

Final Training Report
Master Degree in Veterinary Medicine

**Metabolic and respiratory diseases of small ruminants in Haute-
Vienne (France)**

Ana Raquel Gonçalves Pandeirada

Supervisor

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RESUMO

Para a conclusão do Mestrado Integrado em Medicina Veterinária, no 6º ano é efetuado um estágio curricular de 16 semanas, o qual foi realizado na clínica Capvêto Bellac, localizada no Haute-Vienne, na região de Limousine, em França. A clínica disponibiliza um serviço veterinário misto, da qual fazem parte sete médicos veterinários e cinco assistentes, prestando cuidados desde animais de pecuária a animais de companhia.

As raças de bovinos e ovinos de aptidão de carne predominam nesta região, sendo na sua maioria de raça *Limousine*, prevalecendo os sistemas de produção extensivo e semiextensivo. Durante o inverno, os animais encontram-se estabulados e o restante período do ano estão nas pastagens. Tendo o estágio decorrido durante o inverno possibilitou o acompanhamento do último mês de gestação nas ovelhas.

O presente relatório encontra-se dividido em três partes. As atividades desenvolvidas durante as 16 semanas de estágio são resumidas sucintamente na parte I. Na parte II e III estão descritos quatro casos clínicos em pequenos ruminantes seguidos durante o estágio. A parte II inclui três casos clínicos que abordam as principais doenças metabólicas no último mês de gestação da ovelha, entre as quais toxémia de gestação e hipocalcémia. Posteriormente, na parte III é apresentado um caso clínico em cabritos com idades compreendidas entre os três e seis meses, sendo dada uma breve introdução às doenças respiratórias em caprinos.

PALAVRAS-CHAVE: Pequenos ruminantes; Toxémia de gestação; Hipocalcémia; *Mannheimia haemolytica*; Micoplasmas.

ABSTRACT

During 16 weeks I completed my curricular practical training included in the 6th year of the Master's Degree in Veterinary Medicine at the Veterinary Clinic Capvêto Bellac, located in the Haute-Vienne department, region of Limousine, France. The clinic had available a mixed veterinary service (large and small animals), with a clinical staff of seven veterinarians and five veterinary assistants.

This region has a high predominance of *Limousine* breed of sheep and cattle. Production systems are usually extensive or semi-extensive where in the winter the animals are housed. My internship was during the winter and this allowed me to follow the last month of gestation in ewes.

This report is divided in three parts. In the part I, the overall activities carried out during the internship are described. The parts II and III describe four clinical cases in small ruminants followed during the internship. The part II includes three clinical cases about metabolic disorders that occur in the last month of gestation in ewes and the part III a clinical case of respiratory diseases in kids between three and six months of age.

KEYWORDS: Small ruminants, Pregnancy toxemia; Hypocalcaemia; *Mannheimia haemolytica*; Mycoplasma.

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List of Abbreviations

ALT	Alanine aminotransferase
AST	Aspartate aminotransferase
BALT	Bronchiolar associated lymphoid tissue
BCS	Body condition score
BID	Twice a day
BOHB	β -hydroxybutyrate
BUN	Blood urea nitrogen
CT	Calcitonin
DCAD	Dietary cation-anion difference
H⁺	Hydrogen cation
IM	Intramuscular
IV	Intravenous
KB	Ketone body
NEFA	Non-esterified fatty acid
mEQ/kg	Milliequivalent per kilogram
mg/dL	Milligram per deciliters
mg/L	Milligram per liter
mL	Milliliters
mmol/L	Millimolar per liter
PCR	Polymerase chain reaction
PO	Per os
PT	Pregnancy toxaemia
PTH	Parathyroid hormone
SID	Once daily

Background

This report is divided in three parts. In the first part, most of the activities developed during the internship are described. The second and third parts describe four clinical cases in small ruminants followed during the internship. The second part includes three clinical cases about metabolic disorders that occur in the last month of gestation in ewes and the third part a clinical case about respiratory diseases in kids with ages between 3 and 6 months.

Part I: Background of training

During 16 weeks, between November 4th and February 24th 2021, I completed my curricular practical training included in the 6th year of Master Veterinary Medicine at the Veterinary Clinic Capvêto Bellac, located in the Haute-Vienne department, region of Limousine, France. This internship purpose is to acquire technical and scientific skills aimed at exercising professional activity, promoting exposure to the professional world.

The choice to do the internship at the Capvêto Bellac clinic was due to being inserted in a region with a considerable number of livestock farms. This region has a high predominance of *Limousine* breed of sheep and cattle. Production systems are usually extensive or semi-extensive where in the winter the animals are housed. The internship time was during the winter and this allowed to follow the last month of gestation in ewes.

The clinic provided a mixed veterinary service, which enabled contact with the clinic and medicine of livestock, including dairy cattle and goats, companion animals, and less frequently, equine, exotic, and wild animals. The clinical staff included seven veterinarians, with different specialties, including small ruminants, cattle, horses, surgery, and internal medicine in pets, and five veterinary assistants. Companion animals and some livestock species (e.g. sheep, calves, goats, alpacas) were examined both in the clinic and in the ambulatory clinic. Some of the techniques and activities developed in the internship are shown in Table 1 below and Appendix A.

It was also possible to accompany several consultancies about of reproduction, fertility, feeding and stables' conditions. Furthermore, I followed clinical techniques/ surgeries in pet animals such as orthopaedic surgeries, abdominal surgeries, orchiectomy, ovariectomy, imaging techniques (X-ray, ECG, echocardiography, abdominal and pelvic ultrasound, pelvic, TAC) and blood transfusion.

Table 1. Procedures realized in cattle, sheep, and goat during the internship at Capv  to Bellac Clinic, France, between November 4th and February 24th.

Tract	Interventions	Case numbers		
		Ovines	Bovines	Caprines
Reproductive	Uterine prolapse	2	10	-
	Vaginal prolapse	2	5	-
	Evaluation of bull reproductive performance	-	2	-
	Parturition	26	7	-
	Caesarean section	7	2	-
	Pregnancy diagnosis by ultrasound	-	40	-
	Vasectomy	2	-	-
	Castration	-	26	-
	Metritis	2	3	-
	Placental retention	-	4	-
Digestive	Enteritis	6	-	2
	Peritonitis	2	4	-
	Reticuloperitonitis	-	3	-
Respiratory	Influenza virus	2	4	-
	Bronchopneumonia	6	5	-
	Tracheitis	8	3	-
Urinary	Pyelonephritis	-	1	-
Locomotor	Metatarsus amputation	-	1	-
	Interdigital dermatitis	7	2	-
Neurology	Cortex Necrosis	1	2	-
Prevention	Bluetongue virus (BTV4+ BTV8)	-	50	-
	Blood sampling	25	60	-
	Coprological examination	200	150	15
Neonatal disease	<i>Escherichia coli</i>	6	7	-
	Cryptosporidiosis	-	14	-
	Coronavirus	-	8	-
	Rotavirus	-	6	-
	Coccidiosis	8	5	-
	Omphalitis	5	15	-
	Polyarthritis	3	6	-
	Umbilical hernia	-	2	-
Other techniques	Exploratory laparotomy	1	1	-
	Abscess	3	6	-
	Rectal prolapse	1	2	-
	Foreign body	1	2	-
	Plaster application on fracture	-	3	-
	Necropsies	26	4	4
Metabolic diseases	Hypocalcaemia	7	3	-
	Pregnancy toxaemia	8	-	-
	Hypomagnesemia	5	2	-

Part II: Metabolic diseases in ewes during the last month of gestation

1. Introduction

The gestation in the ewe has a duration of about 145 to 150 days (Edmondson et al., 2012). This can be divided in three phases: implantation, placental development, and foetal growth and development (Scott, 2007). During the last month of gestation, when 80% of foetal growth happens, metabolic diseases such as pregnancy toxemia, hypocalcaemia, and hypomagnesaemia may occur (Schlumbohm & Harmeyer, 2003; Brozos et al., 2011).

1.1 Pregnancy toxemia

1.1.1 Incidence and aetiology

Pregnancy toxemia (PT), also named ketosis, develops in the late stage of gestation of ewes, causing significant economic losses in the sheep industry due to maternal and foetal death. This has a reserved prognosis. PT may be classified into four categories: (1) primary PT, when there is a decline in the plane of nutrition during late pregnancy or fasting period; (2) fat-ewe PT; (3) starvation PT; and (4) secondary PT, that results of concomitant disease (Crilly et al., 2021). These categories are based on risk factors that contribute to this condition, such as cross-breed ewes, insufficient dietary energy (poor roughage quality, inadequate quantity concentrate, or high foetal need), twins or triplet fetuses (decrease rumen capacity due fetal growth), stress, weather conditions, handling, vaccination, inadequate housing condition, parasitism (decreases the body reserves by damage of hepatic tissue), and some pathologies (obesity, severe lameness, vaginal prolapse and ruminal acidosis). Low body condition result in chronic intrauterine growth retardation with consequent reduced availability of energy for the foetus (Scott, 2007).

PT is observed in both thin and obese ewes. Body condition may be determined by condition scoring based on the prominence of the lumbar spinous and transverse processes, the amount of rib-eye muscle and fat cover between the two lumbar processes (Appendix B). A score is given from 0 to 5, where 0 indicates severe emaciation and 5 obesity. Ewes in late gestation should have a body condition score (BCS) between 2.5 to 3.5 (Schulz & Riese, 1983; Crilly et al., 2021). A BCS <2.0 and >4.0 represents a higher risk to develop PT (Crilly et al, 2021). In ewes with BCS >4, PT may occur due to

compression of the rumen by the ewes body fat and its foetus, thereby restricting feed intake (Schulz & Riese, 1983).

Foetal growth shows major development in the last month of gestation, about 80% (Rook, 2000). Thus, lower dietary intake combined with the increasing foetal demand for glucose, makes dietary carbohydrate supplementation essential in late pregnancy of ewes to cover the increased nutritional energy and protein needs by ewes and foetus. When the energy intake is not adequate the ewe's tissue stores of glucose are used as energy source (Schulz & Riese, 1983).

1.1.2 Pathophysiology and clinical signs

Gluconeogenesis is crucial in ruminants because almost all dietary carbohydrates are fermented in the rumen and reticulum to volatile fatty acids acetic, propionic and butyric acid. Propionate is absorbed and metabolized to glucose in the liver, acetate is metabolized in body tissues to long-chain fatty acids which are stored as lipids, and butyrate is converted to β -hydroxybutyrate (BOHB) and absorbed (Aitken, 2007). BOHB is a final product of fat metabolism and predominant circulating ketone body. The triglycerides are mobilized from adipose tissue by lipolysis, resulting in increased plasma levels of non-esterified fatty acids (NEFA), and acetyl-CoA is produced. When there is a deficit of glucose, in the body, acetyl-CoA is used to produce Ketone bodies (BOHB, acetoacetate and acetone) (Olfati et al., 2013; Schulz & Riese, 1983; Aitken, 2007). Ketone bodies (KB) are toxic by-products to compensate the energy deficit (Olfati et al., 2013). High concentration of KB in blood is designated ketosis. Ketosis may cause severe clinical signs and death. KB can be identified in urine. Prolonged urinary excretion of KB results in the loss of sodium and potassium ions and can cause an acidosis. High BOHB levels or keto-acidosis inhibit the hepatic gluconeogenesis which may result in severe clinical signs such as dyspnoea, hypoglycaemic depression of the central nervous system, dehydration, uraemia, and death. Prolonged hypoglycaemia leads to hyperactivity of the adrenal glands, with increased cortisol, preventing insulin action and inhibition of glucose uptake (Schulz & Riese, 1983). The clinical signs of pregnancy toxemia are unspecific such as seclusion, depression, unilateral or bilateral absence of menace reflex, salivation, disorientation, head-pressing, ear twitching, fine muscle fasciculations, dorsiflexion of the neck, teeth grinding, staggering gait, blindness and recumbency, anorexia, distended abdomen, and coma (Scott, 2007).

At post-mortem examination, carcasses are usually emaciated with the decomposition of foetus in utero. The liver shows alterations correlated with a severe hepatic lipidosis, such as being swollen, pale, orange, and friable (Scott, 2007).

Serum parameters including glucose, calcium, urea, cholesterol, phosphorus, and magnesium levels can be useful to evaluate ewes in the last month of gestation (Scott, 2007).

Gestation implies an increase of glucose, and when the energy intake is insufficient the levels of serum BOHB concentrations increases. Serum BOHB levels can be used as marker to monitor energy supply during gestation (Scott, 2007). According to Feijó et al. (2015) subclinical PT occurs when $\text{BOHB} > 0,5 \text{ mmol/L}$, whereas Aitken (2007) considers clinical PT when $\text{BOHB} > 3.0 \text{ mmol/L}$. Plasma glucose and NEFA concentrations are variable in pregnancy toxemia. Foetal death can result in significant increases of plasma glucose concentrations. Ewes with PT have reduced calcium levels $< 1,9 \text{ mmol/l}$, which can be related with poor hydroxylation of vitamin D, which occurs in particular in ewes with severe hepatic damage, e.g. due to parasitism (Scott, 2007).

Anoushepour et al., (2014), performed a study with 20 pregnant Afshari breed ewes, divided into two groups: hyperketonemic and normoketonemic ewes, and in which serum concentrations of NEFA, BUN, ALT, AST, Cortisol, Calcium, Glucose, Total Protein and Ceruloplasmin were compared. A significant decrease in plasma calcium concentration was observed in hyperketonemic ewes. Foetuses retain calcium for skeletal development, thus twins pregnant ewes have a high calcium need, showing a higher risk to develop hypocalcaemia and pregnancy toxemia (Anoushepour et al., 2014).

It is important to distinguish between pregnancy toxemia, hypocalcaemia, and hypomagnesemia. There are several conditions to be considered as differential diagnosis, such as acidosis, listeriosis, hypocalcaemia, impending abortion, polioencephalomalacia and copper intoxication, considered group diseases. Peripheral vestibular lesion, abscess, coenurosis and sarcocystosis, also can be occurs as individual diseases (Scott, 2007).

1.2 Hypocalcaemia

Hypocalcaemia can be a problem in dairy ewes in the period from 6 weeks before to 10 weeks after lambing. The greatest demand for calcium for non-dairy animal occurs in late gestation, 3 to 4 weeks before parturition, especially in females with more than one foetus, because of the foetal bones calcification. Hypocalcaemia occurs due to low plasma calcium concentrations. A complex endocrine regulating system is in place to ensure that extracellular calcium concentration remains within a narrow range ($10\text{-}13 \text{ mg/dL}$) (Saed, 2016).

Calcium concentrations in blood are supported by the regulation of intestinal calcium absorption, renal calcium reabsorption and bone calcium resorption. Calcium fluxes in the

intestines, kidneys and bones are regulated by parathyroid hormone (PTH), calcitriol and calcitonin (CT). Increased calcium concentrations, in the parafollicular cells of the thyroid, above normal physiological levels, cause CT release into the bloodstream. CT acts on the reduction of osteoclasts, reducing calcium resorption from bones. On the other hand, when calcium concentrations are under normal physiological conditions, PTH is activated and increases osteoclast proliferation, increasing the bone resorption activity. PTH also stimulates the secretion of renal 1- α -hydroxylase, that catalyses the hydroxylation of calcidiol to calcitriol. Calcitriol is the active form of vitamin D (1,25 dihydroxycholecalciferol), and it increases calcium concentrations in blood by increasing both intestinal calcium absorption and renal calcium reabsorption (Hernández-Castellano et al., 2020).

Mineral composition in diet should be controlled. High intake of calcium, phosphorus, potassium and sodium cations decreases the production of PTH, and consequently decreases the calcitriol, the absorption and mobilization of calcium from the intestines and bones. Some cases of hypocalcaemia are further complicated by hypophosphatemia and hypomagnesemia. Thus, as prevention to hypocalcaemia in the last six weeks of gestation a low dietary calcium or increased amounts of dietary anions are fundamental to enhance the production and release of parathyroid hormones (Saed, 2016).

2. Clinical Cases - Metabolic Diseases

2.1 Clinical case I

First intervention: Farm with 400 sheep of several meat breeds (*Charolais*, *Suffolk* and *Limousine*), reported that two multiparous ewes during last trimester of pregnancy, showed signs of dyspnoea, anorexia and presented on sternal recumbency in the last 24 hours. On physical examination depression and tachycardia were observed and a BCS of 3/5 was determined. High KB concentration ($>0,4$ mmol/L) was detected in the blood samples collected from the jugular vein. KB was measured with blood ketones test strips by portable meter (Freestyle optium Neo®, Abbott, UK). Final diagnosis was PT. The ewes were treated for PT with 50 ml of hypertonic glucose solution (Energidex®) and 50 ml of calcium gluconate (Calcivitol®), administered intravenously, as glucose and calcium replacement, respectively. Calcium was given by slow intravenous administration, as hypocalcaemia is often associated to pregnancy toxaemia. As additional exams, we could have determined the KB in urine and the blood calcium levels, however due to financial reasons it was not possible. Both treated ewes responded to treatment and recovered.

Second intervention: The following day, a multiparous ewe from the same farm, at the end stage of lambing showed brownish green secretions originating from the vulva, suggesting the occurrence of abortion. It was decided to perform a caesarean section on the left flank, due poor cervical dilation. The foetus was found without vital signs and emphysematous. Penicillin and streptomycin (1ml/10Kg IM SID for three days) and flunixin meglumine (2,2mg/Kg IM SID for three days) were administrated due to high risk to develop a peritonitis.

Third intervention:

Problem: The farmer referred that the last lambs born were smaller than the usual average, and presented soft, weak and without energy.

Diagnosis: Blood sample were collected from the jugular vein from five lambs (L1-L5) with age between one and four days. The total serum proteins were quantified using refractometry with the aim of evaluating the passive transfer of colostrum immunity in lambs (Table 2). Also, the body weight of lambs was determined (Figure 1 and Table 2). Furthermore, five asymptomatic multiparous ewes (E1-E5) (Figure 2) were selected at random from a group of thirty ewes in the last month of gestation, and these were blood sampled to determine the levels of urea and calcium (Table 3) by catalyst one chemistry analyser (IDEXX®) in the Capvêto Bellac clinic. KB was measured for five ewes with blood ketones test strips by portable meter (Freestyle optium Neo®, Abbott, UK) (Table 3). Faecal material was also collected in ewes for coprological analyses and were analysed by zinc sulphate McMaster flotation method in Capvêto Bellac clinic. This method is used to quantitative determination of cestode and nematode eggs in faecal samples (Becker et al, 2016).



Figure 1. Lamb weighing.



Figure 2. Group of ewes in the last month of pregnancy.

Results: In the general physical examination, the five ewes showed asymptomatic. L3 lamb had the total serum protein concentration <50g/L, and L1, L2 and L3 showed a weight <3kg (Table 2). The BCS varied between 2,5 and 3 (Appendix B). Blood biochemical analysis of clinically asymptomatic ewes revealed a low blood urea concentration to E1, E2, E4 and E5. The E1, E2 and E3 showed low blood calcium concentration levels (Table 3). KB were above normal values (>0,4 mmol/L) to E1, E2, E3 and E4 (Table 3). In coprological diagnoses were not found parasites.

Table 2. Evaluation of passive immune transfer in lambs before and after attribution of commercial concentrated feed.

	Before commercial concentrated feed					After commercial concentrated feed						Reference Range
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	
Age Days	1	4	4	2	2	3	1	1	4	5	5	-
Foetus number	2	2	2	2	2	1	2	2	1	2	2	-
Weight Kg	1.6	2.1	1.7	3.9	3.2	6	4	4.2	4.3	5	5	>3*
Serum Total Protein g/L	81	67	40	68	56	45	65	56	58	48	47	>50*

*Reference range by *Ahmad et al., 2000*

L: Lamb

Table 3. Biochemical parameters from clinically asymptomatic pregnant ewes before and after attribution of commercial concentrated feed in the last month of gestation.

	Before commercial concentrated feed					After commercial concentrated feed				Reference range
	E1	E2	E3	E4	E5	E6	E7	E8	E9	
Urea g/L	0.16	0.197	0.257	0.061	0.081	0.165	0.171	0.094	0.185	0.2-0.32*
Calcium mg/L	90	84	77	96	93	97	90	96	111	91-108*
KB mmol/L	0.8	1.2	1.1	0.2	0.7	0,5	0,5	0,2	0,3	0.1-0.4

*Reference range by *IDEXX*

E: Ewe

Discussion: The pregnancy diagnosis by ultrasound was not carried out routinely in this farm. Hence ewes were not separated according to single, twins and triplet pregnancy, which would have enabled a diet personalized for each group in the last 6 weeks of pregnancy. All pregnant ewes remained on pasture until one month prior to lambing, having access to mineral blocks all year. When housed, multiparous were separated from primiparous ewes and grouped according to expected lambing time. At this time, ewes were fed with hay ad libitum, two macro-minerals buckets 25 kg for each group of thirty ewes, and water. After lambing, the ewe and her lambs were separated of the other ewes and

they were put in individual enclosures. Twins and triplet pregnancy involve higher energy needs and without enough energy and protein the body reserves decrease. This results in chronic intrauterine growth retardation with consequent reduced energy available to the foetus (Aitken, 2007). Low urea concentrations indicate a shortage of rumen degradable protein (Scott, 2007). Thus, the absence of concentrated feed in diet can explain the low blood urea concentration to E1, E2, E4 and E5 (Table 2).

Since 80% of foetal growth occurs in the last month of gestation, there is increased energy, proteins and calcium requirement. Most of the ewes have a negative energy/calcium balance in this period (Schlumbohm & Harmeyer, 2003), that justify the low blood calcium concentration to E1, E2 and E3 and the high blood KB concentration to E1, E2, E3 and E5 (Table 2). Foetal development causes a deficit of glucose, being the fat stores used as energy source. This increases blood BOBH levels and the likelihood to PT occur. Ewes with KB>4mmol/L (threshold used by Capveto clinic) showed clinically asymptomatic, suggesting a subclinical PT. The blood KB concentration is a gold standard for PT diagnosis in ewes. Blood glucose levels are variable, and ewes may or not be hypoglycemic. Energy deficit can be tolerated by animals and serum glucose concentration may not decrease significantly (Anoushepour et al, 2014). For this and economic reasons, blood glucose levels were not measured. Schlumbohm and Harmeyer (2003) showed that high KB levels in sheep are often associated with hypocalcaemia in the last six weeks of gestation, due to foetal growth that retains a high amount of calcium from to circulation for skeletal development. The hypocalcaemia induced a decline in plasma glucose concentration, decreasing the endogenous glucose production. Hypocalcaemia and hyperketonaemia have a synergistic effect, and thus promote the onset of PT (Schlumbohm & Harmeyer, 2003).

In the Table 2, the L3 lamb had a total serum protein concentration <50g/L, and the lambs L1, L2 and L3 had a weight <3kg. The passive immune transfer from ewes colostrum to the lamb is fundamental, because the lambs are born without any circulating antibodies, due to epitheliochorial placenta sheep do not allow the passage of immunoglobulins (Nowak & Poidron, 2006). According to the study realized on 83 neonatal lambs breed Pak-Karakul with aim of correlate the level of immunoglobulins to neonatal lamb mortality, where the authors measured the birth weight, total serum proteins, albumin, globulin and immunoglobulins, the neonatal lambs with total serum protein concentration and birth weight with <50g/L and <3Kg, respectively, indicate subsequent death. Furthermore the neonatal lambs with birth weight <3kg suckled an insufficient amount of colostrum, and consequently the serum immunoglobulins levels were low (Ahmad et al., 2000). The lambs in this clinical case showed physically weak, probably were unable to suckle enough

colostrum, resulting in the low total serum protein concentration and weight. Neonatal mortality rates from this farm were not available.

During the growth foetal a poor forage quality, absence of commercial concentrated feed, and limited intake caused by reduction of rumen capacity, leads to nutritional deficiencies (protein, energy, and calcium) (Rook, 2000). Thus, the veterinary recommended to introduce commercial concentrated feed to provide an additional source of energy and protein. According to Gordon (2012) in the beginning 226 g/day/ewe of commercial feed should be offered and after increase to 680-907 g/day until on the final gestation. Two weeks after this feed introduction other six lambs (L6-L11) with age between one and four days were blood sampled and weighed (Table 2). Also, four ewes (E6-E9) were blood sampled and calcium, urea and KB levels determine (Table3). L6, L10 and L11 showed a serum total proteins concentration <50 mg/L, however for all lambs the weight was >3Kg (Table 2). The four ewes (E6-E9) showed the blood urea concentration remained low (<0,2g/L). The calcium and KB are low to E7 and the KB low to E6 (Table 3). A commercial concentrated ration (Appendix C) was offered at 250 g/day/ewe in the last month of gestation for two weeks, however, showed being insufficient considering the blood urea values. During the last six weeks of gestation should be increased gradually the quantity of commercial concentrated feed.

A KB concentration is associated with foetal numbers (Aitken, 2007) and the Table 2 show that the twins pregnancy ewes is prevalent in the flock of this farm. In flocks where foetal numbers are not determined by ultrasound, Aitken (2007) proposes that a target BOHB value of 0.8 mmol/l should be used. In flocks where foetal numbers are known, only twin and triplet pregnancy ewes should be sampled, and BOHB target of 1.1 mmol/l be used. BOHB concentrations above 1.6 mmol/l in individual ewes represent severe metabolizable energy under-nutrition, with increased likelihood of developing PT as pregnancy advances. Sampling 3–4 weeks before the start of lambing, enables the precise determination of any nutritional metabolizable energy deficit and allows timely adjustment of the energy concentration of the ration. If nutritional changes are required, further blood samples should be collected about 2 weeks later to evaluate progress (Aitken, 2007). Several measures should be placed in practice to prevent PT, such as, separation of ewes with a single, twins, and triplet pregnancy is crucial, to offer a quantity of concentrate feeding in the last six weeks of gestation indicated to each group, regular monitoring of BCS and parasitism (Crilly, 2021).

The resolution of this case was not possible, since the farmer did not cooperate, and days later stopped the supplementation to the ewes with commercial concentrated feed.

2.2 Clinical case II

Problem: Group of 11 multiparous ewes in the last month of gestation, in the flock composed by 350 sheep with several meat breeds (*Ille de France*, *F1* and *Causse du Lot*), were treated with erythromycin (Erythrocin[®], Med'Vet, 10mg/Kg IV BID for three days) for footrot. The next day it was reported that two ewes treated with Erythromycin showed signs of fatigue, prostration, anorexia and were in sternal recumbency.

Diagnosis: Physical examination was done to E1 and E2 ewes (Table 4), which were in sternal recumbency. They were lethargic and had tachycardia. Blood samples were collected from four ewes referred to Table 4. Three ewes treated with erythromycin (symptomatic multiparous ewes E1 and E2, and asymptomatic multiparous ewe E3) and one was not treated (primiparous ewe E4). The blood calcium, magnesium, urea, and phosphorus concentrations were measured by catalyst one chemistry analyzer (IDEXX[®]), in the Capveto Bellac clinic, and KB was measured with blood ketones test strips by portable meter (Freestyle optium Neo[®], Abbott, UK) on the farm. Faecal material from four ewes (E1-E4) was also collected for coprological analyses.

Results: All the ewes (E1, E2, E3) that were treated with erythromycin showed high blood KB concentrations (>4 mmol/L). The values of KB were particularly high in ewe E1, that was in sternal recumbency. Furthermore, the blood biochemistry analyses revealed high urea concentrations in four ewes, low calcium and magnesium concentrations in two ewes E1 and E2 (Table 4). A week later after administration of erythromycin, blood samples were collected from three ewes of the same group, to measure KB, urea, and calcium levels. E5 and E6 showed a decrease of urea concentration, however it was still above of the normal values (Table 4). Calcium levels were low in E7 (Table 4). In the four faecal samples were not found gastrointestinal parasites.

Table 4. Blood biochemical parameters from clinically unhealthy and healthy multiparous pregnant ewes 24 hours after treatment with erythromycin, the primiparous ewe not treated with erythromycin and three healthy multiparous pregnant ewes, one week after treatment with erythromycin.

24h after erythromycin administration					One week after erythromycin administration			
	Multiparous ewes			Primiparous ewe	Multiparous ewes			Reference range
	Clinically unhealthy	Clinically healthy	Control	Clinically healthy				
	E1	E2	E3	E4	E5	E6	E7	
KB mmol/L	2.7	0.7	0.9	0.3	0.3	0.4	0.3	0.1-0.4
Urea g/L	0.461	0.412	0.365	0.449	0.342	0.335	0.263	0.2-0.32*
Calcium mg/L	75	89	96	100	96	97	90	91-108*
Magnesium mg/L	22	19	27	25	-	-	-	23-30*
Phosphorus mg/L	44.80	42.70	67.82	43.87	-	-	-	40-89*

*Reference range by IDEXX

E: ewe

Treatment: The clinical findings and high blood KB concentration confirmed a clinical PT in two ewes E1 and E2. These ewes were treated with 50 mL IV of hypertonic glucose solution (Energidex®) and 50 mL IV of calcium and magnesium (Magnésie calcique®), as glucose, calcium, and magnesium replacement, respectively. Calcium was given slow intravenous. Asymptomatic ewe E3 showed a high KB concentration, being administered propylene glycol (Ceto Phytan®, 50 mL/ ewe PO for five days) for 11 ewes that received the erythromycin. Ceto Phytan® is a dietetic supplement with and other constituents, that reduce the risk of ketosis. Oral propylene glycol is used to promote the gluconeogenesis by the liver (Crilly, 2021). The two ewes treated died, and a triplet pregnancy ewe from group that received erythromycin, had a spontaneous abortion.

Discussion: High KB levels confirmed a clinical PT to E1 and E2, and subclinical PT to E3. The E4 (control) did not received erythromycin and was normoketonemic. erythromycin is a macrolide antibiotic and has erythromycin as an active substance. To date there are no contraindications to administrate erythromycin at late pregnant ewes, therefore it was communicated to the laboratory that commercializes it. Two hypotheses for the occurrence of PT are hepatic damage and stress. KB was not elevated in control ewe, however being a primiparous ewe has lower risk to PT. Liver injury from erythromycin is rare, but because of the frequency of its use, has been one of the most common causes of drug induced hepatic damage in previous years in humans (CRID-ILI, 2012). Additionally, the stress caused by erythromycin administration can have triggered a PT.

E1 and E2 also revealed high urea concentration, low calcium, and magnesium concentration, beyond the high KB concentration. In these cases, it is necessary to have attention with calcium administration, due to hepatic damage (Brozos et al., 2011). Hyperketonemia is often associated with hypocalcaemia. Hypocalcaemia induces a decline in plasma glucose concentration during the hyperketonemia in pregnant ewe (Schlumbohm & Harmeyer, 2003).

They remained on pasture up to one month prior to lambing. When housed, multiparous ewes were separated from primiparous ewes and grouped according to expected lambing time and fetus number. In the last month of gestation, the ewes were fed with hay, grass silage, 900g/ewe commercial concentrated feed (Appendix C), salt, and mineral boluses. The grass silage and custom pellet were given on alternate days. The blood urea concentration was elevated for all ewes, except the E7 (Table 4). This can suggest a protein imbalance in the diet. Veterinary recommended reducing the commercial concentrated ration to 600g/day/ewe.

The gastrointestinal parasites were not found in E1-E4. These results were expected, since that the farmer had administered anthelmintic drugs, albendazole and moxidectin, for both the groups of multiparous and primiparous ewes. Albendazole is a benzimidazole used for liver flukes, tapeworms, and stomach worms, and moxidectin is a macrocyclic lactone to gastrointestinal and respiratory worms, *Fasciola hepatica* and *Oestrus ovis*. Papadopoulos et al (2013), demonstrated that liver parasites, as trematode infections to *Fasciola hepatica* is associated with the development of PT. These parasites can cause lesions in the liver, such as cholangiohepatitis, hepatocyte degeneration, micro-abscessation, coagulative necrosis, extensive fibrosis, and loss of hepatic parenchyma (Papadopoulos et al., 2013). Thus, in flocks with several risk factors for PT, as shown in the present clinical case, can have a synergistic effect and increase the predisposition for PT.

In the last 4-6 weeks of pregnancy, the prevention of PT plays an essential role, it is recommended to use a high quality roughage and supplementary concentrate feeding to provide adequate energy intake (In the beginning we can give 226 g/day and after increase to 680-907g/day until on the final gestation), determination of serum or plasma BOHB concentrations to know dietary energy supply relative to metabolic demands, not make feed changes, decrease the stress of the minimum possible, favorable BCS (2,5-3) at lambing, monitor and control parasitism by coprology (Gordon, 2012). Antioxidants can be considered preventive as well. Under many management systems, the potential benefit of more lambs at lambing time is outweighed by the cost of nutritional management required to maintain multiple pregnancies, twin-bearing ewes in hill flocks and triplet-bearing low ground ewes being prone to PT. Separation of ewes by different feeding groups based on:

the results of real-time ultrasound scanning undertaken between days 45 and 90 of pregnancy to determine fetal numbers, keel marks to predict lambing dates, parity, and BCS can serve to ensure adequate nutrition during the gestation (Aitken, 2007).

2.3 Clinical case III

Problem: Farm with a herd of 250 sheep of two meat breeds (*Charolais* and *Limousine*) reported the death of two ewes (Figure 3.a) and three ewes showed signs of fatigue, dyspnoea, anorexia and were found in sternal recumbency (Figure 3.c). These five ewes were in the last month of gestation.

Diagnosis: Blood samples were collected from the jugular vein in the three ewes, to evaluate the KB, calcium, magnesium, and phosphorus concentrations. The biochemical parameters were measured by catalyst, one chemistry analyzer (IDEXX®), in the Capvêto Bellac clinic. KB concentration was determined immediately with blood ketones test strips by portable meter (Freestyle optium Neo®, Abbott, UK) in the farm. Necropsy was performed on the two dead ewes in the farm.

PT, Hypocalcaemia, hypomagnesemia, and hypophosphatemia were considered as differential diagnosis.

Results: Clinical examination revealed tachycardia, lethargy and normal rectal temperature to the three ewes. Ewes had a BCS between 3.5-4 (Appendix B). Blood calcium and magnesium concentration was low for all the three ewes, and for ewe 1, respectively (Table 5). Ewe 2 and ewe 3 showed a lower phosphorus concentration than normal (Table 5). KB was within the normal range, 0.2 (0.1-0.4 mmol/L) for all the ewes. The KB was <4mmol/L, thus PT was not considered.

Post-mortem examination showed a fat carcass (Figure 3.b) without any other relevant findings. The ruminal fluid pH was within the normal range, 6.15 (ref. value: 5.5-7).

Table 5. Biochemical parameters of the three multiparous pregnant ewes.

	Ewe 1	Ewe 2	Ewe 3	Reference range
Calcium mg/L	65	54	28	91-108*
Magnesium mg/L	38	31	20	23-30*
Phosphorus mg/L	44,29	21,32	38,09	40-89*
KB mmol/L	0,2	0,2	0,2	0.1-0.4

*Reference range by IDEXX



Figure 3. a) Dead ewe in the last month of gestation; b) Necropsy without relevant findings, except a high Subcutaneous fat thickness; c) Ewe in sternal recumbency

Treatment: Ewes were treated with 50 ml IV of hypertonic glucose solution (Energidex®) and 50 ml IV of calcium (Calphone®), as glucose and calcium replacement, respectively. Calcium was administered previously by the farmer. Calcium administration should be performed slowly, while the clinician monitors the animals heart rate and rhythm. If arrhythmia presents, the calcium administration should be interrupted (Brozos et al., 2011). All treated ewes responded to treatment and recovered.

Discussion: Serum biochemistry analysis revealed severe hypocalcaemia (<90 mg/L) for the three ewes (Table 5). Ewe 1 showed a hypermagnesemia, ewe 2 a severe and ewe 3 a slight hypophosphatemia.

The farmer offered a commercial mineral supplementation of around 25 Kg/ 50 ewes constantly. 16% calcium and 8% phosphorus were included in the composition. Therefore, it was considered that there was an imbalance in the diet between cations and anions. As treatment it was recommended administer 10g of magnesium chloride per 1Kg of commercial concentrated feed for ten days to compensate the possible excess of cations. In the last six weeks of pregnancy ewes, it is recommended to use an acidogenic diet to activate the calcium mechanisms, because at this time 80% of fetal development occurs. The acidogenic diet has more anions than cations. Thus, the use of a negative dietary cation anion difference (DCAD) before lambing can be crucial to increase calcium concentrations around lambing. Dairy cows excrete dietary cations and anions excess to maintain normal acid-base balance. The net acid intake in dairy cows based on dietary difference between cations and anions is influenced by sodium, potassium, chloride, and sulfur). DCAD diets for dairy cows are calculated based on the following formula: $DCAD = (\text{sodium} + \text{potassium}) - (\text{chloride} + \text{sulfur}) \text{ mEQ/kg of DM}$. Negative DCAD diets reduce the charge ion difference in blood, which decreases blood and urine pH, resulting in metabolic acidosis. Metabolic acidosis is compensated by the bone accepting hydrogen ions (H^+) in exchange for calcium, and inhibits renal calcium reabsorption prepartum, increasing urinary calcium excretion

(Hernández-Castellano et al., 2020). Wójcik et al (2009) showed that pregnant ewes with a diet of low DCAD induce higher calcium mobilization. In conclusion, in the present clinical case could be interesting to introduce a diet with negative DCAD in the last weeks of gestation and subsequent measurement of blood calcium levels in ewes.

Part III: Respiratory diseases in kids

1. Introduction

1.1 Incidence and Aetiology

Respiratory diseases may represent about 5,6% of the total diseases in small ruminants (Chakraborty et al., 2014). They can cause high economic losses, due to poor live weight gain and high rate of mortality between goats. There are several causes that contribute for this, such as an inadequate nutrition, insufficient colostrum intake, poor ventilation, high humidity, immunosuppression, and keeping different age groups together (Kacar et al., 2018). The group rearing and deficient management practices predispose to infectious and contagious diseases. Thus, it may lead to decreased meat and milk production and reduced number of offspring. Adverse weather conditions leading to stress, and immunocompromised, pregnant, lactating, and older animals under such conditions are easily reached by pathological respiratory agents (Chakraborty et al., 2014).

The respiratory disorders concern lower and upper tract. Pneumonia is a common lower tract respiratory problem in goats, with prevalence in young animals with 2-4 months of age. A higher mortality rates occurs between 2-3 weeks of age. Respiratory diseases of goats are multifactorial and there are several agents responsible for these, such as, virus, fungi, bacteria, and others, as a foreign body (Table 6). The bacteria agents more frequently found are *Mannheimia haemolytica*, *Pasteurella multocida*, *Bibersteinia trehalosi*, *Streptococcus pneumonia*, *Bordetella parapertussis* and *Mycoplasma* sp. (*Mycoplasma arginini* and *Mycoplasma ovipneumoniae*) (Kacar et al., 2018).

Mycoplasmas and *M. haemolytica* are a cause of high morbidity and low mortality. Furthermore, the pathogenic capacity *M. ovipneumonia* and *M. arginini* depends on the host, infectious agent, and environmental factors. Both in some cases can be isolated from the lung, trachea, nose, and eyes. *M. ovipneumonia* and *M. arginini* can be found in the healthy animals (Daee et al., 2020).

Table 6. Multiple etiological agents responsible for the respiratory diseases of goats (Chakraborty et al, 2014; Chartier, 2009)

Causes	
Bacterial	Pasteurellosis, ovine progressive pneumonia, mycoplasmosis, enzootic pneumonia, and caseous lymphadenitis
Viral	PPR, parainfluenza, caprine arthritis encephalitis virus, and bluetongue
Fungal	Fungal pneumonia
Parasitic	Nasal myiasis (<i>Oestrus ovis</i>), verminous pneumonia (<i>Dictyocaulus filaria</i> , <i>Protostrongylus</i> , <i>Echinococcus granulosus</i>)
Others	Enzootic nasal tumors (adenopapillomas, squamous cell carcinomas, adenocarcinomas, lymphosarcomas and adenomas) and ovine pulmonary adenomatosis, foreign body, abscesses in the lymph nodes

1.2 Pathogenesis and clinical signs

Daee et al. (2020), showed that *M. ovipneumoniae* and *M. arginine* induce a consolidation in the cranioventral to caudal lobes and pneumonia in sheep. The areas consolidated can be dark red, grey pink or grey. They also found that a presence of a thin layer of fibrin with yellow colour covered the pleural surfaces, rib impressions on the costal surfaces of the diaphragmatic lobes and abscesses containing odourless pus. The histopathologic results showed fibrinopurulent bronchopneumonia and multifocal areas of necrosis with the presence of fibrin, neutrophils, and macrophages. Lymphocytes, plasma cells and fibrinopurulent exudates were associated with bronchiolar associated lymphoid tissue (BALT) hyperplasia. Also, they described that the culture is less sensitive as diagnostic than PCR in identification of Mycoplasmas.

M. haemolytica is considered an important pathogenic agent in goats. *M. haemolytica* is nonmotile, non-spore-forming, facultatively anaerobic, oxidase-positive, and fermentative small gram-negative rods or coccobacilli. The susceptibility to *M. haemolytica* increases with the stress conditions caused by transportation, congested pens and inadequate housing conditions. This agent has multiple potential immunogens, including capsular polysaccharides, lipopolysaccharide, outer membrane proteins, fimbriae, iron-regulated proteins and secreted leukotoxin. Animals infected with pneumonia to *M. haemolytica* develop in the early phase clinical signs as anorexia, hyperthermia (40-41°C), shallow breathing, profuse mucopurulent nasal, and ocular discharges. Later phase occurs dyspnoea and an exhalation grunt. The acute disease caprine is more severe, infected goats may die within 24 hours. This agent can be found in tonsils and nasopharynx. As post-mortem findings, on the liver surface there is “marbling” of the lung with lobules varying

from normal, gray, or red. The lobules undergo coagulation necrosis or haemorrhage. Fibrin rich oedema fluid and interlobular lymphatics are found in interlobular septa. Furthermore, can be observed an excess straw-coloured exudate in thorax, slightly distended interlobular septa, and red area with consolidation, pleural adhesion, and encapsulated foci. Other authors observed an adult goat infected by pastereurellosis with the left and right craniolateral lung lobes consolidated and the presence of frothy exudates in the trachea, bronchi, and cur surface of the lungs. Some histopathological lesions include haemorrhage, oedema, necrosis, and white blood cell infiltration. Pneumonia caused by that bacteria is accompanied by an acute cranioventral fibrinous to fibrinopurulent pleuropneumonia. Macrophages and neutrophils are lysed by bacterial leukocidin at the lung, and the enzymes released by phagocytes cause additional damage to lung tissue (Abbas et al., 2019).

Specific serological and molecular tests have been developed as diagnosis methods of infectious respiratory diseases in small ruminants. Clinical signs, post-mortem findings, sampling, isolation, and confirmation by serological and molecular techniques (ELISAs and PCR) allows an identification and characterization of the pathogen (Chakraborty et al., 2014).

2. Clinical case – Respiratory disease

2.1 Clinical case IV

Problem: Farm with 350 dairy goats of *Alpine* breed, reported the death of three kids with 3 months of age and others of the same group with cough, nasal secretions, dyspnoea, and anorexia. There are three groups of goats on the farm, housed in different buildings: kids with one month of age, adults and kids with ages between three and six months. The kids with ages between 2-5 weeks were bought from other farms.

Diagnosis: Necropsy was performed on the three goats in the farm. Lungs were collected and analysed by the *Laboratoire Départemental d'Analyses et de Recherche de la Haute-Vienne* for research, isolation of the agents. The antimicrobial susceptibility testing also was performed to agent isolated. Faecal material from dead kids was also collected for coprological analyses. The differential diagnoses were pneumonia and gastrointestinal parasites, as well coccidiosis.

Results: Clinical examination findings in kids revealed two kids unhealthy (3-6 months) with tachypnoea, dyspnoea, mucopurulent nasal secretions, hyperthermia (40.4 and 40.9; ref. value: 38.5-39.7), and respiratory noises in the cranioventral area of pulmonary auscultation.

Post-mortem findings in three dead kids showed severe intestinal congestion (Figure 4.a). Heterogeneous regions in pulmonary parenchyma, dark red hepatization consolidation in the cranioventral lung lobes (Figure 4.b), and presence of fibrin on the pleural surface. Cut sections of both affected lungs showed signs in the cranial lobes of congestion and oedema (Figure 4.e). Adherences between the lungs and the thoracic wall (Figure 4.c, d) as well as pericarditis with hydropericardium were also observed (Figure 4.e).

M. haemolytica and *M. arginine* were identified by bacteriologic analyses. Antibiotic susceptibility test was performed for *M. haemolytica*.

In coprological diagnoses were not found parasites.

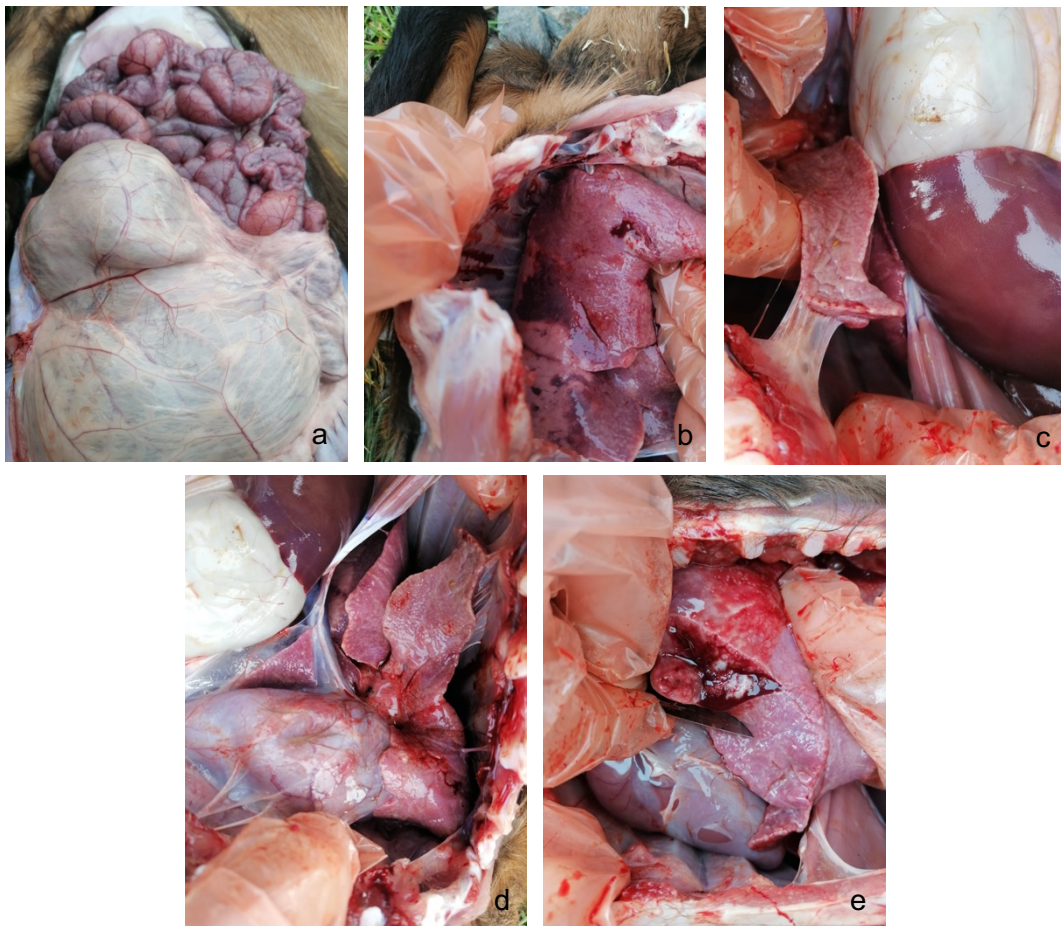


Figure 4. Post-mortem findings in three dead kids: a) Intestine congested; b) Dark red hepatization in the cranioventral lung lobes; c,d) Adherences between the lungs and wall thoracic; d) Lungs congested, presence of fibrine and accumulation of fluid in the pericardial cavity.

Discussion and Treatment: The two kids with hyperthermia were treated with flunixin meglumine (2,2 mg/kg IM SID for three days), that has an anti-inflammatory, antipyretic, analgesic, and antitussive action. Single dose of Tulathromycin (2,5 mg/kg IM) was administered to all the kids with ages between three and six months. Tulathromycin is an antibiotic used for respiratory diseases in cattle. This agent has a high efficacy for gram negative bacteria with bacteriostatic and bactericidal activity. It is necessary only a single dose because it has a rapid absorption, extensive distribution to tissue and slow elimination. These features allow a high capacity of accumulation in lung tissue of antibiotic, during a long-time (Crilly, 2005). Macrolides (tulathromycin, tylosin, erythromycin), quinolones (enrofloxacin, marbofloxacin), beta lactams (procaine penicillin, amoxicillin, ampicillin), tetracyclines (oxytetracycline), cephalosporins (ceftiofur), florfenicol are some antibiotics that can be used for the treatment of pneumonia in small ruminants. Studies demonstrated that marbofloxacin has high benefits in contagious caprine pleuropneumonia and mixed infections (*M. Haemolytica* and *Mycoplasma* spp). However, the marbofloxacin and ceftiofur are considered critical antibiotics in France, not being used in clinical veterinary practice. The florfenicol and tulathromycin also have a successful response (Kacar et al., 2018). By the antimicrobial susceptibility testing (antibiogram) *M. haemolytica* was susceptible to florfenicol, flumequine, and marbofloxacin, and resistant to tulathromycin. However, the antibiogram and bacteriology diagnosis was determined after of the treatment of flock. Despite of these results the kids responded clinically to tulathromycin. The clinical, necropsy and bacteriology findings confirmed the presence of a pathogenic agent, *M. haemolytica* responsible for bacterial pleuropneumonia in kid goats. *M. arginini* can be found in the healthy lungs, considered an apathogenic agent.

The kids with ages between the 3 and 6 months were housed in tall, dark local, cold and unventilated stable (Figure 5). Veterinary recommended to build a shelter for the animals to sleep inside and the folk vaccination. However, the farmer showed reluctance for adaptation of the building and vaccination. To prevent the goat disorders, it is important to control the environmental factors such as air temperature, humidity, and lighting. The enzootic pneumonia is a major cause of losses in intensively housed sheep, being the vaccination important factors. Several types of vaccine are available to control *M. haemolytica*, such as whole cell bacterins, leukotoxin-toxoids, and cell surface iron binding proteins. Leukotoxins shows have an effective action, however they kill white blood cells. It is recommended that the kids be vaccinated under 3 months and revaccinated at 4-6 months. Nevertheless, maternal antibodies for these organisms appear to interfere with vaccination, so kids can be vaccinated with ten days of age and revaccinated three to four weeks later (Tizard, 2020). Furthermore, the recently acquired kids from other farmers could

be infected for *M. haemolytica* from the holding of the origin or even be infected during transport. Changing of environment can make them susceptible to the acquisition or manifestation of infections. The farmer did not perform the quarantine of news kids in the flock and they were placed next to the kids that had been on the farm. The news animals should be kept in isolation at least 30 days to prevent the spread of the herd. Thus, the mixing of recent kids purchased with the herd animals may have been the gateway to *M. haemolytica*.



Figure 5. Group of kids with 4-6 months.

Conclusion

The predominance of extensive production systems and the high number of sheep farms of meat breeds in Bellac were the reasons to choose this topic. In extensive systems, the feeding is less controlled which increases the risk for PT. Thus, it is important to supplement with energy and proteins in the last month of pregnancy. Also, some meat ewes breeds have a high prolificacy which implies a more demanding supplementation. Gestation diagnosis using ultrasonography and coprological analyses are essential for the prevention of PT.

M. haemolytica is one of the agents responsible for respiratory disease in both small ruminants and cattle farms. The measures of biosafety, vaccination and housing conditions are crucial in the prevention of this highly infectious agent. In conclusion, the veterinary medicine has a crucial role to inform and advise the farmer to improve management practices.

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Appendix

Appendix A. Images captured during training in the Capveto Bellac clinic, between 4th November to 24th February.



Figure A1. Ewe vaginal prolapse.



Figure A2. Caesarean section in the ewe.



Figure A3. Plaster application on metatarsal fracture from calve.



Figure A4. Fracture of the jaw.



Figure A5. Uveitis in calve caused for septicemia.



Figure A6. Polyarthrititis from calve.



Figure A7. *Dicrocoelium dendriticum* in the bile content.



Figure A8. *Strongylus* spp worms present in the trachea.



Figure A9. *Taenia saginata* found in the sheep intestine.



Figure A10. *Paraphistomum* worms in the sheep rumen.

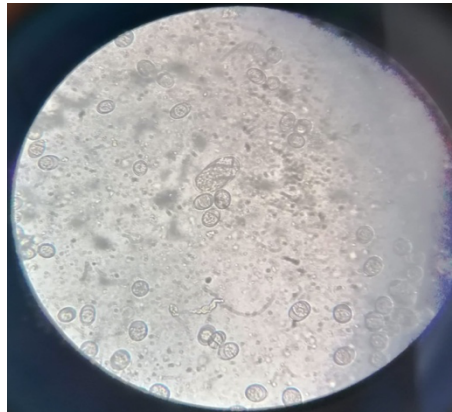


Figure A11. Eggs of *Eimeria* spp in lambs. 40x

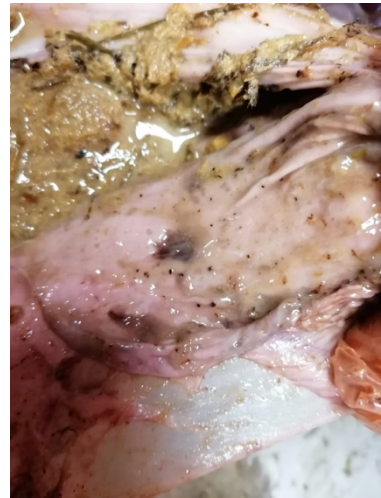


Figure A12. Abomasal ulcers in sheep.

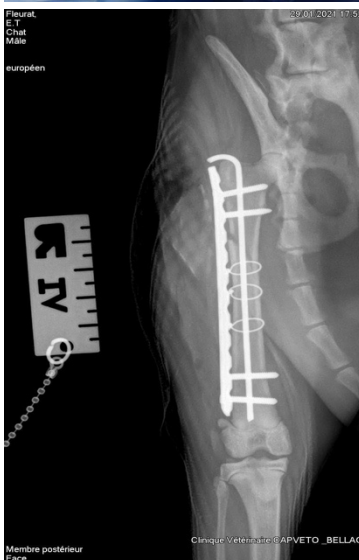
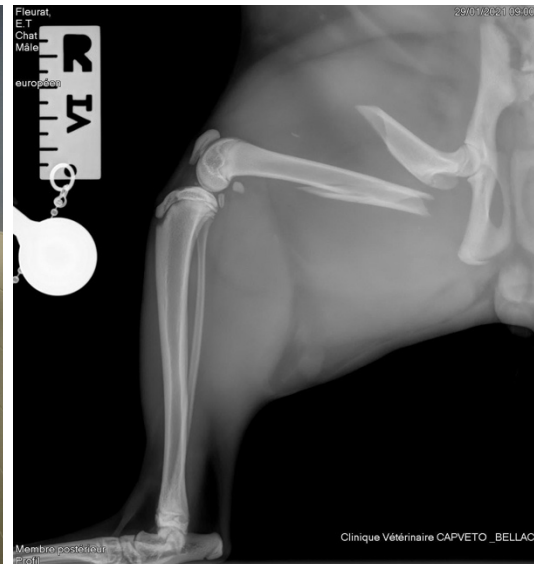


Figure A13. Internal fixation of a femoral fracture in a cat.

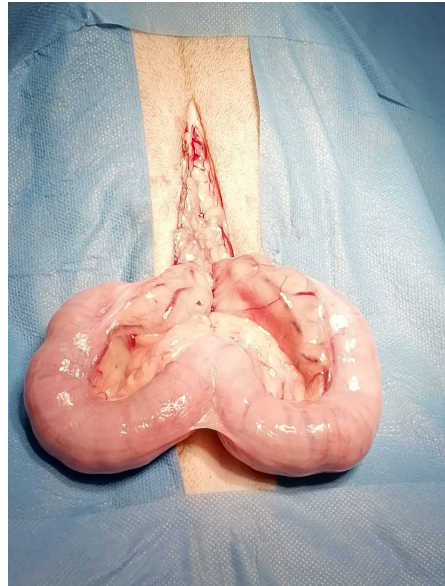
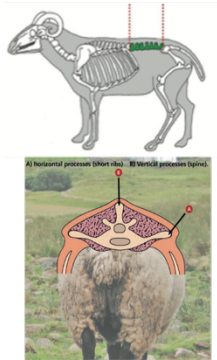


Figure A14. Ovariohysterectomy of a dog with pyometra.

Appendix B. Body Condition Scoring (BCS) of sheep (Williams & Macdonald, 2018).



For the evaluation of BCS the animal should be relaxed and follow these steps:

- 1- Locate 13th long rib;
- 2- Using the balls of fingers and thumb, feel the level of fat cover over the vertical processes (spine) with thumb and the level of roundness of muscle and fat cover over the horizontal processes (short ribs) with fingers.
- 3- The final step is to assess the eye muscle and its cover by pressing the fingers into the area between the vertical and horizontal processes.

Score 1	The vertical (spine) and horizontal (short ribs) processes are prominent and sharp. The fingers can be pushed easily below the horizontals and each process can be felt. The loin is thin with no fat cover.
Score 2	The vertical processes (spine) are prominent but smooth, individual processes only being felt as corrugations. The horizontal processes (short ribs) are smooth and rounded but it is still possible to press the fingers under. The loin muscle is of moderate depth but with little fat cover.
Score 3	The vertical processes (spine) are smooth and rounded; the bone is only felt with pressure. The horizontal processes (short ribs) are also smooth and well covered; hard pressure is required with the fingers to find the ends. The loin muscle is full with a moderate fat cover. Most ewes are in between scores and 2 and 3 so it is necessary to refine the scoring to half scores.
Score 4	The vertical processes (spine) are only detectable as a line. The ends of the horizontal processes (short ribs) cannot be felt. The loin muscles are full and have a thick covering of fat.
Score 5	Neither the vertical (spine) nor the horizontal (short ribs) processes can be felt even with pressure. It would be most unusual to have a ewe with a score of 5 in a commercial flock.

Appendix C. Nutrient content of commercial concentrated feed to ewes in farms included in the clinical cases I and II.

Nutrient	Clinical case I*	Clinical case II**
Crude protein %	18.1	18.0
Crude fat %	2.8	3.0
Raw ash %	7.7	7.8
Crude fiber %	9.0	12
Phosphor g/kg	5.5	-
Calcium g/kg	12.0	-
Sodium g/kg	2.3	-
Iron mg/kg	30	-
Manganese mg/kg	50	75
Zinc mg/kg	110	83
Selenium mg/kg	0.18	0.30
Cobalt mg/kg	0.23	0.45
Iodine mg/kg	2.0	1.20
Vitamine A UI/kg	6000	84000
Vitamine D3 UI/kg	1500	2520
Vitamine E	20 UI/kg	35 mg/kg

* Commercialized by Axereal®, France

** Commercialized by Evialis®, France