مقاومة مضادات الميكروبات في عزلات الإشريكية القولونية للمضادات الحيوية الشائعة الاستخدام. وأظهرت عزلات الإشريكية القولونية مقاومة عالية ضد 4 من 6 مضادات حيوية مختبرة وهي أموكسيسيلين ، أمبيسلين ، تتراسيكلين وتريميثوبريم - سلفاميثوكسازول. من ناحية أخرى ، كانوا حساسين للأزثروميسين فقط وحساسية وسيطة اللستربتومايسين.

كما تم فحص النشاط الطبيعي المضاد للميكروبات من مستخلص الطحالب البحرية (*النانوكلوروبسيس اوكيولاته*) (*Nannocloropsis oculata*) كتجربة معملية للتغلب على مقاومة مضادات الميكروبات الكيميائية والتي لها ايضا اثرضارعلى صحة الانسان والحيوان.

على الرغم من أن طحلب *النانوكلوروبسيس اوكيولاته* *Nannocloropsis oculata* له تاثيرات متوسطة عندما يكون منفردا ضد عزلات الإبل من الايشريشيا القولونية ، إلا أنه ثبت أن له تأثيرًا تآزريًا عند مزجه مع قرص الاموكساسلين Amoxacilline (في المختبر) وأصبحت العزلات حساسة لهذه المجموعة. ونوصى بإجراء مزيد من الدراسات لاكتشاف تركيبات صيدلانية بيطرية جديدة من هذا الطحلب.

الكلمات الدالة: حيران الإبل ، التهاب ملتحمة العين، مستخلص الطحالب البحرية ، مقاومة المضادات الحيوية.