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MINERALS PROFILE, BIOCHEMICAL AND HAEMATOLOGICAL STUDIES ASSOCIATED WITH SOME PARASITIC AFFECTIONS IN FARM HORSES

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SUMMARY

A total of 40 farm horses in a governmental horse farm suffering from intermittent fever, icterus, anorexia, haemoglobinuria and / or oliguria were used to perform clinical and diagnostic studies on equine babesiosis, of which 25 *B. equi* infected horses were used to perform minerals profile, biochemical and haematological studies associated with equine babesiosis. *B. equi* was the only species to be recognized in this study. The morphometric data indicated that the mean length and width of single pear shape babesia was 2.08 and 1.41μ, respectively. Examination of blood films revealed an incidence rate of 87.5% with *B. equi* in horses showing the previous clinical symptoms and a parasitaemia of 0.5-2% infected RBCs with *B. equi*.

Also, a total of 20 *P. equorum* infected foals and 25 strongyle infected horses (*S. vulgaris and Trichonema spp.*) suffering from emaciation, recurrent colic, chronic intermittent diarrhoea and intermittent lameness were used to study changes in serum minerals, biochemical parameters and haematological picture associated with helminths infestations in farm horses.

Concerning the minerals profile, there was significant decrease in the levels of serum sodium, iron, copper, cobalt and zinc, while a significant increase in serum potassium was recorded in *B. equi* infected horses. Also, there was significant decrease in the level of serum calcium, sodium, iron, copper, cobalt and zinc in *P. equorum* infected group. In strongyle infected group, there was significant decrease in serum calcium, inorganic phosphorus, magnesium, sodium, potassium, iron, copper, cobalt and zinc levels.

Regarding the biochemical findings, there was a significant increase in TSP, globulins, bilirubins, ALP, AST, γ-GT and urea levels, while a significant decrease in glucose level was also recorded in *B. equi* infected horses. A significant increase in direct bilirubin, γ-GT and urea levels, while a

significant decrease in ALP, AST and glucose levels were also observed in *P. equorum* infected group. In strongyle infected group, there was significant increase in total protein, globulins, ALP and AST levels, while, a significant decrease was observed in albumin level.

Concerning the haematological picture, significant decrease was observed in RBCs count, Hb content, PCV% and lymphocytes %, while, a significant increase was observed in ESR, total leucocytic count, neutrophils and eosinophils % in B. equi infected horses. In *P. equorum* infected foals, significant decrease was observed in RBCs count, Hb content, PCV % and lymphocytes, while, a significant increase of eosinophils was also reported. In strongyle-infected group, there was significant decrease in RBCs count, Hb content, PCV % and lymphocytes, while significant increase was recorded in ESR, TLC, neutrophils and eosinophils.

Nutrient concentrations in the total diets of horses were analyzed and found to be sufficient according to those suggested by National Research Council (NRC), 1989. Thus, changes in blood constituents will be attributed to the effect of parasites on the host and not due to malnutrition.

INTRODUCTION

Egypt is considered as one of the most famous countries in breeding the world reknowed Arabian horses for both local market, participation in international events as well as exportation (El-Baroudy, 1987).

Equine babesiosis is a tick born intraerythrocytic protozoal disease of horses caused by *Babesia equi* and *Babesia caballi*. The disease is endemic in most tropical and subtropical areas of the world, including Europe, Asia, Africa, America and Australia continents (Barbosa et al., 1995). The mortality rate of untreated cases reached 50% in *Babesia caballi* infection while in case of that of Babesia equi, the animal remained weak for long period after showing acute symptoms of the disease (Friedhoff and Liebisch, 1978). Diagnosis of acute babesiosis in horses is based on clinical symptoms, confirmed by the detection of Babesia parasites in Giemsa stained blood smears. There is no detailed reports about haematological and biochemical response to clinical babesiosis in horses (Schein, 1992).

Strongylosis is one of the most important parasitic diseases affecting equids caused by many nematodes called strongyles (*S. vulgaris* and *Trichonema spp.*) and cause deaths when control measures are neglected. Clinical disease results not only from the presence of adults in the intestine, but also from larval migration in the intestinal wall and circulating system (Radostitis et al., 1994).

In Egypt, ascariasis and strongylosis have recognized as major problems with a serious influence on the development and growth of young horse livestock. They may be the cause of serious troubles in equine breeding, causing wasting and loss of body condition which is manifested by changes in the constituents of blood elements (Hassan, 1993).

There is no reports have been obtained on the effect of strongylosis and parascariasis on minerals profile in farm horses in Egypt, and only a very few reports have discussed the biochemical and haematological response in equines.

Therefore, we present in this study the most important changes in minerals profile, biochemical and haematological picture associated with equine babesiosis, parascariasis and strongylosis in horse farms in Egypt.

MATERIALS ANND METHODS

1. Animals.

A total of 40 farm horses, up to three years age, in a governmental horse farm suffering from intermittent fever, icterus, anorexia, haemoglobinuria and / or oliguria were used to perform clinical and diagnostic studies (using Giemsa-stained smears) on equine babesiosis, of which 25 *B. equi* infected horses were used to perform minerals profile, biochemical and haematological studies associated with equine babesiosis. A total of 20 *P. equorum* infected foals and 25 strongyle infected horses (*S. vulgaris* and / or *Trichonema spp.*) suffering from emaciation, recurrent colic, chronic intermittent diarrhoea and intermittent lameness were used to study changes in serum minerals, biochemical parameters and haematological picture associated with helminths infestation in farm horses. A total of 10 apparently healthy non-infected horses were used as control.

2. Ration.

Ration offered for animals in a governmental horse farm basically included concentrate mixture, crushed corn, barley and wheat bran. Additionally, animals were supplemented with seasonal green fodders essentially Alfa Alfa (green berseem) in winter, besides some cultivated grasses and sweet corn (green maize) in summer. However, roughages (wheat straw) and sodium chloride were also offered. All ration constituents offered to the animals were biochemically analyzed for detailed ingredients percentages as well as the recognized minerals content according to the technique carried out by Association of Official Analytical Chemists (AOAC, 1990).

3. Samples.

1. Anti-coagulated blood samples: used for haematological study.
2. Giemsa-stained blood films (obtained from venous blood): used for differential leucocytic count.
3. Giemsa stained blood films: collected from ear veins for identification of babesia species.
4. Serum samples: used for determination of

serum minerals and performing the biochemical study.

5. Faecal samples: used for parasitological examination.

4. Parasitological examination.

A- Identification of *Babesia species:*

- The Giemsa stained blood films obtained from ear viens were examined for the presence of Babesia species according to Soulsby (1982).
- The recognized *Babesia* species was subjected to morphometric analysis using (VIA-150 Image Marker Measurement system, Boeckeler Instruments).
- The percentage of parasitaemia was estimated according to Parker (1973).

B- Parasitological examination of helminths:

Diagnosis of equine helminths is determined chiefly by the microscopic examination of the worm eggs using concentration flotation, sedimentation and McMaster techniques. Eggs of *P. equorum* are very characteristic and easy to identify. Eggs of Strongyles (*S. vulgaris and Trichonema* spp.) are very similar to one another and differentiation is difficult by accurate measurement and comparison of their morphological properties. The larvae (L3) of these nematodes, obtained after fecal culture are easily distinguishable with the aid of light microscope (Thienpont et al., 1986). The 3rd larval stages of *S. vulgaris* are characterized by presence of 28-32 intestinal cells with well-defined long column shape. *Trichonema* spp. L3 is characterized by presence of 8 rectangular intestinal cells. The larvae of *S. vulgaris* and *Trichonema spp.* are also characterized by long and filamentous tail sheath. Identification of the collected larvae was performed according to "Illustrated keys to Genera and Species of Domestic Equids " by Lichtenfels (1975). Heavily infested horses (EPG ≥ 500) with *P. equorum* and strongyles were used for biochemical, haematological and mineral profile studies.

5. Haematological examination.

Total erythrocytic count (RBCs), total leucocytic count (WBCs), differential leucocytic count (DLC), haemoglobin content (Hb), packed cell volume (PCV) and erythrocyte sedimentation rate (ESR) were done as described by Schalm (1979) and Cheesbrough and McArthur (1980).

6. Minerals profile.

Serum calcium, magnesium, sodium, potassium, iron, copper, cobalt, zinc and manganese were determined using Atomic Absorption Spectrophotometer (Perkin Elmer Mod. 3300, USA) according to the method of Fernandez and Kahn (1971). Inorganic phosphorus was determined according to Goldenberg (1966).

7.Biochemical analysis.

Determination of total serum proteins (TSP) and albumin, total bilirubin, direct bilirubin, alkaline phosphatase (ALP), aspartate amino transferase

(AST), alanine amino transferase (ALT), γ-glytamyl transferase (γ-GT), urea, creatinine, glucose, antistreptolysin O (ASO) and C-reactive protein (CRP) were carried out according to Weichslboum (1946), Perry et al. (1986), Doumas et al. (1987), Kind and Kind (1954), Reitman and Frankel (1957), Persijn (1971), Chaney and Marbach (1962), Artiss et al. (1984), Bonder and Mead (1974), Curtis et al. (1988) and Gosling and Dickson (1992), respectively.

8. Statistical analysis.

Analysis of variance and studentís t-test were used. Differences were considered significant at $P<0.05$ and highly significant at $P<0.01$. Data were expressed as mean ± standard error (Snedecor and Cochran, 1976).

RESULTS

1. Results of Babesia species infection:

The giemsa stained blood films were shown in Fig. (1), which demonstrated that the majority of the parasites were rounded and tend to occur peripherally in erythrocytes, while other forms as dot, ovoid, single and double pear-shape were also observed. Also, the characteristic form of *B. equi* (multese cross form) was observed. The morphometric data in table (1) indicated that the mean length and width of single pear shaped babesia was 2.08 and 1.41μ, respectively. Examination of blood films revealed that the percentage of parasitaemia (infected RBCs with *B. equi*) was ranging between 0.5-2%. Examination of 40 blood giemsa stained smears obtained from horses suffering from intermittent fever, icterus, anorexia, haemoglobinuria and / or oliguria revealed an incidence rate of 87.5% infection with *B. equi*.

2. Results of changes in serum minerals associated with some parasitic affections:

The minerals profile in farm horses suffering from parasitic affections were shown in table (2). There was a significant decrease in the level of serum sodium, iron, copper, cobalt and zinc, while, a significant increase was recorded in serum potassium in *B. equi* infected horses. Also, there was significant decrease in the level of serum calcium, sodium, iron, copper, cobalt and zinc in *P. equorum* infected group. In strongyle infected group, there was significant decrease in serum calcium, inorganic phosphorus, magnesium, sodium, potassium, iron, copper, cobalt and zinc levels.

3. Biochemical findings associated with some parasitic affections in farm horses:

There was a significant increase in TSP, globulins, bilirubins, ALP, AST, γ-GT and urea levels, while a significant decrease in glucose level was also recorded in *B. equi* infected horses. 20% and 28% of *B. equi* infected horses were positive seroreactors against ASO and CRP tests, respectively in *B. equi* infected group. A significant increase in direct bilirubin, γ-GT and urea levels, while a significant decrease in ALP, AST and glucose levels were also observed in *P. equorum* infected group. In strongyle infected horses, there was a significant increase in TSP, globulins, ALP and AST, while a significant decrease was observed in albumin level (Table, 3).

4. Haematological changes associated with some parasitic affections in farm horses:

Significant decrease was observed in total erythrocytic count, haemoglobin content, packed cell volume and lymphocytes (%), while significant increase was found in ESR, total leucocytic count, neutrophils and eosinophils (%) in *B. equi* infected horses. In *P. equorum* infected foals, there was a significant decrease in RBCs count, Hb content, PCV% and lymphocytes. Eosinophilia was also recorded. In strongyle infected group, there was significant decrease in RBCs count, Hb content, PCV% and lymphocytes, while significant increase was recorded in ESR, WBCs count, neutrophils and eosinophils (Table, 4).

5. Results of analysis of nutrient concentrations in total diets.

Nutrient concentrations in total diets for horses in a governmental horse farm (dry matter basis) were shown in table (5), which revealed that crude proteins, crude fiber and fat percentages as well as minerals and trace elements were adequate as those recommended by National Research Council (NRC, 1989).

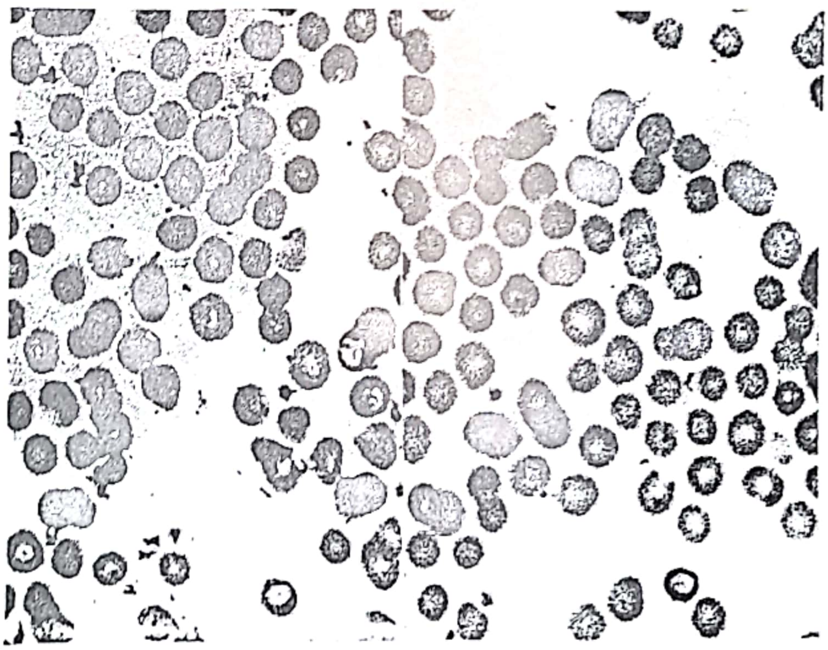

Fig. (1): Photomicrograph of stained blood film from naturally infected horse showing the characteristic "multese" form of *B. equi* (x 1000).

Table (1): Measurement of single pear shape of *Babesia equi merozoites* .

Observations	Single pear shape of *B.equi*	
	Length (µ)	width (µ)
1	1.95	1.30
2	2.20	1.39
3	2.16	1.33
4	2.22	1.36
5	2.09	1.63
6	2.29	1.47
7	2.15	1.40
8	1.96	1.36
9	1.96	1.40
10	1.99	1.50
11	2.06	1.33
12	2.08	1.47
13	2.08	1.33
14	1.95	1.43
Mean	2.08±0.03	1.41±0.02

Table (2) :Changes in serum minerals associated with some parasitic affections in farm horses.

Parameter	Healthy non-infected horse (Control group)	Babesia equi infected horses	*P.equorum* infected horses	Strongyle infected horses
Serum calcium (mg%)	11.43±0.30	12.35±0.42	10.14±0.12*	9.86±0.14**
Serum inorganic phosphorus (mg%)	6.14±0.23	5.82±0.33	5.67±0.23	4.06±0.32**
Serum magnesium (mg%)	2.72±0.22	2.28±0.21	2.67±0.12	1.90±0.05*
Serum sodium (mEq/l)	132.35±6.67	115.3±5.42*	103.03±5.29*	86.79±3.73**
Serum potassium (mEq/l)	4.25±0.30	5.83±0.27*	3.81±0.35	3.33±0.22*
Serum iron (µg%)	268.25±11.20	189.8±11.9**	204.0±16.5**	213.9±16.20*
Serum copper (µg%)	143.76±8.91	108.8±4.2**	98.80±1.00**	96.27±1.40**
Serum cobalt (µg%)	31.60±1.89	25.26±0.77*	23.69±1.26*	24.26±0.22*
Serum zinc (µg%)	88.35±1.96	54.8±3.40**	75.50±1.70**	72.90±1.50**
Serum manganese (µg%)	2.50±0.42	1.84±0.19	2.20±0.43	2.03±0.47
Number of examined animals	10	25	20	25

* $P< 0.05$
** $P<0.01$

Table (3): Biochemical findings associated with some parasitic affections in farm horses

Parameter	Healthy non-infected horses (Control group)	Babesia equi infected horses	P.equorum infected horses	Strongyle infected horses
TSP (g/dl)	6.80±0.34	9.32±0.04**	6.50±0.60	8.78±0.42**
Albumin (g/dl)	3.50±0.26	3.66±0.05	3.30±0.02	2.02±0.21**
Globulins (g/dl)	3.30±0.23	5.66±0.10**	3.20±0.04	6.76±0.12**
A/G ratio	1.06	0.65	1.03	0.30
Total bilirubin (mg/dl)	1.20±0.25	6.85±0.07**	1.50±0.02	1.15±0.02
Direct bilirubin (mg/dl)	0.27±0.05	1.37±0.03**	0.40±0.02*	0.28±0.03
Indirect bilirubin (mg/dl)	0.93±0.26	5.48±0.16**	1.10±0.02	0.87±0.02
ALP (U/l)	265.70±20.84	335.0±17.20*	247.7±16.17*	326.00±8.94*
AST (U/l)	190.00±5.63	279.2±0.67**	126.8±7.90**	304.4±13.6*
ALT (U/l)	13.00±2.44	8.86±0.07	9.13±0.10	13.89±0.96
γ-GT (U/l)	5.32±0.16	6.60±0.02**	6.80±0.04**	5.51±0.07
Urea (mg/dl)	18.75±2.69	36.31±0.37**	33.20±2.48**	20.80±0.14
Creatinine (mg/dl)	1.30±0.29	1.06±0.03	1.10±0.04	1.68±0.09
Glucose (mg/dl)	95.75±0.01			
ASO	Negative	62.25±0.52**	67.30±1.39**	91.32±1.88
		20% Positive (200 IU/ml) 80% Negative	--	---
CRP	Negative	28% Positive 72% Negative	--	--
No. of examined animals	10	25	20	25

* P< 0.05
** P<0.01

Table (4): Haematological changes associated with some parasitic affections in farm horses.

	Parameter	Healthy non-infected horse (Control group)	Babesia equi infected horses	P.equorum infected horses	Strongyle infected horses
	RBCs count ($10^6/\mu l$)	9.14±0.37	6.53±0.12**	8.09±0.27*	7.03±0.30**
	Hb content (g%)	13.73±0.18	10.2±0.28**	11.92±0.43*	9.99±0.18***
	PCV (%)	38.00±1.40	30.37±0.48*	32.8±0.08*	30.23±0.16*
	ESR:				
	mm / 60 min.	58.80 ± 0.87	61.93 ± 0.05*	60.37± 0.36	66.59± 0.08**
	mm / 120 min.	63.66 ± 1.18	64.71± 0.03	63.98± 0.11	59.51± 0.22**
	WBCs count ($10^3/\mu l$)	9.08 ± 0.04	14.6 ± 0.66**	8.99 ± 0.03	13.66 ± 0.08**
Differential leucocytic count	Neutrophils (%)	43.00 ± 0.26	46.36± 0.22*	43.67± 0.19	47.39± 0.17*
	Eosinophils (%)	4.50±0.13	25.0 ± 0.17**	11.33 ± 0.1**	8.64 ± 0.17**
	Basophils (%)	0.50 ± 0.02	0.50 ± 0.09	0.50 ± 0.01	0.50 ± 0.02
	Lymphocytes (%)	50.00 ± 1.34	26.0± 0.17**	42.2± 0.38**	40.87± 0.09**
	Monocytes (%)	2.00 ± 0.13	2.14±0.15	2.27±0.10	2.06±0.17
	Number of examined animals	10	25	20	25

* $P < 0.05$
** $P < 0.01$

Table (5): Nutrient concentrations in total diets for horses in a horse farm

	Dry matter	Moisture %	Crude Protein %	Crude Fiber %	Fat %	Ash %	Ca %	P %	Mg %	Cu ppm	Fe ppm	Zn ppm	Mn ppm	Co ppm	Na %	K %
Concentrate	90.42	9.58	12.00	13.82	2.68	9.83	2.40	0.75	0.31	3.00	130.00	65.10	71.10	0.30	0.03	0.41
Crushed corn	87.72	12.28	7.60	3.17	2.37	1.06	0.26	0.50	0.17	2.00	60.40	21.10	11.30	0.10	0.01	0.35
Barley	87.79	12.21	11.40	5.13	1.38	2.89	0.36	0.50	0.15	3.00	73.30	34.80	15.90	0.10	0.04	0.48
Alfa-Alfa	87.85	12.15	16.90	23.52	2.56	8.31	1.45	0.37	0.36	13.80	500.00	450.00	57.90	0.20	0.09	1.73
Grass	91.43	8.57	11.40	22.13	2.44	9.20	0.48	0.13	0.13	6.21	85.31	20.00	30.00	0.10	0.04	0.96
Wheat bran	88.87	11.13	15.00	11.00	2.81	5.36	0.14	1.15	1.15	13.00	170.00	96.00	110.00	0.20	0.05	1.13

DISCUSSION

Examination of 40 giemsa-stained blood smears obtained from horses suffering from intermittent fever, icterus, anorexia, haemoglobinuria and / or oliguria revealed an incidence rate of 87.5% with Babesia equi. Evidence for the presence of Babesia equi in Egypt was previously presented by El-Battawy (1989). The morphology of the Babesia strain was almost typical to those previously reported by different authors as Abdel-Hady (1981). This was shown in the morphological study on stained blood films from infected horses, which revealed that the majority of the parasites were rounded and tend to occur peripherally in erythrocytes, with other forms as dot, ring, ovoid and pear-shape were also recorded. Also, the characteristic form of *B. equi* " maltese cross form" was observed (Fig. 1) due to division of the parasite into four daughter organisms.

The morphometric study revealed that the mean length and width were 2.08 mμ and 1.41μ , respectively (Table, 1). Soulsby (1982) reported that equines were infected with two species, large species *B. caballi* (2.5 -4 μ in length) and small one *B. equi* (2 μ in length). Mahoney et al. (1977) carried out a comprehensive study of the parasite. The majority of the parasite (69%) seen in blood smears were round with a mean diameter of 1.69 μ . 20% of the remaining parasites were oval, with a mean size of 1.99 x 1.29μ. Other forms seen were single pear shaped forms (1.89 x 1.01 μ) and maltese cross forms (1.31 x 0.84 μ). The clinical picture of babesiosis in horses was variable and may be manifested by fever, icterus, anorexia and /or oliguria. Similar results recorded by Wall et al. (1987), who reported fever, poor performance, anorexia, jaundice and haemolytic anaemia associated with *B. equi* infection in horses.

However, Chandrawathani et al. (1998) reported that none of the horses, which were positive for *B. caballi* and *B. equi,* showed clinical signs of the infection. In our study, examination of blood films revealed that the percentage of parasitaemia (infected RBCs with *B. equi*) ranging between 0.5 - 2 %. Similar results obtained by Ribeiro et al. (1995) who reported that parasitaemia ranged from 0.01 to 0.18% in foals infected with *B. equi*..

The most important changes in serum minerals associated with equine babesiosis in horse farms (Table 2) were in the form of significant decrease in serum sodium, iron, copper, cobalt and zinc and significant increase in serum potassium. The increased values of serum potassium may be attributed to intravascular haemolysis as discussed by Pandey and Misra (1987). Similar results obtained by Al-Delaimi et al. (1989), who reported no changes in serum calcium, magnesium and phosphorus in Arabian horses, from Iraq, suffering from babesiosis. They also reported a significant increase in serum potassium. On the other hand, our results disagree with Pandey and Misra

(1987) who recorded increased level of serum iron and copper with normal values of serum sodium in *B. divergens* infection in cattle; Abou-Zeina (1989) who reported no significant changes in serum cobalt in sheep with piroplasmosis and Heerden et al. (1990) who reported no changes in serum sodium and potassium. Since copper is reported to be essential for proper utilization of iron (Underwood, 1977), it must be given in treatment of babesiosis. Therefore, administration of minerals preparation seemed to be helpful to overcome babesiosis (Makarevich, 1988).

Concerning changes in serum minerals associated with equine parascariasis and strongylosis (Table 2), there was significant decrease in serum calcium, sodium, iron, copper, cobalt and zinc in *P. equorum* infected horses and significant decrease in serum calcium, inorganic phosphorus, magnesium, sodium, potassium, iron, copper and zinc levels in strongyle infected animals.

Similar results obtained by Bown et al. (1989) who reported that intestinal parasitism has been shown to affect mineral uptake and in particular that of phosphorus and calcium. Lambs infected with T. colubriformis exhibit impaired phosphorus absorption, increase losses of endogenous calcium and phosphorus, lower plasma phosphorus and as a result, reduce bone formation. Also, hypophosphataemia may be due to the decrease of calcium level to make Ca / P ratio constant in blood. The drop in calcium level may probably be due to either the occurred hypoalbuminaemia (since at least 40% of calcium is transported in the blood bound to albumin) or a reduction in calcium absorption in the upper intestine (Swenson, 1984). Calcium and magnesium might compete for the binding sites on the plasma protein molecules and so hypoalbunaemia may be responsible for the occurrence of reduced level of both Ca and Mg (Amin et al., 1990). The decreased level of serum sodium and potassium in strongyle infected horse agree with those mentioned by Brar et al. (1998) who reported low sodium and potassium levels in horses suffering from diarrhoea associated with ulceration of the colon and caecum due to *S. vulgaris* larval migration. The low level is probably because of losses in the faeces and urine and reduction in the diet. Reduction in trace elements in animals infected with gastrointestinal parasites can be explained by the fact that parasitic infections may lead to loss of appetite with consequence of great loss in blood (Kaneko and Cornelius, 1970), while, Wegger (1980) attributed the decrease in minerals level in parasitic infections to impaired absorption or increased excretion of concerned elements. The decreased copper level is explained by Bang et al. (1990) who showed that infection of sheep with *T. circumcincta* affected copper metabolism through the elevation of pH of the abomasum and duodenal ingesta and the reduced abomasal activity decreases the solubility of dietary copper intake and thus lowers the uptake of copper by liver. They also added that impaired intestinal absorption of trace elements is most frequent with occurrence of diarrhoea that accompanies gastrointestinal parasitism.

The depression of serum iron and the developed anaemia associated with parasitic affections may due to chronic blood loss (Beisal et al., 1974). The decreased serum zinc level appear to be a characteristic response during parasitic infections (Abdel-All, 1991).

Concerning the biochemical findings associated with *B. equi* infection in horses (Table, 3) there was significant increase in TSP, globulins, bilirubins, ALP, AST, -γ-GT and urea levels, while a significant decrease in glucose level was also recorded. Similar results obtained by Hailat et al. (1997) who reported significant increase in AST, ALP, TSP, -γ-GT, blood urea and bilirubin associated with haemolytic anaemia due to equine babesiosis, and Ivanova (1976) who recorded hypergloblinaemia in animals infected with Babesia spp. The significant increase in the mean values of liver enzymes AST and γ-GT and the substantial increase in the mean levels of ALP could be explained by the presence of massive centrilobular degeneration and coagulative-type necrosis of hepatocytes. The damaged hepatocytes resulted in leakage of these enzymes into the plasma. The increased values of bilirubins with a decrease in blood glucose may be attributed to intravascular haemolysis. Therefore, intravenous glucose therapy is essential for treatment of babesiosis associated with serious weakness and low blood glucose values (Pandey and Misra, 1987). However, our results disagree with those mentioned by Hailat et al. (1997) who reported decreased level of TSP in five horses suffering from babesiosis; Heerden et al. (1990) who reported that creatinine, urea, total proteins, albumin, total bilirubin, glucose, γ-GT and ALP were found to be within normal ranges in horses with babesiosis and Gupta and Sinha (1988), who reported increased level of blood glucose and decreased level of serum proteins.

Concerning the biochemical findings associated with *P. equorum* infection in foals (Table, 3), there was significant increase in direct bilirubin, γ-GT and urea levels, while significant decrease was observed in ALP, AST and glucose level. These results agree with Hassan (1993) who reported no change in serum albumin, ALT and creatinine while disagree with the same author who recorded significant decrease in TSP and globulins and no change in AST and bilirubins.

Concerning the biochemical findings associated with strongyle infection (Table, 3), the rise in AST and ALP was recorded and probably caused by muscle wasting and extensive ulceration of the colon and caecum caused by massive migration of strongyle larvae; also small and large intestines contain large quantities of ALP which is released on cellular damage and such damage might have played a part in raising AST levels (Greatorex 1975). Concerning γ-GT in strongyle infected group, no significant changes was observed. These results disagree with Klei et al. (1982) who reported significant increase in γ-GT in ponies infected with *S. vulgaris*. Concerning changes in serum proteins in strongyle infected horses, the total serum proteins showed significant increase due to significant increase of globulins level, while the albumin level was significantly decreased. These results disagree with Church et al. (1986) who reported a decreased total serum proteins level in strongyle infected foals. The marked hypoalbuminaemia resulted from the emerging larvae or feeding of the luminal parasites causing intestinal wall damage and protein losing enteropathy (Reilly et al., 1993). The marked increase in the globulin level attributed to the significant increase in β_2-globulin level and IgG (Kent, 1987) and this increase may be indicative of an immunologic response to tissue invasion by strongyle larvae. The available literature concerning the ASO level of equines were found to be rare. However, Carter et al. (1991) concluded that antibody to Streptolysin O was a good indicator of infection.

The haematological findings associated with babesiosis in horses were in the form of significant decrease in RBCs count, Hb content, PCV (%) and lymphocytes (%). Significant increase in ESR, WBCs count, neutrophils (%) and eosinophils (%) were also recorded (Table, 4). Similar results obtained by Silvey (1996) who reported haemolytic anaemia in the form of decreased RBCs count, Hb content, PCV (%), leucocytosis associated with neutrophilia and eosinophilia and varying degrees of haemoglobinuria in horses infected with *B. equi*. The haematological response observed in this study indicates the possibility of suppression of erythropoietic activity of bone marrow in clinical babesiosis. This anaemia was primarily due to the destructive effect of the parasites on erythrocytes (Soulsby, 1982). However, our results disagree with Al-Delaimi et al. (1989) who reported monocytosis associated with equine babesiosis; Kohayagawa et al. (1990) who reported leucopenia, neutropenia and eosinopenia during babesia parasitaemia period in cattle and Wright (1973) who recorded lymphocytosis along with leucocytosis during babesial infection.

Concerning the haematological picture associated with *P. equorum* infection in foals (Table 4), significant decrease was observed in RBCs count, Hb content, PCV% and lymphocytes, while significant increase of eosinophils was also observed. Similar results obtained by Hassan (1993) who reported significant decrease in RBCs count, Hb content, PCV% and lymphocytes. He also reported leucocytosis attributed to eosinophilia, neutrophilia and monocytosis in horses infested with round worms.

Concerning the haematological changes associated with strongyle infection (Table, 4), there was significant decrease in RBCs count, Hb content and PCV%. The ESR was increased and leucocytosis occurred due to eosinophilia and neutrophilia. Lymphocytopenia was also recorded. These findings disagree with Greatorex (1975) who reported normal leucocytic count accompanied with eosinopenia; Bailey et al. (1984) who reported increased lymphocytes level and no changes in eosinophils; Church et al. (1986) who reported sharp rise in basophils and Shalaby (1987) who found no changes in blood picture but only decreased monocytes and eosinophilia which occurred due to allergic effects against the parasite.

Concerning the nutrient concentrations in the total diets for horses in a governmental horse farm (Table, 5), it was found that ration constituents were sufficient according to those suggested by National Research Council, 1989. Thus, changes in blood constituents will be attributed to the effect of parasites on the host and not due to malnutrition.

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