STUDIES ON HAEMATOLOGICAL AND BIOCHEMICAL CHANGES IN LAMBS EXPERIMENTALLY INFECTED WITH *SARCOCYSTIS FUSIFORMIS* AND *SARCOCYSTIS CAMELI*

A.A. WAHB, MAGDA A.H.EL-REFAII, R.H. YOUSSEF

Animal Health Research Institute, Agricultural Research Centre, Giza, Egypt.

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Abstract

Haematological and biochemical changes that occurred during the acute stage of infection of newly born lambs infected with *Sarcocystis fusiformis* and *Sarcocystis cameli* were presented. Experimental studies had been conducted on nine labs, three-three-months old, divided into 3 groups. The first was left as non-infected control. Each lamb of the second and third groups was inoculated orally with 50,000 *S.fusiformis* and 50,000 *S.cameli* sporocysts respectively. Total red blood cells (RBCs), haemoglobin (Hb), packed cell volume (PCV) and white blood cells count (WBCs), mean corpuscular volume (MCV), mean corpuscular haemoglobin concentration (MCHC), mean corpuscular haemoglobin (MCH), as well as, serum total protein (TP) and its fractions, serum glutamic oxaloacetic transaminase (GOT), creatine phosphokinase (CPK) and lactic dehydrogenase (LDH) were determined weekly for eight weeks. A significant decrease ($P<0.05$) in RBCs, Hb and PCV started at 3rd week post-inoculation ($P>I$) in lambs infected with *S.fusiformis* and at 4th or 5th week P.I. in lambs infected with *S.cameli*. Also, a significant increase ($P<0.05$) in WBCs was recorded in 1st - 2nd week P.I.Albumin and A/G ratio decreased, and globulin increased significantly ($P<0.05$) during the period of 3rd or 4th week to 8th week as week as well as a significant increase ($p<0.05$) in GOT from 4th and 3rd week I.P. lambs infected with *S.fusiformis* and *S.cameli* respectively. A significant increase ($P<0.05$) in CPK and LDH was recorded in both infected groups during the interval from 3rd or 4th week to 5th or 6th week P.I.

INTRODUCTION

Sarcocystis is a common protozoon parasite affecting many species of domestic and wild animals. It is considered as one of a great economic importance, as it affects the general condition of animals and causing great losses in their productivity. In Egypt, the infection rate was 97-100% in buffaloes (El-Afifi et al., 1963; Nassar, 1982), 82% in cattle (El-Afifi et al. 1963) and 71-84% in camels (Wahba, 1994). Furthermore, the incidence of sarcocystosis in man was between

6% and 10% (World Health Organization, 1981). This parasite is a cyst-forming sporozoa with an obligatory two hosts cycle, carnivores as defiitive hosts and herbivores as intermediate hosts. *Sarcocystis species* are thought to be host-specific for their intermediate hosts (Dubey, 1980). However, Wahba (1994) reported that *Sarcocystis fusiformis* of buffaloes and Sarcocystis cameli of camels could be transmitted to lambs. In the intermediate host, Sarcocystis has a vascular and a muscular phases. Clinical manifestations in acute sarcocystosis is characterized by fever, anorexia, cachexia, emaciation and anaemia (Meads, 1976, Giles *et al.*, 1980). These signs are evident at the time of vascular phase for about one month after infection, then followed by cysts formation in the muscles. Diagnosis of sarcocystosis in living animals is considered difficult because there is no pathognomonic signs.

The present study was undertaken to elucidate some of haematological and serum biochemical changes that may occur in experimental Sarcocystis infection of lambs. This may provide further aid in diagnosis of infection during the acute stage.

MATERIALS AND METHODS

Parasite-free 6 puppies (4 weeks old) purchased from a special petbreeder were divided into two groups each of three. Freshly and naturally infected meat with *S.fusiformis* cysts of buffaloes and *S.cameli* cysts of camels, slaughtered at El-Bassatine abattoir, were obtained and fed to puppies of the first and second groups respectively. Puppies of both groups were sacrificed 18 days post infection. Mucosal scrapings from the small intestine were collected and digested by pepsin solution according to Jacobs and Melton (1957). The obtained sporocysts in saline solution, were inoculated to lambs. The infective dose of sporocysts was calculated by using haemocytometer immediately before administration to lambs.

Nine newly born lambs obtained from a farm of Animal Production Research Institute were isolated with mothers and kept suckling for one week before removed and given powdered milk, then dried balanced ration. They were kept clean under coccidia free hygienic conditions. All were checked for serum antibodies against Toxoplasma and Sarcocystis using specific antigens before being infected with sporocysts of *S.fusiformis* and *S.cameli.* When lambs were three-months old, they were divided into three groups. The lambs of the first group were left as non-infected controls. The lambs of the second and third groups were inoculated orally each with 50, 000 *S.fusiformis* sporocysts and 50,000 *S.cameli* sporocysts respectively by means of a fine stomach tube.

Uncoagulated and coagulated blood for serum samples from each infected and non-infected control lambs were collected on the day of inoculation (zero day) and then weekly till the 8th week P.I. Uncoagulated blood samples were used for determination of total red blood cells (RBCs), haemoglobin (Hb), packed cell volume (PCV) and wite blood cell count (WBCs) according to Schalm (1986), Wintrobe *et al.* (1967) and Coles (1980). Erythrocyte indices [mean corpuscular volume (MCV), mean corpuscular haemoglobin concentration (MCHC) and mean corpuscular haemoglobin (MCH] were calculated according to equations recorded by Benjamin (1970). Serum samples were analyzed for total protein (TP) (Peters, 1968), albumin (Drupt, 1974), glutamic oxaloacetic transaminase (GOT) (Reitman and Frankel, 1957), creatine phosphokinase (CPK) (Morin, 1977) and lactic dehydrogease (LDH) (Buhl and Jackson, 1978). Results were tabulated and statistically analyzed by ANOVA (SPSS Win. Version 5).

RESULTS

Table 1a showed a significant lowering of RBCs, Hb and PCV values ($P<0.05$), which started earlier in lambs infected with S.fusiformis (3rd week P.I.) than in those infected with S.cameli (4th or 5th week P.I.), while, the mean number of WBCs significantly increased ($P<0.05$) at 1st week P.I. and lasted to 2nd week in case of *S.fusiformis* or 3rd week in *S.cameli.*

Table 1b showed a significant increase ($P<0.05$) of MCV in both infected groups at 8th week P.I. There was a significant increase ($p<0.05$) of MCHC which started earlier in lambs infected with *S.fusiformis* (4th week P.I.) than in those infected with S.cameli (6th week P.I.) Concerning MCH, there was a significant increase ($P<0.05$) from 4th till 8th week P.I. of lambs with *S.fusiformis*, while it increased at 5th and from 7th till 8th week P.I. of lambs with *S.cameli.*

Table 2 presented a significant decrease ($P<0.05$) of TP in both infected groups during the period of 4th to 6th week P.I., then became increased at 7th and 8th week P.I. in lambs infected with *S.cameli* and *S.fusiformis* respectively, with a significant variation ($P<0.05$) than in control group. In parallel with protein changes, albumin and A/G ratio decreased and globulin increased significantly ($P<0.05$) during the period from 3rd or 4th week to 8th week P.I.

Table 3 demonstrated a significant increase ($P<0.05$) of GOT, starting from 4th week P.I. with *S.fusiformis* or 3rd week after *S.cameli* infection, until 8th or 7th week. P.I. respectively, while, significant increase of CPK or LDH occurred in both infections during the period from 3rd or 4th week to 5th or 6th week P.I.

Table 1a. Haematological picture (mean ± SE) in lambs experimetally infected with *Sarcocystis fusiformis* and *Sarcocystis cameli* during the experimental period.

Experim-ental period	Control				Lambs infected by *S. fusiformis*				Lambs infected by *S. cameli*			
	RBCs ($x10^6$/ml)	Hb (gm/100ml)	PCV (%)	WBCs ($x10^3$/ml)	RBCs ($x10^6$/ml)	Hb (gm/100ml)	PCV (%)	WBCs ($x10^3$/ml)	RBCs ($x10^6$/ml)	Hb (gm/100ml)	PCV (%)	WBCs ($x10^3$/ml)
Zero day	12.53 ± 0.50	10.37 ± 0.14	37.00 ± 1.00	12.90 ± 0.65	12.70 ± 0.32	10.10 ± 0.06	38.33 ± 0.66	14.70 ± 1.04	12.13 ± 0.29	10.23 ± 0.09	36.33 ± 1.46	12.73 ± 1.16
1st week	11.78 ± 0.39	10.40 ± 0.15	37.33 ± 0.88	13.03 ± 0.73	12.10 ± 0.50	10.10 ± 0.06	37.67 ± 0.34	16.53 * ± 1.04	11.97 ± 0.18	10.33 ± 0.18	36.00 ± 1.53	14.57 * ± 0.97
2nd week	11.93 ± 0.12	10.33 ± 0.07	36.67 ± 0.88	13.03 ± 0.87	11.53 ± 0.59	10.13 ± 0.09	36.67 ± 0.66	17.63 * ± 1.24	11.77 ± 0.09	10.27 ± 0.12	36.33 ± 1.20	14.00 ± 0.85
3rd week	12.1 ± 0.10	10.50 ± 0.29	36.00 ± 0.58	12.50 ± 0.76	11.00 * ± 0.65	9.93 * ± 0.09	33.67 * ± 0.88	10.90 ± 4.40	11.70 ± 0.06	10.17 ± 0.12	35.00 ± 1.16	15.77 * ± 1.53
4th week	12.06 ± 0.23	10.2 ± 0.20	37.33 ± 0.34	13.43 ± 0.70	9.03 * ± 0.32	9.03 * ± 0.09	27.67 * ± 1.20	15.33 ± 0.69	11.13 ± 0.24	9.67 * ± 0.24	34.00 * ± 1.16	12.93 ± 1.17
5th week	11.93 ± 0.18	10.37 ± 0.03	35.67 ± 0.88	13.33 ± 0.84	8.93 * ± 0.50	8.83 * ± 0.28	26.67 * ± 1.20	14.57 ± 0.56	9.47 * ± 0.14	9.03 * ± 0.18	30.00 * ± 1.73	12.37 ± 0.68
6th week	11.58 ± 0.18	10.0 ± 0.12	34.33 ± 0.88	13.53 ± 0.92	8.81 * ± 0.99	8.83 * ± 0.26	27.00 * ± 1.16	14.10 ± 1.48	10.03 * ± 0.54	9.27 * ± 0.40	29.67 * ± 1.46	13.37 ± 0.67
7th week	12.37 ± 0.06	10.2 ± 0.12	35.33 ± 0.88	13.77 ± 0.62	9.27 * ± 0.47	9.20 * ± 0.31	29.00 * ± 1.53	13.67 ± 0.97	9.97 * ± 0.22	9.47 * ± 0.47	30.67 * ± 2.19	12.17 ± 0.77
8th week	14.72 ± 2.39	10.23 ± 0.20	36.00 ± 0.58	13.10 ± 0.72	9.05 * ± 0.91	9.40 * ± 0.31	26.33 * ± 1.34	14.80 ± 1.01	9.60 * ± 0.60	9.83 * ± 0.09	31.33 * ± 0.88	12.40 ± 1.01

Values are expressed as mean ± SE

* Significant at $p < 0.05$ using ANOVA test

LSD : 1.03 (RBCs), 0.34 (Hb), 1.86 (PCV) & 2.09 (WBCs)

Table 1b. Erythrocyte indices (mean ± SE) in lambs experimentally infected with *Sarcocystis fusiformis* and *Sarcocystis cameli* during the experimental period.

Experim-ental period	Control			Lambs infected by *S. fusiformis*			Lambs infected by *S. cameli*		
	MCV (μ^3)	MCHC (%)	MCH (μμg)	MCV (μ^3)	MCHC (%)	MCH (μμg)	MCV (μ^3)	MCHC (%)	MCH (μμg)
Zero day	29.57 ± 0.79	28.08 ± 1.13	8.30 ± 0.37	31.55 ± 1.04	26.36 ± 0.49	8.31 ± 0.17	30.04 ± 1.94	28.27 ± 1.29	8.44 ± 0.17
1st week	31.73 ± 0.94	27.89 ± 0.87	8.86 ± 0.43	31.21 ± 1.06	26.82 ± 0.13	8.38 ± 0.39	30.10 ± 1.38	28.84 ± 1.65	8.64 ± 0.25
2nd week	30.74 ± 0.96	28.21 ± 0.51	8.66 ± 0.12	32.02 ± 2.28	27.66 ± 0.59	8.83 ± 0.45	30.87 ± 0.84	28.34 ± 1.30	8.73 ± 0.16
3rd week	29.75 ± 0.29	29.21 ± 1.27	8.68 ± 0.30	30.86 ± 2.25	29.56 ± 1.02	9.09 ± 0.51	29.87 ± 1.06	29.14 ± 1.31	9.01 ± 0.34
4th week	30.98 ± 0.29	27.33 ± 0.69	8.47 ± 0.27	30.63 ± 0.85	32.75 * ± 1.14	10.02 * ± 0.35	30.56 ± 1.09	28.46 ± 0.65	8.68 ± 0.12
5th week	29.92 ± 1.17	29.1 ± 0.64	8.69 ± 0.16	29.96 ± 1.46	33.16 * ± 0.46	9.93 * ± 0.42	31.74 ± 2.19	30.26 ± 1.38	9.55 * ± 0.35
6th week	29.63 ± 0.38	29.17 ± 0.98	8.64 ± 0.19	31.26 ± 2.78	32.79 * ± 1.25	10.25 * ± 1.03	29.90 ± 3.08	31.26 * ± 0.34	9.33 ± 0.93
7th week	28.58 ± 0.83	28.89 ± 0.57	8.25 ± 0.10	31.63 ± 3.34	31.80 * ± 0.80	10.01 * ± 0.84	30.70 ± 1.49	30.96 * ± 0.71	9.49 * ± 0.26
8th week	25.63 ± 3.65	28.46 ± 1.02	7.35 ± 0.97	29.61 * ± 2.81	35.76 * ± 0.68	10.57 * ± 0.97	33.03 * ± 3.14	31.42 * ± 0.69	10.34 * ± 0.78

Values are expressed as mean ± SE

* Significant at $p < 0.05$ using ANOVA test

LSD : 3.07 (MCV), 1.55 (MCHC) & 0.83 (MCH)

Table 2. Serum total protein and its fractions (Mean ± SE) in lambs experimentally infected with *Sarcocystis fusiformis* and *Sarcocystis cameli* during the experimental period.

Experimental period	Control				Lambs infected by *S. fusiformis*				Lambs infected by *S. cameli*			
	T. protein (gm/100ml)	Albumin (gm/100ml)	Globulin (gm/100ml)	A/G ratio	T. protein (gm/100ml)	Albumin (gm/100ml)	Globulin (gm/100ml)	A/G ratio	T. protein (gm/100ml)	Albumin (gm/100ml)	Globulin (gm/100ml)	A.G ratio
Zero day	6.42 ± 0.09	3.23 ± 0.15	3.19 ± 0.12	1.02 ± 0.08	6.24 ± 0.15	3.66 ± 0.31	3.08 ± 0.26	1.21 ± 0.32	6.83 ± 0.20	3.54 ± 0.25	3.17 ± 0.49	1.20 ± 0.23
1st week	6.51 ± 0.08	3.21 ± 0.11	3.30 ± 0.15	0.98 ± 0.08	6.28 ± 0.16	3.67 ± 0.19	3.09 ± 0.18	1.17 ± 0.13	6.79 ± 0.10	3.19 ± 0.27	3.13 ± 0.20	1.05 ± 0.15
2nd week	6.58 ± 0.14	3.27 ± 0.17	3.32 ± 0.10	0.99 ± 0.07	6.28 ± 0.01	3.53 ± 0.24	3.08 ± 0.03	1.13 ± 0.10	6.67 ± 0.16	3.20 ± 0.04	3.15 ± 0.08	1.04 ± 0.02
3rd week	6.50 ± 0.18	3.44 ± 0.16	3.06 ± 0.02	1.12 ± 0.05	6.23 ± 0.13	2.98 ± 0.49	3.06 ± 0.02	0.86 * ± 0.17	6.52 ± 0.34	3.16 ± 0.16	3.54 * ± 0.15	1.03 ± 0.06
4th week	6.58 ± 0.14	3.48 ± 0.14	3.10 ± 0.03	1.12 ± 0.05	5.59 * ± 0.39	2.17 * ± 0.50	3.53 * ± 0.13	0.58 * ± 0.16	6.05 * ± 0.24	2.06 * ± 0.49	3.89 * ± 0.27	0.59 * ± 0.16
5th week	6.52 ± 0.28	3.12 ± 0.25	3.40 ± 0.07	0.92 ± 0.07	5.32 * ± 0.26	1.39 * ± 0.31	3.93 * ± 0.15	0.34 * ± 0.08	5.44 * ± 0.34	1.39 * ± 0.41	4.05 * ± 0.05	0.36 * ± 0.12
6th week	6.74 ± 0.22	3.54 ± 0.14	3.20 ± 0.08	1.11 ± 0.02	6.06 * ± 0.10	2.08 * ± 0.11	3.89 * ± 0.13	0.52 * ± 0.03	6.10 * ± 0.12	2.17 * ± 0.21	4.02 * ± 0.01	0.56 * ± 0.07
7th week	6.46 ± 0.02	2.92 ± 0.19	3.54 ± 0.19	0.84 ± 0.09	6.73 ± 0.14	2.49 ± 0.21	4.15 * ± 0.14	0.59 * ± 0.08	6.81 * ± 0.20	2.58 ± 0.18	4.31 * ± 0.22	0.62 * ± 0.06
8th week	6.63 ± 0.14	3.31 ± 0.17	3.32 ± 0.29	1.01 ± 0.13	7.23 * ± 0.34	2.76 * ± 0.43	4.45 * ± 0.21	0.62 * ± 0.11	7.23 * ± 0.34	2.78 * ± 0.51	4.47 * ± 0.10	0.64 * ± 0.15

Values are expressed as mean ± SE

* Significant at $p < 0.05$ using ANOVA test

LSD : 0.34 (Total protein), 0.46 (Albumin), 0.29 (Globulin) & 0.20 (A/G ratio)

Table 3. Serum enzymes level (Mean ± SE) in lambs experimentally infected with *Sarcocystis fusiformis* and *Sarcocystis cameli* during the experimental period.

Experim-ental period	Control			Lambs infected by *S. fusiformis*			Lambs infected by *S. cameli*		
	GOT (U/ml)	CPK (U/L)	LDH (U/L)	GOT (U/ml)	CPK (U/L)	LDH (U/L)	GOT (U/ml)	CPK (U/L)	LDH (U/L)
Zero day	64.67 ± 1.46	123.05 ± 15.4	138.43 ± 3.81	61.33 ± 3.39	118.66 ± 17.46	131.84 ± 3.81	58.33 ± 4.06	94.48 ± 9.59	134.04 ± 9.59
1st week	70.33 ± 6.90	123.05 ± 25.37	149.42 ± 2.20	60.33 ± 7.85	127.45 ± 8.79	125.25 ± 3.81	64.67 ± 0.66	112.06 ± 20.16	131.84 ± 3.81
2nd week	70.67 ± 6.99	120.85 ± 15.87	123.05 ± 5.82	64.67 ± 5.90	151.62 ± 7.62	136.24 ± 7.93	70.33 ± 2.61	110.93 ± 12.43	123.05 ± 9.59
3rd week	74.33 ± 3.84	92.29 ± 3.87	118.65 ± 6.60	86.67 ± 21.29	162.60 ± 38.36	153.81 * ± 9.59	102.33 * ± 18.68	151.62 ± 11.43	140.63 ± 5.82
4th week	67.00 ± 3.01	109.87 ± 5.82	134.04 ± 5.82	121.33 * ± 22.49	281.26 * ± 14.43	252.69 * ± 38.92	129.33 * ± 18.21	257.09 * ± 49.97	188.97 * ± 17.60
5th week	66.33 ± 5.49	92.29 ± 0.00	118.66 ± 3.82	151.00 * ± 23.90	325.20 * ± 7.93	257.09 * ± 30.24	144.33 * ± 10.15	343.88 * ± 48.73	274.67 * ± 27.57
6th week	72.33 ± 2.67	112.06 ± 16.61	138.43 ± 10.08	134.33 * ± 5.24	239.51 * ± 44.49	213.14 * ± 41.97	128.67 * ± 8.36	184.58 ± 43.27	232.92 * ± 34.36
7th week	76.00 ± 2.00	153.81 ± 55.53	138.43 ± 13.74	125.33 * ± 8.26	175.78 ± 57.32	153.81 ± 36.02	111.33 * ± 11.85	158.21 ± 6.60	156.01 ± 7.93
8th week	77.67 ± 5.46	96.68 ± 13.38	136.24 ± 15.40	108.33 * ± 8.02	160.41 ± 34.58	123.05 ± 11.64	68.67 ± 12.59	116.46 ± 9.59	140.63 ± 5.82

Values are expressed as mean ± SE

* Significant at $p < 0.05$ using ANOVA test

LSD : 17.82 (GOT), 114.66 (CPK) & 29.95 (LDH)

DISCUSSION

The present studies on haematological and biochemical changes in lambs experimentally infected with *S.fusiformis* and *S.cameli* showed that, during the whole period of experiment, all lambs in both infected and non-infected control groups were apparently in good condition and the body temperatures remained within the normal levels. However, previous authors stated that acute sarcocystosis was characterized by fever, anorexia, cachexia, emaciation, enlarged palpable lymph nodes, excessive salivations, nervousness, lameness and hair loss on the extremities (Fayer and Johnson, 1973, Dubey, 1976, Meads, 1976, Giles *et al.*, 1980; Phillips and Ford, 1987, Dey *et al.*, 1995). Acute sarcocystosis in this study was accompanied by the significant lowering of RBCs, Hb and PCV levels (Table 1a), which started from 3 or 4 weeks P.I. until the end of the experiment. Anaemia has been recorded on day 28 P.I. of lambs by S.ovicanis (Leek *et al.*, 1977, Leek and Fayer, 1980, Phillips and Ford, 1987) and also after *S.fusiformis* and *S.cruzi* infection of calves (Mahrt and Fayer, 1975, Frelier and Lewis, 1984, Mahaffey *et al.*, 1986). Moreover, infection of goats with *S.capracanis* (Wadajkar *et al.* 1995) and piglets with *S.meisheriana* (Kunita *et al.* 1990) showed the same haematological changes of anaemia on the 7th 35th day post-infection. However, Foryet *et al.* (1995) recorded that calves inoculated orally with 250,000 sporocysts of *S.sybillensis* and *S.wapiti* were not anaemic and their PCV of whole blood were not significantly different. It has been suggested that erythropoenia was attributed to the loss of circulating erythrocytes (Fayer and Prasse, 1981), while, Frelier and Lewis (1984) considered that immune mechaism involved in the anaemia of sarcocystosis could include antibody directed antibody directed against host RBCs. The early significant incrase of WBCs (one week after infection) in both infected groups (Table 1a) may support the last interpretation, that it may be related to the erythrophagocytosis. Moreover, the excessive destruction of the erythrocytes in the present study was substituted by the significant increase ($P<0.05$) of both MCHC and MCH (Table 1b) in both infected groups, which later on, MCV was significantly increased (at 8th week P.I.) as the result of bone marrow response.

This study represents also the attempt to clarify the serum protein response of lambs to experimental infection with Sarcocystis from different species (Table 2). The ovine hosts in this study reacted in much on the same to S.fusiformis and *S.cameli*. The same effects were previously recorded in lambs infected with *S.ovicanis* (Leek and Fayer, 1980) or with *S.tenella* (Phillips and Ford, 1987), in calves inoculated with Sarcocystis sporocysts from dogs (Fayer *et al.*, 1977) and

also in piglets infected with S.miescheriana (Dey *et al.*, 1995). In the present study, the decrease in serum TP observed during the period of 4-6 weeks P.I. was correlated with aforementioned haematological changes. The reduction in serum albumin levels (4-8 weeks post-inoculation) in both infected groups accounted for most of the reduction in TP. Leek *et al.* (1977), suggested that the decrease in TP level could result from possible loss of kidney function, substantiated by their histopathologic findings of glomerulonephriti. Fayer *et al.* (1977), considered that the lowering in serum albumin level may be due to severely depressed food intake, haemorrhage, kidney damage or myocarditis. On the other hand, the increase in serum globulin fraction (Table 2) began on the 3rd or 4th week after inoculation until the end of the experiment. This appeared to be in response to the antigenic stimulation of the infectious agent. The increases in globulin level accounted for most of the increase observed in serum TP on the 7th - 8th week post-inoculation. these changes are typical of the significant shift ($P<0.05$) in A/G ratio during the acute and cyst formation stages of infection, particularly, at the 5th week post-ioculation. However, Lal-Singh *et al.* (1994), respected that A/G ratio was altered on the 60th day after infection of goats with *S.capracanis*. Concerning the same species of Sarcocystis, Pachecho *et al.* (1994), determined that there were increases in TP, albumin and globulin fraction and A/G ratio during schizogony and cyst formation, but the changes were not characteristic of sarcocystosis. Moreovr, changes in TP was not significant in calves infected with *S.fusiformis* (Mahrt and Fayer, 1975).

Cyst developmental stage was monitored by significant increases ($P<0.05$) in the serum levels of GOT, CPK and LDH (Table 3). These changes were somewhat paralleled in both infected groups during the period of 4th-6th week P.I. These reflected the extensive tissue damage or necrotic changes in skeletal muscles. Quite similar fidings were registered in lambs infected with S.ovicanis (Leek and Fayer, 1980) and in calves inoculated by *S.fusiformis* (Mahrt and Fayr, 1975). However, Phillips and Ford (1987) reported that LDH was elevated 24 and 28 day and from 42 to 78 days P.I., while, GOT was inceased from 45 to 66 days, and CPK was increased from 52 to 72 days after infection of lambs with *S.tenella*. Early increase of serum GOT and GPT (on days 10 and 20) was estimated after experimental infection of goats with *S.capracanis* (Wadajkar *et al.* 1995).

This study showed that, besides the haematological changes which occurred in acute stage of infection (schizogony stage), the combined changes of serum protein fractions especially A/G ratio, and GOT, CPK and LDH levels may aid in the diagnosis

of field cases during cyst formation stage. In addition, similar biochemical finding in both infected groups idicated that some *Sarcocystis species* are not specific for their intermediate host.

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دراسات عن التغيرات الهيماتولوجية والبيوكيماوية في الحملان المعدية تجريبياً بطفيل ساركوسيستس فيوزيفورمس وساركوسيستس كاميللي

أحمد أنور وهبة ، ماجدة عبد الحي الرفاعي، رؤف حلمي يوسف

معهد بحوث صحة الحيوان – مركز البحوث الزراعيه – وزارة الزراعة – الدقى – جيزة .

تم إجراء هذه الدراسة علي تسعة حملان، قسمت إلي ثلاث مجموعات المجموعة الأولي تركت بدون عدوي، بينما تمت عدوي كل حمل من المجموعتين الثانية والثالثة علي حده عن طريق الفم بعدد ٥٠٠٠ حويصلة ساركوسيستس فيوزيفورمس و ساركوسيستس كاميللي علي التوالي.

تم تحديد كرات الدم الحمراء والبيضاء، حجم الخلايا الحمراء ونسبة الهيموجلوبين أيضا، وتم فحص السيرم لقياس البروتين الكلي، أنزيم الترانس أمينيز، كرياتين فسفوكينيز، لاكتيك دي هيدروجينيز.

وقد وجد أنه حدث أنخفاض لكل من كرات الدم الحمراء، الهيموجلوبين وحجم الخلايا الحمراء وذلك في الأسبوع الثالث في الحملان المعدية بساركوسيستس فيوزيفورمس بينما حدث ذلك في الأسبوع الرابع أو الخامس في الحملان المعدية بساركوسيستس كاميللي، كما أرتفع عدد كرات الدم البيضاء في الأسبوع الأول والثاني بعد العدوي وفي الأسبوع الثالث علي التوالي، من الناحية الأخري أنخفض البروتين الكلي في كلتا المجموعتين في الأسبوع الرابع إلي السادس من العدوي، كم أنخفض الألبيومين ونسبة الألبيومين إلي الجلوبيولين وأرتفع الجلوبيولين في الأسبوع الثالث أو الرابع إلي الأسبوع الثامن من العدوي، وأرتفع أنزيم الترانس أمينيز من الأسبوع الرابع والثالث بعد عدوي الحملان بساركوسيستس فيوزيفورمس وساركوسيستس كاميللي علي التوالي، كما أرتفع الكرياتين فوسفوكينيز ولا كتيك دي هيدروجينيز في كلتا المجموعتين أثناء الأسبوع الثالث أو الرابع إلي الخامس أو السادس من العدوي.