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An Abattoir Survey of Pneumonia and Pleuritis in Slaughter Weight Swine from 9 Selected Herds.

II. Enzootic Pneumonia of Pigs: Microbiological Findings and their Relationship to Pathomorphology

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Falk, K., S Høie and B. M. Lium: An abattoir survey of pneumonia and pleuritis in slaughter weight swine from 9 selected herds. II. Enzootic pneumonia of pigs: Microbiological findings and their relationship to pathomorphology. Acta vet. scand. 1991, 32, 67–77. – Lungs from 191 slaughter pigs with gross lesions indicative of enzootic pneumonia of pigs (EPP) and 80 grossly normal lungs, all originating from 9 different herds, were subjected to microbiological and pathological examinations. The microbiological studies included both bacterial and mycoplasmal culture and also testing for *Mycoplasma hyopneumoniae* antigen in tissue by indirect immunofluorescent technique. *M. hyopneumoniae, Pasteurella multocida* and *Mycoplasma hyorhinis* were detected in 83 %, 43 % and 37 % of the pneumonic lungs, respectively. *Mycoplasma flocculare* was the most frequently isolated organism in the non-pneumonic lungs. The greatest amounts of macroscopic pneumonia (25.2 %) were recorded in lungs with all the three agents *M. hyopneumoniae, P. multocida* and *M. hyorhinis* present. The anmounts of pneumonia in lungs with *M. hyopneumoniae* alone and in concurrence with *P. multocida,* were 9.3 % and 15.6 %, respectively. *M. hyorhinis* was also, in this study, associated with higher frequency of diffuse pleuritis. These findings indicate that *M. hyorhinis* might be involved in the pathogenesis of pneumonia in slaughter pigs. Ninety-six per cent of the isolates of *P. multocida* from pneumonic lungs could be characterized as type A. In the herds which had the most severe pneumonia problems, toxin production was detected in 83 % of the *P. multocida* strains while only 28 % were toxigenic in herds with subclinical to moderate pneumonia problems.

mycoplasmas; *Mycoplasma hyopneumoniae; Mycoplasma hyorhinis; Mycoplasma flocculare;* bacteriology; *Pasteurella multocida.*

Introduction

Several microbial species have been demonstrated in studies on enzootic pneumonia of pigs (EPP). The most important are *Mycoplasma hyopneumoniae, Mycoplasma hyorhinis* and *Pasteurella multocida* (*L'Ecuyer et al.* 1961, *Friis* 1971a, *Gois et al.* 1975, *Bölske et al.* 1980, *Gois et al.* 1980, *Morrison et al.* 1985). There has been considerable confusion concerning the cause of EPP. Most authors now, however, seem to accept that *M. hyopneumoniae* is the primary etiological agent (*Whittlestone* 1979, *Ross* 1986). The precise role of *M. hyorhinis* and *P. multocida* have been more difficult to determine. *P. multocida* has probably not the ability to colonize the lungs of healthy animals, but as a secondary invader this agent makes the pneumoniac lesions considerably more severe (*Morrison et al.* 1985, *Ciprian et al.* 1986). The pathogenicity of *P. multocida* in the lung seems to vary between strains (*Pijoan & Fuentes* 1987). *M. hyorhinis* occurs commonly both in normal and

pneumonic lungs as well as on the nasal mucosa in pigs. Opinions vary on the pathogenicity of *M. hyorhinis* for the porcine lung. Several strains of this organisms have experimentally been shown to induce pneumonia in piglets (*Friis* 1971b, *Gois & Kuksa* 1974), and it seems possible that the pulmonary pathogenicity of *M. hyorhinis* is strain variable (*Ross* 1986). It is not known whether *M. hyorhinis* can enhance the severity of EPP or not (*Whittlestone* 1979, *Ross* 1986).
A slaughter house survey of pneumonia in 9 selected swine herds in the south-eastern part of Norway has revealed prevalence of lesions indicative of enzootic pneumonia (EPP) ranging from 9 % to 82 % (*Lium & Falk* 1991). In the present paper the microbial flora in samples from these lungs is reported. The relation between microbial and pathomorphological findings is also elevated.

Material and methods

Selection of herds

The investigation was initiated by the identification and selection of 9 field pig herds (Herds A-D, J-K and S) of different sizes and management practices, all located in the south-eastern part of Norway. The herds were arranged into 3 groups according to the degree of respiratory problems. Group I comprised herds with severe respiratory problems (herds A-D). Group II comprised herds with subclinical to moderate respiratory problems (herds J-M) and in group III clinical information and previous abattoir recordings indicated no respiratory problems (herd S).

Sampling procedure

A total of 855 lungs from slaughter pigs were collected and evaluated macroscopically. Out of these, 191 lungs with gross lesions indicative of EPP and 80 grossly normal lungs were selected for further examination. Bronchopneumonia scores were calculated based on estimation of the approximate percentage of lung surface with pneumonic tissue in each lobe. An overall bronchopneumonia score was then calculated as described by *Morrison et al.* (1985). A detailed description of pathomorphological findings in these herds has been reported in other papers (*Falk* 1988, *Lium & Falk* 1991).
Following macroscopic evaluation, adjacent sections were taken for the cultivation of mycoplasmas and bacteria, histological evaluation and indirect immunofluorescent (IIF) testing. In lungs with no lesions, samples were taken from the right middle lobe.

Mycoplasma testing

Each piece of the lung tissue to be examined was put into boiling water for 5 s to destroy surface contaminants. Approximately 1 g of this tissue, including a bronchus and several small bronchioles, was then aseptically prepared and homogenized in a Stomacher 80 Lab-Blender, using 9 ml of Friis mycoplasma medium (without added antibiotics) as diluent (*Friis* 1974a, *Friis* 1975).
Primary mycoplasma isolation trials were performed as described by *Friis* (1974a, 1975). A selective medium for *M. hyopneumoniae* (*Friis* 1979) was also included in this investigation. Lung suspensions were cultured in tubes in serial 10-fold dilutions (10^{-1}–10^{-5}) and incubated in a roller drum at 37°C for 21 days. Cultures with acid shift were subcultured 3–5 times and subsequently inoculated on Friis agar (*Friis* 1974a, *Friis* 1975). Plates were incubated in a humid atmosphere chamber with 8 % CO_2 at 37°C. Isolated mycoplasmas were identified serologically by the disc growth inhibition (DGI) test as described by *Friis* (1974a) using rabbit hyperimmune sera against *M. hyopneumoniae* (NCTC 10110), *M. floc-*

culare (NCTC 10143), *M. hyosynoviae* (NCTC 10167) and a pool of sera against 3 strains of *M. hyohinis* (NCTC 10130, NCTC 10121 and a Danish isolate). The production of antigens for immunization of rabbits was done as described by *Friis* (1974a) while immunization was essentially carried out as described by *Carroll et al.* (1976) omitting injections in foot pads. All mycoplasma strains for immunization were kindly provided by Dr. N. F. Friis, Copenhagen.

Indirect immunofluorescence (IIF) examination for the presence of *M. hyopneumoniae* antigens in lung tissue was performed essentially as described by *Armstrong et al.* (1983). Rabbit hyperimmune serum against *M. hyopneumoniae* and commercial FITC-labelled swine-antirabbit serum (Dakopats, swine anti rabbit Ig, Code: F205) were used in the test.

Bacteriology

Bacteriological examination studies were performed by inoculating the lung suspensions on blood agar plates (heart infusion agar with 5 % bovine blood) and on bromthymol blue lactose sucrose agar plates. Blood agar plates were streak-inoculated with β haemolytic *Staphylococcus aureus* as nursing strain. The plates were incubated in a 10 % CO_2atmosphere at 37°C and examined after 24 and 48 h. Routine procedures for bacteriological diagnostic work were followed. Except for the mycoplasmas, sparse, concurrent growth of various bacterial species or no growth was recorded as "insignificant bacteriological findings".

P. multocida isolates were further identified as capsular type A and D by using the hyaluronidase test (*Carter & Rundell* 1975) and the acriflavine flocculation test (*Carter & Subronto* 1973). The acriflavine test was slightly modified, as the bacterin from cultures on blood agar plates was suspended in the acriflavine solution on a glass slide and examined in a stereo microscope (*Bækbo* 1986). The isolates were tested for toxin production by the embryonic bovine lung (EBL) cell culture assay (*Rutter & Luther* 1984).

The serological diagnosis of *Actinobacillus (Haemophilus) pleuropneumoniae* was performed by the rapid slide agglutination test using 6-hour mucoid colonies grown on modified PPLO agar (*Nicolet* 1971). Hyperimmune sera against serotypes 1 to 10 were produced in rabbits as described by *Nielsen & O'Connor* (1984). The strains Shope 4071, S1536, S1421, M62, K17, Femø, WF83, 405, CVJ13261 and D13039, representing serotypes 1 to 10, respectively, were received from Dr. R. Nielsen, Copenhagen, and used for the immunization purpose.

Statistical analysis

Standard microcomputer software (SAS Institute Inc., Cary, NC, USA) was used to tabulate data and to perform descriptive statistics.

Results

Microbiological findings

Results of the microbiological examinations are given i Table 1. The 3 most frequently detected organisms in the pneumonic lungs were *M. hyopneumoniae, P. multocida* and M. hyorhinis detected in 158 (83 %), 82 (43 %) and 70 (37 %) lungs, respectively. These 3 organisms were detected alone or in combinations in 181 (95 %) of the pneumonic lungs. Demonstration rates of *M. hyopneumoniae* in individual herds varied from 74 % to 94 %, from 8 % to 56 % for *P. multocida* and from no isolation to 77 % for *M. hyorhinis.* Detection rates in herd groups I and II were 79 % and 92 % for *M. hyopneumoniae,* 48 % and 33 % for *P. multo-*

Table 1. Microbiological findings in 271 lungs with and without macroscopically diagnosed enzootic pneumonia (EPP).

Microbial species	Lungs with EEP (N = 191)		Lungs without EEP (N = 80)	
	No. of isolations	Per cent	No. of isolations	Per cent
Mycoplasma hyopneumoniae by culture	114	60	0	0
Mycoplasma hyopneumoniae by IIF	140	73	2	3
Mycoplasma hyopneumoniae by culture or IIF*	158	83	2	3
Mycoplasma hyorhinis	70	37	5	6
Mycoplasma flocculare	24	13	15	19
Mycoplasma hyosynoviae	1	1	1	1
Mycoplasmas not isolated	29	15	57	71
Pasteurella multocida	82	43	4	5
Streptococcus spp.	26	14	7	9
Actinobacillus pleuropneumoniae	6	3	0	0
Haemophilus parasuis	4	2	0	0
Actinomyces pyogenes	9	5	0	0
Coliform bacteria	5	3	3	4
Insignificant bacteriological findings**	90	47	69	86

* Indirect immunofluorescent testing
** Not including mycoplasmas

cida and 45 % and 18 % for *M. hyorhinis,* respectively.

M. flocculare was the most frequently isolated organisms in lungs with no pneumonic lesions. Insignificant bacteriological findings were recorded in 86 % of these lungs. *M. hyopneumoniae* was not cultivated from any of the non-pneumonic lungs, but 2 of these lungs were positive by IIF.

The presence of *M. hyopneumoniae* was studied both by cultural isolation and by IIF. One hundred and fourteen (60 %) pneumonic lungs were positive by cultivation and 140 (73 %) were positive by IIF. Ninety-six (50 %) were positive in both tests. The isolation rates and the rates of IIF positive for the individual herds, varied from 41 % to 89 % and from 56 % to 91 % for the two groups of herds, respectively. Seventeen percent of the specimens were negative both by cultivation and IIF, ranging from 5 % to 27 % in individual herds.

Of the 26 isolates of streptococci from pneumonic lungs 20 (77 %) were identified as *Streptococcus suis.* The 6 strains of *A. pleuropneumoniae* isolated originated from 2 herds in group I. These isolates were all serotype 2. *Bordetella bronchiseptica* was not demonstrated in this investigation.

Of the 75 isolates of *P. multocida* from pneumonic lungs, 72 strains (96 %) were characterized as type A and 3 strains (4 %) as type D. In the non-pneumonic lungs, 1 strain was characterized as type A and 3 strains as type D. Toxin production was detected in 45 (83 %) of the type A strains in herd group I and in 5 (28 %) of the type A strain in group II. All the type D strains from pneumonic lungs were toxigenic. From non-pneumonic lungs 1 of the type A strains

Table 2. Frequency (%) of *Mycoplasma hyopneumoniae* (Hyop), *Mycoplasma hyorhinis* (Hyor) and *Pasteurella multocida* (Mult) and combinations of these organisms demonstrated in 191 pneumonic swine lungs.

Herds		Hyop + Hyor − Mult − (N = 67)	Hyop − Hyor + Mult − (N = 8)	Hyop − Hyor − Mult + (N = 5)	Hyop + Hyor + Mult − (N = 24)	Hyop + Hyor − Mult + (N = 39)	Hyop − Hyor + Mult + (N = 10)	Hyop + Hyor + Mult + (N = 28)	Hyop − Hyor − Mult − (N = 10)
A	(N = 32)	44	0	3	9	22	6	9	6
B	(N = 46)	28	4	9	9	22	9	15	4
C	(N = 34)	21	15	0	21	18	9	15	3
D	(N = 18)	17	0	0	28	6	6	44	0
Group I	(N = 130)	28	5	4	15	18	8	18	4
J	(N = 12)	75	0	0	8	0	0	8	8
K	(N = 15)	73	0	0	0	20	0	0	7
L	(N = 21)	29	0	0	14	38	0	14	5
M	(N = 12)	33	8	0	8	33	0	8	8
Group II	(N = 60)	50	2	0	8	25	0	8	7
S	(N = 1)	0	0	0	0	0	0	0	100
Group III	(N = 1)	0	0	0	0	0	0	0	100
Total	(N = 191)	35	4	3	13	21	5	15	5

and 2 out of the 3 type D strains were toxigenic.

Prevalence of microbial species and their relation to bronchopneumonia score

The frequencies of cases of concurrent demonstration of *M. hyopneumoniae, M. hyorhinis* and *P. multocida* from pneumonis lungs are presented in Table 1. The most frequent findings were *M. hyopneumoniae* alone (35 %). *M. hyopneumoniae* and *P. multocida* appeared in 21 % of the cases and *M. hyopneumoniae* with *M. hyorhinis* and *P. multocida* in 15 %. The isolation of *M. hyopneumoniae* alone varied from 17 % to 75 % between herds while the frequency of *M. hyopneumoniae* with *M. hyorhinis* and *P. multocida* varied from 0 to 44 %. In herd group I, which showed almost twice the bronchopneumonia score compared to herd group II, the frequency of *M. hyopneumoniae* isolates alone was significantly lower than in group II ($p < 0.01$).

The overall detection of *M. hyopneumoniae* was not related to the extent of bronchopneumonia score (mean pneumonia score = 14.0 %). The relations between bronchopneumonia score and microbial findings are presented in Fig. 1 and Fig. 2. *M. hyorhinis* in combination with *M. hyopneumoniae* did not seem to influence the bronchopneumonia score. The score was significantly higher when *P. multocida* was isolated along with *M. hyopneumoniae* (15.6 %) compared to the demonstration of *M. hyopneumoniae* alone (9.3 %) ($p < 0.05$). The highest bronchopneumonia scores were recorded in the lungs from which both *M. hyorhinis* and *P. multocida* were isolated together with *M. hyopneumoniae* (25.2 %). A similar rela-

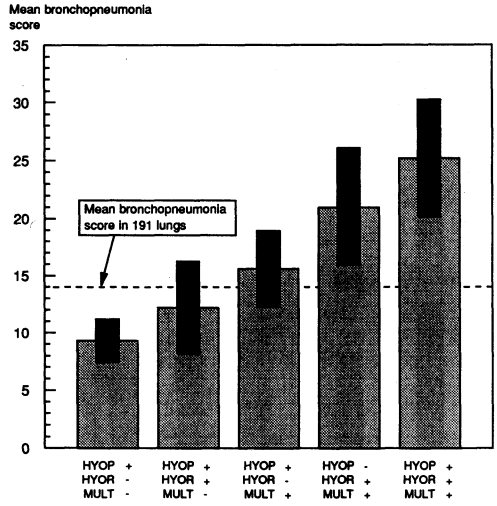

Figure 1. Relation between bronchopneumonia score and the demonstration of *Mycoplasma hyopneumoniae* (HYOP), *Mycoplasma hyorhinis* (HYOR) and *Pasteurella multocida* (MULT) and various combinations of these organisms in 191 lungs with EPP. (Black bars indicate ± 2x standard error of the mean).

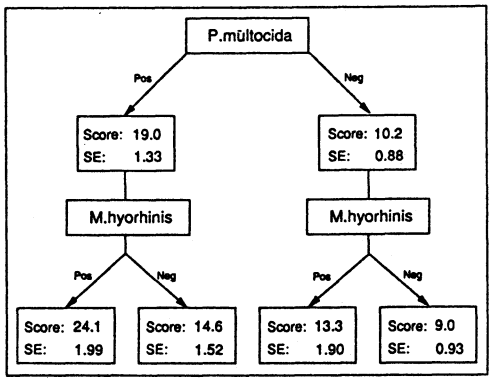

Figure 2. Relation between mean bronchopneumonia score (Score) and the demonstration of *Pasteurella multocida* and *Mycoplasma hyorhinis* in 191 pneumonic lungs. (SE = Standard error of the mean).

tionship between high score and the isolation of *M. hyorhinis* or *P. multocida* was demonstrated when higher bronchopneumonia scores than 15.0 % were considered. In these lungs the isolation frequencies of *M. hyorhinis* and *P. multocida* were 59 % and 69 %, respectively. In cases with bronchopneumonia scores less than 5.0 %, the isolation frequencies of *M. hyorhinis* and *P. multocida* were 18 % and 8 %, respectively. The toxigenic abilities of *P. multocida*, as determined by the EBL cell culture assay, did not seem to enhance the bronchopneumonia score. However, herds in group I, which had the highest overall bronchopneumonia scores, also had the highest frequencies of toxigenic *P. multocida* strains. The relationship between *P. multocida*, *M. hyorhinis* and the bronchopneumonia score is shown in Fig. 2. It should be noted that the presence of *M. hyorhinis* seemed to have no effect on the bronchopneumonia score unless *P. multocida* was also demonstrated simultaneously. In such cases, however, bronchopneumonia scores were significantly increased ($p < 0.05$). The results shown in Fig. 2 were basically the same for herd group I and for herd group II, except that bronchopneumonia scores in group II were generally lower. No occasion was found between the demonstration of toxigenic *P. multocida* type A strains and the severity of pneumonia lesions.

The mean bronchopneumonia score in lungs from which *Actinobacillus* (*Haemophilus*) *pleuropneumoniae* or *Actinomyces pyogenes* were detected was 21 % and 23 %, respectively.

The demonstration of *M. hyorhinis* was associated with a significantly ($p < 0.01$) higher percentage of lungs with generalized pleuritis (56 %) compared to those with no isolation (27 %).

Discussion

The frequent occurrence of *M. hyopneumoniae* followed by *P. multocida* and *M. hyorhinis* demonstrated in the present work is in agreement with other field studies on EPP (*L'Ecuyer et al.* 1961, *Friis* 1971a, *Gois et al.* 1975, *Bölske et al.* 1980, *Gois et al.* 1980, *Osborne et al.* 1981, *Morrison et al.* 1985). In the present study, indirect immunofluorescent (IIF) technique was included for the demonstration of *M. hyopneumoniae* owing to the difficulties in the cultivation of this species. This significantly enhanced the detection rate which is in agreement with other authors who regard the use of more than one method as a necessity rather than an advantage (*Gois et al.* 1975, *Whittlestone* 1979, *Armstrong et al.* 1984, *Ross* 1986). No attempts were made to increase the isolation rates for *M. hyorhinis* and *P. multocida*. In fact, single or a few pasteurella-like organisms were often seen when results were recorded as "insignificant bacteriological findings".

According to the results in this study, the severity of pneumonic lesions was not influenced by the isolation rates of *M. hyopneumoniae* and the frequency of samples positive by IIF. There was, however, a slight, but insignificant decrease when bronchopneumonia score exceeded 15 %. This is in disagreement with both *Gois et al.* (1975) who reported that *M. hyopneumoniae* was more frequently detected in lungs with low bronchopneumonia score and *Morrison et al.* (1985) who concluded that the detection of *M. hyopneumoniae* was positively associated with the severity of pneumonic lesions.

On the other hand, in those cases where *P. multocida* was isolated together with *M. hyopneumoniae*, the pneumonic lesions were found to be far more severe. This finding is in agreement with several other investigations at field level (*Gois et al.* 1975, *Gois et al.* 1980, *Morrison et al.* 1985) as well as with experimental studies (*Smith et al.* 1973, *Gois et al.* 1975, *Bækbo* 1986, *Ciprian et al.* 1986). However, several studies have shown that *P. multocida* is unable to cause pneumonia unless the defence mechanisms in the lungs are impaired (*Bækbo* 1986, *Ciprian et al.* 1986, *Farrington* 1986).

This study also confirms reports by other authors, indicating that *P. multocida* type A is the predominant type found in pneumonic lesions in pigs (*Pijoan et al.* 1984, *Bækbo* 1986, *Kielstein & Schimmel* 1986). This may be due to the large hyaluronic acid capsule in these strains, interfering with the phagocytosis by alveolar macrophages, as proposed by *Pijoan et al.* (1984). The frequency of toxigenic *P. multocida* type A strains isolated in this study was surprisingly high compared to other reports. *Pijoan et al.* (1984) found that 2 of 11 type A strains were weakly toxigenic while *Bækbo* (1986) and *Kielstein & Schimmel* (1986) found 19 % and 21 % toxigenic type A strains, respectively. Herds in group I which showed the highest overall bronchopneumonia score did also have a significant higher proportion of toxigenic *P. multocida* strains compared to group II. However, the herds in these 2 groups were too different to make any conclusions about the significance of this finding (*Lium & Falk* 1991).

Although *M. hyorhinis* is frequently isolated from pneumonic swine lungs, its pathogenicity is controversal. *M. hyorhinis* causes polyserositis and arthritis in young pigs, but experimental studies have shown that certain strains of *M. hyorhinis* may also induce pneumonia in gnotobiotic piglets (*Friis* 1971b, *Gois & Kuksa* 1974). As mentioned earlier, it is possible that the pulmonary pathogenicity of *M. hyorhinis* is strain variable (*Ross* 1986). *M. hyorhinis* has not been shown to influence the severity of pneumo-

nic lesions in EPP (*Whittlestone* 1979, *Ross* 1986). In the present study, however, the presence of *M. hyorhinis* significantly increased the effect of *P. multocida* on the bronchopneumonia score. These findings were supported by the finding that the herds with the most serious pneumonia problems (group I) did have the highest proportion of pigs infected with *P. multocida* and *M. hyorhinis*. The finding of *M. hyorhinis* was also, in this study, associated with a higher frequency of generalized pleuritis. This finding may be associated with the pathogenic properties of this species to piglets, causing polyserositis and arthritis.

Experimental studies have indicated that *M. flocculare* does not cause significant pneumonic lesions in pigs although pathological findings have been reported in the lung and the nasal mucosa of gnotobic pigs infected with *M. flocculare* (*Friis* 1973, *Friis* 1974b, *Armstrong et al.* 1987). In this investigation, *M. flocculare* was commonly found in both pneumonic and non-pneumonic lungs. This comfirms reports by other authors indicating that this species is widely distributed on pig populations (*Friis* 1973, *Whittlestone* 1979, *Ross & Whittlestone* 1983, *Ross* 1986).

Streptococci were frequently demonstrated in the present investigation. However, there was no significant difference between the frequencies of streptococci demonstrated in normal tissue compared to pneumonic tissue. Several authors have reported similar observations of streptococci (*L'Ecuyer et al.* 1961, *Gois et al.* 1975, *Osborne et al.* 1981) or gram positive cocci (*Morrison et al.* 1985).

The pathogenesis of EPP is a dynamic process, frequently involving several microbiological species as well as management procedures and environmental conditions (*Little* 1975, *Pijoan* 1986). Consequently, this investigation of lungs from slaughter pigs represents just one phase of a dynamic process, and the results obtained may not be totally realistic. However, the study confirms that *M. hyopneumoniae* is a major etiological factor in EPP, although the direct effect of this organism on the extent of pneumonia lesions judged at time of slaughter seems to be moderate. Although *M. hyopneumoniae* was not detected in 17 % of the pneumonic lungs in this study, the lung damage may have been initiated by the organism. This view is supported by the histological findings and by serological findings reported elsewhere (*Falk* 1988, *Falk & Lium* 1991). An important effect of *M. hyopneumoniae* may be impairment of the lung defence mechanisms leading to secondary infections by other microbes as suggested by *Adegboye* (1978). The extent, and possibly also the duration, of pneumonic lesions are influenced by secondary infections by other microorganisms, mainly *P. multocida*. The present results also indicate that *P. multocida* and *M. hyorhinis* may co-operate in producing pathological processes in the lung.

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Sammendrag

En slaktehusundersøkelse over pneumoni og pleuritt hos slaktegris fra 9 utvalgte besetninger. II. Enzootisk pneumoni hos gris: Mikrobielle funn og deres relasjon til patomorfologi.

Hundreognitten slaktegrislunger med patologiske forandringer som kunne tyde på enzootisk pneumoni hos gris (EPP), samt 80 lunger med normalt utseende, ble undersøkt patologisk og mikrobiologisk. De stammet alle fra 9 utvalgte besetninger.

De mikrobiologiske undersøkelsene omfattet dyrkning med hensyn på både bakterier og mykoplasmer. I tillegg ble indirekte immunfluorescensteknikk anvendt for påvisning av *Mycoplasma hyopneumoniae* i lungevev.

M. hyopneumoniae, Pasteurella multocida og *Mycoplasma hyorhinis* ble påvist i henholdsvis 83 %, 43 % og 37 % av de pneumoniske lungene. *Mycoplasma flocculare* var den vanligst påviste mikroorganismen i normale lunger.

Enkeltlunger der både *M. hyopneumoniae, Pasteurella multocida* og *Mycoplasma hyorhinis* ble påvist, hadde størst utbredelse av pneumoni (25.2 %). I lunger der *M. hyopneumoniae* ble påvist alene eller i kombinasjon med *P. multocida,* var utbredelsen av pneumoni henholdsvis 9.3 % og 15.6 %. I denne undersøkelsen ble det også påvist en sammenheng mellom forekomst av *M. hyorhinis* og diffus pleuritt. Disse funnene tyder på

at *M. hyorhinis* har betydning for patogenesen ved pneumoni hos slaktegris.

Nittiseks prosent av *P. multocida* isolatene fra pneumoniske lunger var type A. Fra de besetningene som hadde de mest uttalte pneumoniproblemene, ble toksinproduksjon påvist hos 83 % av de isolerte *P. multocida* stammene, mens bare 28 % av stammene fra de besetningene som hadde moderate pneumoniproblemer var toksinogene.

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