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PULMONARY HELMINTHOSES IN SHEEP: PREVALENCE, MORPHOLOGICAL FEATURES OF THE PARASITES, GROSS AND HISTOLOGICAL ASSESSMENT OF THE AFFECTED LUNGS, AND EVALUATION OF CONCURRENT BACTERIAL DISEASES

HELMINTOZELE PULMONARE LA OVINE: PREVALENȚĂ, STUDIU MORFOLOGIC AL PARAZIȚILOR, LEZIUNI MACROSCOPICE ȘI HISTOLOGICE DE LA NIVEL PULMONAR ȘI EVALUAREA PATOLOGIILOR BACTERIENE CONCURENTE

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ABSTRACT | REZUMAT

Respiratory diseases have a significant impact on the sheep industry in terms of economic losses and animal welfare. This study aimed to investigate the prevalence and morphological characteristics of pulmonary nematodes and echinococcosis in sheep and the associated lung diseases. A total of 2784 lungs from sheep were postmortem examined. Following the gross examination, the identified lesions were classified into seven categories, and 30 lung samples were collected for histological assessment. The Baermann method was performed on 42 selected faeces samples and lung fragments for the identification of the species of the parasites. Furthermore, microbiological analysis was also conducted to identify concurrent bacterial infections. Grossly, lung lesions were identified in 1571 sheep (56.42%). The predominant findings were of verminous pneumonia caused by strongyles (31%), either alone or combined with echinococcosis (21%), and granulomatous pneumonia associated only with echinococcosis (26.5%). Other notable lesions included bacterial pneumonia (7.2%) and lung tumours (1.84 %). Eight cases of lung tumours were associated with verminous pneumonia. Larvoscopic analysis revealed infection with *Muellerius capillaris* (15 cases), *Protostrongylus rufescens* (6 cases), *Dyctiocaulus filaria* (4 cases), and mixed *Muellerius* and *Protostrongylus* infection (8 cases). Bacterial pneumonia was identified in 113 sheep, with 191 cases also exhibiting verminous pneumonia. Predominant bacterial isolates included *Pasteurella pneumotropica* and *Vibrio metschnikovii*. The present study highlights the prevalence of parasitic and bacterial pneumonia as a significant health problem in the sheep population from Romania. It also highlights the importance of improved antiparasitic treatment and better management of bacterial respiratory disease to reduce the impact of respiratory disease in sheep flocks.

Keywords: sheep, lungworms, pathology, larvoscopy

Patologia respiratorie are un impact negativ asupra industriei de creștere a ovinelor, afectând atât bunăstarea animalelor cât și economia fermei. Scopul principal al acestui studiu a fost reprezentat de evaluarea prevalenței patologiei pulmonare la ovine și prezentarea caracteristicilor morfologice ale leziunilor pulmonare induse de paraziți, bacterii, precum și aspectele macroscopice și microscopice ale formațiunilor tumorale. În acest studiu, au fost incluși 2784 de pulmoni de ovine, ce au fost examinați post-mortem într-un abator din Transilvania. În urma examinării macroscopice, leziunile identificate au fost clasificate în 7 categorii; 30 de probe de pulmoni au fost recoltate pentru evaluarea histologică. Identificarea speciilor de paraziți s-a realizat utilizând metoda Baermann pe 42 de probe de fecale și fragmente pulmonare, iar identificarea bacteriilor asociate leziunilor pulmonare s-a realizat prin metode microbiologice. Leziuni macroscopice au fost identificate la 56.42% dintre pulmonii analizați. Pneumonia verminoasă a fost leziunea cea mai frecvent identificată (31%) fie ca leziune unică sau în asociere cu echinococoza (26.5%); echinococoza ca leziune unică a fost identificată la 21% dintre cazurile examinate. Alte leziuni notabile identificate au fost reprezentate de pneumonia bacteriană (7,2%) și tumorile pulmonare (1,84 %). Totodată, la 8 cazuri de tumori pulmonare au fost identificate concomitent leziuni de pneumonie verminoasă. Din totalul de 42 de probe analizate larvoscopic, *Muellerius capillaris* a fost identificat majoritar (15 cazuri), urmat de *Protostrongylus rufescens* (6 cazuri), *Dictyocaulus filaria* (4 cazuri) și de infestațiile parazitare mixte (8 cazuri). Principalele bacterii identificate la cazurile de pneumonie bacteriană au fost *Pasteurella pneumotropica* și *Vibrio metschnikovii*. Prezentul studiu evidențiază prevalența crescută a pneumoniei parazitare și a celei bacteriene, indicând o problemă semnificativă în populațiile de ovine din Transilvania. De asemenea, acest studiu subliniază importanța tratamentului antiparazitar și necesitatea îmbunătățirii managementului afecțiunilor respiratorii bacteriene în populațiile de ovine.

Cuvinte cheie: ovine, nematode pulmonare, patologie, larvoscopie

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Respiratory diseases are considered significant disorders affecting various livestock species worldwide. These diseases negatively impact the sheep industry, resulting in substantial financial losses to sheep flocks (8). Parasitic diseases in sheep have a major impact on the economic output of farmers, also significantly influencing animal welfare and productivity (19). Especially when respiratory disease overlaps with immunosuppression, stress, pregnancy, lactation, or when affected animals are very young or geriatric and weak, the impact of lung pathology on animal production is often significant (3). Despite its importance, pneumonia remains a leading cause of mortality among sheep, posing a serious threat to the sheep industry (11). Pneumonia is a multifactorial disease that involves an interaction between the host, a variety of pathogens (parasitic, viral, bacterial), and environmental factors (7). The most important parasitoses in sheep are represented by strongylidosis and echinococcosis (*Echinoccocus granulosus*). Pulmonary strongyles belong to the genera: *Dictyocaulus, Protostrongylus, Muellerius, Cystocaulus* (25). Lung infections with strongyles occur more frequently in animals that feed on pastures with lush vegetation, and their contamination is intense during rainy periods. Parasitic formations are active at moderate temperatures, between 10 and 21°C, while the cool and humid environment is extremely favourable (14–16). The parasites can be located in the bronchi, bronchioles, or lung alveoli, causing bronchitis, pneumonia, or bronchopneumonia (3,21,22). The diagnosis of pulmonary strongyles in small ruminants is based on the presence of characteristic respiratory clinical signs during high-risk periods of the year, on the presence of larvae in faeces and postmortem examination of lungs (1).

The objectives of the study were: 1) evaluation of the prevalence of the main pulmonary parasites in a large cohort of adult sheep from Transylvania, 2) morphological evaluation (macroscopic and histopathological) of the lesions of verminous pneumonia in slaughtered sheep, 3) correlation of morphological aspects with the presence of different species of pulmonary helminths, 4) microbiological evaluation of pulmonary lesions of a bacterial nature (secondary lesions), associated with pulmonary nematodes.

MATERIALS AND METHODS

Study animals and sample collection

The epidemiological study was carried out between July 2022 and October 2022, in a private slaughterhouse in the Transylvania region (Romania). For this study, lungs from a total number of 2784 adult sheep were evaluated at 4 different time intervals: July, August, September, and October 2022.

Macroscopic examination

The macroscopic examination consisted of the morphological evaluation and classification of lung lesions found in sheep. The observed lesions were described and assigned to each case and classified according to the predominant lesion, as follows: 1) strongyle-induced verminous pneumonia (granulomatous, nodular, on the dorsal surface of the lungs), 2) echinococcosis/echinococcal cysts, 3) mixed, but dominated by strongyles or echinococcosis, 4) bacterial pneumonia (areas of pulmonary densification, necrosis, abscesses), 5) mixed parasitic and bacterial, 6) tumoral (adenocarcinoma) and 7) mixed tumoral and parasitic. All lung changes that could not be classified by gross examination were collected for cytological and histopathological examinations.

Histopathology and cytology

A cytologic examination was performed using the impression smear method, from the affected lung areas in 30 cases. The obtained samples were stained using the Dia Quick Panoptic technique (DQP, Reagens Kft, Budapest, Hungary). For histopathological examination, approximately 2/3 cm lung tissue samples were collected from different pulmonary regions and stored in a 10% neutral buffered formalin solution. After formalin fixation (approximately 24-48 hours), the samples were trimmed and transferred to histological boxes for processing using the standard paraffin embedding protocol. The obtained paraffin blocks were sectioned using a manual microtome (Thermo Scientific™ HM 325 Rotary Microtome) and stained with haematoxylin and eosin (H&E). Subsequently, the cytological and histological samples were examined using an Olympus BX41 microscope. The images were captured using the Olympus UC-30 digital camera and Stream Basic software (Olympus).

Parasitological examination

During the slaughterhouse examination, faeces were collected from each individual with lung lesions for larval species identification by the Baermann method. Finally, samples (fragments of lungs) were collected for the evaluation of parasitic formations by molecular techniques (PCR).

Microbiological examination

For the microbiological examination, the collected samples (fragments of lungs with lesions) were examined at the Department of Infectious Diseases of the Faculty of Veterinary Medicine Cluj-Napoca. API 20NE kits (BioMérieux, France) for Gram-negative germs and GN24 (Tody, Romania) kits for Gram-positive bacteria were used for the identification of microorganisms. Antimicrobial susceptibility testing was performed by the Kirby-Bauer diffusimetric method.

RESULTS AND DISCUSSION

Gross features

From the total number of 2784 sheep lungs examined, macroscopic changes were observed in 1571 cases (56.42%). The most common lesions were verminous pneumonia (with gross features consistent of Strongyles infestation), followed by verminous pneumonia and echinococcosis, and simple echinococcosis.

Lesions suggestive of bacterial pneumonia/abscesses, verminous and bacterial pneumonia, and verminous pneumonia and tumours were also observed (Fig. 1).

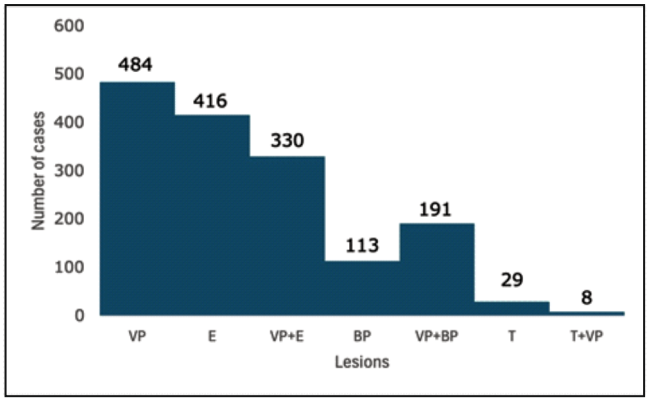

Fig. 1. Distribution of lung lesions in slaughtered sheep. VP - verminous pneumonia (with strongyles), E - echinococcosis, BP - bacterial pneumonia, T - tumours

On gross examination, in the verminous pneumonia cases (with strongyles), the lesions were bilaterally observed, mainly on the dorsal side of the diaphragmatic lobes, easily noticed as slightly raised plaques, of grey-brown colour, as well as miliary nodules (2-5 mm) (Fig. 2A). In the severe cases, these lesions were accompanied by areas of pulmonary atelectasis or pulmonary densification, observed bilaterally, mainly in the cranio-ventral area of the lungs. Upon opening of the trachea and bronchi, within these affected areas, an increased amount of mucus and a large number of strongyles were noticed (Fig. 2B).

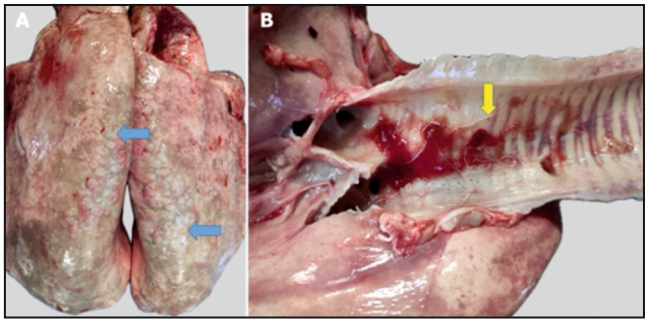

Fig. 2. Parasitic pneumonia - gross features. A. Bilateral, severe granulomatous pneumonia (blue arrows) associated to strongyles infestation. B. Adult nematodes in the tracheobronchial lumen (yellow arrow)

Cytological and histopathological analysis of lung lesions

Parasitic pneumonia

The nodular and plaque-like lesions observed on gross examination corresponded histologically to well-defined granulomatous lesions, composed of large numbers of macrophages (including multinucleated and epithelioid macrophages), lymphocytes, plasma cells, and neutrophils, centred on strongyle larvae, adults, and/or embryonated eggs (Fig. 3A).

The adjacent alveolar septa were diffusely thickened by fibrous connective tissue, mononuclear inflammatory cells and bundles of smooth muscle fibres (fibromuscular hyperplasia). In other areas, these findings were accompanied by type II pneumocyte hyperplasia, pulmonary atelectasis, aggregates of eosinophils, and mineral deposits. Multifocally, the parasitic granulomas were almost completely calcified (Fig. 3B). Numerous bronchi and bronchioles were dilated, containing within the lumen adult parasites, mucus, cellular debris, and a large number of inflammatory cells (Fig. 3C). Cytological examination (DQP staining) of both tracheobronchial mucus and pulmonary nodules revealed numerous larvae and embryonated eggs (Fig. 3D).

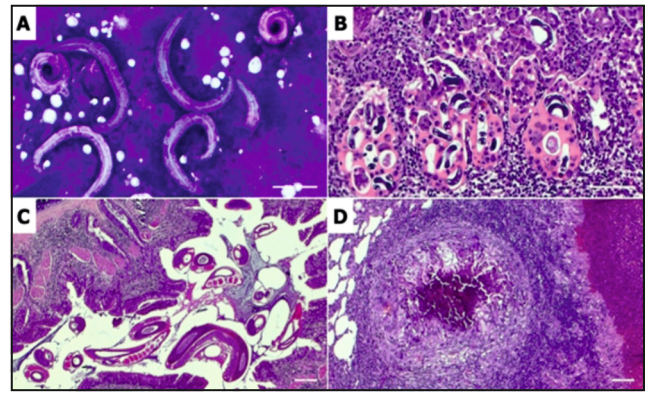

Fig. 3. Parasitic pneumonia - cytological and histological features A. In severe cases, cytological examination of the tracheal mucus revealed multiple strongyle larvae. DQP staining, bar= 50um. B. Histologically, the Strongyles larvae were mainly present within the lung alveoli and were associated with predominantly histiocytic inflammation. H&E staining, bar=50um. C. In the lumen of the bronchi, a large amount of mucus and numerous adults of strongyles were histologically observed; sheep H&E staining, bar=50um. D. Microscopically, the central areas of the parasitic granulomas were multifocally replaced by dystrophic calcification; sheep H&E staining, bar=50um

Lung lesions induced by *E. granulosus* (Fig. 4A) infection consisted in the presence of numerous cystic formations (hydatid cyst) of different sizes, ranging from 1 cm to 7 cm. On cross section, the parasitic structure was composed of a central cavity containing clear fluid, which was lined by a smooth membrane (*membrana proligera*). In some cases, the parasitic cystic structures were degenerated, with a yellowish tinge and granular appearance, or mineralised with a hard consistency to palpation.

Histologically, the lesions were represented by a granulomatous, nodular reaction centred on the cystic parasitic structure. The hydatid cyst was composed of an acidophilic membrane, with a thickness of approximately 100-150 µm, which delimited the cavity containing the *protoscolices*. At the periphery, the granu-

lomatous reaction was composed of numerous epithelioid macrophages and multinucleated giant cells (foreign body type), eosinophils, and small lymphocytes (Fig. 4B). Granulomas were delimited from the adjacent pulmonary parenchyma by an abundant fibrous capsule.

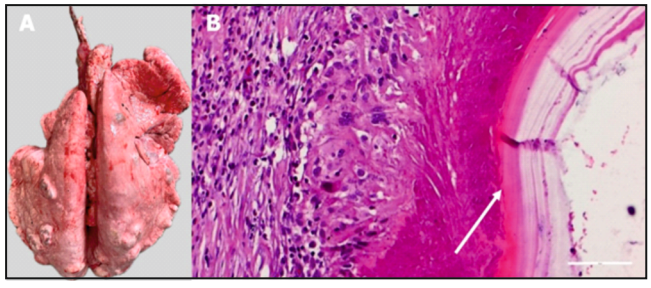

Fig. 4. Pulmonary echinococcosis – gross and histological features. Microscopically, granulomatous inflammation was observed around the echinococcus cyst. H&E staining, bar=50um

Bacterial pneumonia

Bacterial pneumonias were identified in 113 cases (7.19%), and those associated with verminous pneumonia in 191 cases (12.6%). These were characterised by areas of red-grey lung densification in the cranio-ventral region of the lungs or as randomly distributed lung abscesses in the lung parenchyma. The lung abscesses showed a creamy yellow necrotic/ purulent material and were surrounded at the periphery by a fibrous capsule (Figs. 5A and 5B).

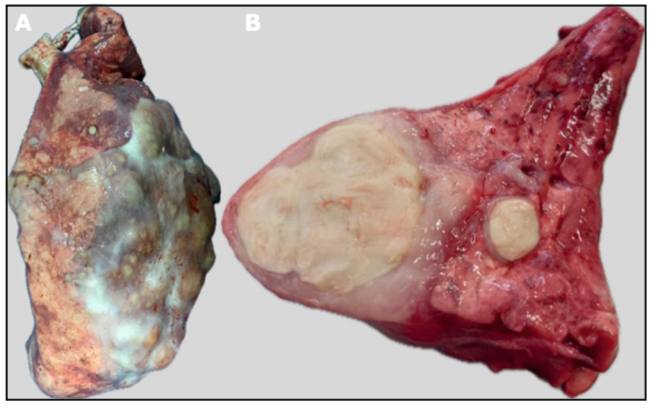

Fig. 5. Bacterial pneumonia - gross features. A. Approximately 60% of the lung parenchyma is replaced by multiple abscesses, associated with pleural fibrosis. B. Cross-section of lung abscesses showing a concentric lamellar pattern of the pus

Lung tumours

Lung tumours (lung adenocarcinoma) were observed in 29 cases. In other 8 cases, the pulmonary tumours were associated with lesions of verminous pneumonia. All cases of lung neoplasms were histologically confirmed as adenocarcinomas. The neoplastic lesions were observed unilaterally or bilaterally, affecting mainly the diaphragmatic lobes. Tumours consisted of dense, palpable grey nodules or large tumour masses that replaced lung lobes. On cross section, the lung tumours showed a homogeneous appearance, grey in colour, sometimes with foci of necrosis and haemorrhage. Concomitant involvement of two or three lung lobes was observed in 4 cases.

Cytological examination of lung tumours revealed mainly epithelial cells (type II pneumocytes) arranged in nests, acini or palisade. Neoplastic cells were cubic or polygonal, with variably distinct borders and a moderate N/C ratio. The cytoplasm of the neoplastic cells was finely vacuolated and bluish. Nuclei were round/ oval in shape, centrally or paracentrally located, with finely granular chromatin and 1-2 variably distinct basophilic nucleoli. Anisocytosis and anisokaryosis were reduced, and mitoses were rarely observed. In all cases, the cytological aspects were suggestive of a well-differentiated lung adenocarcinoma.

Histologically, the neoplasms showed an expansive or infiltrative character within the adjacent lung parenchyma. Depending on the arrangement of the cells, the tumours were classified into acinar (Fig. 6A) or papillary histological subtypes.

The neoplastic cells were cubic or polygonal, with poorly distinct borders, acidophilic cytoplasm, and a moderate N/C ratio. The nuclei were located basal, central or paracentral, hypochromic, round-oval, with 1-3 basophilic nucleoli. Anisokaryosis and anisocytosis were moderate with rare mitoses. The fibrous stroma was moderate and infiltrated with a moderate number of lymphocytes, plasma cells, macrophages, and rare neutrophils. Multifocal areas of necrosis with haemorrhage and neutrophilic infiltrate were present in some cases. Neoplastic emboli were observed in 3 cases. In 8 cases, the lung tumours were accompanied by lesions of parasitic pneumonia (Figs. 6B and 6C).

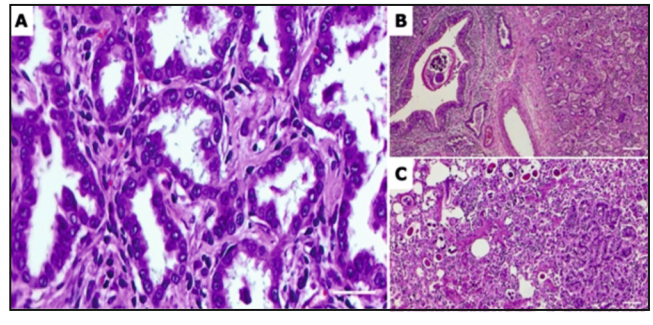

Fig. 6. Lung adenocarcinoma - histological features. A. Histologically, the neoplasms were composed of cubic/ polygonal epithelial cells arranged in mainly in acini, delimited by a moderate fibrous stroma. H&E staining, bar=20m. B. In some cases, the neoplastic nodules (right side of the image) were associated with adult parasites located either in the lumen of a bronchi (left side of the image), within the alveoli or interstitium. H&E staining, bar=100m. C. Presence of parasites in the lumen of the bronchioles and alveoli (left side of the image) adjacent to a pulmonary adenocarcinoma. H&E staining, bar=100m

Larvoscopical and microbiological analysis

Larvoscopic examination after performing the Baermann method on a number of 42 sheep with verminous pneumonia lesions, the *Muellerius capillaris* infestation was identified in a number of 15 samples (35.8%), *Protostrongyllus rufescens* in 6 cases (14.3 %), *Dyctiocaulus spp* in 4 cases (9.5%) and mixed infestation with *M. capillaris* and *P. rufescens* in 8 cases (19%). In 9 cases, the samples were negative (21.4 %). The microbiological examination was performed on a number of 4 samples with bacterial pneumonia lesions. The main bacterial organisms identified and their sensitivity to some drugs used in current practice are shown in Table 1.

Pneumonia is a significant threat in the sheep industry, often leading to important economic losses. Lung lesions are often influenced by several factors, such as environmental conditions and the physiological state of the animal. Both bacterial and viral pneumonia have a negative impact on the sheep industry (20). Also, economic losses due to lungworm infections include reduced growth rates and carcass weights, increased vulnerability to other diseases, and rejection at slaughter. Pulmonary nematode infections in small ruminants are often underdiagnosed because lungworm testing is not typically included in the routine parasitological tests ordered by veterinarians for clinical laboratories (17). Epidemiologically, lung nematodes of small ruminants are less pathogenic compared to those present in large ruminants but cause significant losses, especially in Mediterranean countries but also in Australia, Europe, North America, and Africa (1,18). In other studies, it was observed that the prevalence of pulmonary parasites diagnosed by postmortem examination was 62.3%, being significantly higher in sheep than in goats. In Australia, the overall prevalence of lung nematode lesions in sheep identified after slaughter, reported by Hanks et al., 2021, was 79% (87% in lambs and 69% in adults, respectively) (6). These results are similar to those found in our study, with the prevalence of viral pneumonia being 63.97%.

The diagnosis of lung nematodes in small ruminants is based on the presence of characteristic respiratory clinical signs during high-risk periods of the year, the presence of larvae in faeces, and postmortem examination of animals (1)

Small ruminants are most frequently infected with *M. capillaris*, mixed infections with *M. capillaris* and *D. filaria* being identified in a smaller number of individuals. *D. filaria* is rarely present as a single etiological agent in sheep. The prevalence of protostrongyles reported in sheep flocks in Spain is 11.6%, of which 97.9% were represented by *M. capillaris* (4,10).

Table 1

Interpretation of the inhibition zone diameters in the isolated strains; CLSI (2022)

	***P 10 µg**	**TY 30 µg**	**ENR 5 µg**	**DO 30 µg**	**L 30 µg**	**MAR 5 µg**	**GEN 30 µg**	**AMC 30 µg**	**TUL 30 µg**	**FFC 30 µg**	**COT 25 µg**	**O 30 µg**
Sample 1												
2.1 *Pasteurella pneumotropica*	R	S	S	R	R	S	S	I	S	S	I	R
2.2 *Vibrio metschnikovii*	R	R	S	S	I	S	S	S	R	S	S	R
2.3 *Pseudomonas alcaligenes*	R	R	S	S	R	S	S	R	R	S	S	I
Sample 2												
11.1 *Cryseobacterium indologenes*	R	R	I	R	R	S	S	S	R	I	S	I
11.2 *Alcaligenes faecalis*	R	R	S	S	R	S	S	S	S	S	R	R
11.3 *Pasteurella pneumotropica*	R	R	S	R	R		R	S	R	S	S	R
Sample 3												
13.1 *Enterococcus faecalis*	S	I	S	S	S	S	S	S	S	S	S	S
13.2 *Pasteurella* spp.	S	S	S	S	S	S	S	S	S	S	S	S
19.1 *Shewanella putrefasciens* group	R	R	S	S	I	S	R	S	S	S	S	R
Sample 4												
19.2 *Cryseobacterium indologenes*	R	R	S	I	R	S	S	R	R	S	S	R
19.3 *Enterococcus faecium*	S	S	S	S	S	S	S	S	S	S	S	S

*P = penicillin, TY = tylosin, ENR = enrofloxacin, DO = doxycycline, L = lincomycin, MAR = marbofloxacin, GEN = gentamicin, AMC = amoxicillin/clavulanic acid, TUL = tulathromycin, FFC = florfenicol, O = oxytetracycline. R = resistant, I = intermediate, S = sensitive

On a national level, in the Transylvania region, a very high prevalence of pulmonary parasitosis diagnosed postmortem in sheep was reported. Verminous pneumonia was identified in most cases (58.1%), with predominance of *Protostrongylus* spp./ *Muellerius* spp co-infection. Mixed infections with *Strongylus* spp./ *Echinococcus* spp. were identified in 14.9% of cases (23). In the current study, sheep were most frequently infected with *M. capillaris* (n=15) and *P. rufescens* (n=6). *D. filaria* was identified in 4 cases, and mixed infection with *M. capillaris* and *P. rufescens* in 8 sheep.

Animals that are more than one-year-old and not previously infected with pulmonary parasites have a higher chance of infection (18). In this study, all evaluated sheep were adults, aged 3–6 years; over 90% of the cases were female.

The incidence of the parasitic diseases does not always follow the typical seasonal pattern, but it can also be influenced by the characteristics of the pasture (irrigated versus dry), its management, and the density of the intermediate host (5). In our study, lung lesions were observed equally in the individuals examined during the summer (July and August) and in the autumn months (September, and October).

The gross and histological aspects of verminous pneumonia in sheep differ according to the etiological agent. In both *Dictyocaulus spp.* and *Muellerius spp.* infections, the lesions are mainly localised in the dorsal areas of the caudal lobes.

Dictyocaulus spp. infection is characterised by 4 phases of disease progression. Apart from the first phase (penetration phase), in which the lesions are not significant, phase-specific lesions are described for each phase. In the pre-patency phase, the lesions described are visible at about one-week post-infection and are characterised by eosinophilic exudate, which blocks respiratory bronchioles, excessive mucus production, alveolar collapse, and possible emphysema. The patent phase is associated with the presence of parasites in the lower airways. Also, inflammatory lesions in the lower airways and lungs produce clinical signs. The animals that manage to survive will reach the post-patent stage, where peribronchial fibrosis, alveolar epithelialisation, possible pulmonary oedema, interstitial emphysema, and secondary bacterial infections may be observed (13).

According to the study carried out by Panayotova and Alexandrov (2010), the different species of parasites of the family *Protostrongylidae* produce similar lesions both macroscopically and microscopically. Furthermore, the same study mentions that there would also be some different aspects depending on the nematode involved. In *M. capillaris* infection, the lesions are mainly nodular, firm, and gray. Nodular lesions have also been identified in *P. rufescens*, *C. ocreatus*, and *N. linearis*. In goats, the microscopic lesions in animals infected with protostrongylids are mainly localised in the alveoli, terminal bronchi, and bronchioles, while in sheep the lesions are centred in the interstitium. At the same time, the lungs of sheep infected with protostrongylylids seem to be more severely affected, regardless of age (12). Pathological findings identified in the present study are consistent with those described in the literature.

Secondary bacterial infections (e.g., *Pasteurela multocida*) occur frequently, especially in adult individuals (2,9), this was also observed in the cases included in the present study. Other bacteria known to induce purulent pneumonia are *Actinobacillus licheniformis*, *Trueperella pyogenes* or *Staphylococcus aureus* subsp. *anaerobius* (2).

Ovine pulmonary adenocarcinoma (OPA) is a type of malignant lung tumour caused by a Jaagsiekte sheep retrovirus infection. It has been reported with a worldwide distribution except in a few countries, such as Australia, New Zeeland, and Iceland. In Romania, there is only one recent study regarding ovine pulmonary adenocarcinoma (OPA), the data referring to the prevalence of OPA, the morphological aspects of tumours and the diagnostic methods (24). In the present study, a relatively large number of sheep with lung tumours were associated with verminous pneumonia (n=8). This fact could suggest that the latter could represent a favourable factor in the development of lung cancer in sheep, an aspect that requires further studies in this domain.

CONCLUSIONS

Parasitic pneumonia, caused by strongyles and/or echinococcus cysts, was the most common lesion observed in slaughtered sheep from Romania (Transylvania). In many cases, the parasitic pneumonias were mixed, involving both strongyles and echinococcosis. The high prevalence of pulmonary echinococcosis in sheep confirms a lack of deworming of dogs in the areas from where sheep originated. *M. capillaris* and *P. rufescens* were the most common pulmonary strongyles involved in the development of verminous pneumonia in Transylvanian sheep. Bacterial infections, such as those with *Pasteurella* spp., are frequently associated with viral cases of pneumonia, as well as parasitic pneumonia, being considered secondary lesions. A large number of lungs tumours were associated with parasitic lesions in sheep, suggesting that the latter may be a contributing factor in the development of lung cancer in this species, an issue that requires further study in this field.

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