

## EVALUATING BLOODWORK PROFILES IN SHEEP: INSIGHTS INTO COENUROSIS

### EVALUAREA PROFILURILOR SANGUINE LA OI: PERSPECTIVE ASUPRA COENUROZEI

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#### ABSTRACT | REZUMAT

Coenurosis, caused by the larval stage of *Taenia multiceps*, represents a serious parasitic threat to sheep populations globally, resulting in marked neurological impairment and significant economic losses. The development of cysts within the central nervous system, particularly in the brain and spinal cord, necessitates timely and accurate diagnosis for effective management and control. This study aims to assess differences in standard blood chemistry profiles between sheep diagnosed with coenurosis and other sheep. Clinically, no neurological or other symptoms were observed in the control subjects; however, the group that has been diagnosed with coenurosis presented such symptoms. The findings indicate a range of blood chemistry alterations, predominantly affecting the hepatobiliary system, which may be associated with parasitic infection by *Fasciola hepatica*. While all sheep exhibited elevated creatine kinase levels—a potential marker of coenurosis—these elevations alone are insufficient for diagnosis without accompanying specific brain isoenzyme measurements. Recent research highlighting the specificity of plasma kynurenic acid levels for diagnosing coenurosis offers an alternative diagnostic pathway for clinicians, particularly when CT imaging is not readily accessible. This biomarker could significantly aid in diagnosing coenurosis in settings where advanced imaging options are limited.

**Keywords:** sheep, coenurosis, blood

Cenuroza, patologie cauzată de stadiul larvar al *Taenia multiceps*, reprezintă o amenințare parazitară serioasă pentru populațiile de oi la nivel global, ducând la afectări neurologice marcante și pierderi economice semnificative. Dezvoltarea chiștilor în sistemul nervos central, în special în creier și măduva spinării, necesită diagnosticare rapidă și precisă pentru o gestionare eficientă. Acest studiu își propune să evalueze diferențele din profilurile standard de biochimie sanguină între oile diagnosticate cu cenuroză și alte oi. Din punct de vedere clinic, la subiecții din grupul de control nu s-au observat simptome neurologice sau alte simptome, însă grupul diagnosticat cu cenuroză a prezentat astfel de simptome. Rezultatele indică o serie de modificări ale parametrilor biochimici sanguini, afectând în principal sistemul hepatobiliar, care pot fi asociate cu infecția parazitară provocată de *Fasciola hepatica*. Deși toate oile au prezentat niveluri crescute de creatinkinază—un posibil marker al cenurozei—aceste creșteri, în sine, nu sunt suficiente pentru diagnostic fără măsurători specifice ale izoenzimelor cerebrale asociate. Cercetările recente, care subliniază specificitatea nivelurilor plasmatice de acid kinurenic pentru diagnosticarea cenurozei, oferă o alternativă diagnostică pentru clinicieni, în special în situațiile în care tomografia computerizată (CT) nu este ușor accesibilă. Acest marker ar putea fi de mare ajutor în diagnosticarea cenurozei în medii cu opțiuni limitate de imagistică avansată.

**Cuvinte cheie:** oi, cenuroză, sânge

Coenurosis is a parasitic disease affecting livestock worldwide, caused by *Taenia multiceps*, a taeniid cestode that inhabits the small intestine of dogs and other canids during its adult stage. The larval form of *T. multiceps* induces coenurosis in its intermediate hosts, often resulting in the death of the infected animals (8).

The disease is characterised by the development of cysts that are frequently located in the brain and spinal cord of these intermediate hosts. Clinical manifesta-

tions of coenurosis include head deviation, blindness, hypermetria, ataxia, stumbling, and paralysis, with these neurological symptoms attributed to the presence of cysts and the compression on the nervous tissue. In many cases, coenurosis leads to mortality, and in some instances, diagnosis is made postmortem, as no clinical signs were evident during the animal's life (4).

The objective of this study is to evaluate whether there are any significant haematological and biochemical alterations in the blood of sheep affected by coenurosis by comparing it with samples from animals that do not suffer from this disease. Establishing such an undemanding approach to diagnose coenurosis would prove beneficial, especially in field conditions.

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## MATERIALS AND METHODS

This study was conducted on 16 sheep (14 ewes and 2 rams) from a farm located near Baia Mare, Romania. The animals were divided into two distinct groups based on clinical and diagnostic criteria. The first group comprised nine adult sheep that exhibited no neurological symptoms and showed no evidence of cysts upon computed tomography (CT) imaging. The second group included seven sheep that displayed a range of neurological symptoms, including lethargy, ataxia, disorientation, difficulty maintaining balance, behavioural changes, circling, lateral deviation of the head, and head pressing. Sheep from the second group, presenting neurological symptoms, underwent anaesthesia using a standardised protocol. Premedication was achieved with atropine (1 mg/animal, intravenously) and diazepam (0.5 mg/kg, intravenously). Induction of anaesthesia was performed with ketamine (2 mg/kg, intravenously), followed by the administration of propofol intravenously to effect. Anaesthesia was maintained using isoflurane (2% minimum alveolar concentration) in 100% oxygen, delivered via endotracheal intubation. The animals were positioned in dorsal recumbency for imaging purposes. CT scans subsequently revealed the presence of cysts within the brains of all sheep in this group.

Blood samples were collected from the jugular vein of all sheep and placed into EDTA tubes and serum-separating tubes. The samples were subsequently sent to the internal laboratory of the Faculty of Veterinary Medicine in Cluj-Napoca for analysis.

### Statistical analysis

To assess differences in bloodwork parameters between the two groups, we employed Welch's t-test, using IBM SPSS Statistics (IBM SPSS Statistics for Windows, Version 27.0., Armonk, NY: IBM Corp). Parameters with p-values < 0.05 were considered statistically significant. Summary statistics (mean  $\pm$  standard deviation) were calculated to provide context for the observed differences.

## RESULTS AND DISCUSSIONS

The statistical analysis of hepatobiliary function parameters between groups revealed variable results. Glutamate dehydrogenase (GldH) was elevated in one sheep from group 1 and one sheep from group 2, while aspartate aminotransferase (ASAT) values remained within normal limits for all animals in group 1 and was elevated from 1 sheep in group 2, no statistical significance was observed regarding those parameters.

Gamma-Glutamyl Transferase (GGT) levels were significantly elevated in Group 2 compared to Group 1 ( $p = 0.001$ ) (Fig. 1). Group 1 had a mean GGT of 66.06 U/l ( $\pm 17.82$ ), while Group 2 averaged 124.76 U/l ( $\pm 27.10$ ). This consistent elevation in Group 2 reflects hepatobiliary stress and potential secondary parasitic infections. The elevated GGT in Group 2 aligns with the neurological symptoms and highlights the role of

hepatobiliary dysfunction in affected animals. Alkaline Phosphatase (ALP) levels also differed significantly ( $p = 0.013$ ), with Group 2 exhibiting a mean of 622.33 U/l ( $\pm 308.69$ ) compared to 208.50 U/l ( $\pm 100.38$ ) in Group 1 (Fig. 2). Elevated ALP is consistent with hepatobiliary damage or biliary obstruction, corroborating the GGT findings.

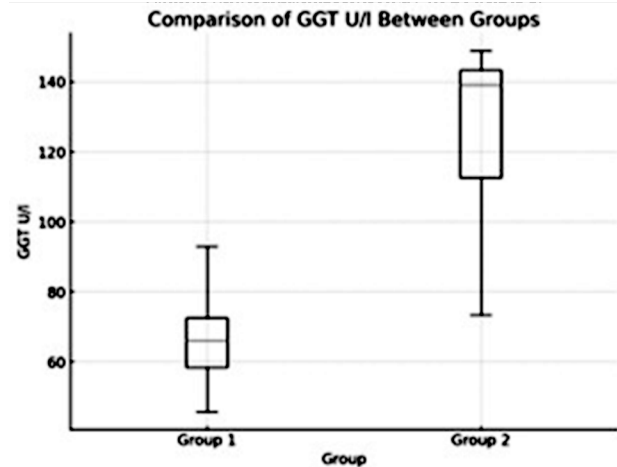


Fig. 1. Comparison of GGT between groups

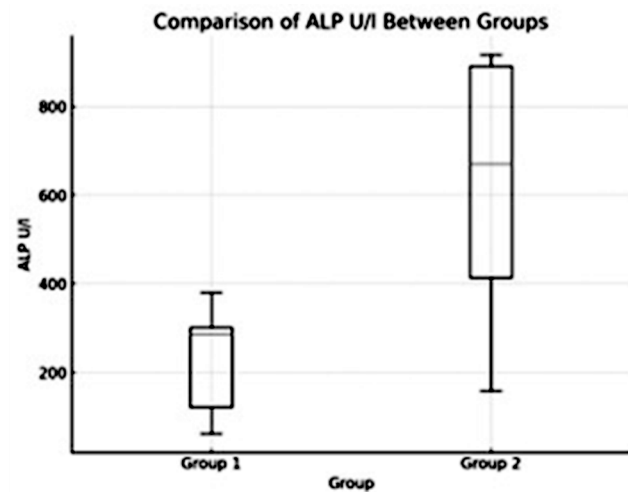


Fig. 2. Comparison of ALP between groups

This parameter could serve as an additional indicator of liver dysfunction secondarily correlated with coenurosis-affected sheep. The statistical analysis shows a strong positive correlation ( $r=0.830$ ) between GGT levels and coenurosis. Other studies also reported elevated GGT levels in sheep with coenurosis, associating it with hepatic stress and possible concurrent parasitic infections (4). This suggests hepatobiliary dysfunction as a potential indirect symptom of the disease, likely linked to parasitic liver damage or systemic effects. Tas *et al.* (2023) highlighted GGT as a consistent marker in sheep with parasitic infections but emphasised that GGT elevation alone is insufficient for diagnosis without clinical context or additional markers (5). Statistical analysis for ALP shows a moderate to strong positive correlation ( $r = 0.695$ )

**Table 1**

**Bloodwork results from the first group of sheep (1/2)**

No.	GldH U/l	ASAT U/l	GGT U/l	ALP U/l	Prot. g/dL	Album. g/dL	γ-glob. g/dL	Cholest. mg/dL	Tgl mg/dL
1	10.4	40.3	50.1	285.4	6.8	3.1	1.39	140.9	30.2
2	7.3	37.9	45.8	304.2	6.4	2.93	1.45	108.5	58.7
3	5.3	27.5	92.9	152.6	7.5	3.14	1.48	295.9	26.2
4	8.6	44	64.6	300.6	7	3.5	1.32	107.3	27.7
5	11.4	46.3	72.6	61.8	7.1	2.54	1.5	124.1	61.3
6	6.9	51.1	58.5	301	6.4	2.72	1.41	126	20.4
7	5.7	54.4	66.1	379.5	6.35	2.87	1.26	113.9	23.3
8	9.6	42.6	66.8	76	6.75	3.03	1.8	128.7	59.5
9	17.8	30.7	79.6	121.1	7.6	2.87	1.16	139.5	48.7
Reference values	< 15	<60	10-30	40.4-200	6-8	2.46-2.92	1.2-1.82	57.9-154.6	13.1-35

**Table 2**

**Bloodwork results from the first group of sheep (2/2)**

No.	Cu <sup>2+</sup> μmol/l	Fe <sup>3+</sup> μg/dL	Ca mg/dL	Ph mg/dL	Mg mg/dL	CK U/l
1	38.7	170.7	7.4	5.41	3.13	260.4
2	41.2	161.1	6.23	5.98	3	303.8
3	20.4	182.5	7.2	6.8	3.35	242.8
4	44.4	171.3	8	5	3.2	271.5
5	29.6	122.3	7	4.73	3.7	220.5
6	46.2	202.9	7.3	4.91	3.9	315.1
7	36.5	175.6	7.6	5	4	255.2
8	16.4	146.3	7.4	4.98	3.8	242.9
9	31.3	185.2	9.8	6.5	4	220.6
Reference values	12.9-29.3	111.7-224	8.2-12.8	3-8	1.94-3.65	20-120

between ALP levels and coenurosis, reinforcing its association with biliary obstruction or hepatic stress. Gonzalo-Orden *et al.* (2000) found elevated ALP in coenurosis cases, attributing it to chronic liver impairment secondary to parasitic load. Varcasia *et al.* (2022) observed elevated ALP in sheep exposed to copper-rich environments, cautioning against interpreting ALP elevations as disease-specific without controlling for environmental factors (Table 1, Table 2).

Copper levels differed significantly ( $p = 0.025$ ), with Group 1 averaging 33.86 μmol/l (±10.36) and Group 2 averaging 21.29 μmol/l (±9.47). This variation likely reflects environmental factors, such as copper-rich soil, rather than a direct association with coenurosis. These findings emphasise the importance of considering external influences when interpreting trace minerals (Table 3, Table 4).

Iron levels remained within normal limits for all animals in group 1 and were altered in 3 sheep from group 2; without statistical relevance, potentially reflecting altered trace mineral metabolism.

Gamma-globulin (γ-globulin) levels trended lower in group 2, this finding was inconsistent and not sta-

tistically significant. Total protein levels were comparable between groups. These markers might indicate mild immunosuppression or decreased globulin production in some affected animals but lack the consistency needed for diagnostic use.

Cholesterol levels showed a statistically significant difference ( $p = 0.005$ ) between groups. Group 1 exhibited a mean cholesterol of 142.76 mg/dL (±58.69), while Group 2 had a mean of 66.50 mg/dL (±28.73). Despite the statistical difference, all observed values fell within the reference range, suggesting that the difference may lack clinical relevance. Cholesterol does not appear to be a reliable marker for differentiating between sheep with and without coenurosis-related neurological symptoms.

Hypertriglyceridemia was altered in four individuals from group 1 and one individual from group 2, without clinical and statistical relevance.

Magnesium was slightly elevated in group 2, while calcium levels were lower. Neither difference was statistically significant. These trends may reflect dietary or metabolic imbalances rather than direct effects of coenurosis. Hypocalcaemia in group 2 could relate to

Table 3

## Bloodwork results from the second group of sheep (1/2)

No.	GldH U/l	ASAT U/l	GGT U/l	ALP U/l	Prot. g/dL	Album. g/dL	γ-glob. g/dL	Cholest. mg/dL	Tgl mg/dL
1	6.24	38.1	148.8	903.8	7.1	3.22	1.17	122.1	30.8
2	7.78	62	142.1	916.8	6.9	3.24	0.81	49.7	24.8
3	16.1	39.3	144.5	878.8	6.8	3.06	1.38	58.8	32.2
4	9.61	43.7	111.3	670.6	6.45	2.31	1.27	86.5	31
5	8.2	66.7	139.1	547.2	8	2.33	1.78	61.1	32
6	11.9	37.2	114.1	157.9	7.3	2.09	2.07	38.8	19.8
7	5.9	38.3	73.4	281.2	5.9	1.94	1.08	48.5	35.8

Table 4

## Bloodwork results from the second group of sheep (2/2)

No.	Cu <sup>2+</sup> μmol/l	Fe <sup>3+</sup> μg/dL	Ca mg/dL	Ph mg/dL	Mg mg/dL	CK U/l
1	15	320.6	8.2	6.9	2.87	626.7
2	17	214.4	6.9	7.4	2.68	1715.9
3	14.8	267.1	7.4	9	3.3	845.2
4	32.5	177.9	7.2	4.25	3.7	354
5	16.5	178.6	7.4	6.05	6.4	248.9
6	37.4	136.8	6.5	5.53	4.1	256.8
7	15.8	281.6	6	4.74	3.8	265.4
Reference values	12.9-29.3	111.7-224	8.2-12.8	3-8	1.94-3.65	20-120

dietary deficiencies or altered metabolism associated with parasitic stress. Creatine Kinase (CK) was consistently elevated in both groups, with no statistically significant difference. The lack of group-level variation suggests CK is influenced by other stressors (like muscle stress or neurological involvement) rather than coenurosis alone. CK elevation may result from muscle or neurological damage caused by coenurosis but is insufficiently specific without brain isoenzyme data (4) emphasised the importance of brain-specific CK isoenzymes, which were not measured in this study, as more specific indicators of central nervous system involvement in coenurosis. Its diagnostic value increases when paired with imaging or clinical signs like head pressing and ataxia.

The consistent elevation of gamma-glutamyl transferase (GGT) and alkaline phosphatase (ALP) across all sheep in this study, combined with aspartate aminotransferase (ASAT) changes indicative of hepatic stress in some cases, suggests a likely parasitic aetiology, potentially involving *Fasciola hepatica*. Chronic hepatobiliary damage from such infection could plausibly explain the observed alterations in protein, cholesterol, and triglyceride levels, reflecting hepatic impairment's effects on lipid and protein metabolism. In the context of sheep coenurosis, the potential implication of GGT and ALP arises from the pathophysiology of the disease, which often involves inflammation and tissue damage in the brain and occasionally systemic effects. GGT and ALP levels might be altered in disea-

ses associated with tissue damage or parasitic infections. However, their specificity to coenurosis is limited because these enzymes typically reflect hepatic or systemic inflammation rather than localised brain lesions caused by *T. multiceps*. Therefore, while GGT and ALP may show changes in some cases of coenurosis due to secondary effects like systemic inflammation or hepatic involvement, they are not definitive biomarkers for diagnosing this condition in sheep.

The elevation in creatine kinase is potentially attributable to muscle stress, likely secondary to abdominal discomfort associated with hepatobiliary pathology. However, the possibility of coenurosis as an underlying cause cannot be ruled out, as central nervous system involvement can also elevate creatine kinase. For creatin-kinase to have a higher diagnostic value, the specific brain isoenzyme should be evaluated, as well as the isoenzyme for muscles.

The variations observed in calcium, phosphorus, and magnesium are likely attributable to dietary deficiencies. Elevated copper levels warrant further environmental investigation, given the potential influence of high-copper soil around the farm. Should environmental factors be implicated, further analysis would be essential to understand the effects of copper-rich soil on these animals.

The case of the fourth sheep in the second group is of particular interest, as this individual was diagnosed with coenurosis via computed tomography (CT) and subsequently underwent surgical cyst drainage. The

current findings reflect the animal's condition four months post-procedure. Hepatobiliary parameters demonstrate partial improvement, with aspartate aminotransferase (ASAT) levels stabilizing within the reference range. However, gamma-glutamyl transferase (GGT) and alkaline phosphatase (ALP) remain elevated, indicating persistent hepatobiliary stress.

Total protein levels have normalised, likely due to the resolution of clinical symptoms, which has restored the sheep's ability to maintain adequate nutritional intake. Despite these improvements, creatine kinase (CK) activity remains elevated. This persistent elevation is likely attributable to the incomplete removal of the cyst, suggesting ongoing muscular or neurological stress. These findings underscore the need for further monitoring and potential additional intervention to address the residual pathology.

Many affected sheep do not display clinical signs in what is referred as the quiescent stage until the disease has progressed significantly, complicating the timing and selection of individuals for blood testing by farm veterinarians (2). Recent studies have also highlighted the diagnostic potential of plasma kynurenic acid levels in sheep with coenurosis, demonstrating high specificity. This marker offers a practical diagnostic alternative, especially for clinicians who may find plasma sampling more feasible than CT scanning for suspected cases of coenurosis (3,6). Blood test results indicate that cyst drainage may not be as effective as complete cyst removal (5). Continued monitoring of this sheep's clinical and biochemical parameters will be necessary to assess whether cyst drainage alone can enable a long-term return to normal function.

Computed tomography (CT) scans remain the most valuable diagnostic tool currently available, as they provide a clear visualization of the cyst and aid in differentiating coenurosis from other central nervous system masses (1, 7).

## CONCLUSIONS

This study found no pathognomonic changes in standard blood chemistry panels that would reliably assist clinicians in diagnosing coenurosis in sheep. Given the high number of animals on farms, early detection of coenurosis before clinical onset appears unlikely. Among the routinely performed tests, creatine kinase (CK) may be a useful indicator of coenurosis, particularly when elevated CK levels are observed alongside neurological symptoms.

In such cases, measuring the specific brain isoenzyme of CK is recommended for enhanced diagnostic accuracy. The disappearance of clinical symptoms following cyst drainage in the coenurosis-affected sheep in this study suggests that cyst drainage could be considered a therapeutic option.

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