SEROLOGICAL SURVEY OF WILD BOAR (Sus scrofa) IN LIGURIA, ITALY

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Abstract: During the hunting season 1992/93 it has been possible to collect 450 Wild boar serum samples. A serological survey on Hog Cholera has been carried out, with the aim to reveal the presence of this disease in Liguria, since there have been recently revealed some cases in Wild boar in the nearby Tuscany. All samples examinated were negative. Later on tests for African Swine Fever, Foot and Mouth disease, Aujeszky disease, Lyme disease and Parvovirus were carried out on the same serum samples.

Keywords: Suidae, Hog Cholera, African Swine Fever, Foot and Mouth disease, Aujeszky disease, Lyme disease, Parvovirus, Epidemiology, Europe.

IBEX J.M.E. 3: 83-84

1. Introduction

During the hunting season 1992/1993 it has been possible to collect 450 Wild boar serum samples (Tab.1). A serological survey on Hog Cholera has been carried out. The aim was to search for the presence of this disease in Liguria, since there have been recently revealed some cases in Wild boar in the nearby Tuscany (Cordioli *et al.*,1993; Forletta *et al.*,1993). Later, serological test for African Swine Fever, Foot and Mouth disease, Aujeszky disease, Lyme disease and Parvovirus were carried out on the same sera.

Table 1: Distribution of examinated sera.

Tot.	Imperia	Savona	Genova	La Spezia
450	100	3	24	323

2. Material and Methods

Sera were tested for the detection of antibodies against Hog Cholera and Aujeszky disease with two competition E.L.I.S.A. kits according to the indication of Agricultural Research Department, Central Veterinary Institute, Lelystad (the Netherlands) and Istituto Zooprofilattico Sperimentale della Lombardia e dell'Emilia, Brescia (Italy); an indirect E.L.I.S.A. test has been used for the detection of antibodies against African Swine Fever, according to the indications of Istituto Zooprofilattico Sperimentale della Sardegna, Sassari (Italy). Lyme disease antibodies have been detected with an Indirect Fluorescent technique using slides with *Borrelia burgdorferi* antigen (BioMerieux) an anti-pig fluorescein labelled globulin. Antibodies anti-parvovirus have been detected with Hemoagglutination Inhibition test.

3. Results

The results are shown in tables 2, 3, 4, 5.

Table 2: Results of serological tests for Hog Cholera, African Swine Fever, Foot and Mouth disease (Type O-A-C).

Examinated	Negative	Positive
450	450	0

Table 3: Results of serological test for Aujeszky disease and titre of positive sera.

Total			Negative			Positive	
430			390			40	
Titre detected	1/4	1/10	1/16	1/40	1/64	1/160	1/256
Number of sera	1	6	4	17	4	7	1

Table 4: Results of serological test for Lyme disease.

Examinated	Negative	Positive
95	95	0

Table 5: Results of serological test for Parvovirus and titre of positive sera.

Total	Negative			Positive					
96	1			95					
Titre detected	1/16	1/32	1/64	1/128	1/256	1/512	1/1024	1/4096	1/8192	1/16384
Number of sera	2	8	14	23	8	5	4	3	11	17

4. Conclusion

Referring to African Swine Fever and Foot and Mouth disease, our results are those expected, considering that our region is free from these two diseases. The serological positivity for Aujeszky disease and Parvovirus can be compatible with literature data.

We have tested 95 sera for Lyme disease, but we haven't found any positivity.

In conclusion it is difficult to explain the absence of positivity for Hog Cholera since there are no natural barriers between our surveyed territory and the nearby Massa Carrara province, where an outbreak of this disease has been reported and Parma province where several serological positivities were recorded (Cordioli *et al.*,1993; Forletta *et al.*,1993).

For this reason a further survey is being carried out on a sample taken from the border territory.

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PATHOLOGY OF WILD BOAR (Sus scrofa) IN LIGURIA, ITALY, BETWEEN 1989 AND 1992

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Abstract: During the hunting season of four years (1989 - 1992), organs and whole bodies of wild boars have been examined following a routinary investigation concerning trichinellosis and the presence of pathological lesions. The following lesions have been detected: 1 (0.01%) case of trichinellosis out of 7,282 examined samples; 17 (4.3%) cases of tuberculosis and 55 (13.9%) cases of tuberculous-like lesions out of 395 examined samples; 5 cases (2.9%) of localizations of *Cysticercus tenuicollis* in the liver and 1 (0.6%) case of hydatidosis with localization of the cyst in the lung out of 172 examined samples; 86 (36.9%) cases of verminous bronchopneumonia out of 233 examined samples; 2 (3.2%) cases of hydrometra and 1 (1.6%) case of subperimetrial cysts out of 62 examined samples. Four cases of Sarcoptic mange have also been diagnosed. The examination, in the same period of time, of 24 wild boars found dead revealed the presence of bronchopneumonia in 6 (25%) subjects, gastroenteritis in 4 (16.7%) subjects and injuries in 16 (66.7%) subjects. The relationship of the examined diseases with the human health along with the importance of the veterinary control in order to assure the food safety for the human consumption are discussed.

Keywords: Wild boar, *Sus scrofa,* Suidae, Parasites, Diseases, Human health.

IBEX J.M.E. 3:85-87

1. Introduction

Every year about 6,000 wild boars are hunted in the Liguria region (Italy). That number in the last few years has been constantly increasing and, according to the prevision, will continue also in the future. Usually the hunted animals are subjected only to trichinoscopic examination (Ord. Reg. Lig. 1161, 31 Nov. 1988). In order to evaluate the hazards for the public health deriving from the consumption of this meat and to know the diffusion of the most relevant diseases of this species, a sample of animals has been examinated. The animals have been collected during four hunting seasons from 1989 to 1992 in the hinterland of Imperia and La Spezia provinces (Liguria). The animals were aged from three months to four years, mostly younger than one year.

2. Results and discussion

The following pathologies have been detected (Tab. l):

Trichinellosis: samples of tongue and diaphragm from 7,282 wild boars have been examined. Only one adult male was found naturally infected with *T. britovi* (T3): it showed 120 larvae/g in the diaphragm. Macroscopically no lesions were found.

Tuberculosis: 395 animals were examined for tuberculosis; 17 (4,3%) showed typical tuberculous macroscopic lesions. All these animals showed multiple nodules in submandibular and retropharingeal lymphonodes. In 9 animals lesions were detected also in lung and mediastinic lymphonodes, in 4 animals in liver, in 2 animals in periarticular carpal tissue and in 1 animal in spleen, inguinal and prescapular lymphonodes. The lesions appeared as multiple nodules characterized by a central caseous area of necrosis often associated with calcification and surrounded by a connective reaction. Peripheral tissue appeared hyperplastic and hyperemic. The size varied from 2-3 mm to 4-5 cm, in some cases, in several nodules located in the lymphonodes, the necrotic areas assumed a radiated pattern. In the lung the nodules were distributed either deep into the parenchyma or well visible under the pleura. In the liver the nodules were distributed both in the parenchyma and in the periportal lymphonodes. Histology of the lesions showed characteristic granulomas having a necrotic caseous and often calcified center surrounded by ephitelioid and giant cells along with granulation tissue. Immunohistochemical staining of typical lesions showed several positive foci, mainly localized in the peripheral areas of granulomas.

Table 1: Lesions detected in wild boars in Liguria from 1989 to 1992.

Lesion	No of animals examined	No of cases detected	%
Trichinellosis	7282	1	0.01
Tuberculosis	395	17	4.3
Tuberculous-like lesions	395	55	13.9
Verm. br. pneumonia	233	86	36.9
Cysticercosis	172	5	2.9
Hydatidosis	172	1	0.6
Hydrometra	62	2	3.2
Subperimetrial cyst	62	1	1.6
Sarcoptic mange	-	4	-
Broncho-pneumonia	24*	6	25
Gastroenteritis	24*	4	16.7
Traumatic lesions	24*	16	66.7

*Animals found dead

Isolation attempts performed on samples obtained from typical lesions allowed to culture in 6 animals acid-fast bacilli which for growth rate, growth temperature and pigment production were attributed to the complex M. *tubercolosis*. Biological testing gave the following results: 6 subjects positive for M. *bovis* and 4 subjects positive for M. *tuberculosis*.

Tuberculous-like lesions: 55 (13.9%) out of 395 animals showed these lesions localized only in the submandibular and retropharingeal lymphonodes. Lesions were characterized by central necrosis and calcification with absence of a radiated pattern. The necrotic material was easy to detach from surrounding tissue; the latter appeared hyperplastic. The size varied from 1 mm to 3-4 cm; in some cases several nodules aggregated in a single lesion. Histological examination showed the presence of a necrotic centre surrounded by a thin connective capsule, while the inflammatory reaction was absent; no giant cells were observed.

Verminous broncho-pneumonia: 233 lungs have been examined, 86 (36.9%) were positive for parasites belonging to the family Protostrongilidae. The lesions were represented by foci of enphysema in the apical lobes, the bronchi were full of adult parasites. In subpleural position nodules of a rice-grain size were also found.

Cysticercosis: 172 animals were examined for cysticercosis. C. *tenuicollis* (*T. marginata* or *hydatigena*) was the only species detected in the liver of 5 animals (2.9%); it had the typical cystic aspect with a diameter of 2-3 cm containing a clear fluid in which it was visible the protoscolice.

Hydatidosis: 1 case of hydatidosis has been detected out of 172 examined animals. 5 sterile cysts were found, 2 to 5 cm size, distributed in the lung.

Genital lesions: 62 female genital tracts were examined: two uteri (3.2%) showed hydrometra characterized by a collection of clear watery fluid into the lumen. One uterus (1.6%) had a 4 cm wide subperimetrial cyst localized at the confluence of the horns, having a thin and transparent wall containing clear fluid, probably of congenital origin.

Sarcoptic mange: 4 wild boars showed thick, wide cutaneous areas of alopecia with scabs localized on the head, neck, back and thigh. Microscopic examination of the scraping revealed mite of the genus *Sarcoptes*.

Broncho-pneumonia and gastroenteritis: the lesions observed in these cases were similar to those non-specific observed in domestic pigs.

Traumatic lesions: The cases reported (16 out of 24) were consequences of car accidents or falls in precipices. The examination of this 24 wild boars found dead revealed the presence of bronchopneumonia in 6 (25%) subjects, gastroenteritis in 4 (16,7%) subjects and injuries in 16 (66.7%) subjects.

Cardiac and renal pathological lesions observed in this survey are object of two other communications of the Symposium.

This study reveals that several diseases, including zoonoses, can affect the Wild boar living in the Liguria hinterland. Although all of them are of scientific interest, it must be pointed out that the Wild boar is carrying a number of lesions which harbours parasites or infectious agents potentially dangerous for the human health (*i.e*, mange, trichinellosis, tuberculosis). Therefore the authors believe that a strict veterinary control is needed before licensing the meat of this species to the human consumption.

The material, methods and references are not stated in this paper, but they are available from the authors.

BACTERIOLOGICAL EXAMINATION OF MEAT OF WILD BOARS SHOT DOWN IN PIEDMONT AND LIGURIA, ITALY

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Abstract: Muscle samples from 71 wild boars shot down were taken within 24 h post mortem for bacteriological determination. Total viable bacteria, Enterobacteriaceae, Enterococci, Staphylococci, Clostridia, *Campylobacter* and *Salmonella* were enumerated. In inner parts of meat the total bacterial count was slightly lower than that of surface samples, varying from 10^3 to 10^4 cfu/g.
However, remarkable amounts of Enterobacteriaceae, Enterococci and coagulase-positive Staphylococci were found both on the surface and in inner parts of a large part of the meat samples.
No *Campylobacter* was detected in any case, whereas strains of *Salmonella* were found on the surface and in inner parts of 3 samples.
An improvement of sanitary inspection of such game wild boars intended to private consumption should be useful. Bleeding of animals as soon as possible after death can be effective means to avoid the presence of infection or toxi-infection microorganisms in game meat.

Keywords: Wild boar, *Sus scrofa*, Suidae, Hunting, Microbiological analyses.

IBEX J.M.E. 3: 88-89

1. Introduction

lt was calculated that in 1988 lived in ltaly nearly 1,5 million wild boars and this number has increased in the following years. Therefore, for some years now, hunting boars has increased the numbers of animals shot down too. Once killed, in general the animals are bled, eviscerated and skinned in precarious hygienic conditions.
Their meat is used to prepare both fresh or cured meat products with possible health risks for consumers. Since wild boars have been examined by many Authors as reservoir of pathogenic bacteria in offals (Kniewallner, 1969; Bromel & Zettl, 1973; De Boer *et al.*, 1983; Chiesa *et al.*, 1987) and meat (Mignone *et al.*, 1990), we performed microbiological analyses with the aim to control the microbiological quality of this kind of meat from boars shot down in Piedmont and Liguria.

2. Material and methods

Continuing a previous research (Mignone *et al.*, 1990) we examined 71 samples of Wild boar's muscles taken from the neck, determining their microflora on the surface and on the deep. Two different groups were considered: Group A: 41 samples from boars shot down and immediately bled, skinned and eviscerated in the open air; Group B: 30 muscle samples of animals shot down and bled outdoors, but skinned and eviscerated in a closed room with a good hygienic care. Microbiological analyses included the determination of Total viable count, Enterobacteria, Enterococci, enteropathogenic Staphylococci, sulphite-reducing *Clostridia*, *Campylobacter* spp. and *Salmonella* spp..

3. Results and discussion

The results obtained were summarized in Figures 1 and 2. No *Campylobacter* was detected in any case, whereas 3 strains of *Salmonella* were isolated on the surface and in the deep tissue of 3 different samples. That leads us to conclude that the bacteria diffused into the blood stream during the agony of the animals. High amounts of coliforms were found on the surface of the muscles examined as well as in their inner parts. In about one third of the samples examined in the deep (71% of the group A and 83% of the group B) charges of coagulase-positive Staphylococci ranging between 10^3 and 10^4 cfu/g were detected.
It can be concluded that the environmental conditions in which the animals are eviscerated and skinned are not so important to affect unfavourably the wholesomeness of meat. On the contrary it is important that the animals are bled as soon as possible and then skinned and eviscerated at the latest within 6 hours after the death. lt would be desiderable that this kind of meat might be regularly inspected by a special veterinary service like that is pre-

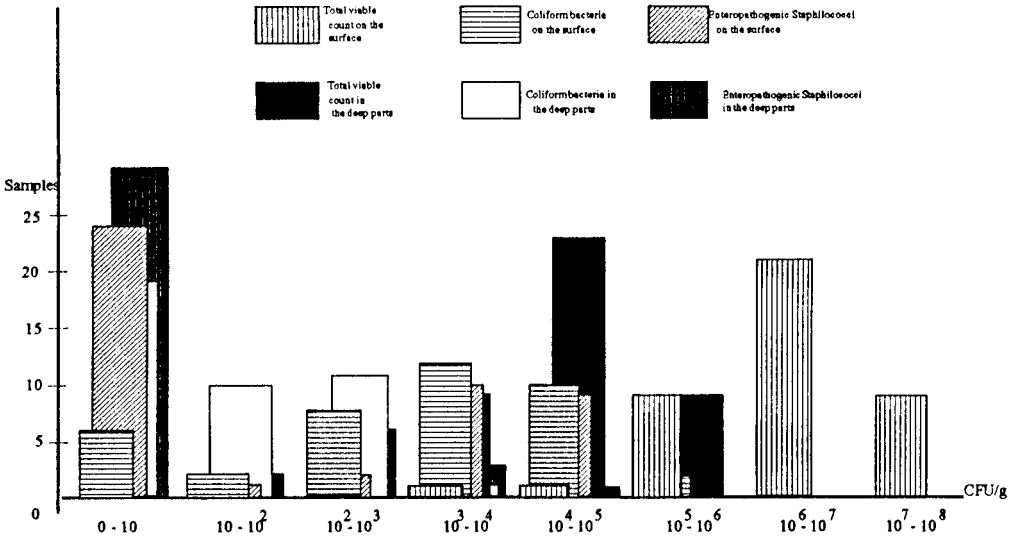

Figure 1: Results of total viable count, coliform bacteria and enteropathogenic Staphilococci in group A

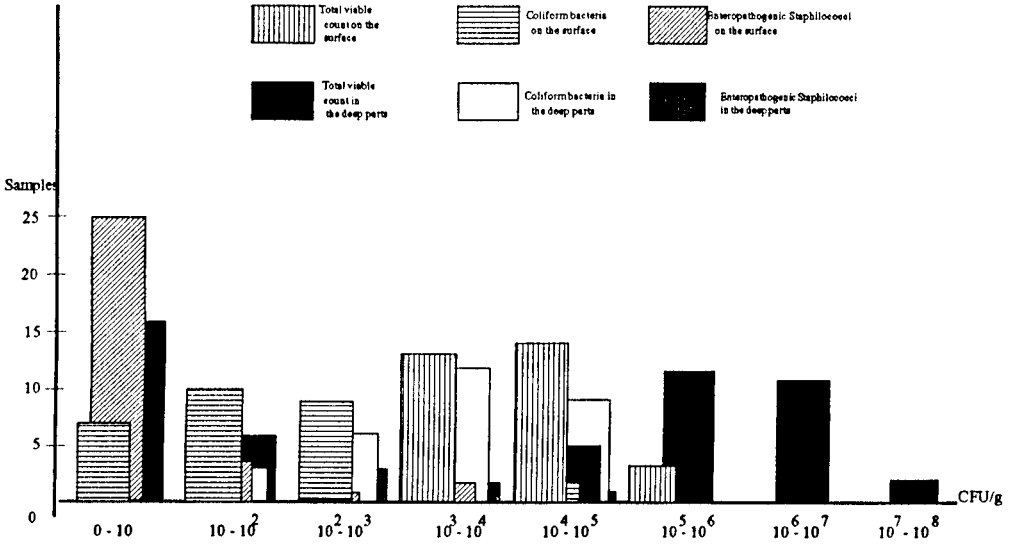

Figure 2: Results of total viable count, coliform bacteria and enteropathogenic Staphilococci in group B

scribed by Italian law (D.M. 16.10.1986 and D. Lvo. 559/1992).

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ANATOMO-HISTOPATHOLOGICAL OBSERVATION ON THE RENAL PATHOLOGY IN THE WILD BOAR (Sus scrofa)

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Abstract: In order to describe and to better define the prevalence of renal pathology in the Wild boar in natural conditions, the authors collected the kidneys of 248 wild boars, between 1 and 3 years old, hunted in the area of Appennino Ligure, in Imperia province.
Following the observation of the macroscopic lesions, the kidneys were fixed and embedded for the histopathological evaluation. The predominant lesion, seen in 19.75% of the animals, was the interstitial nephritis characterized by scattered foci of mononuclear cell infiltration, often localized around the blood vessels. The immunohistochemical examination for the presence of leptospiral antigen, carried out on animals with interstitial nephritis, was negative.

Keywords: Wild boar, *Sus scrofa,* Suidae, Kidney, Nephritis.

IBEX J.M.E. 3:90-91

1. Introduction

In Italy, the pathology of Wild boar (*Sus scrofa*) has been increasingly studied because of its important relationship with human and animal health (Mignone *et al.*,1990; Biolatti *et al.*,1992; Ferrari *et al.*,1992).
Renal pathology in the Wild boar is not very well documented: we know there are no reports on this topic in the veterinary literature of the last twenty years. However, since a large part of renal pathology in other mammals is due to infective microrganisms such as *Leptospira* sp., it seems important to evaluate the incidence of renal pathology in the Wild boar.

2. Material and methods

Tissue samples were collected from 248 kidneys during three hunting seasons (1990,1991,1992) in Imperia province (Liguria, Italy). Shot animals were between 1 and 3 years old. Although both sexes were represented, no data on the sex were available.
Kidneys were excised after death as soon as possible, fixed in 10% buffered formalin and finally sent to the Diagnostic Laboratory at the Istituto Zooprofilattico Sperimentale, Turin, for further tissue processing and histopathological evaluation. After macroscopic evaluation of the kidney, representative fragments were sampled and embedded in paraffin.
Four µm sections were stained with Hematoxylin and Eosin, and PAS method for histopathological examination.
The immunohistochemical technique with primary antiserum raised against *Leptospira interrogans* serovar *pomona*, was carried out according to a previously published procedure (Scanziani *et al.*, 1991).

3. Results

Macroscopic lesions were found in 36 animals (14.5%). Six animals showed renal pelvis urolithiasis with mild hyperemia and catarrhal inflammation. 30 animals showed 1-3 focal lesions consisting of 1-2 mm white spots. In one case a single, white, firm, 4 mm thick nodule was observed. No other macroscopic lesions were found. Histopathological evaluation of sections from macroscopically-affected and -non affected kidneys revealed the presence of subacute to chronic interstitial nephritis in 49 animals (19.75%). Histological lesions were more severe in macroscopically affected kidneys and consisted in nodular and/or diffuse foci of mononuclear cells infiltration. Epithelial tubules cells surrounded by inflammatory cells showed mild degenerative changes while no interstitial fibrosis was observed. Histopathological analysis of the single nodule revealed a proliferation of pleomorphic atypical

lymphocytes and some large lymphoblasts with hyperchromatic and non-cleaved or -folded nuclei associated with degeneration and necrosis of surrounded epithelial tubules cells.
Renal pelvis urolithiasis was characterized histologically by diffuse plasma cells and few neutrophils infiltration under the pelvis epithelium.
Immunohistochemical studies performed on kidneys with interstitial nephritis for the detection of leptospiral antigens were all negative.

4. Discussion

The presence of light mononuclear infiltrations in renal lesions, as we observed, is not suggestive of leptospiral infection (Scanziani *et al*, 1990); moreover immunohistochemical findings on pathologic kidneys tested with primary antiserum against *Leptospira* sp. were absolutely negative. Ponti *et al.* (1991) report that in Sardinia 10.6% of wild boars are serological positive for *Leptospira* serovar. *pomona, grippotyphosa* and *bratislava*; on the contrary our results indicate that in Liguria the disease is not so widespread.
It is noteworthy that sardinian wild boars were reared, while our animals were hunted. It's likely that the closer relationship between sardinian Wild boar and domestic pig is responsible for the serologic positivity.
In one case, the histological finding of a focal localization of pleomorphic lymphoid cells with numerous atypical mitosis, suggests the presence of a lymphoma. However, the unavailability of other parenchymal organs, such as visceral lymphonodes, liver, spleen, bone marrow and lungs, commonly involved in swine lymphoma (Moulton & Harvey, 1990) and the absence of clinical history, preclude any further classification of lymphoma.

5. Aknowledgements

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CARDIAC PATHOLOGY OF THE SARDINIAN WILD BOAR (Sus scrofa) WITH PARTICULAR ATTENTION TO ENDOCARDIOSIS

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Abstract: The endocardiosis, occasionally worsened by valvular prolapse, has been often described in adult and young pigs. It has been observed that haemodynamics, immunological, genetic and constitutional factors are involved. 48 wild boars were examined. The animals were shot down in hunting season 1992-93 and came from the 4 sardinian districts. All the hearts were grossly examined and the cardiac valves were treated for light microscopy. We didn't observe prominent lesions but small nodular and translucent thickening of the valvulare edge. No valve prolaps was present. Microscopic examination showed mixomatosis, oedema, metachromasia and Alcian-positivity in 27 mitralis (56.25%) and 6 tricuspis valves (12.5%). In 2 wild boars parietal endocarditis was also found.

Keywords: Wild boar, *Sus scrofa,* Suidae, Anatomo-Pathology, Heart, Myocarditis.

IBEX J.M.E. 3:92-93

1. Introduction

Endocardiosis, occasionally worsened by valvular prolapse, has often been described in adult and young pigs. It has been observed that haemodynamic, immunological, genetic and constitutional factors are involved. Some authors have suggested an analogy of swine endocardiosis with Marfan's disease in man. Since the literature is limited we believed interesting to carry out a systematic study of the heart of the Wild boar, paying particular attention to endocardiosis. Our aim was to determine the extent and characteristics of the different lesions and compare them with those of the domestic pigs.

2. Observations

The subjects of this study were 48 wild boars of both sexes, 2 months to 7 years old and weighing 4-70 kg from 4 sardinian districts, shot in the 1992 - 1993 hunting season. The hearts were examined grossly and then paraffin-embedded, stained with H.E. Polychrom Alcian - PAS, Toluidin Blue and Weigert-Van Gieson for L.M.

No prominent lesions were observed, only moderate nodular and translucent thickening of the valvular edge. No valve prolapse was present. Microscopic examination showed mixomatosis, oedema, metachromasia and Alcian-positivity in 27 mitralis (56.25%) and 6 tricuspis valves (12.5%) but these percentages are lower if only severe lesions are taken into consideration.

On analyzing the data by age, we found a higher prevalence rate in young boars and an increase in severity in the older animals.

We also found foci of endocarditis in 2 hearts (4%), giant-cells-granulomatous myocarditis (Ziehl-Nielsen-negative) in 3 ones (6%), eosinophilic myocarditis in 4 ones (8%), lymphoplasmacell myocarditis in 12 ones (25%) and purulent myocarditis in 2 ones (4%) in both left and right sides of the hearts.

Sarcocystis at different stages, with thick and hairy walls, were found in 73% of the subjects.

No significant difference was evident between males and females.

3. Discussion

In the Sardinian Wild boar, the endocardiosis is less widespread than in the domestic pig; accordingly, the severity of the lesion is not comparable with that described in the latter.

On the basis of our epidemiological data it is difficult to show an ethiological and pathogenic similarity between endocardiosis in the Wild boar and in the domestic pig: in any case the farmer is less exposed to the risk factors.

Some interesting data which emerged from our study were the relatively high prevalence of

endocardiosis in young boars and, on the other hand, the high number of small lesions found in adult boars. In our opinion, these findings can be explained only by accepting that the young animal is more exposed to the patholgy than the adult subject, probably because the young boar is more affected by anatomical and stress factors. It seems, however, that the lesions, although apparently serious, can regress and disappear. In contrast, adults remain exposed to factors provoking a degenerative endocardial process. These factors, probably of different origin (alimentary, infectious, etc.) are not however able to cause serious damage. Likewise, the changes and inflammatory processes observed in the course of our study, although frequent, did not appear to be serious. The finding of myocarditis is of particular interest in the light of recent investigations showing tubercular infection in wild boars. The other types of myocarditis that were found (eosinophilic and lymphoplasm cell) can be considered a manifestation of a moderate reaction to the frequent presence of sarcocystis. On the whole, our findings seem to confirm that the cardiac pathology of the Sardinian Wild boar, as previously seen in studies about their cardiac pathology, is much less influenced by negative factors than that of the domestic pig. However, a study on a large number of subjects should be done to confirm our data.

A CONTRIBUTION TO THE STUDY OF CARDIAC PATHOLOGY IN WILD BOAR (Sus scrofa)

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Keywords: Wild boar, *Sus scrofa,* Suidae, Heart, Endocardiosis, Myocarditis, Italy, Europe.

IBEX J.M.E. 3:94

The heart of 156 wild boars of both sexes killed during an hunting season, in Piedmont and in Liguria (Italy), has been examined in a program regarding cardiac pathology. The following results have been obtained:
1) Endocardiosis of mitral valve: 15 (9.6%) hearts showed endocardial lesions similar to the ones described in the domestic pig although less severe and less frequent.
2) Non purulent myocarditis: 8 (5.1%) hearts showed small foci of non purulent cellular infiltration distributed in several histological sections of the myocardium.
3) *Sarcosporidium* spp. in the myocardial fibers without signs of surrounding tissue reaction.
4) Fat tissue metaplasia: 2 (1.3%) hearts showed areas completely replaced by fat tissue in the wall of the left atrium.
5) Coronary arteriosclerosis: 10 (6.4%) hearts showed signs of arteriosclerosis of the intramural coronary arteries, characterized by intimal proliferation of muscle and elastic fibers.

In conclusion we may state that the observed lesions are morphologically similar to the ones described in the domestic pigs although less severe and less frequent.

MODELS FOR PREDICTING THE DYNAMICS AND CONTROL OF CONTACT-SPREAD DISEASES IN FERAL PIGS (Sus scrofa) IN AUSTRALIA

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Abstract: Feral pigs *(Sus scrofa)* are a major pest in Australia because of the agricultural and environmental damage they cause and because they have the potential to form a significant reservoir of exotic diseases such as foot and mouth disease (FMD) and classical swine fever. To address the second issue, two types of epidemiological models have been used. Simple deterministic models have been used to predict the threshold density of feral pigs for the persistence of FMD, the rate of spread of FMD and the effectiveness of control and surveillance techniques. In addition a user-friendly software package (AUSPLAGUE) has been developed around a spatial model for contact-spread diseases in feral pigs. The model places in a landscape context management techniques for containment and eradication of disease and aspects of feral pig ecology relevant to epidemics, such as movements and social behaviour. AUSPLAGUE will be used as a training and decision-support tool for planning the eradication of disease in feral pigs and could serve as a prototype for other diseases of feral animals and native wildlife.

Keywords: Feral pig, *Sus scrofa,* Suidae, Epidemiology, Model.

IBEX J.M.E. 3:95-97

1. Introduction

Feral pigs (*Sus scrofa*) are distributed widely through much of eastern and northern Australia (Wilson *et al.*, 1991). They are considered a pest of agriculture and the environment and a variety of techniques are used to control them (McIlroy, this volume). Also of major concern is the potential of feral pigs to harbour endemic or exotic diseases. This paper reviews the results from epidemiological models for diseases spread primarily by direct contact, for example foot and mouth disease (FMD) and classical swine fever (CSF) and describes a new computer simulation model, AUSPLAGUE, for the spatial dynamics and control of disease in feral pigs.

2. Results from conventional mathematical models

Non-spatial models and spatial diffusion models have been used to predict the conditions for establishment and forecast the subsequent progress of FMD and CSF in feral pigs in south-eastern Australia. For example, estimates of threshold densities (K_T) for epidemics of FMD in wild pigs are 7 pigs/km^2 (range 2 - 14) in semi-arid floodplains (Pech & Hone, 1988) and < 0.1 pigs/km^2 in Namadgi National Park (NNP) in the south-eastern tablelands of New South Wales (Pech & McIlroy, 1990). The differences in K_T partly reflect differences in the capacities of feral pigs to transmit disease in the two contrasting habitats, as well as the generally poor quality of data on contact rates and transmissibility of infectious doses of FMD under field conditions. For comparison, estimates of K_T based on data from Pakistan suggest that CSF might establish only in some wetlands and river systems of Australia which have very high densities of feral pigs (Hone *et al.*, 1992).

The models have been used to assess the likely effectiveness of control procedures (Pech & Hone, *op cit.*) as well as preventative actions such as surveillance or pre-emptive reduction of feral pig densities (Pech *et al.*,1988). Currently there is no systematic surveillance of disease in feral pigs in Australia. Hone and Pech (1990) showed that relying on opportunistic reporting by hunters could result in widely dispersed, and difficult to manage, epidemics of exotic diseases. This conclusion was supported by the estimate from a diffusion model of a relatively rapid rate of spread, 2.8 km /day, of FMD in feral pigs in NNP (Pech & McIlroy, *op cit.*).

Despite the availability of quantitative predictions from models such as those outlined above, exotic disease contingency plans can be difficult to formulate because the generality of predictions is unknown, their associated errors are often large, and the published studies may not apply to the particular conditions of a disease outbreak. A computer simulation model, AUSPLAGUE, is being developed to address some of these problems.

3. Structure and design of AUSPLAGUE

AUSPLAGUE has been designed to: (a) simulate the dynamics of a contact-spread disease by modelling the behaviour of pigs within habitats (because this determines the rate of spread of disease between individual pigs), and the time spent by pigs in each type of habitat (because this affects the rate of spread of disease across a landscape); (b) simulate the effects of a range of control methods on disease dynamics; (c) place the epidemiological and control models in spatially realistic settings; (d) enable non-specialists to use the models interactively to explore ways of managing exotic diseases. AUSPLAGUE employs a four-stage procedure of setting up a scenario, introducing a disease, then using a range of techniques to trace and control an epidemic (Pech *et al.* 1992; Pech, 1992).

The first step in creating a scenario is to select a study area from a digital map of a region familiar to the user. Superimposed on this is a habitat map for feral pigs and demographic data including birth and death rates, age distribution, the average density of pigs, the relative density in each type of habitat and seasonal variation in the use of habitats by pigs. AUSPLAGUE uses an estimate of the average density of feral pigs for the entire study area then scales the density in each habitat type within the selected area using either the relative frequency of observations from prior telemetry studies, or expert assessment of pigs' relative affinity for types of habitat.

Diseases are characterised by a standard set of parameters: case mortality, duration of the latent period, duration of the infectious period, duration of immunity (if any), and the transmission rate. For contact-spread diseases, the transmission rate combines the rate of contact between animals and the probability of transfer of an infectious dose when contact is made. In AUSPLAGUE, the pathogen is introduced into the feral pig population by selecting and "infecting" one or more animals. The "infected" pigs are assumed to be at the beginning of their infectious period and are immediately capable of naturally infecting nearby susceptible animals. AUSPLAGUE provides an opportunity to explore a wide range of methods of disease introduction by enabling the user to choose the size, location and timing of the initial infection.

In AUSPLAGUE, the progress of an epidemic can be traced with counts of the numbers of animals in each disease class, or by a convex polygon which delimits the infected area. As well, the disease status of individual pigs can be displayed at each time step during a simulated epidemic. A range of control methods including trapping, poisoning, hunting and aerial baiting, can be initiated by the user at any time. Although AUSPLAGUE can show explicitly the impact of each technique, simulations can be made more realistic by displaying only the information gathered from techniques, such as trapping or shooting, where live animals or carcases can be retrieved.

Because AUSPLAGUE is a stochastic model, repeated runs from the same initial conditions will not give identical results. AUSPLAGUE is designed to save and retrieve the values of all parameters and the locations and disease status of all pigs at any time during a run. The user can repeat the run several times to assess the variability in the outcome.

4. Sub-models within AUSPLAGUE

4.1. Movements of feral pigs

In the absence of disease or other control methods, the relative density of feral pigs in each habitat type should be maintained at the appropriate levels for each season. AUSPLAGUE achieves this by relating the speed of each pig's movements to the habitat type at its current location. At present, insufficient data are available to characterise the distribution of movements for each habitat in NNP. For each age/sex class of pigs, AUSPLAGUE uses a single reference distribution of movements which has been amalgamated from sequences of radiotelemetry records in all types of country. At each iteration in the computer simulation, the next movement for each pig is assigned firstly from the reference distribution then rescaled for each habitat type.

Preliminary analysis suggests that the social structure of feral pigs in NNP comprises mainly solitary adult males with fluid groups of juveniles of both sexes and adult females (McIlroy, unpublished data; Pech *et al.*, 1993). The

observed group structures have been modelled using a modified version of the tendency-distance interaction models described by Warburton and Lazarus (1991). These models are biologically plausible and are particularly suitable for computer simulation techniques because they rely only on the positions of nearby pigs to calculate the next movement for each individual.

4.2. Control techniques

AUSPLAGUE includes three categories of control techniques to evaluate the timing and allocation of resources required to prevent, contain or stamp-out an epidemic. Spot controls such as traps and spot baiting have a point location but may have associated catchment areas. Linear controls such as bait lines or fences are represented as connected straight line segments and may also have associated catchments. The third category which includes hunting teams and broad scale aerial baiting, is applied across areas and is represented by a mosaic of rectangles. Each control technique has a prescribed effectiveness and duration.

Methods used to trace the progress of an epidemic are similar to that for pig control and could include sampling techniques such as "Judas pigs" and traps "baited" with sows in oestrus (McIlroy, this volume). In AUSPLAGUE, disease surveillance information can be flagged specifically; in training exercises, all other sources of information can be hidden from the user to allow an assessment of exotic disease control strategies using a realistic knowledge base.

5. Conclusion

The management of native and feral animals is a significant component of Australian contingency plans for exotic animal diseases. This is partly because some feral species are abundant, and partly because surveillance, eradication or containment of disease in wild animals differs substantially from that in confined herds or flocks of domestic animals. Conventional epidemiological models have provided useful but limited guidelines for plans to eradicate exotic diseases in feral pigs. A computer simulation model, AUSPLAGUE, is being developed to integrate disease dynamics, host population dynamics, control and surveillance methods and landscape data. The software is portable, interactive and user-friendly and will be useful as a training tool for testing and developing management strategies.

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