THE DIAGNOSTIC VALUE OF PLASMA ELECTROLYTES AND ENZYMES IN GASTROINTESTINAL HAEMORRHAGIC PARASITISM: STUDIES IN GOATS INFECTED WITH *SCHISTOSOMA BOVIS*

G. K. Mbassa[1] and P. Willeberg[2] [1]*Central Laboratory, Department of Clinical Studies, and* [2]*Department of Animal Science and Animal Health, Royal Veterinary and Agricultural University, Bulowsvej 13, DK-1870 Frederiksberg C. Denmark and* [1]*Faculty of Veterinary Medicine Sokoine University of Agriculture, P. O. Box 3016 Morogoro, Tanzania.*

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SUMMARY

The effects of continuous gastrointestinal haemorrhages due to parasites on plasma electrolytes and enzymes were evaluated for testing their complementary or supplementary diagnostic value to fecal egg count, haematocrit, erythrocyte counts and haemoglobin determinations. Plasma Ca, Mg, P, Na and K, total serum proteins, alkaline phosphatase, alanine aminotransferase, aspartate aminotransferase and creatinine kinase were determined through an autoanalyzer in 36 *Schistosoma bovis* infected, 36 uninfected West African Dwarf and 138 Danish Landrace goats free from infection. Infected goats developed diarrhea within six weeks, and 61.1 % were hypocalcaemic, with 94.4 % specificity. Alkaline phosphatase, alanine aminotransferase, creatinine kinase activities were significantly lowered in 75 %, 63.9 % and 61.1 % infected goats compared with 11.1 %, 19.4 % and 2.3 % non infected controls respectively. The specificities for the tests were 88.9, 80.6 and 86.1 % respectively. There were hypomagnesaemia, hypophosphataemia, hyponatraemia, hypoglycaemia and hyperproteinaemia of low magnitudes. Creatinine, bilirubin, urea nitrogen, potassium and aspartate aminotransferase were not significantly different in infected and control goats. Plasma Ca, Na, proteins and enzymes were found to be valuable supplementary tests in detection of animals with chronic gastrointestinal haemorrhages, particularly when reference values are known.

INTRODUCTION

Most parasitic infections frequently occur subclinically. Their diagnostic methods of foecal egg counts, indirect fluorescent antibody test, enzyme linked immunosorbent assay and indirect haemagglutination yield good results only at certain peak effects of infection beyond which they produce many false negative animals (Saad *et al.*, 1984a; Kassuku *et al.*, 1986; Maddison, 1986). The infections cause pathologic syndrommes associated with general or specific changes in the blood, serum or plasma. Gastrointestinal nematodes and trematodes cause insidious blood loss, chronic hepatic and gastrointestinal lesions (Saad *et al.*, 1984a; Yason and Novilla, 1984; Vercruysse *et al.*, 1985; Vercruysse and Schanderyl, 1986; Diaw and Vassilides, 1988). Gastrointestinal bleeding results in hypoalbuminaemia with compensatory hyperglobulinaemia, leading to overall hyperproteinaemia (Saad *et al.*, 1984b). Many electrolytes are bound to albumin (Kaneko, 1989) and its loss through haemorrhages lowers their plasma concentrations. Parasitic infections are known to alter plasma alkaline phosphatase (Milne, 1985), alanine aminotransferase, aspartate aminotransferase, creatinine kinase and gamma glutammyl transpeptidase activities through hepatic, gastrointestinal, skeletal and cardiac muscle lesions (Monrad *et al.*, 1982; Bogin *et al.*, 1988; Boyd, 1988). The extent by which these

can aid the diagnosis of parasitism is, however, not known, because the magnitude of alteration is also unknown. The degree of clinical chemical change depends on the stage of the disease, and unless this is determined the diagnosis remains speculative. In order to obtain reliable diagnosis based on such analysis the magnitude of changes in plasma electrolytes, globulins, albumin and enzymes must be quantitative evaluated in clinically healthy animals compared with known sick individuals of identical conditions, results of which are useful for cross sectional studies. The aim of this investigation was to quantitatively study the magnitude of electrolytes, enzymes and other parameters altered in *Schistosoma bovis* infection in goats as a model for other parasitic infections.

Table 1. Categories of goats investigated, number, similarities and differences between them.

Conditions	Animal group 1	2	3	4	5	6	7
Age (months)	6-10	6-10	6-10	A	A	A	A
Breed	D	D	L	L	L	L	L
Infection	+	-	-	-	-	-	-
Pregnant	-	-	-	+	-	-	-
Lactation I	-	-	-	-	+	-	-
Lactation II	-	-	-	-	-	+	-
Lactation III	-	-	-	-	-	-	+

D = Dwarf, L = Landrace, Lactation I= 20 -30 days, II= 60 - 90 days and III > 120 days, A= adult.

MATERIALS AND METHODS

External jugular vein blood samples were collected in heparinized vacuum tubes (B-D vacutainer) from 36 six to 10 months old dwarf goats six weeks after subcutaneous infection with 1000 metacercaria of *Schistosoma bovis*, 36 uninfected controls and 138 landrace goats free of infection (Table 1).

Plasma calcium and magnesium were determined by atomic absorption spectrophotometer 5000 (PERKIN ELMER). Inorganic phosphate, sodium and potassium were determined by COBAS FARA (ROCHE) autoanalyzer. Plasma activities of alanine aminotransferase (ALAT, 2.6.1.2), aspartate aminotransferase (ASAT, 2.6.1.1) creatine kinase (CK, Creatine-N-phosphotransferase, 2.7.3.2) and alkaline phosphatase (ALP,3.1.3.1) were kinetically determined on COBAS FARA analyzer. In the same analyzer plasma glucose was determined after deproteinization with perchloric acid, urea nitrogen by enzymatic UV test with urease and glutamate dehydrogenase, creatinine by the kinetic picrate method, total bilirubin by reaction with 4-sulphobenzene-diazonium chloride to form azobilirubin and total serum protein by the Biurret method.

The results were statistically analyzed by the Statistical Analysis System soft ware (Cary, NC, USA). Means and logarithimic means of parameter values of infected and control goats were compared by t test. Frequency distributions of the logarithms of parameters of infected and control goats were plotted and

used for selection of critical values in zones where the two distribution curves overlapped. The logarithimic frequency distributions were used because they accurately describe the biological systems (Flensburg and Willeberg, 1976). The critical value for each electrolyte and enzyme activity was selected for use in deciding whether the alteration was so low or high. Animals with larger deviations than the critical value were test positives (T+), otherwise test negatives (T-). The sensitivity and specificity of each test were calculated from two by two tables (Baldock, 1987; Martin, et al. 1987). The proportions of T+ goats in groups 3 - 7 were determined at the same critical values.

RESULTS

Plasma Ca^{2+}, Mg^{2+}, inorganic PO_4^{2-} and Na^+ were significantly decreased in infected goats (Table 2), thus hypocalcaemic, hypomagnesaemic, hypophosphotaemic and hyponatr-aemic. The critical values for testing these conditions were 2.34, 0.85, 2.10 and 145.00 mmol/l, at log values of 0.369, -0.071, 0.322 and 2.16 respectively. Animals with values below these were categorized as test positives (T+) for decreased specific electrolyte. Plasma potassium level was not significantly different in the two groups of goats. Total serum proteins were higher in infected (70.03 g/l) than in control goats (66.17 g/l) but not statistically significant.

A greater proportion (61.1%) of infected animals were hypocalcemic (T+) than in all other disease free goats (fig. 1). Mg^{2+}, Na^+, K^+, and PO_4^{2-} were not greatly altered by infection and were not important electrolyte tests to complement haematological analysis. Both their sensitivities and specificities were low (table II).

The electrolyte tests on groups 3 - 7 landrace goats which were clinically healthy showed a variable proportion of animals whose calcium concentration were lower than the critical values (2.34 mmol/l for calcium), therefore detected as test positives (T+). There were distinctly more T+ to hypocalcaemia in 6 - 10 month old landrace goats of group 3 (30 %), than in control dwarf goats (group 2) of the same age where only 6 % were T+. Twenty seven percent of the pregnant, 35% of the 60 - 90 and 23 % of the 20 - 30 days in lactation and 13 % of the dry goats (> 120 days after parturition) were detected as hypocalcaemic (Ca^{2+} < 2.34 mmol/l). ALP, ALAT and CK activities were significantly lower in infected than in control goats, that of ASAT was not different between the groups (Table 2). ALP activity was 0.42 - 16.3 and 2.9 - 81.8 (mean ± standard deviation of 3.85 ± 3.98 and 14.8 ± 15.49) μkat/l in infected and control goats respectively. For ALAT, CK and ASAT these were 0.05 - 0.34 (0.16 ± 0.079), 1.61 - 7.58 (2.84 ± 1.346) and 1.07 - 5.99 (1.61 ± 0.80) respectively in infected goats, whereas in the control group they were 0.15 - 0.46 (0.26 ± 0.072), 1.84 - 6.56 (3.48 ± 0.99) and 0.97 - 3.48 (1.49 ± 0.39) respectively for the same enzymes. The critical activity values to ascertain that an animal was test positive to schistosomiasis were 4.5, 0.19 and 2.60 μkat/l for ALP, ALAT and CK respectively, or -0.653, -0.721 and 0.415 in logarithms. Test positive goats (T+) had their parameter levels below the critical values and vice versa for T- animals (Table 2). The sensitivities of the three enzymes were 75.0, 63.9 and 61.1 %, the specificities were 88.9, 80.6 and 86.1 % respectively. ALP, ALAT and CK tests distinctly identified the infected goats (Fig. 1). The enzymes in healthy group 3 - 7 landrace goats showed a variable number of T+ animals (fig. 1). The ALP activity was lower in lactating than in pregnant goats, thereby many were false T+. ALAT activity was lower in pregnant than in other groups of adult goats, thus some were false T+.

Table 2: The means and logarithmic means ± standard deviations of blood parameters in infected and noninfected dwarf goats.

	Infected		Non-infected		Test Parameters		
Parameter	Absolute	Log.	Absolute	Log.	C.V.	SE	SP
Ca^{2+} mmol/l	2.30±0.196	0.36±0.04	2.52±0.14	0.40±0.02***	0.37	61.1	94.4
Mg^{2+} mmol/l	0.87±0.092	-0.06±0.05	0.94±0.11	-0.03±0.05**	-0.07	33.3	83.3
PO_4^{2-} mmol/l	2.27±0.665	0.34±0.13	2.63±0.52	0.41±0.09**	0.32	36.1	86.1
Na^{+} mmol/l	144.7±3.16	2.16±0.01	147.8±3.68	2.17±0.01**	2.16	47.2	72.2
ALP μkat/l	3.85±3.98	0.39±0.41	14.82±15.49	1.05±0.30**	0.65	75.0	88.9
CK μkat/l	2.84±1.346	0.42±0.16	3.48±0.99	0.53±0.11*	0.42	61.1	86.1
ALAT μkat/l	0.16±0.079	-0.84±0.22	0.26±0.07	-0.60±0.12***	-0.72	63.9	80.6
Glucose mmol/l	3.05±0.48	0.48±0.07	3.52±0.65	0.54±0.08**	-	-	-
K mmol/l	4.68±0.38	0.67±0.03	4.61±0.45	0.66±0.04^{N}	-	-	-
Proteins g/l	70.0±13.9	1.84±0.09	66.17±6.40	1.82±0.05^{N}	-	-	-
ASAT μkat/l	1.61±0.799	0.18±0.13	1.49±0.39	0.16±0.09^{N}	-	-	-
Urea mmol/l	6.18±1.64	0.78±0.11	6.87±2.35	0.81±0.18^{N}	-	-	-
Creatinine μmol/l	76.3±10.01	1.88±0.06	80.5±21.3	1.89±0.13^{N}	-	-	-
Bilirubin μmol/l	3.42±1.99	0.47±0.25	3.72±1.73	0.53±0.19^{N}	-	-	-

*$p<0.05$, **$p<0.001$, ***$P < 0.0001$, ^{N}Not significant, C.V. = critical values in log scale,
SE = % sensitivity and SP = % specificity.

Table 3: The means ± standard deviations of plasma electrolytes, serum proteins, enzymes and other parameters in schistosoma free landrace goats (groups as in Table 1).

Parameter	3	4	5	6	7
Ca^{2+} mmol/l	2.54±0.15	2.41±0.14	2.39±0.28	2.53±0.28	2.54±0.17
Mg^{2+} mmol/l	0.92±0.09	1.04±0.11	0.99±0.14	1.07±0.12	0.97±0.09
PO_4^{2+} mmol/l	2.51±0.65	1.18±0.48	2.28±0.91	2.54±0.64	1.92±0.41
Na^+ mmol/l	147.4±5.5	150.0±1.82	149.6±2.08	149.2±4.34	152.3±2.01
K^+ mmol/l	4.51±0.55	4.35±0.44	4.38±0.45	4.36±0.45	4.14±0.49
ALP μkat/l	14.1±8.42	17.8±17.49	18.7±10.1	20.6±20.1	15.2±13.8
ALAT μkat/l	0.23±0.05	0.20±0.06	0.24±0.07	0.24±0.07	0.27±0.07
ASAT μkat/l	1.27±0.24	1.58±0.43	1.44±0.30	1.42±0.30	1.22±0.41
CK μkat/l	3.68±1.63	4.13±1.55	3.75±1.10	3.67±1.25	4.20±1.74
Proteins g/l	66.5±6.4	68.6±5.88	73.3±7.19	74.9±5.44	72.3±7.1
Urea N mmol/l	8.52±2.33	7.65±3.03	6.40±3.15	4.86±2.21	9.10±2.83
Creatinine μmol/l	76.4±22.4	69.2±12.9	68.1±10.0	67.5±11.4	64.3±13.9
Bilirubin μmol/l	3.9±1.63	3.27±0.96	3.27±1.19	4.04±1.35	2.76±0.77
Glucose mmol/l	2.87±0.33	2.85±0.40	2.89±0.56	2.95±0.28	3.03±0.40

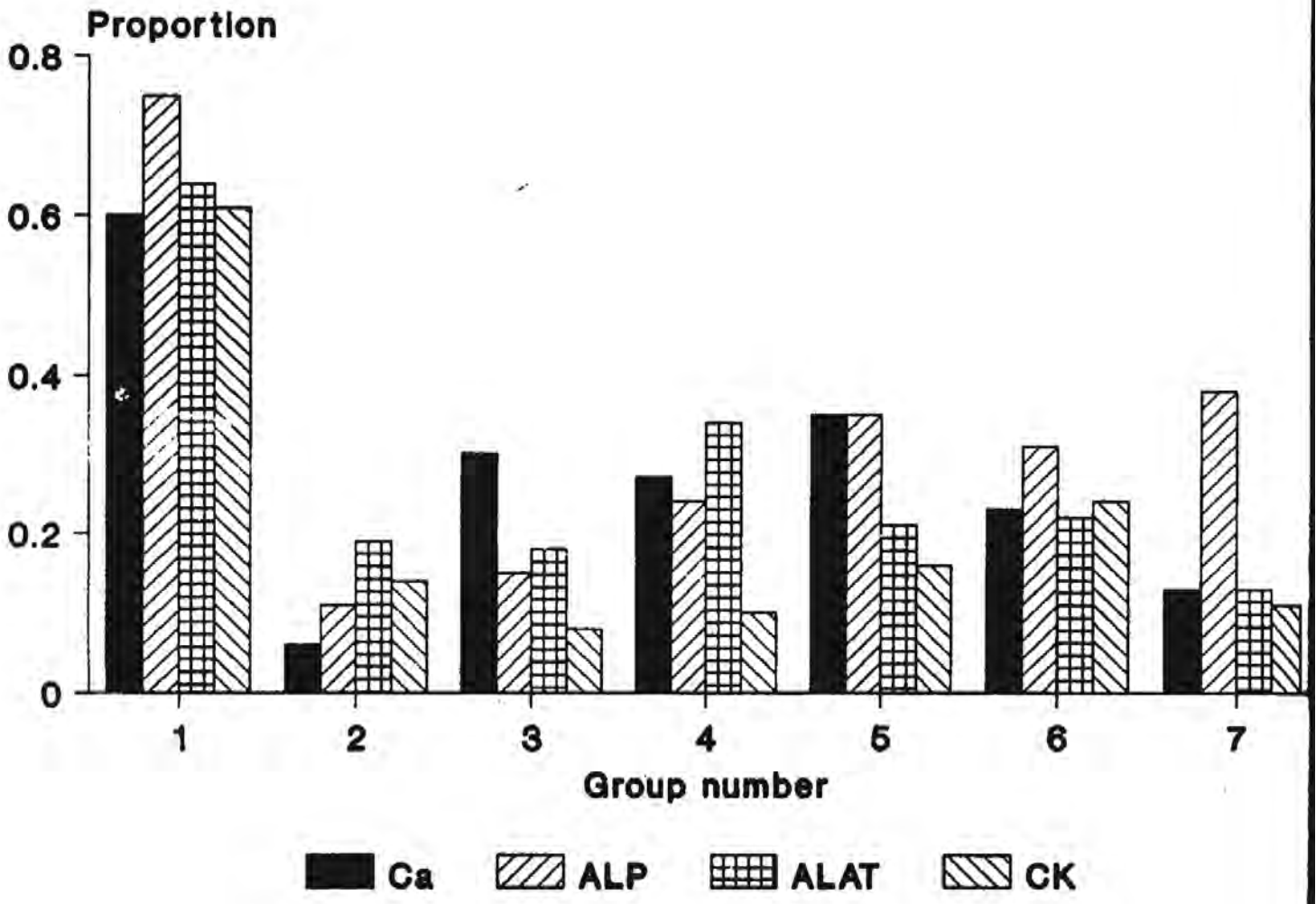

Figure 1: The proportions of test positive animals for hypocalcaemia, and the lowering of enzyme activities in Dwarf goats; infected (group 1) and non infected (group 2), 6 - 10 months old compared with Landrace goats: 6 - 10 months old (group 3), adults: pregnant (group 4), 20 - 30 days in lactation (group 5), 60 -90 days in lactation (group 6) and more that 120 days in lactation (group 7). Ca = Calcium, ALP = Alkaline phosphatase (EC. 3.1.3.1), ALAT = Alanine amino transferase (EC. 2.6.1.2), CK = Creatine kinase (EC. 2.7.3.2).

Apart from the infected goats only those in 60 - 90 day lactation had low CK activity, hence some were false T+.

Series interpretations was done by combining tests involving two or more enzymes meaning that an animal was test positive for parasitism only when the activity levels of all the grouped enzymes were lower than the critical values. The sensitivity and specificity for ALP, ALAT, and CK together were 44.4 and 97.2 % respectively. Coupling of ALAT and CK in the test resulted in 44.4 % sensitivity and 94.4 % specificity.

Urea, creatinine and bilirubin levels were slightly but not significantly decreased in infected goats compared with those of control animals, whereas glucose was significantly lower in the former than in the latter (Table 2). These were excluded for use as tests.

DISCUSSION

Blood tests are surrogative, detecting the effects of parasitism not parasites. The tests in this study are based on point analysis on the day of sampling. The results may deviate from natural cases. They, however, mimic the disease situation. The selection of the schistosomiasis as a model was based on the fact that it causes anaemia and produces signs representing a clinical syndrome of gastro and extragastrointestinal helminthiasis.

Calcium is maintained within narrow limits as free Ca^{2+}, ultrafiltrable Ca^{2+} in complexes or bound to albumin. Since hypoalbuminaemia is reported to occur in this disease through intestinal haemorrhages (Saad *et al.*, 1984b), the hypocalcaemia observed in Schistosoma infected goats was probably associated with low plasma albumin. Among the infected animals 61.1 % were detected to be hypocalcaemic and 94.4 % of non infected goats were detected as not hypocalcaemic, thus both sensitivity and specificity were high (Table 2). In the test 14 infected goats were not hypocalcaemic (false negatives), whereas only 2 control goats had Ca^{2+} levels lower than the critical value of 2.34 mmol/l (false T+).

A decrease in plasma calcium concentration often occurs in lactating cows (Rowlands, et al. 1975) and goats (Hassan, *et al.*, 1986; Wojcik, *et al.*, 1986). The hypocalcaemic goats (false T+) in groups 4, 5, and 6 in late pregnancy and early lactation could thus be an effect of lactation and pregnancy (fig. 1). There were subsequently less T+ animals in group 7 (> 120 days after kidding i.e dry animals) indicating the disappearance of this effect. There was , however, a distinctly higher proportion of T+ animals for hypocalcaemia in infected than in all other disease free goats. The false T+ goats in groups 3 which were of similar ages to the infected goats (thus eliminating the age factor), was confounded by breed and environment which are known to influence plasma electrolytes (Catarsini, *et al.* 1982; Kumaresan and Ndzingu Awa, 1984).

Magnesium, Na and P were only slightly lowered within 6 weeks of Schistosomiasis, whereas K levels were not altered. The hypomagnesaemia, hyponatraemia and hypophosphataemia were of low magnitudes for testing early Schistosomiasis. Hypophosphataemia results from deficiency of vitamin D or malabsorption due to intestinal malfunctions including parasitic inflammations (Kaneko, 1989), this probably accounts for the hypophosphataemia in Schistosoma infected goats.

Low Na levels occur in cases of large losses of intestinal fluid, adrenal insufficiency or renal diseases. It was revealed that there were no changes in urea, bilirubin and creatinine indicating that the kidneys and adrenal glands were not affected. The hyponatraemia in the infected goats was therefore probably due to the loss of intestinal fluid by diarrhea, thus it is proportional to disease severity. Quantitative analysis would enable detection of chronic low grade parasitic gastrointestinal infections. Hypokalaemia occurs in decreased intake, severe vomiting, diarrhea or alkalosis. Plasma levels in the infected goats were slightly but not significantly higher than in control goats.

ALP occurs in multiple isoenzymes (Tolling, 1988) in bile duct canaliculi, intestinal, renal tubular and placental epithelia, hepatocytes and osteoblasts and is of

high diagnostic value for liver, bone and endocrine diseases in dogs (Milne, 1985). ALP activity is elevated in hepatic fibrosis, obstruction or lipidosis, osteopathy, diabetes mellitus, hypothyroidism, hyperadrenocorticoidism and starvation but lowered in reduced bone growth, achondroplasia and hypophosphatasia (Swarup *et al.*, 1986). The decrease in ALP activity in Schistosoma infected goats was probably due to depressed osteoblastic activity and haemorrhagic diarrhea as reported earlier (Vercruysse, et al. 1988). ALP activity was lower in 27 (75 %) infected and 4 (11.1 %) non infected goats (thus sensitivity 75 and specificity 88.9 %). The wide variations of ALP activity in ruminants (Boyd, 1988; Mbassa and Poulsen, 1991), however, reduces its diagnostic significance.

ALAT, a catalyzer of transamination of L-alanine and alpha oxoglutarate to pyruvate and glutarate is elevated in hepatocellular disorders, cardiac infarcts and muscular dystrophies (Boyd, 1988). Plasma ALAT activity was observed to be unaltered in Schistosoma infected goats (Vercruysse *et al.*, 1988) and calves (Mahmoud *et al.*, 1987), but it was depressed in 63.9 % of infected and 19.4 % non infected goats of the present investigation. The sensitivity and specificity were 63.9 % and 80.6 % respectively. The disagreement between the sources is probably due to the differences in duration of infection at the time of blood sampling. The lowering of ALAT activity in this infection probably resulted from tissue destruction due to parasite migrations and eggs in gut walls, deficiency of cofactor and ions such as Ca^{2+} and Mg^{2+} induced by alimentary malabsorption. The traumatic parasite effects cause vascular damages, malbsorptions, diarrhea, protein catabolism and alteration of serum enzyme levels (Yason and Novilla, 1984; Vercruysse *et al.*, 1985; 1988). ALAT activity is a useful surrogative test in parasitic infections because of its narrow range in disease free animals.

CK activity is elevated in neurological and muscular disorders, myocardial diseases and selenium - Vitamin E deficiency (Boyd, 1988). Mahmoud *et al.* (1987) observed an increased CK activity in Schistosoma infected calves contrary to present observations in goats where it was lower in 22 (61.1 %) of the 36 infected goats and 5 (13.9 %) of the 36 control animals. The disagreement is probably accounted for by age and species differences. The weakness and non inflammatory muscle wasting resulting from protein loss through intestinal haemorrhages and diarrhea is more severe in younger than in older animals, thus depression of CK activity. The sensitivity and specificity of CK activity test were 61.1 and 86.1 % respectively.

The activity of cytosol and mitochondrial ASAT isoenzyme in all cells and plasma increase in hepatic and neuromuscular diseases (Boyd, 1988; Bogin *et al.*, 1988). The lack of alteration of ASAT activity in *S. bovis* infected calves (Mahmoud *et al.*, 1987), sheep and goats (Vercruysse *et al.*, 1988) and after 6 weeks of infection with *S. bovis* in the present goats indicate that this enzyme is not affected by this disease.

In series interpretation ALP, ALAT and CK activities were lower in 16 infected goats and 1 control, whereas ALAT and CK were lower in 16 infected and 2 control animals.

The proportions of T+ and T- animals were similar in groups 2 and 3 goats (same age, different breed) indicating that ALP, ALAT and CK do not seem to be influenced by breed (fig. 1). ALP appears to be affected by age and lactation because there were many false T+ in groups 4 - 6. ALP activity is high in young animals due to osteogenesis and in late pregnancy (Kumaresan and Ndzingu Awa, 1984, Mbassa and Poulsen 1991). CK was low during the second to third months of lactation, but seems to be influenced to a minor degree by these factors.

Urea is synthesized in the liver as a mechanism for excretion of ammonia during catabolism of amino acids. The levels are elevated in accelerated protein catabolism caused by gut haemorrhage with amino acid degradations, fever, burns, starvation and infections, and in decreased excretion due to renal diseases. Decreased levels are due to diminished protein intake and hepatic insufficiency (Kaneko, 1989). Schistosomiasis induced gastrointestinal haemorrhages, albumin hypercatabolism and hepatic lesions (Saad *et al.*, 1984b) may cause elevation of urea, but

advanced liver syndromes result in decreases (Kaneko, 1989). The decrease in the present infected goats at 6 week stage was not significant, thus it was of limited diagnostic value.

Plasma creatinine is elevated in renal and muscular diseases (Maas, 1983). Since the level was not altered in infected goats, the kidneys and muscles evidently were not affected. Bilirubin, a product of erythrocyte destruction is bound to albumin for hepatic conjugation with glucuronic acid. Total and unconjugated bilirubin are elevated in haemolytic diseases. Hepatic infections including Schistosomiasis and intra or post hepatic bile duct obstructions increase unconjugated and total bilirubin. Total bilirubin was not altered in the present infected goats, similar to findings by Vercruysse *et al.* (1988) because the parenchyma damage or obstruction occurs gradually (Monrad *et al.*, 1982; Saad *et al.*, 1984a).

Glucose comes from alimentary nutrient absorption and hepatic gluconeogenesis, both of which may be impaired in schistosomiasis (Saad *et al.*, 1984a). This could explain the hypoglycaemia observed in infected goats of the present study. Similar effects were observed in Fascioliasis (Swarup *et al.*, 1986). Hypoglycaemia can be a useful surrogative test in chronic gastrointestinal and hepatic parasitism.

In conclusion hypocalcaemia, hypomagnesaemia, hypophosphataemia and hyponatraemia occur in parasitic infections including Schistosomiasis. ALP, ALAT, and CK are also lowered reflecting the effect on osteogenesis and metabolic depression. Quantitative evaluation of these effects can serve to detect hepatopathies and gastroenteropathies in subclinically and chronically infected animals. The tests have high sensitivities and specificities. Careful interpretations are required because breed, physiological state and age may affect their levels in the plasma. Bilirubin, urea, creatinine and glucose are lowered in Schistosoma infected goats but not to diagnostic levels in six weeks of infection.

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REFERENCES

Baldock F. C. (1987). Operating characteristics of diagnostic tests, interpretation of results and criteria for selecting a test. **Austr. Vet. Pract.** 17:126-130.

Bogin E., Avidar Y., Merom M. Soback S. and Brenner G. (1988). Biochemical changes associated with fatty liver syndrome in cows. **J. Comp. Pathol.** 98:337-347

Boyd J. W.(1988). Serum enzymes in diagnosis of diseases in man and animals. **J. Comp. Pathol.** 98:381-404

.Catarsini O., Chiofalo L., Pugliese A., Domina F. and Magistri C. (1982). Metabolic profile in goats. I. Blood serum levels of some electrolytes (phosphorus, clacium, potassium, magnesium and sodium). **Ann. della Facolta Med. Vet.** XIX:201-209.

Diaw O. T. and Vassilides G. (1988). Epidemiology of Schistosomiasis of livestock in Senegal. **Rev. élevage Med. Vet. des pays Trop.** 40:265-274

Flensburg J. and Willeberg P. (1976). Studies on age specific leukocyte and lymphocyte counts in normal Friesian, Red Danish and Jersey cattle in Denmark. **Nord. Vet. Med.** 28:150-159

Hassan G. A., El-Nouty F. D., Samak M. A. and Salem M. H. (1986). Relationship between milk production and some blood constituents in Egyptian Baladi goats. **Beitrage Trop. Landwirt. Veterinarmed.** 24(H2): 213-219.

Kaneko J. J. (1989). Clinical Biochemistry of domestic animals. 3rd Edn. Academic Press Inc. Orlando Florida, 1-797.

Kassuku A. A., Christensen N. Ø., Nansen P. and Monrad J. (1986). Clinical Pathology of *Schistosoma bovis* infection in goats. **Res. Vet. Sci.** 40:44-47

Kumaresan H. and Ndzingu Awa D. (1984). Influence of age and pregnancy on serum calcium, inorganic phosphorus and alkaline phosphatase activity in red Sokoto goats. **Rev. élevage Med. Vet. des pays Trop.** 37:477-481.

Maas J. (1983). Interpreting serum chemistry screens in cattle. **Modern Vet. Pract.** Dec. 1983, 963-967

Maddison S. E. (1986). Schistosomiasis. In K. Walls and P. M. Schantz edn, Immunodiagnosis of parasitic diseases Vol. I. Helminthic parasites, (Academic Press inc. Harcourt Brace Jovanovick Publishers Orlando Florida), 1-37

Mahmoud O. M., Elsamani F., Gameel A. A. and Taylor M. G. (1987). Serum enzyme changes in calves experimentally infected with *Schistosoma bovis*. **J. Comp. Pathol.** 97:335-339.

Martin W. S., Meek A. H. and Willeberg P. (1987). Veterinary Epidemiology: Principles and methods,(Iowa State Univ. Press Ames), 48-76, 121-148.

Mbassa G.K and Poulsen J.S.D, (1991). Profiles of plasma enzyme activities in growing dwarf and Danish Landrace kids. **Journal of Vet Med A.** 38

Milne E. M. (1985). The diagnostic value of alkaline phosphatase in canine medicine: a review. **J. Small Anim. Pract.** 26:267-278.

Monrad J., Christensen N. O., Nansen P. and Frandsen F. (1982). Clinical Pathology of *Schistosoma bovis* in sheep. **Res. Vet. Sci.** 33: 382-383.

Rowlands, G. J., Manston R., Pocock R. M. and Dew S. M. (1975). Relationship between stage of lactation and pregnancy and blood composition in a herd of dairy cows and the influence of seasonal changes in managemant on these relationships. **J. Dairy Science** 42:349-362.

Saad A M., Hussein M. F., Dargie J. D. and Taylor M. G. (1984a). The Pathogenesis of experimental *Schistosoma bovis* infections in Sudanese sheep and goats. **J. Comp. Pathol.** 94: 371-385.

Saad A. M., Hussein M. F., Bushara H. O., Dargie J. D. and Taylor M. G. (1984b). Erythrokinetics and albumin metabolism in primary experimental *Schistosoma bovis* infection in zebu calves. **J. Comp. Pathol.** 94:249-262.

Swarup D. Upadhyay D. and Pachauri S.P. (1986). Some biochemical indices in naturally occurring Fascioliasis in goats. **Res. Vet. Sci.** 40:276-277.

Tolling K. T. (1988). Serum alkaline phosphatase isoenzymes in horses. Variations with age, training and different pathological conditions. **J. Vet. Med. A** 35:13-23.

Vercruysse J., Fransen J., Southgate V. R. and Rollinson D. (1985). Pathology of *Schistosoma curassoni* infection in sheep. **Parasitol.** 91:291-300.

Vercruysse J. and Schanderyl P. (1986). Parasitological and pathological observations on Schistosomiasis in sheep in Senegal. **J. Helminthol.** 58:219-220.

Vercurysse J., Fransen J. Southgate V. R., Rollinson D. and Majeleine W. (1988). Clinical pathology of experimental *Schistosoma curassoni* infections in sheep. **Res. Vet. Sci.** 44:273-281.

Wojcik, S., Saba L., Bialkowski Z. and Rozaniecka K. (1986). Examination of the metabolic profile of blood in goats. **Medycyna Weterynaryjna** 42:113-115.

Yason C. V. and Novilla M. N. (1984). Clinical and pathological features of experimental *Schistosoma japonicum* infection in pigs. **Vet. Parasitol.** 17:47-64.