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Risk factors for bovine periodontal disease – a preliminary study

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ABSTRACT

The work presented in this pilot study aimed to identify potential risk factors associated with bovine periodontitis development. Bovine periodontitis is a multifactorial polymicrobial infectious disease for which the aetiopathogenesis and risk factors are not fully understood. From cattle slaughtered in an abattoir in Scotland, 35 dental arcades with periodontal lesions and 40 periodontally healthy arcades were selected over seven visits for study. Multivariable logistic regression analysis was used to evaluate the association between periodontitis and the independent variables, gender, age and breed. For every increase in year of age, cattle were 1.5 times more likely to have periodontitis. A graphical analysis indicated that within the limits of this study, we could not detect any major influence of breed on the age-effect. Although logistic regression analysis demonstrated that periodontitis lesions are more prevalent with increasing age of cattle the underlying mechanisms remain unclear. It is likely that periodontitis is an important cause of oral pain in older cattle and can contribute to reduced productivity/performance. Further studies with a larger sample size are necessary to elucidate the associations between potential risk factors and periodontitis in cattle and to define its effects on animal welfare and productivity.

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Implications

This pilot study emphasises the importance of bovine periodontitis, a disease neglected and unknown to most producers and veterinarians. Little is known about the risk factors associated with bovine periodontitis but their elucidation is important in helping to control the disease. The present study shows that periodontal lesions are relatively common in cattle herds and the results of multivariable logistic regression analyses demonstrated that periodontitis lesions tend to be more prevalent with increasing age of cattle. Routine clinical examination of the bovine oral cavity is essential if this disease is to be diagnosed in a live animal.

Introduction

Healthy teeth are extremely important for effective eating and rumination. Dairy cows, on average, eat for 265 min and ruminate for 441 min per day. They produce approximately 578 cuds per day, each involving 55 chewing cycles totaling over 17 000 chews per day (Braun et al., 2015). Abnormal mastication and rumination are sensitive indicators of many disorders, including infectious diseases. Although poor productivity is the main reason for culling cattle, dental disease is rarely considered as a possible explanation (Fadden et al., 2015). Dental disease such as periodontitis can be painful leading to inefficient mastication with consequential loss of body condition and weight, increased susceptibility to disease and decreased productivity, with consequent welfare and economic impacts.

In cattle raised extensively in Brazil, a high frequency of an aggressive form of periodontitis has been described in calves since the 1960s and it is generally associated with livestock on newly formed or reformed pastures (Dutra et al., 1993; Döbereiner et al., 2000). Some herds can be severely affected by a mortality rate of up to 22.1% reported on some farms (Tims et al., 1992). Bovine periodontitis has also been reported in Europe and the United States (Ingham, 2001; Fadden et al., 2015; Borsanelli et al., 2016). Periodontitis is probably, as in other species, a painful condition in cattle.

Periodontitis in cattle, unlike in other species has been neglected by veterinarians and scientists for many decades. This may in part be due to the challenges of clinical diagnosis and the attendant difficulties in undertaking epidemiological surveys and assessing the possible risk factors involved. This is despite an increased awareness amongst stockmen of the importance of relieving pain when treating other diseases in cattle (Remnant et al., 2017). In human patients, it is well accepted that the prevalence and severity of periodontal lesions tend to increase with age. Our hypothesis is that age is a risk factor for bovine periodontitis development. Whether this is due to increasing exposure to causative

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factors in the environment or to changes in the animals' disease susceptibility over time remains to be elucidated.

Epidemiological studies are essential if we are to elucidate the aetiology of periodontitis, identify risk factors, define its effects on the health and welfare of affected animals and design control measures (Albandar, 2002). In this pilot study, we evaluated possible risk factors associated with the occurrence of periodontal lesions in cattle. The preliminary results of this study have been published in a poster format (Viora et al., 2018).

Material and methods

Dental arcade evaluation

From 250 cattle slaughtered daily in an abattoir in Scotland, 35 dental arcades with periodontal lesions and 40 periodontally healthy controls were selected for this study over seven visits from September to November 2015. The animals were selected as a convenience sample and to select animals from different herds, every fifth head was examined as it passed down the slaughter line and then classified into one of the following categories: periodontally healthy animal or animal with periodontitis. Due to operational logistics, it was not always possible to follow the complete slaughter; thus, data collection varied between visits. It was not possible to determine the reason for sending the cattle for slaughter, some were prime cattle, others were culled animals (failing to perform or reason unknown).

The criteria for the diagnosis of periodontal lesions was the presence of gingival retraction (i.e., the tooth root was visible at the gingival margin), the existence of a periodontal pocket (the distance from the gum margin to the bottom of the periodontal pocket as measured with a graduated universal periodontal probe) greater than 5 mm in depth and suppuration (the presence of pus inside the periodontal pocket) (Borsanelli et al., 2016). The probe was inserted into the base of the periodontal pocket, applying a light force and moved gently around the tooth surface and pocket depth measurement obtained. Since animals were examined *post-mortem* it was not possible to evaluate bleeding on probing. Healthy animals had no evidence of gingival retraction, no periodontal pockets, no suppuration and no evidence of any other oral disease.

The data relating to periodontal pathology were noted in an odontogram developed for the study. The sex, breed and age of animals were collected from the animals' passports.

Data analysis

Multivariable logistic regression analysis was performed to investigate the association between the independent variables (age, sex and breed) and the presence of periodontitis. Odds ratios (OR – representing the increased or decreased likelihood of periodontitis given exposure to these variables) with 95% confidence intervals (95% CI) were also calculated.

All analyses were performed using the R software (version 3.6.1). To estimate whether the occurrence of periodontitis in different breeds followed the same age profile, a multivariable logistic regression model with glm function (R-base package) was made considering breed and age (generalised linear model = periodontitis ~ breed + age + breed*age).

Results

Fig. 1 shows a sample of pictures taken from animals affected by the periodontal disease with gingival recession and periodontal pockets. Of the 75 slaughtered cattle evaluated in this study, 66 were female and nine were male (Supplementary Table S1), with an overall mean age of 5.3 years (range 1.4–16.5 years). The mean age of animals with periodontitis was 7.4 years (range 1.5–6.5 years) and for periodontally healthy animals the mean age was 2.9 years (range 1.4–10.6 years). A wide range of breeds was identified, the most common being Limousin, Holstein-Friesian and Aberdeen Angus (Supplementary Table S1). For statistical analysis, the 75 animals were grouped into two categories, dairy ($n = 20$) or beef ($n = 55$) cattle. A higher prevalence of periodontal lesions in the 35 affected animals was observed between left mandibular third premolar and first molar (40%), between right maxillary third premolar and first molar (28.6%), at the left maxillary third premolar (28.6%) and at the right first incisor (28.6%) (Supplementary Table S2). Single lesions were seen in one (2.9%) specimen, 2–4 in 19 (54.3%) and >5 in 15 (42.8%). Premature loss of teeth was observed in three (8.6%) animals with periodontitis.

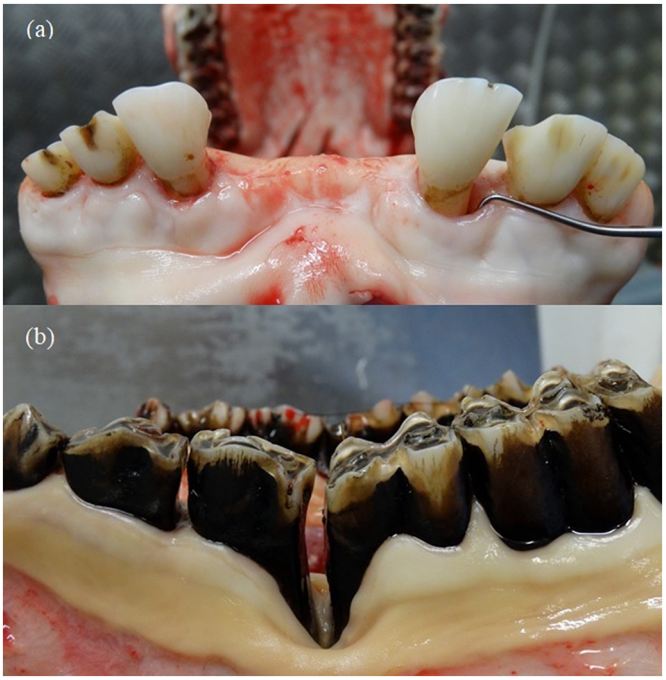

Fig. 1. Examples of bovine periodontal lesions. (a) Absence of the first right incisor (401) and the first left incisor (301). Presence of gingival recession with root exposure and periodontal pockets deeper than 10 mm in the left second incisor (302) and presence of gingival recession in the right second incisor (402). (b) Presence of gingival recession with root exposure and periodontal pocket deeper than 5 mm between the third premolar (407) and the first molar, right mandible (408). Substantial presence of biofilm.

Fig. 2 summarises the distribution of the data points collected and the output from the multivariable logistic regression model. The association between age and periodontitis is very clear for both breed categories although the confidence bands are wide. Visually, the age-predictions are similar in the age interval where both breeds are represented but the results of the statistical analysis of the associations (5% alpha-level) between periodontitis in cattle and gender or breed were inconclusive (OR: 2.8; 95% CI: 0.53 to 15.38 and 0.04 to 20.43, respectively) (Table 1).

Discussion

The occurrence of dental problems in farm animals, including periodontal disease, has been recorded in sheep in Scotland (Riggio et al., 2013) and New Zealand (Bruère et al., 1979) and in cattle in the North of England (Ingham, 2001), the United States (Fadden et al., 2015), Brazil (Döbereiner et al., 2000) and the West of Scotland (Borsanelli et al., 2016). The present study shows a potential oral health problem in beef and dairy cattle, which can have unilateral or bilateral involvement of the masticatory teeth.

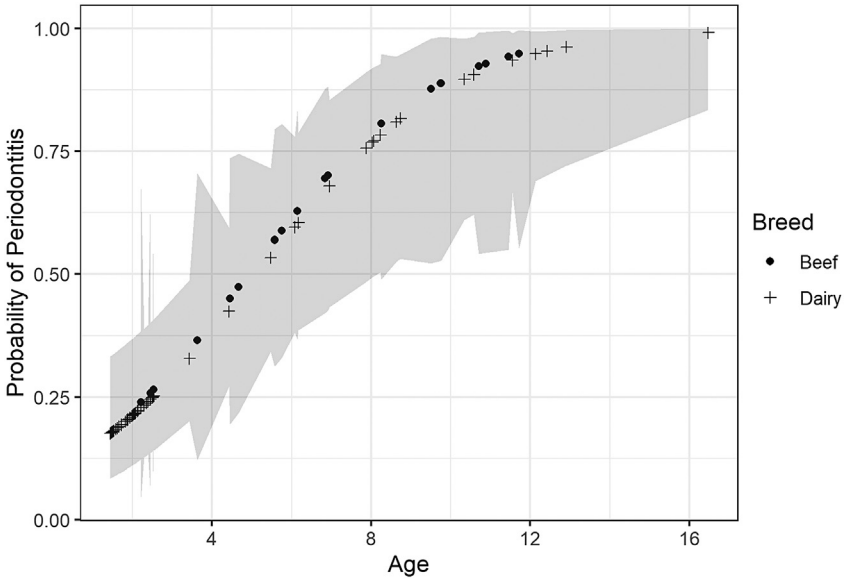

Fig. 2. Logistic curves to predict probabilities of periodontal lesions occurrence according to breed and age, with the multivariate logistic regression model. The graph shows the probability of periodontitis in cattle increases with age regardless of the breed of the animal (dairy or beef).

The current pilot study of a broad spectrum of cattle demonstrates a substantial increase in periodontitis with increasing age. Visually (Fig. 2), we cannot detect systematic influences of breed and gender but the substantial uncertainty (wide confidence intervals) and limited sample size (low statistical power) prohibit meaningful conclusions from statistical testing of minor effects (Bello and Renter, 2018). Data and estimates from this pilot study can be useful for planning studies with sufficient statistical power to detect risk factors with moderate and minor effects.

Bovine periodontitis is a progressive infectious process that causes cumulative and progressive pathology, readily seen in slaughtered animals. The periodontal lesions that develop throughout the productive life of animals can be characterised by the formation of periodontal pockets, gingival recession, clinical attachment loss and premature loss of teeth. The unpredictable disease occurring in many cattle herds raised extensively in tropical biomes in Brazil has dramatic effects on animal health, such as high mortality, low feed efficiency, weak and unproductive animals and large economic losses (Döbereiner et al., 2000). Several potential periodontal pathogens appear to be involved (Borsanelli et al., 2018). This aggressive form of bovine periodontitis may reflect a particular epidemiological condition associated with environmental or modifying factors (such as genetics), but at present remains unexplained. Several of the clinical, pathological and epidemiological aspects of the Brazilian disease are similar to those described in New Zealand, particularly the high incidence of lesions after the grazing of newly deforested (Page and Schroeder, 1982) or intensively cultivated areas. However, descriptions of severe outbreaks of an aggressive form of the disease do not detract from the importance of the chronic form.

Table 1
Multivariable logistic regression results on the association between variables and the odds of bovine periodontitis.

Coefficients	OR[1]	95% CI[2]	*P*-value
Gender	2.88	0.53–15.38	0.2
Breed	0.69	0.04–20.43	0.8
Age	1.53	1.06–2.60	0.04
Breed: age	1.01	0.57–1.61	0.94
Pseudo R squared	0.28		

[1] OR: Odds ratios.
[2] CI: Confidence intervals.

The destructive periodontal diseases are different from many other chronic inflammatory diseases since the presence of infectious agents alone cannot cause the loss of periodontal tissues. Studies in humans suggest that the progression of periodontal disease is not linearly continuous and factors that affect its predictability need to be identified (Albandar, 2002). Risk factors can be defined as distinguishing characteristics or exposures which increase the probability of developing periodontitis or that lead to a measurable change (loss) in the state of periodontal tissue support (Albandar, 2002). In humans, risk factors such as age, sex, race/ethnicity, smoking, obesity, diabetes and osteopenia/osteoporosis have been suggested. Gender is not a direct risk for periodontitis, although men tend to have worse periodontal health than women (Albandar, 2002). The prevalence and severity of periodontitis in people increase with age, suggesting that this may be a risk factor for the disease. However, this idea has been questioned, with the contention that the 'age effect' is the result of prolonged exposure to real risk factors rather than the consequence of age itself (Papapanou et al., 1991). When evaluating the association between gender, weight and age in periodontal disease in dogs, Carreira et al. (2015) concluded that gender did not appear to be a risk factor although older dogs tended to have more advanced disease. Due to the small sample size of this pilot study, we could not meaningfully study the effect of gender.

Although not investigated in the present study, the black pigmented supragingival biofilm that accumulates on the dental crown of cattle also appears to be a risk factor for periodontitis of the masticatory teeth (Saraiva et al., 2019). Thus, the strong association of iron in the pigmented supragingival biofilm with the occurrence of periodontitis suggests the presence of microorganisms that use this element in their metabolism. Such micro-organisms include *Porphyromonas asaccharolytica, Porphyromonas endodontalis, Prevotella intermedia* and *Prevotella melaninogenica* which have all been shown in cases of bovine periodontitis (Borsanelli et al., 2015).

The results of this pilot study can help to define the design of a larger more complete study, with a sample size that is sufficient to further evaluate the risk factors for bovine periodontitis. Although slaughterhouse studies can provide useful information on herd prevalence and risk factors, large scale epidemiological studies on live animals are essential in the future. To date, these have rarely been completed due to the difficulty of examining animals without chemical restraint and the challenge of carrying out the 'gold-standard' oral examination because of the anatomy of the ruminant dental arch. However, protocols have

been developed to facilitate the clinical examination of the bovine oral cavity and with training and experience, the assessment can become a routine procedure (Borsanelli et al., 2015). Future studies will need to assess the effects of different management systems, grassland, feedstuffs and geographical location on the prevalence of periodontitis. The effects of periodontitis on production and fertility indicators such as body weight, milk yield, pregnancy rate and culling rate will also need to be addressed.

Bovine periodontitis is likely to be a painful chronic condition and must be considered a welfare issue. However, oral pain may have only subtle effects on cattle behaviour, and thus the disease is easily ignored and neglected. In the present study, multivariable logistic regression analysis demonstrated that periodontitis lesions are more prevalent with increasing age of cattle. However, within the limits of the current investigation, we hypothesise that increasing age may not necessarily represent a risk factor *per se* for the development of bovine periodontitis, but may simply reflect the cumulative exposure over time to environmental risk factors.

Supplementary materials

Supplementary data to this article can be found online at https://doi.org/10.1016/j.animal.2020.100121.

Ethics approval

Ethical approval was not sought for the work described in this manuscript. No research was conducted on live animals. All materials were obtained *post-mortem* from a licensed abattoir in the United Kingdom.

Data and model availability statement

None of the data were deposited in an official repository. Data available upon request.

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Author contributions

Ana Carolina Borsanelli: Conceptualisation, methodology, formal analysis, investigation, data curation, writing – original draft, writing – review & editing. Lorenzo Viora: Conceptualisation, methodology, investigation, writing – original draft, writing – review & editing. Timothy Parkin: Formal analysis, data curation, writing – review & editing. David F. Lappin: Conceptualisation, methodology, validation, formal analysis, resources, data curation, writing – original draft, writing – review & editing. David Bennett: Conceptualisation, methodology, writing – original draft, writing – review & editing. George King: Conceptualisation, methodology, writing – original draft, writing – review & editing. Iveraldo S. Dutra: Conceptualisation, methodology, writing – original draft, writing – review & editing, supervision, funding acquisition. Marcello P. Riggio: Conceptualisation, methodology, validation, resources, writing – original draft, writing – review & editing, supervision, project administration, funding acquisition.

Declaration of interest

The authors declare that they have no competing interests.

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