



Periodontitis in sheep in Pernambuco, Northeastern Brazil¹

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ABSTRACT.- Wicpolt N.S., Lima T.S., Silva-Filho G.B., Bom H.A.S.C., Fonseca S.M.C., Silva M.R., Almeida V.M., Riet-Correa F., Souza F.A.L. & Mendonça F.S. 2022. **Periodontitis in sheep in Pernambuco, Northeastern Brazil.** *Pesquisa Veterinária Brasileira* 42:e07074, 2022. Laboratório de Diagnóstico Animal, Universidade Federal Rural de Pernambuco, Rua Dom Manoel de Medeiros s/n, Dois Irmãos, Recife, PE 52171-900, Brazil. E-mail: fabio.mendonca@ufrpe.br

Cases of periodontitis in sheep from the Agreste and Zona da Mata regions of Pernambuco, Northeastern Brazil, are described. Information on breed, age and sex of affected animals as well as clinical and pathological aspects of the disease were obtained during farm visits. Fifteen animals from a total of 450 Santa Inês sheep, aged between three and twelve years, showed low body condition score, dull coat, and difficulty in feeding followed by pain on palpation of the mandibular region. Physical examination of the oral cavity of affected animals and *post mortem* findings of slaughtered individuals revealed varying degrees of periodontitis, wear, fracture, mobility, and loss of teeth associated with gingival retraction, presence of biofilm and food packing between incisors, premolars and molars teeth. Increased mandibular volume was observed in eight animals and, in two of them, an abscess fistula, exclusively in mandibular teeth. The occurrence of periodontitis in sheep had not been recorded until now in Northeastern Brazil and, thus, this is the first description of cases in the region.

INDEX TERMS: Periodontitis, sheep, Brazil, periodontal disease, tooth wear, tooth mobility, small ruminants.

RESUMO.- [Periodontite em ovinos em Pernambuco, Nordeste do Brasil.] Descrevem-se casos de periodontite em ovinos provenientes das regiões do Agreste e Zona da Mata de Pernambuco, Nordeste do Brasil. Informações sobre raça, idade e sexo dos animais afetados bem como os aspectos clínicos e patológicos dos surtos foram obtidos a partir de visitas às propriedades e são reportados. 15 animais de um total de 450

ovinos da raça Santa Inês, com idade entre três a doze anos de idade manifestaram baixa condição corporal, pelagem sem brilho e dificuldade de alimentar-se, acompanhado de dor à palpação na região mandibular. O exame físico da cavidade oral dos animais afetados e os achados *post mortem* de indivíduos abatidos revelaram graus variados de periodontite, desgaste, fratura, mobilidade e perda dentária, associados a retração gengival, presença de biofilme e compactação de resíduos alimentares entre os dentes incisivos, pré-molares e molares. Em oito animais havia aumento de volume mandibular e em dois deles observaram-se abscessos fistulados que ocorreram exclusivamente nos dentes mandibulares. A ocorrência de periodontite em ovinos não têm sido registrada no Nordeste do Brasil, sendo estes os primeiros casos descritos na região.

TERMOS DE INDEXAÇÃO: Periodontite, ovinos, Brasil, doença periodontal, desgaste dentário, mobilidade dentária, pequenos ruminantes.

INTRODUCTION

Periodontitis is a chronic infectious disease characterized by inflammation of tooth-supporting tissues, typically associated

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with dysbiosis of the biofilm (Hajishengallis & Lamont 2012) that naturally forms in the teeth of ruminants. Several factors are associated with the predisposition to this disease in herds, especially the quality of the food provided (Arcaute et al. 2020). When pathogenic microorganisms proliferate to levels greater than those of the microbiota of the oral cavity, it is possible that an inflammation may set in, culminating in the formation of sulcus and gingival retraction, dental impairment, and consequent tooth loss. Abscesses, fistulas and pain are usually the most reported alterations in animals with periodontitis, which start to manifest loss of weight and of productive functions (Spence & Aitchison 1986, McGregor 2011) due to the difficulty in feeding.

Cases of periodontitis are reported worldwide (Suzuki et al. 2006, Silva et al. 2016, Arcaute et al. 2020) and zooarchaeological studies indicate that the occurrence in herbivores can be dated back to the Neolithic period (Haimovici & Haimovici 1971), when animals began to be used as a source of food and draught power by man.

In Brazil, periodontitis was recorded in cattle in Mato Grosso, in the 1970s and 1980s, as a condition called “swollen face”, in which cattle developed a severe increase in mandibular volume secondary to the loss of bone tissue and subsequent fibrous osteodystrophy (Dutra et al. 1993, 2000, Döbereiner et al. 2004). Given the better understanding of the epidemiology and pathogenesis of the disease, cases of swollen face in cattle are reported only sporadically nowadays. In sheep, the disease is popularly known as “broken mouth” and is mainly characterized by exposure of the roots and premature loss of incisor teeth, but chewing teeth are also affected (Spence et al. 1980). In Brazil, cases of periodontitis in sheep and goats have been described in the North and Southeast regions of the country (Silva et al. 2016, 2019, Borsanelli et al. 2017, 2021, Campello et al. 2019). No data on the disease is available for other regions.

During investigations into the causes of diseases in sheep in the Zona da Mata and Agreste regions of Pernambuco, Brazil, cases of periodontitis have been observed by our research group. Yet, the disease is little known by veterinarians and farmers in the region and, for this reason, causes economic losses by interfering with the productive performance of affected animals. To our knowledge, there is no scientific information on the occurrence of periodontitis in sheep herds in Pernambuco and, therefore, cases of the disease may be underreported. The aim of this study was to describe the epidemiological and clinicopathological aspects of periodontitis in sheep in the state of Pernambuco.

MATERIALS AND METHODS

Cases of periodontitis in sheep herds in the state of Pernambuco, Brazil, are described. Information on the clinical history and health and food management of two herds of sheep was obtained through interviews with the people responsible for the farms, which are located in the Agreste and Zona da Mata regions of the state. Affected animals were clinically examined, giving special attention to the periodontal evaluation. The procedures performed were previously authorized by the Animal Use Ethics Committee (CEUA) of the “Universidade Federal Rural de Pernambuco” (UFRPE) under license 126/2018.

Animals that were slaughtered on the property or that died during the follow-up period were submitted to a *post mortem* evaluation of the head for better observation of premolar and molar teeth

injuries. Periodontal evaluation included checking for the presence of periodontal pockets, gingival retraction with or without food accumulation, root exposure, tooth mobility, presence of biofilm and abscess. Additionally, *post mortem* intraoral radiography was performed to assess the occurrence of bone resorption. For histological analysis, mandible fragments, including the periodontal ligament of four severely affected sheep that had increased mandibular volume, were decalcified in Bock's solution (12.5% formic acid and 20% sodium citrate in a 1:1 mixture) (Tolosa et al. 2003). After this procedure, all samples were routinely processed for histopathology, stained with hematoxylin-eosin (HE), and then examined under a light microscope.

RESULTS

The disease was diagnosed in two sheep herds belonging to the municipality of Bezerros (8°14'33" S and 35°47'7" W) and Limoeiro (7°52'20" S and 35°26'23" W), respectively. The first farm was located in the Agreste region of Pernambuco and ten animals from a herd of 280 sheep were affected. The second farm was located in the Zona da Mata region of Pernambuco; in this case, five sheep out of a herd of 170 animals showed periodontal alterations. Both farms adopted the same production management, consisting of a semi-extensive system with access to pasture composed of *Brachiaria decumbens* and received shopped Elephant grass (*Pennisetum purpureum*), Bermuda grass (*Cynodon dactylon*), and concentrate feed supplied in the trough. In both farms, it was reported that, before the disease, the pasture had received phosphate fertilization and herds had been supplemented with mineral salt produced on the farm itself.

The herds were composed of 450 Santa Inês sheep together. Of these, 15 sheep (3.33%) - four (26.7%) male and eleven (73.3%) female - presented increased mandibular volume and/or altered incisors. The affected animals were aged between three and twelve years (86.7%) and two sheep (13.3%) were younger than three years.

During the physical examination of sheep with periodontitis, no changes in respiratory and heart rates or ruminal motility were observed. Nonspecific clinical changes, mostly characterized by low body condition score, pale mucous membranes, pasty stools, dull coat, and bristly hair were frequently observed. Clinical changes related to periodontitis consisted of pain on palpation of the mandibular region in cases in which bone volume was increased (this was a commonly observed change affecting only one side of the mandibles of sheep with periodontitis). In the evaluation of the incisor teeth, it was observed that in 100% of the examined sheep, there was gingival resection, wear, intense mobility, and loss of teeth in addition to food packing between the teeth and in the gingival sulcus (Fig.1-4). Eight sheep presented increased volume in the mandibular body (53.3%), and in two of them (13.3%), an abscess fistula was observed. Intraoral radiographic examination in two sheep showed impacted permanent teeth, forming mixed dentition, and periapical lesions in the lower third premolar tooth on the left side. In the evaluation of the second dental arch, intrusion of the second and third molar teeth was observed with periapical lesion and radiopacity of the trabecular bone (consistent with an abscess).

In the necropsy of four sheep, it was noted that incisors teeth showed changes consisting mainly of gingival retraction, gingival sulcus formation, and tooth root exposure accompanied

by mobility and loss of incisors, in addition to food followed between the teeth. All animals had fractures of one or more incisor teeth. These lesions were observed at varying intensities among animals and were not associated with abscesses.

In molars and premolars, injuries were severe and included formation of sharp tooth edges, malocclusion, loss of periodontal ligament, gingival retraction, presence of biofilm, dentin exposure, and abscess formation. Dental intrusion followed by abscess was most frequently observed in mandibular molar teeth. The packing of food residues was better observed after the removal of the teeth and after the section of the mandibular bone (Fig.5-8).

Light microscopy showed the replacement of the periodontal ligament by a thick band of connective tissue with infiltrate predominantly composed of lymphocytes and plasmocytes and, occasionally, macrophages and degranulated neutrophils. In bone tissue, there was a multifocal reduction in the quantity and thickness of alveolar bone trabeculae followed by endosteal proliferation. Osteoclasts frequently surrounded the bone trabeculae amidst the fibrosis (Fig.9-12).

DISCUSSION

The cases of periodontitis presented here were characterized by varying degrees of wear, fracture, mobility and loss of teeth associated with gingival retraction, biofilm formation and food packing in incisor, premolar and molar teeth. Abscess and fistula formation occurred exclusively in mandibular teeth while loss of tooth density and fracture were pronounced in the incisors. The lesions particularly affected sheep aged over 36 months, similar to previous reports in dairy goats (Campello et al. 2019) and sheep (Spence et al. 1980, Silva et al. 2016,

Arcaute et al. 2020). These findings draw attention to the presence of periodontitis in sheep herds in Pernambuco and reinforce the need to manage the oral health of these animals.

Sheep are more susceptible to periodontal disease than goats (Bartosiewicz 2008), but compared to cattle, they are affected to a similar extent in terms of prevalence and severity of lesions (Holmes et al. 2021). Periodontal regions near erupting premolars and molars are the major sites of lesions in cattle with periodontitis. The main reason for this localization is related to the trauma caused by the emergence of the permanent tooth, which causes ulceration, periodontal pockets, followed by osteolysis of the alveolar bone. From this process, chronic ossifying periostitis with uni or bilateral bone bulging of the jaws, comprises the main clinical picture of "swollen face" (Döbereiner et al. 1974). In cattle, incisor involvement is not commonly observed (Döbereiner et al. 2000). Periodontitis in cattle in Brazil has been classically associated with changes in pasture management and affect herds in outbreaks. However, the frequency of reports of this disease has drastically decreased, being sporadic nowadays.

In sheep, periodontitis is observed affecting the regions of incisors, premolars and molars teeth (Borsanelli et al. 2017, 2021). The reason for the early wear of incisors is uncertain, but ingestion of high fertility grasses, the abrasive action of the soil during the seizure of food and the presence of acid substances in the soil have already been identified as factors related to the wear of the incisors of sheep with periodontitis (Mitchum & Bruere 1984). In Brazil, periodontitis affecting small ruminants have been reported mainly in the North (Silva



Fig.1-4. Dental and periodontal lesions in Santa Inês sheep with periodontitis. (1) Severe gingival retraction and impacted food between incisors teeth. (2) Tooth enamel demineralization of incisors evidenced by the change in density of the apex of the crowns. (3) Loss of teeth. (4) Brittle teeth.



Fig.5-8. Lesions in the mandible, molar and premolar teeth in sheep with periodontitis. (5) Abscess fistula in the mandible. (6) Malocclusion due to wear and sharp edges in the upper 2nd and 3rd molars. (7) Evidence of dental intrusion in the mandibular 2nd and 3rd molars. (8) Formalin-fixed cross-section of mandible body of a sheep, right vestibular view, with impacted grass at the malocclusion site of the molar teeth.

et al. 2016, 2019) and Southeast (Borsanelli et al. 2017, 2021) regions. In Pará, a prevalence of 3.7% was described in sheep (Silva et al. 2016), similar to that observed in the present study. However, these data can be highly variable; rates over 70% of the herd have been reported (Campello et al. 2019).

The supragingival biofilm was observed in all affected sheep in both farms described here. This change is identified as one of the main factors associated with the development of periodontal lesions in ruminants (Dutra et al. 2000, Saraiva et al. 2019, Borsanelli et al. 2021). The present study did not aim to identify bacteria present in the biofilms of affected sheep, but species of the genera *Petrimonas*, *Porphyromonas*, *Prevotella*, and *Fusobacterium* stand out among the predominant microorganisms in the gingival sulcus of sheep with periodontitis (Borsanelli et al. 2017, 2021), being similar to periodontitis in humans (Hajishengallis

2015). Biofilm can be identified as a brown to blackened layer that is deposited, in varying amounts, on the surface of teeth and gingival sulcus (Borsanelli et al. 2017). This plaque is made up of salivary and food substances, and a microbiota that, when in dysbiosis, causes periodontitis. Higher biofilm scores are directly related to higher frequency and severity of gingival recession and tooth wear (Campello et al. 2019), justifying the importance of its assessment and prevention.

Multiple factors favor the occurrence of periodontitis in sheep. Beyond the presence of supragingival biofilm other factors such as behavioral, environmental and genetic contribute to the clinical manifestation of the disease (Arcaute et al. 2020). In relation to the cases of periodontitis presented here, recent pasture fertilization associated with inadequate supplementation of herds with mineral salt produced on the farm may have contributed to the occurrence of the disease.

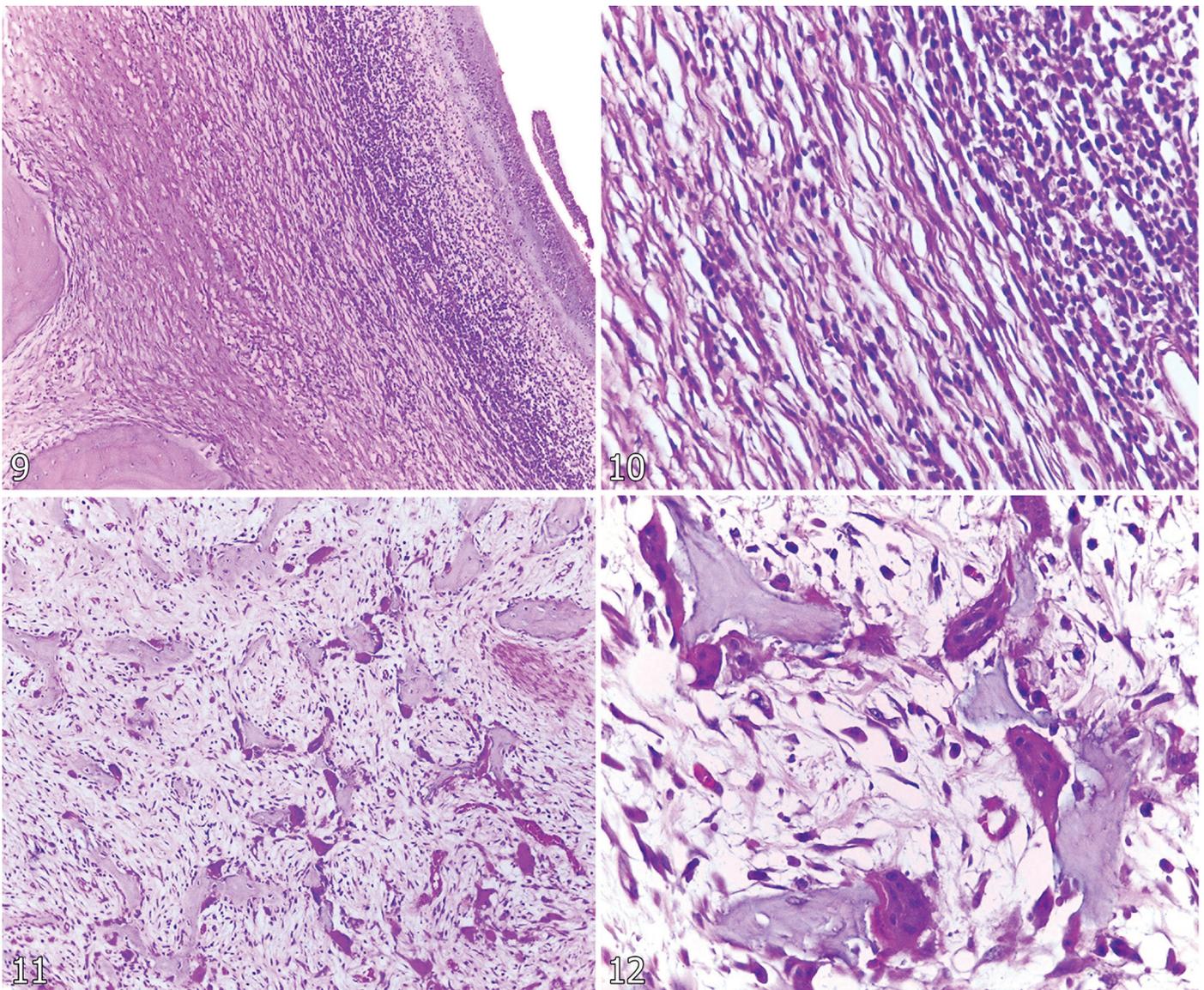


Fig.9-12. Photomicrograph of bone fragments from the mandible of sheep with periodontitis. (9, 10) replacement of the periodontal ligament by connective tissue and inflammatory cells. (9) HE, obj.10x. (10) HE, obj.40x. (11, 12) Marked resorption of bone trabeculae with several osteoclasts surrounding the trabeculae and proliferation of connective tissue and mild histiocytic infiltrate. (11) HE, obj.10x. (12) HE, obj.40x.

In studies carried out in Spain, hard diets containing plant material with edges and sharp areas and acidic foods were the main risk factors associated with cases of periodontitis in sheep (Arcaute et al. 2020). Despite the difficulties related to feeding sheep during droughts in Northeastern Brazil, it is important to be aware when using silage, given the almost twice greater risk of an animal suffering mandibular injury than those who did not consume it (Arcaute et al. 2020). Considering the epidemiology of periodontitis in sheep, the role of genetic and environmental factors needs to be better understood (Holmes et al. 2021). Oral lesions have been reported more commonly in Awassi breeds (Al Sadi & Younis 2010) suggesting that the genetic profile may contribute to oral disorders that may predispose the disease.

The radiographic findings described here indicated loss of bone structure in the region of the tooth root, which is a factor responsible for the extension and severity of dental damage. Periodontitis also affected young sheep, although this age group was least affected in this work, it suggests the disease is important causing economic loss even related to young animals. In older sheep, dental intrusion, indicates traumatic displacement of the tooth into the alveolus and is considered the alteration that most affects the supporting tissues (Oliveira et al. 2004, Morello et al. 2011). This severe lesion worsens the inflammation and increases the extension of periodontitis, which may be accompanied by abscess or can act as a predisposing factor.

The microscopic findings observed in sheep with periodontitis in this study were similar to those seen in previous studies and are mainly characterized by the presence of mononuclear inflammatory infiltrate, bone resorption and periodontal ligament destruction with varying degrees of severity (Orr et al. 1979, Alexandru et al. 2020). Varying degrees of osteoid matrix maturation and mandibular bone fibrosis were also frequently noted.

CONCLUSION

Considering the multifactorial characteristics of periodontitis, it is important to adopt prevention strategies on sheep farms where the disease occurs. The choice of the breed should prioritize sheep that are not predisposed to dental disorders; hard forrages with sharp edges as well as acidic foods should be avoided; add a routine inspection of the oral cavity, particularly evaluating the levels of biofilm deposition and gingival lesion are essential to prevent economic loss in farms where periodontitis occurs.

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REFERENCES

- Al Sadi H.I. & Younis H.B. 2010. Oral lesions in sheep in Mosul Area. *Iraq. Vet. Res.* 3(2):21-26. <<https://dx.doi.org/10.3923/vr.2010.21.26>>
- Alexandru B.C., Popa M., Oana L., Georgiu C., Tabaran F., Macri A., Purdoi R., Istrate D., Dogaru G., Lazăr C., Bosca B., Peştean C., Constantin A.M. & Şovrea A. 2020. Induction of chronic marginal periodontitis in an experimental sheep model: clinical, radiological and histological evaluation. *Rom. Biotechnol. Lett.* 25(3):1511-1525. <<https://dx.doi.org/10.25083/rbl/25.3/1511.1525>>
- Arcaute M.R., Lacasta D., González J.M., Ferrer L.M., Ortega M., Ruiz H., Ventura J.A. & Ramos J.J. 2020. Management of risk factors associated with chronic oral lesions in sheep. *Animals* 10(9):1529. <<https://dx.doi.org/10.3390/ani10091529>> <PMid:32872584>
- Bartosiewicz L. 2008. Environmental stress in early domestic sheeps, p.3-13. In: Miklíková Z., Thomas R. (Eds.), *Current Research in Animal Palaeopathology: proceedings of the Second ICAZ-Animal Palaeopathology Working Group Conference, Oxford.*
- Borsanelli A.C., Athayde F.R.F., Agostinho S.D., Riggio M.P. & Dutra I.S. 2021. Dental biofilm and its ecological interrelationships in ovine periodontitis. *J. Med. Microbiol.* 70(7):1473-5644. <<https://dx.doi.org/10.1099/jmm.0.001396>> <PMid:34313584>
- Borsanelli A.C., Gaetti-Jardim Jr E., Schweitzer C.M., Viora L., Busin V., Riggio M.P. & Dutra I.S. 2017. Black-pigmented anaerobic bacteria associated with ovine periodontitis. *Vet. Microbiol.* 203:271-274. <<https://dx.doi.org/10.1016/j.vetmic.2017.03.032>> <PMid:28619155>
- Campello P.L., Borsanelli A.C., Agostinho S.D., Schweitzer C.M., Gaetti-Jardim Jr. E., Döbereiner J. & Dutra I.S. 2019. Occurrence of periodontitis and dental wear in dairy goats. *Small Rumin. Res.* 175:133-141. <<https://dx.doi.org/10.1016/j.smallrumres.2019.05.004>>
- Döbereiner J., Dutra I.S. & Rosa I.V. 2004. A etiologia da “cara inchada”, uma periodontite epizootica dos bovinos. *Pesq. Vet. Bras.* 24(1):50-56. <<https://dx.doi.org/10.1590/S0100-736X2004000100011>>
- Döbereiner J., Dutra I.S., Rosa I.V. & Blobel H. 2000. “Cara inchada” of cattle, an infectious, apparently soil antibiotics-dependant periodontitis in Brazil. *Pesq. Vet. Bras.* 20(2):47-64. <<https://dx.doi.org/10.1590/S0100-736X2000000200001>>
- Döbereiner J., Inada T. & Tokarnia C.H. 1974. “Cara inchada”, doença peridentária em bovinos. *Pesq. Agropec. Bras.* 9:63-85.
- Dutra I.S., Botteon R.C.M. & Döbereiner J. 2000. Modification of the microflora associated with the periodontal lesions of “cara inchada” in calves transferred to a disease-free área. *Pesq. Vet. Bras.* 20(2):71-74. <<https://dx.doi.org/10.1590/S0100-736X2000000200003>>
- Dutra I.S., Matsumoto T. & Döbereiner J. 1993. Surtos de periodontite em bezerros (“cara inchada”) associados ao manejo do solo. *Pesq. Vet. Bras.* 13(1/2):1-4.
- Haimovici A. & Haimovici S. 1971. Sur la presence de parodontopathies marginales sur des restes subfossiles de mammiferes de stations pre- et protohistoriques du territoire de la Roumanie. *Bull. Group. Int. Rech. Sci. Stomatol. Odontol.* 14:259-271.
- Hajishengallis G. & Lamont R.J. 2012. Beyond the red complex and into more complexity: the polymicrobial synergy and dysbiosis (PSD) model of periodontal disease etiology. *Mol. Oral Microbiol.* 27(6):409-419. <<https://dx.doi.org/10.1111/j.2041-1014.2012.00663.x>> <PMid:23134607>
- Hajishengallis G. 2015. Periodontitis: from microbial immune subversion to systemic inflammation. *Nat. Rev. Immunol.* 15(1):30-44. <<https://dx.doi.org/10.1038/nri3785>> <PMid:25534621>
- Holmes M., Thomas R. & Hamerow H. 2021. Periodontal disease in sheep and cattle: Understanding dental health in past animal populations. *Int. J. Paleopathol.* 33:43-54. <<https://dx.doi.org/10.1016/j.ijpp.2021.02.002>> <PMid:33647860>
- McGregor B.A. 2011. Incisor development, wear and loss in sheep and their impact on ewe production, longevity and economics: a review. *Small Rumin. Res.* 95(2/3):79-87. <<https://dx.doi.org/10.1016/j.smallrumres.2010.11.012>>
- Mitchum G.D. & Bruere A.N. 1984. Solubilisation of sheep’s teeth: a new look at a widespread New Zealand problem. *Proceedings of the 14th Seminar of the Society of Sheep and Beef Cattle Veterinarians of the New Zealand Veterinary Association*, p.44-56.

- Morello J., Ribeiro F.C., Roldi A., Pereira R.S., Barroso J.M. & Intra J.B.G. 2011. Sequelas subsequentes aos traumatismos dentários com envolvimento endodôntico. *Bras. Pesq. Saúde* 13(2):68-73.
- Oliveira F.A.M., Gerhardt de Oliveira M., Orso V.A. & Oliveira V.R. 2004. Traumatismo dentoalveolar: revisão de literatura. *Revta Cir. Traumatol. Buco-Maxilo-Facial* 4(1):15-21.
- Orr M.B., O'Callaghan M.W., West D.M. & Bruere A.N. 1979. A syndrome of dental abnormalities of sheep: II. The pathology and radiology. *N. Z. Vet. J.* 27(12):276-278. <<https://dx.doi.org/10.1080/00480169.1979.34672>>
- Saraiva J.R., Ramos M.M.B., Borsanelli A.C., Schweitzer C.M., Gaetti-Jardim Jr. E., Höfling J.F., Ramos T.N.M. & Dutra I.S. 2019. Chemical and structural composition of black pigmented supragingival biofilm of bovines with periodontitis. *Pesq. Vet. Bras.* 39(12):933-941. <<https://dx.doi.org/10.1590/1678-5150-PVB-6352>>
- Silva N.S., Borsanelli A.C., Gaetti-Jardim Júnior E., Schweitzer C.M., Silveira J.A.S., Bomjardim H.A., Dutra I.S. & Barbosa J.D. 2019. Subgingival bacterial microbiota associated with ovine periodontitis. *Pesq. Vet. Bras.* 39(7):454-459. <<https://dx.doi.org/10.1590/1678-5150-PVB-5913>>
- Silva N.S., Silveira J.A.S., Lima D.H.S., Bomjardim H.A., Brito M.F., Borsanelli A.C., Dutra I.S. & Barbosa J.D. 2016. Epidemiological, clinical and pathological aspects an outbreak of periodontitis in sheep. *Pesq. Vet. Bras.* 36(11):1075-1080. <<https://dx.doi.org/10.1590/S0100-736X2016001100003>>
- Spence J. & Aitchison G. 1986. Clinical aspects of dental disease in sheep. *In Pract.* 8(4):128-135. <<https://dx.doi.org/10.1136/inpract.8.4.128>>
- Spence J.A., Aitchison G.U., Sykes A.R. & Atkinson P.J. 1980. Broken mouth (premature incisor loss) in sheep: The pathogenesis of periodontal disease. *J. Comp. Pathol.* 90(2):275-292. <[https://dx.doi.org/10.1016/0021-9975\(80\)90064-x](https://dx.doi.org/10.1016/0021-9975(80)90064-x)> <PMid:7437108>
- Suzuki S., Mitani A., Koyase K., Oda S.-I., Yoshinari N., Fukuda M., Hanamura H., Nakagaki H. & Noguchi T. 2006. A model of spontaneous periodontitis in the miniature goat. *J. Periodontol.* 77(5):847-855. <<https://dx.doi.org/10.1902/jop.2006.050203>> <PMid:16671878>