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BACTERIOLOGICAL STUDIES AND BIOCHEMICAL PARAMETERS OF RESPIRATORY INFECTION IN OSTRICHES

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SUMMARY

A total of 40 (20 from each) diseased and apparently healthy ostriches were examined. The age of examined birds ranged between 3-12 months were suffering from respiratory diseases. Samples were collected from private farms in El-Wady El-Gadid and Alexandria Governorates. The most prevalent bacteria were *E. coli* (53.33%) followed by *S. aureus* (30%), *P. aeruginosa* (21.66%), *P. haemolytica* (20.83%), Micrococcus spp. (18.33%), K. pneumoniae (16.66%), *S. pneumoniae* (15.83%), *P. mirabilis* (15%), while *A. pyogenes* (14.16%), *P. multocida* and *C. freundii* (7.50%), other bacterial pathogens isolated in low rates were non haemolytic streptococci, *Corynebacterium haemolytica*, *P. vuglaris* and *K. oxytoca*. The most predominant *E. coli* serogroups were: O1, O6, O18, O25, O26, O44, O55, O78, O86, O114, O119, O125, O142, O152, O157 and five strains were serologically untyped, meanwhile serogrouping of *P. aeruginosa* revealed "9" different "O" serogroups which were (A.B.F.I.H.J.K.L.N.). Whereas antibodies of *M. gallisepticum* were detected in sera of three diseased ostriches.

Antibiograms were done on the most predominant isolates. Infected ostriches showed significant increase in some haematological values (MCV, MCH, total leucocytes, lymphocytes and monocytes), but RBCs, PCV and Hb% were decreased. A marked elevation in serum levels of total protein, globulin, AST, ALT, K, calcium and magnesium were recorded.

INTRODUCTION

The ostrich (Struthio camelus) is a commercially

raised species that originated in Africa. The ostriches industry is transition form a breeder and a progeny to a production phase. During the production of breeding stock for foundation flocks, ostrich farmers experienced many problems associated a new agribusiness. During this time, the various husbandry conditions and exposure of immature ostriches to other animal species under confinement auctions and changes of ownership create stress and expose ostriches to microbial pathogens, some of them were pathogenic but others innocuous to ostriches but potentially pathogenic to other species including human being (Cadman et al., 1994 and Kelly et al., 1996). They can also be carriers of zoonotic diseases usually related to mammals e.g. wesselsbron disease (Allwright, 1996) and Crimean, Congo haemorrhagic fever (Swanepoel et al., 1998).

Respiratory diseases cause great economic losses in ostriches, not only due to high mortality and morbidity rates but also to poor food conversion rates and decrease in egg production and hatchability (Dho and Lafont, 1984).

Bacterial pneumonia is an important cause of morbidity in ostriches, most isolated bacterial pathogens are *Escherichia coli*. *Pseudomonas aeruginosa* infections are important because ostrich strains were resistant to many antibiotics as is commonly noted with mammalian isolates of *Pseudomonas aeruginosa* (Welsh et al., 1997).

Mycoplasma is of considerable economic importance since it plays a part in the respiratory disease complex. Cadman et al. (1994) reported that antibodies to *M. gallisepticum* and/or *M. synoviae* have been documented in an incidence of 11% from ostriches in Zimbabwe.

The presents study was planned to investigate the various bacterial infections incriminated in respiratory infections of ostriches. Serological identification of the most prevalent isolates, studying the effect of different chemotherapeutic agents on the isolates as well as to study the influence of the isolated organisms causing respiratory affections on the blood picture, protein, some enzymes and minerals in serum of diseased ostriches.

MATERIAL AND METHODS

I. Sample collection:-

Blood samples were collected from 20 apparently healthy and 20 diseased ostriches suffering form respiratory manifestations (sneezing, nasal discharge, ruffling). The age of these ostriches ranged between 3-12 months. Samples were collected form private farms in El-Wady El-Gadid and Alexandria Governorates. One portion of blood was allowed to clot at room temperature and then centrifuged for 10 minutes at 3000 X g, sera were separated and stored at -20°C for bacteriological study and determination of some parameters. Another portion of blood was mixed

with EDTA as anticoagulant for hemograms (Schalm et al., 1975).

Samples from organs and nasal swabs:- Samples were collected from healthy birds after slaughter, as well as from diseased birds, which were suffering from depression, ruffled feather, inappetance and respiratory signs (tracheal rales, nasal discharge, severe sinusitis, sneezing and cough). Post-mortem examination showed petechial haemorrhages on the heart, liver, spleen and kidneys, severe tarcheitis, congestion of trachea with bloody exudates in the tracheal lumens and pulmonary inflammation, yellowish white nodules often accompanied by diphtheritic membrane were found in the pharyngeal, tracheal mucosa and the lungs. Some birds showed enlarged liver and kidneys with focal areas of necrosis.

II. Bacteriological examination:-

Samples from sera were directly cultured onto blood agar and MacConkey agar media. Lungs, liver, kidneys and tracheal contents were directly cultured onto blood agar and MacConkey agar plates, other loopfull was directly transferred to pre-enrichment fluid media i.e. nutrient broth, selenite broth and PPLO broth. Nasal swabs were directly cultured into nutrient broth, all inoculated broth were incubated at 37°C for 24 hours except selenite broth which incubated for 18 hours and then an inoculum was cultivated onto differential selective media including MacConkey agar, SS agar and PPLO agar plates. All inoculated plates were incubated aerobically at 37°C for 24 hours. The suspected colonies were examined morphologically, culturally as well as biochemically as described by Boone and Castenholz (2001).

Serological identification

Serological identification of *Escherichia coli* using O-antisera were employed according to Edwards and Ewing (1972). *Pseudomonas aeruginosa* isolates were serotyped using Pseudomonas antisera according to Homma (1982). All antisera were obtained from Denka Seiken" Laboratory Tokyo, Japan.

For detection of mycoplasma antibodies, Nobilis *Mycoplasma gallisepticum* and *Mycoplasma synoviae* antigens (Intervet) were used.

Antibiogram:

In vitro drug sensitivity test of the most pathogenic bacterial isolates were done against (11) different chemotherapeutic agents as described by Boone and Castenholz (2001).

III. Haematological studies:-

A. Haemoglobin estimation:-

The methods used for determination of Hb was adopted by Denington and Lucas (1955).

B. Erythrocytic and leucocytic count:-

Red and white cells were counted according to Campbell (1988).

C. Differential leucocytic count:-

Thin blood films were prepared and stained with May Grunwold stain and zoo cells were counted (Schalm et al., 1975), the percentage of each type was calculated.

IV. Biochemistry analysis:-

The clear sera from blood samples were used for biochemistry determination of total protein according to Sonnenwirth and Jaret (1980); albumin after Drupt (1974), calcium after Glinder and King (1972); magnesium after Gindler (1971); aspartate aminotransferae activity (AST), alanine aminotransferae activity (ALT), alkaline phosphatase, total protein and creatinine were estimated colorimetrically using (BioMerieux kits), while sodium and potassium were determined using Flame photometer and calculated according to Oser (1979).

V. Statistical analysis:-

Statistical analysis of the obtained data was performed using t-test according to method described by Selvin (1996).

RESULTS

Bacteriological findings of apparently healthy and diseased ostriches revealed different types of microorganisms as shown in tables (1- 3).

Serological typing of (64) strains of *E. coli*, proved to be belonging to 15 different serogroups in addition to 5 strains were untypable as illustrated in table (4). Serological identification of 28 strains of *P. aeruginosa* revealed 9 serogroups.

The results of antibiogram were recorded in table (5). The most isolated pathogens were sensitive to enrofloxacin. While the remaining antibiotics gave variable results.

Blood profile:-

Average values RBCs, Hb, PCV, MCV, MCH and MCHC are shown in Table (6). The data revealed that the respiratory bacterial infection in ostriches resulted in a significant decrease in RBCs, Hb% and PCV, while MCV and MCH values increased. Table (6) showed that the results of total and differential leucocytic count where total leucocytic count, lymphocytes and monocytes were elevated. Meanwhile, neutrophils count decreased in diseased ostriches.

Biochemical parameters:-

The effect of respiratory infections in ostriches on some biochemical parameters in serum compared to apparently healthy ostriches were recorded in table (7) which showed a significant elevation of serum total proteins, globulins, AST, ALT, potassium, calcium and magnesium in diseased ostriches, while values of alkaline phosphatase, total bilirubin, sodium and craetinine did not differ from values of apparently healthy ostriches.

Table (1): Incidence of positive cases yielded bacterial isolates from apparently healthy and diseased ostriches.

Type of examined samples	Apparently healthy			Diseased ostrich			No. of samples yielded mixed bacterial isolates		
	No. of examined samples	No. of positive samples	%*	No. of examined samples	No. of positive samples	%*	Total No.	No. of positive samples	%**
Sera	20	-	-	20	17	85	40	15	37.5
Lungs	20	4	20	20	20	100	40	19	47.5
Trachea	20	4	20	20	20	100	40	11	27.5
Liver	20	2	10	20	17	85	40	17	42.5
Kidneys	20	3	15	20	18	90	40	10	25
Nasal swabs	20	11	55	20	20	100	40	20	50.

* The percentage was calculated according to the total number of samples (20) of each (apparently healthy or diseased ostriches).

** The percentage of mixed bacterial isolates calculated according to the total number of samples (40).

Table (2): Incidence and types of bacterial isolates recovered form apparently healthy ostriches.

Type of microorganisms	Sera		Trachea		Lung		Liver		Kidney		Nasal swabs		Total	%
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%		
A. Gram positive														
1. *S. aureus*	-	-	2	10	2	10	1	5	2	10	2	10	9	7.5
2. *S. epidermidis*	-	-	3	15	2	10	2	10	2	10	4	20	13	10.83
3. Non haemolytic Streptococci	-	-	1	5	-	-	-	-	-	-	-	-	1	0.83
4. Micrococcus spp.	-	-	1	5	-	-	2	10	1	5	-	-	4	3.33
B. Gram negative bacilli														
1. *E. coli*	-	-	4	20	3	15	7	35	6	30	2	10	22	18.33
2. Klebsiella spp.	-	-	1	5	-	-	1	5	1	5	1	5	4	3.33
3. *P. mirabilis*	-	-	2	10	1	5	3	15	3	15	2	10	11	9.17
4. Citrobacter spp.	-	-	1	5	1	5	2	10	-	-	3	15	7	5.83
5. *P. aeruginosa*	-	-	2	10	-	-	-	-	-	-	-	-	2	1.66

Table (3): Incidence and types of bacterial isolates recovered form diseased ostriches.

Type of microorganisms	Sera		Trachea		Lung		Liver		Kidney		Nasal swabs		Total	%
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%		
A. Gram positive														
S. aureus	6	30	7	35	10	50	5	25	3	15	5	25	36	30
S. pneumoniae (Diplococcus)	5	25	6	30	6	30	2	10	-	-	-	-	19	15.83
Actinomyces pyogenes	5	25	-	-	2	10	4	20	6	30	-	-	17	14.16
Micrococcus spp.	4	20	3	15	1	5	5	25	5	25	4	20	22	18.33
Non haemolytic Streptococci	1	5	1	5	-	-	1	5	-	-	1	5	4	3.33
Corynebacterium haemolytica	1	5	-	-	1	5	-	-	-	-	-	-	2	1.66
B. Gram negative bacilli														
E. coli	11	55	9	45	9	45	14	70	11	55	10	50	64	53.33
K.pneumoniae	6	30	2	10	8	40	-	-	2	10	2	10	20	16.66
P. aeruginosa	3	15	7	35	4	20	5	25	1	5	6	30	26	21.66
P. haemolytica	5	25	3	15	6	30	5	25	6	30	-	-	25	20.83
P. mirabilis	3	5	2	10	2	10	7	35	-	-	4	20	18	15
P. vulgaris	1	5	1	5	1	5	-	-	-	-	-	-	3	2.50
C. freundii	1	5	2	10	1	5	1	5	2	10	2	10	9	7.50
K. oxytoca	1	5	1	5	-	-	1	5	3	15	-	-	6	5
P. multocida	4	20	-	-	2	10	3	15	-	-	-	-	9	7.50

Table (4): Serological identification of some pathogenic strains recovered from ostriches.

*Escherichia coli			*Pseudomonas aeruginosa		
Serogroups	No.	%	Serogroups	No.	%
O1	5	7.81	A	4	14.29
O6	7	10.93	B	2	7.14
O18	6	9.38	F	2	7.14
O25	6	9.38	I	2	7.14
O26	5	7.81	H	6	21.43
O44	4	6.25	J	5	17.86
O55	4	6.25	K	3	10.71
O78	2	3.13	L	3	10.71
O86	3	4.69	N	1	3.57
O114	4	6.25			
O119	3	4.69			
O125	4	6.25			
O142	2	3.13			
O152	3	4.69			
O157	1	1.56			
Untyped	5	7.81			
Total	64	100		28	100

N.B. * % calculated according to total number of each examined pathogens isolated from diseased ostriches.

Table (5): The antibiogram of the most pathogenic bacterial isolates recovered form diseased ostriches.

Tested pathogens / Antibiotic discs	*S.aureus*	*S. pneumoniae*	*Actinomyces Pyogenes*	*C. haemolytica*	*Micrococci*	*E. coli*	*K. pneumoniae*	*P. aeruginosa*	*P. haemolytica*	*P. mirabilis*	*P. vulgaris*	*C. freundii*	*K. oxytoca*	*P. multocidia*
Enrofloxacin (10 µg)	SS	SS	S	S	S	SS	SS	SS	S	SS	S	S	S	SS
Neomycin (30 µg)	R	R	S	S	R	SS	S	R	R	S	R	S	S	R
Ampicillin (10 µg)	R	SS	S	S	S	R	R	R	S	R	R	R	R	S
Oxytetracycline (30 µg)	S	SS	R	R	S	R	SS	R	R	R	R	R	S	S
Oxalinic acid (2 µg)	R	S	R	R	R	R	R	R	R	R	S	S	R	R
Chloramphenicol (30 µg)	R	R	R	R	R	S	S	R	R	R	R	R	R	R
Trimethoprim (1.25 µg)	S	S	R	R	S	R	R	R	S	R	R	S	SS	R
Streptomycin (10 µg)	R	S	R	R	R	R	R	R	R	R	R	R	R	R
Cefadroxil (30 µg)	R	S	R	R	S	S	R	R	R	R	R	R	S	R
Gentamicin (10 µg)	SS	SS	S	S	R	S	SS	SS	SS	R	R	S	S	S
Colistin sulphate (50 µg)	R	R	R	R	R	R	R	R	R	S	R	R	R	R
Erythromycin (15 µg)	SS	SS	S	S	R	R	S	R	R	R	R	R	R	R

SS = Highly sensitive S = Sensitive R = resistant

Table (6): Mean values of some parameters in healthy and diseased ostriches (mean ± S.E.).

	RBCs	Hb	PCV	MCV	MCH	MCHC	WBCs	Differential leucocytic count X 10³/ml (%)				
	X 10^6/ml	g/dl	%	Fl	pg	g/dl	X 10^3/ml	Neutro.	Lymph.	Mono.	Eosin.	Baso.
Healthy	5.1 ± 0.16	13.6 ± 0.09	37.4 ± 0.99	73.33 ± 0.08	26.49 ± 0.05	36.0 ± 0.02	6.57 ± 0.34	62.25 ± 0.32	61.85 ± 0.37	2.39 ± 0.14	1.80 ± 0.17	1.00 ± 0.11
Diseased	3.24 ± 0.09*	10.7 ± 0.15*	32.6 ± 0.70*	100.93 ± 0.15*	30.9 ± 0.03*	32.80 ± 0.03	18.08 ± 0.51**	50.22 ± 0.88*	83.1 ± 0.88*	6.55 ± 0.29*	1.05 ± 0.49	2.05 ± 0.20

* Significant at $P < 0.05$

** Highly significant at $P < 0.01$.

Table (7): Mean values of some biochemical parameters in serum samples of healthy and diseased ostriches (mean ± S.E.).

Parameter \ Group	Healthy	Diseased
T.P. (g/dl)	4.88 ± 0.10	7.04 ± 0.09**
Albumin (g/dl)	2.83 ± 0.07	2.05 ± 0.03
Globulins (g/dl)	2.83 ± 0.07	4.22 ± 0.096*
AST (u/l)	126.3 ± 2.39	159.25 ± 0.44*
ALT (u/l)	3.18 ± 0.20	13.35 ± 0.44**
ALP (u/l)	356.4 ± 10.18	364.65 ± 14.11
Total bilirubin (mg/dl)	0.49 ± 0.02	0.56 ± 0.03
Sodium (mmol/L)	140.5 ± 2.05	142.1 ± 0.51
Potassium (mmol/L)	2.89 ± 0.05	4.27 ± 0.12*
Calcium (mg/dl)	12.8 ± 0.9	18.59 ± 0.17*
Magnesium (mg/dl)	2.32 ± 0.05	4.99 ± 0.04*
Creatinine (mg/dl)	0.26 ± 0.02	0.39 ± 0.01

* Significant at $P < 0.05$

** Highly significant at $P < 0.01$.

DISCUSSION

Respiratory disease conditions are responsible for great economic losses in ostrich industry (Barnes and Gross, 1997).

As shown in table (1), 85% of sera from diseased ostriches were positive for known bacterial pathogen also a percent was 20% and 100% from both lungs and trachea, 10%, 85% from liver and 15%, 90% from kidneys whereas 55%, 100% from nasal swabs from apparently healthy and diseased ostriches, respectively, also, the most examined samples of ostriches yielded mixed bacterial isolates.

A variety of Gram positive and Gram negative organisms have been isolated form respiratory diseases in ostriches either in single or mixed forms. These results are in agreement with those reported by Welsh et al. (1997) who reported that more than 23.5% of ostrich lungs were positive for known bacterial pathogens.

Table (3) shows that *E. coli* was the predominant bacteria isolated from diseased ostriches, the rate of its isolation was 53.33%. Followed by *S. aureus* (30%), *P. aeruginosa* (21.66%), *P. haemolytica* (20.83%), Micrococcus spp. (18.33%), *K. pneumoniae* (16.66%), *S. pneumoniae* (15.83%), *P. mirabilis* (15%), while *A. pyogenes* (14.16%), *P. multocida* and *C. freundii* (7.50%) each, other bacterial pathogens isolated in lower percentages were non-haemolytic streptococci, *C. haemolytica*, *P. vulgaris* and *K. oxytoca*. These results agree with those reported by Welsh et al. (1997), Knobl et al. (2001) and Ley et al. (2001) who isolated *E. coli* from 91% of dressed carcasses of ostriches in Ohio and Indiana. Maurer et al. (1998) mentioned that *Escherichia coli* establishes a secondary respiratory tract infection in birds following inhalation of contaminated dust and litter particles, *E.coli* expressed adhesions under conditions reflective of the ambient temperatures present in poultry houses. The microbial adhesions allow *E. coli* attach to cell types in respiratory tract. Moreover, Momotani et al. (1995) isolated *P. aeruginosa* from ostriches showing respiratory symptoms and at necropsy yellowish white nodules, often accompanied by pseudodiphtheritic membranes were found in oral, pharyngeal, tracheal and air sac mucosa in the lungs, oesphageal serosa and abdominal peritoneum. Pandey et al. (2001) reported a case of pneumonitis, caused by *P. aeruginosa* in adult male ostrich in Zambia. The bird had severe greenish diarrhoea, fever, convulsion, respiratory distress and dehydration, Nakamura et al. (1997) isolated *E. coli* and *S. aureus* from broilers showing symptoms of upper respiratory lesions. The isolation of different types of bacteria confirmed with those reported by Welsh et al. (1997) who isolated different types of bacteria from respiratory samples from ratite mainly *K. pneumoniae* (2.3%), Klebsiella spp. (1.1%), *Pseudomonas* spp. (0.8%), and Staphylococcus spp. (0.6%).

Youseif et al. (2001) isolated *P. haemolytica* from diseased ostriches in Egypt aged 2.5-3 month old suffering form 33% mortality. Furthermore, Abdel-Aziz (2000) isolated *P. haemolytica* from trachea, liver and lungs of dead broiler and layer chickens.

In the present study, there was no isolation of *M. gallisepticum* or synoviae isolates form infected lungs but antibodies of *M. gallisepticum* was detected in the sera of 3 ostriches. These results coincide with that reported by Cadman et al. (1994) who detected antibodies of *Mycoplasma gallisepticum* and/or *M. synoviae* from ostriches in Zimbabwe. Also, Verwoerd (2000) mentioned that *Mycoplasma* spp. were regularly found in upper respiratory disease syndrome complicated by opportunistic bacterial pathogens mainly *P. multocida* in ostriches. Otherwise, our results were in contrast with those reported by Tully and Shane (1996) who reported that it was more effective to culture mycoplasma from ostriches than to detect it serologically. Also, Ley et al. (2000) who reported that none of the ostriches had antibodies against *M. synoviae* or *M. gallisepticum*.

Serological study for some pathogens isolated from diseased ostriches. Table (4) revealed that 15 different serogroups of *E. coli* were O1, O6, O18, O25, O26, O44, O55, O78, O86, O114, O119, O125, O142, O152, O157 and 5 strains were untyped. These results agree with those reported by Knoble et al. (2001) who isolated *E. coli* from ostriches with respiratory disease and in serogrouping of eight *Escherichia coli* revealed that four isolates belonged to serogrouping O2, two to serogroup O78, one to serogroup O9. There were risk in reference of serology of *E. coli* in ostriches but no hazards in similar studies in chickens were observed. Kumar et al. (1996) mentioned that *E. coli* O75, O78, O88, O112 and O148 were more pathogenic when injected intraperitoneally and birds showed respiratory distress. Sanjiv-Kumar et al (1996) serotyped *E. coli* from chickens which were belonged to 12 serotypes namely: O18, O45, O73, O75, O78, O84, O88; O103, O112, O128, O147 and O148.

In the present work, serogroups of *P. aeruginosa* isolated from diseased ostriches were belonging to (A, B, F, I, H, J, K, L, N.) as shown in table (4). Similar study in turkeys was done by Ali (1999) revealed that "0" serogroups of *P. aeruginosa* (K.M.J.G.) from turkey embryos and turkeys poults.

It is clear that, there was a marked difference between the sensitivity of bacterial pathogens against different chemotherapeutic agents (Table 5) where the most isolated pathogens were sensitive to enrofloxacin also all tested isolates except Micrococcus, *Proteus mirabilis* and Proteus vulgaris were sensitive to gentamicin while variable results were recorded with the maining antiboiotics. These results were in agreement with those

reported by Summano et al. (1998) who used enrofloxacin in treatment of broiler naturally infected with *Mycoplasma gallisepticum* and *Escherichia coli*. Also, Ali (1999) reported that *P. aeruginosa* strains were sensitive to enrofloxacin and gentamicin. Furthermore, Welsh et al. (1997) stated that amikacin, fluoroquinolones and enrofloxacin would be of the first choice to treat Gram negative bacilli isolated from diseased ratites especially *E. coli* and *K. pneumoniae*, whereas amoxicillin would be a good choice to fight most Gram positive bacteria especially Staphylococcus spp. Ley et al. (2001) in antimicrobial susceptibility test on *E. coli* isolated from ostriches showed resistance to erythromycin, neomycin, oxytetracycline and streptomycin.

Haematology has been used as a tool for the evaluation of the health status of sick birds (Coles, 1986) and helps in the diagnosis of some infectious diseases. The morphological characteristics of ostrich blood cells are nearly similar to those described in any other bird species (Bannett et al., 1992). This fact helps in the analysis of the obtained results because there is a lack of basic informations with regard to the relation between abnormal health entities and the haematological changes observed in ostriches (Fudge, 1996 and Robertson and Maxwell, 1996).

The results of erythrogram showed significant decrease in total erythrocytic count, haemoglobin concentration and packed cell volume, while the leukogram showed significant elevation in total leukocytic count, lymphocytes and monocytes, but neutrophils count decreased. These findings are found to be in accordance with those reported by Randa Hassan (1996) and Mendez et al. (2000) who found that *P. multocida* infection in turkeys, chickens and hens cause drop in RBCs count, Hb, PCV values and heteropeñia. Also, Gupta et al. (1988) and Kumar et al. (1995) recorded that pleuropneumonia due to mycoplasmas caused significant decrease in the total erythrocytes, Hb and PCV values, while neutrophils, monocytes counts were elevated. Jain (1993) mentioned that leucocytosis generally characterizes the bacterial infection as a defense mechanism and Fadel (2000) attributed the haematological changes which occur in case of infection with *P. aeruginosa*, Corynebacterium and *S. pneumoniae* due to circulated bacterial toxins and decrease capacity of lung aeriation. On the other hand, Rose et al. (1988) found that I/V inoculation of *P. multocida* in turkeys produced significant increase in neutrophils whereas the percentage of lymphocytes and monocytes were significantly decreased.

Concerning the results which reflect the effect of respiratory infections on some biochemical parameters in serum of ostriches, there was a significant increase in the level of total protein, globulins, liver enzymes (except ALP), potassium, calcium and magnesium (Table, 7).

These results were in agreement with those reported by Fadel (2000). Meanwhile, Hochleithner (1994) attributed the increase in the level of immunoglobulins in case of respiratory infections in ostriches to stimulation of the immune system.

The recorded significant elevation in AST and ALT activities agreed with that reported by Coles (1986) who reported that AST activity increased in serum of animals during infection. It was found that measurement of ALT activity is more sensitive marker to liver damage than AST enzyme (Kaneko, 1996). The enzyme is present in high concentration in the cells and it is released to the circulation even under relatively mild liver injury (Sami et al., 1995).

Mineral profile showed significant rise in K, Ca and Mg levels. These finings accentuates the findings of Chang et al. (1988) and Brown and Jones (1996) who pointed out that calcium and magnesium levels increased in respiratory infected birds and this may be explained on the basis that in most chemical determinations, the calcium measured is bound to serum protein, therefore calcium levels will rise in case of rising level of protein.

Regarding to our results, it is concluded that respiratory pathogens were dangerous that might threaten ostrich flocks and need further surveillance of these pathogen in ostriches. Also, antibiotic use must be guided by in vitro susceptibility testing for isolated pathogens. Also, application of comprehensive measures of preventive medicine and biosecurity will reduce the risk of infection.

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