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Oral affections in an *ex situ* population of marsh deer (*Blastocerus dichotomus*): a retrospective study (1990-2020)[1]

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ABSTRACT.- Borsanelli A.C., Saraiva J.R., Pádua D.B., Athayde F.R.F., Vaccari J., Zanetti E.S. & Dutra I.S. 2022. **Oral affections in an *ex situ* population of marsh deer (*Blastocerus dichotomus*): a retrospective study (1990-2020).** *Pesquisa Veterinária Brasileira 42:e07096, 2022*. Departamento de Medicina Veterinária, Escola de Veterinária e Zootecnia, Universidade Federal de Goiás, Rodovia Goiânia-Nova Veneza Km 8, Goiânia, GO 74690-900, Brazil. E-mail: anaborsanelli@ufg.br

Oral diseases are limiting to health, welfare, and conservation practices, especially in the case of endangered animals. In this retrospective study, a survey on oral health-related conditions noted in the clinical records for 261 deer comprised in an *ex situ* population of the Marsh Deer Conservation Center (CCCP) over 30 years (1990-2020) was carried out. Of these, 49 (18.77%) marsh deer (31 females - 63.27% and 18 males - 36.73%) had clinical oral affections; the affected deer's mean age was 8.9 years. Logistic regression analysis was performed, and the variable age was significantly associated with the presence of dental affections. Thus, with a change in the age category, a deer had eight times the chance of manifesting oral affections; therefore, age can be considered a risk factor for the manifestation of oral affections in the species. Increased facial volume (65.3%), accumulation of food in the mouth (36.7%), tooth loss (22.4%), fistulas (22.4%), mucosal or palatal lesions (22.4%), tooth wear (20.4%), and tooth root exposure (18.3%) were the most frequently recorded lesions. The relatively high occurrence of oral affections in *Blastocerus dichotomus* reiterates the importance of oral health care when deer are kept in human care.

INDEX TERMS: Oral affections, odontogenic abscess, deer, marsh deer, *Blastocerus dichotomus*, tooth wear, periodontal disease.

RESUMO.- [**Afecções bucais em uma população *ex situ* de cervos-do-pantanal (*Blastoceru dichotomus*): um estudo retrospectivo (1990-2020).**] As doenças bucais são limitantes para as práticas de saúde, bem-estar e conservação, especialmente no caso de animais ameaçados de extinção. Neste estudo retrospectivo, realizou-se um levantamento sobre condições relacionadas à saúde bucal observadas nos registros clínicos de 261 cervídeos que compunham uma população *ex situ* do Centro de Conservação do Cervo-do-Pantanal durante um período de 30 anos (1990-2020). Destes, 49 (18,77%) cervos-do-pantanal (31 fêmeas (63,27%) e 18 machos (36,73%)) apresentavam afecções clínicas bucais; e a idade média dos cervídeos afetados foi de 8,9 anos. Realizou-se a análise de regressão logística e a variável idade mostrou associação significativa com a presença de afecções dentárias. Assim, com a mudança de categoria de idade, um

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cervídeo teve oito vezes mais chances de manifestar afecções bucais; portanto, a idade pode ser considerada como fator de risco para manifestação de afecções bucais na espécie. Aumento de volume facial (65,3%), acúmulo de alimentos na boca (36,7%), perda dentária (22,4%), fístulas (22,4%), lesões nas mucosas ou palatinas (22,4%), desgaste dentário (20,4%) e exposição de raiz (18,3%) foram as lesões mais registradas. A ocorrência relativamente alta de afecções bucais em *Blastocerus dichotomus* reitera a importância dos cuidados com a saúde bucal quando os cervídeos são mantidos sob cuidados humanos.

TERMOS DE INDEXAÇÃO: Afecções bucais, abscesso odontogênico, cervídeos, cervo-do-pantanal, *Blastoceru dichotomus*, desgaste dentário, doença periodontal.

INTRODUCTION

The marsh deer (*Blastocerus dichotomus*) is considered the largest representative of deer in Latin America and is one of the largest mammals in the Brazilian territory (Duarte et al. 2012). In Brazil, the species originally occupied an entire territory (Tomas et al. 1997); however, its population drastically reduced owing to several factors, such as the spread of infectious and parasitic diseases (Tomas et al. 1997, Szabó et al. 2007), predatory hunting activities (Duarte et al. 2012), drainage of floodplain areas for agro-industrial purposes, and most importantly by environmental modifications due to the construction of hydroelectric plants (Tiepolo et al. 2010).

This species is classified as vulnerable in the Red List of Endangered Species of the International Union for Conservation of Nature (IUCN) (Duarte et al. 2016). It is included in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES); the National Action Plan for the Conservation of Ungulates (PAN Ungulates) by the "Ministério do Meio Ambiente/Instituto Chico Mendes de Conservação da Biodiversidade" (Ministry of the Environment/Chico Mendes Institute for Biodiversity Conservation - ICMBio) (Brazil 2019); and the National Program for *ex situ* management of threatened species (Brazil 2018) coordinated by the "Associação de Zoológicos e Aquários do Brasil" (Association of Zoos and Aquariums of Brazil - AZAB). The "Centro de Conservação do Cervo do Pantanal" (Marsh Deer Conservation Center - CCCP) is currently responsible for one of the world's largest *ex situ* marsh deer populations. The CCCP is in one of the remnants of the Tietê River floodplain in the municipality of Promissão (SP, Brazil) and was created to reduce the impacts caused by the filling of the Três Irmãos Hydroelectric Power Plant reservoir (CCCP 2020). The CCCP plays an important role in the conservation of marsh deer. The species is considered a biological indicator because an increase or decrease in its population reflects the balance of the local ecosystem.

In addition to the multiple and complex factors that threaten the conservation of marsh deer in nature (Tiepolo et al. 2010, Duarte et al. 2012), oral affections are described as an important limiting condition for survival of animals. Several periodontal diseases have been described in different species of deer in different countries (Doerr & Dieterich 1979, Williams 1980, Azorit et al. 2012). Periodontitis, mandibular osteomyelitis, tooth wear, odontogenic abscesses, dental fractures, enamel hypoplasia, pigmentation, and early tooth exfoliation represent some of the main oral pathologies reported in free-living deer (Williams 1980, Stimmelmayr et al. 2006, Konjevic et al. 2011). Within reach of conventional means of scientific records, reports on oral affections in marsh deer kept in captivity are rare. Given the need to promote advances in the conservation of the species and in the knowledge of the main oral lesions that affect marsh deer, the present study aimed to carry out a retrospective evaluation of individual clinical records of deer at the CCCP from its implementation in the 1990s to 2020.

MATERIALS AND METHODS

Marsh Deer Conservation Center (CCCP). Marsh Deer Conservation Center (CCCP) is located in Promissão/SP (-21.313622, -49.796625) and was founded in 1990 after the discovery of the marsh deer population in the lower course of the Tietê River, where the Três Irmãos Hydroelectric Power Plant was being built. Currently, CCCP is responsible for maintaining approximately 60% of marsh deer in Brazil, representing one of the largest populations of this species in captivity worldwide (CCCP 2020).

The management protocol used at CCCP has been adapted over the years. Information regarding the control of births, deaths, reproduction, transfer of specimens between institutions, and reintroduction into natural areas, among other data, is recorded in individual files. The marsh deer are kept in paddocks ranging from 500m^2 to 2000m^2. Occasionally, they can remain in pens (during pregnancy/parturition/lactating or when undergoing any treatment) and are monitored daily by specialists.

Animal population. All records of marsh deer (*Blastocerus dichotomus*) from the CCCP from 1990 to 2020 were reviewed, totaling 358 animals. However, 97 files represented deer captured during the filling of the Três Irmãos Hydroelectric Power Plant reservoir and were reintroduced into nature soon after capture. Therefore, these marsh deer were excluded from the study, and in the end, 261 forms were considered. Currently, the CCCP population consists of 45 deer born in captivity and descendants of rescued animals.

Animal diet. The diet of CCCP deer is based on forage cultivated, such as hibiscus (*Hibiscus*) and blackberry (*Morus alba*); or native, such as marsh grass (*Paspalum conspersum*) suitable for the selective habits of deer, and pumpkin (*Abobra tenuifolia*); concentrate (horse feed: 12-15% crude protein, 5-8% ether extract, 10-12% fibrous matter); and water *ad libitum*. Currently, food is offered in variable amounts and calculated according to individual intake (1.2kg to 2.4kg for adult animals). The cultivated forage is fertilized two to three times a year, and the native pastures are mowed monthly as a measure to prevent and control ticks. During 2013 and 2014, the native pastures were treated with urea to optimize tick control.

Clinical records. The 261 clinical files were thoroughly evaluated, and the clinical data recorded included deer identification, sex, age, date of birth, date of death, cause of death, oral conditions, and other information related to the health status of the marsh deer. Information and keywords related to other oral affections were searched in the clinical records to determine the oral condition of the deer. The information includes reports of facial swelling, facial abscess, tooth root exposure, tooth absence, fractured teeth, gingival bleeding, periodontitis, accumulation of food/grass in the mouth, lesions on the tongue, palate, and cheek or mucous membranes and tooth wear. Then, these data were grouped according to their similarity. Owing to the lack of exact knowledge of the registration of age of some deer, in months, as some were captured adults, they were classified into the following categories: young (1-12 months), adult

(1-10 years), and senior (above10 years). Only data from marsh deer whose records contained the dates of birth and death (134 animals) were used to calculate the life expectancy of the animals. Most of the information in the forms was annotated by five veterinarians who have been part of the CCCP technical staff since its foundation.

Statistical analysis. Logistic regression analysis was performed to investigate the association between independent variables (age and sex) and the presence of dental affections using R software. Odds ratios were also calculated with lower and upper 95% confidence limits (confidence interval). Differences were considered statistically significant at a probability level of $p<0.05$.

RESULTS

Of the 261 marsh deer included in the present study, 141 (54.02%) were adults, 31 (11.88%) were seniors, and 89 (34.1%) were young. Of these, 137 (52.49%) were female, and 124 (47.51%) were male. In CCCP, the average life expectancy of adult deer was six years, and in the case of infant mortality, the average age group affected was represented by deer aged three months. The main oral affections observed in the marsh deer are described in Table 1. Of the 49 deer with oral affections, 31 were female (63.27%), and 18 were male (36.73%). Twenty-seven (55.1%) were categorized as adults, 20 (40.82%) were seniors, and two (4.08%) were young. The mean age of deer with oral affections was 8.9 years. The oral affections reported in the two young deer consisted only in the presence of increased facial volume/abscess and food accumulation. The most frequent oral affections reported in the 27 adult deer were increased facial volume/abscess, food accumulation, tooth loss and tooth root exposition (Table 1). The most frequent oral affections in the 20 senior deer were food accumulation, increased facial volume/abscess, fistula and tooth wear (Table 1). Some primary lesions are shown in Figures 1 to 5.

The degree of risk between the dependent variable (oral affection) and the suspected factors (age and sex) were analyzed using logistic regression, indicating that the age of the deer was significantly associated with dental disorders. Thus, at each age category change, a deer has eight times the chance of developing a dental lesion (95% confidence interval: 4.28 to 16.28; $p<0.001$). The sex variable was not significantly associated with records of oral affections (95% confidence interval: 0.21 to 0.63; $p=0.213$).

Among the documented causes of mortality, there were records of septic or toxic shock (9.6%), heart failure (4.2%), and respiratory failure (4.6%). Other causes of death included euthanasia (2.7%), pneumonia (1.53%), enzootic hemorrhagic disease (1.53%), poisoning (0.77%), bluetongue (0.77%) and tick infestation (0.38%). However, in most files (59.8%), the cause of death has not been determined.

DISCUSSION

The occurrence of oral affections was relatively frequent in the population of deer kept in captivity. Studies on the occurrence of oral diseases in marsh deer are relatively scarce. However, periodontal pathological processes are recognized as important factors influencing the survival and perpetuation of deer.

Tooth wear and periodontal diseases are the major oral diseases identified in several species of domestic ruminants (Silva et al. 2016, Borsanelli et al. 2017a, Campello et al. 2019). They are characterized by a multifactorial etiology, with the capacity to destroy teeth and compromise their support structures (Dyer et al. 2000, Holt & Ebersole 2005).

In deer, dental integrity and oral health are associated with digestive efficiency and productivity, reflecting these animals' body conditions and life expectancy (Stimmelmayr et al. 2006). Tooth wear, a disease that occasionally co-occurs with periodontal diseases in small ruminants (Campello et al. 2019), is characterized by an irreversible loss of the dental crown primarily without bacterial involvement. The severity compromises dental integrity and causes painful sensitivity owing to the involvement of innervated structures of the tooth (Levitch et al. 1994, Imfeld 1996).

On the other hand, the set of periodontal diseases involves a group of multifactorial infectious and inflammatory diseases with different types of clinical manifestations, whose etiology is associated with dysbiosis of the oral biofilm (Hajishengallis 2015, Kinane et al. 2017). Clinical signs initially include an inflammatory gingival process (gingivitis), characterized by

Table 1. Oral affections recorded in clinical files of 49 marsh deer (Blastocerus dichotomus) bred in captivity from 1990 to 2020

Oral affection	Young deer (%)	Adult deer (%)	Senior deer (%)	Total (%)
Increased facial volume/abscess	2* (6.2)	19 (59.4)	11 (34.4)	32 (65.3)
Food accumulation	1 (5.5)	5 (27.8)	12 (66.7)	18 (36.7)
Tooth loss	0 (0.0)	5 (45.5)	6 (54.5)	11 (22.4)
Fistula	0 (0.0)	2 (18)	9 (81.8)	11 (22.4)
Mucosal or palate lesions	1 (9.1)	3 (27.3)	7 (63.6)	11 (22.4)
Tooth wear	0 (0.0)	2 (20)	8 (80)	10 (20.4)
Tooth root exposition	0 (0.0)	5 (55.6)	4 (44.4)	9 (18.3)
Occlusion change	0 (0.0)	1 (20)	4 (80)	5 (10.2)
Tooth fracture	0 (0.0)	2 (40)	3 (60)	5 (10.2)
Gingivitis	0 (0.0)	4 (80)	1 (20)	5 (10.2)
Periodontitis	0 (0.0)	1(25)	3 (75)	4 (8.2)
Dental mobility	0 (0.0)	2 (50)	2 (50)	4 (8.2)
Osteomyelitis	0 (0.0)	1 (50)	1 (50)	2 (4.08)
Bone resorption	0 (0.0)	0 (0.0)	2 (100)	2 (4.08)
Dentin exposition	0 (0.0)	0 (0.0)	1 (100)	1 (2)

* Number.

edema, hyperemia, spontaneous bleeding, or probing, which may induce necrosis (Logan et al. 1995, Lyon 2005, Ramos et al. 2019), or progression of periodontal involvement (Hajishengallis 2015, Shaw et al. 2016). In sheep, periodontitis and odontogenic abscesses are associated with the use of newly cultivated forage (Silva et al. 2016).

The etiology of tooth wear in deer is not completely clear; however, the disease differs among free-living (Stimmelmayr et al. 2006) and captive wild species (Cuozzo et al. 2010). In the present study, tooth wear was reported in 10 (20.4%) marsh deer, and its occurrence was more common in older deer. In deer from different regions of North America, age was also strongly associated with compromised dental integrity (Stimmelmayr et al. 2006, Mackenzie et al. 2011).

In Canada, mandibular deformities with abscessing dental lesions have been described in reindeer (*Rangifer tarandus*)

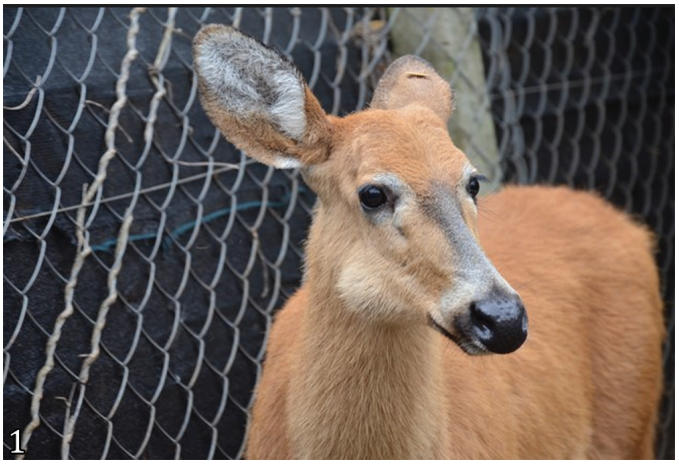

Fig.1. Increased volume on the right side of the face of an adult *Blastocerus dichotomus* from Marsh Deer Conservation Center, São Paulo, Brazil.

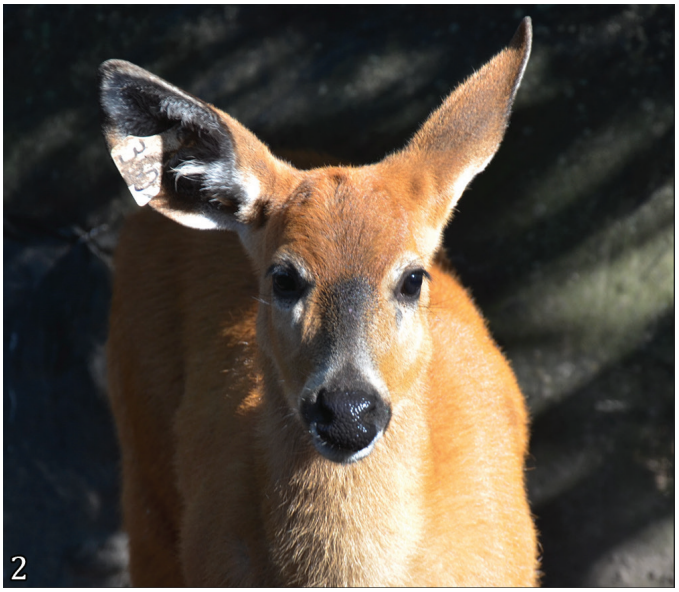

Fig.2. Increased volume on the left side of the face of a five-month-old *Blastocerus dichotomus* from Marsh Deer Conservation Center, São Paulo, Brazil.

Fig.3. Gingival recession with furcation involvement in mandibular molar teeth, food accumulation, and lesion due to adjacent infection observed in the *post mortem* examination of a senior *Blastocerus dichotomus* from Marsh Deer Conservation Center, São Paulo, Brazil.

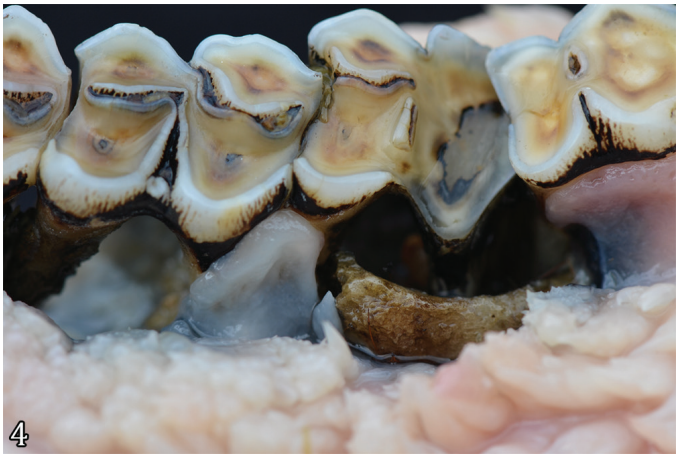

Fig.4. Excessive tooth wear with dentin exposition on permanent masticatory teeth, tooth root exposition and alveolar bone exposition observed in the *post mortem* examination of a senior *Blastocerus dichotomus*.

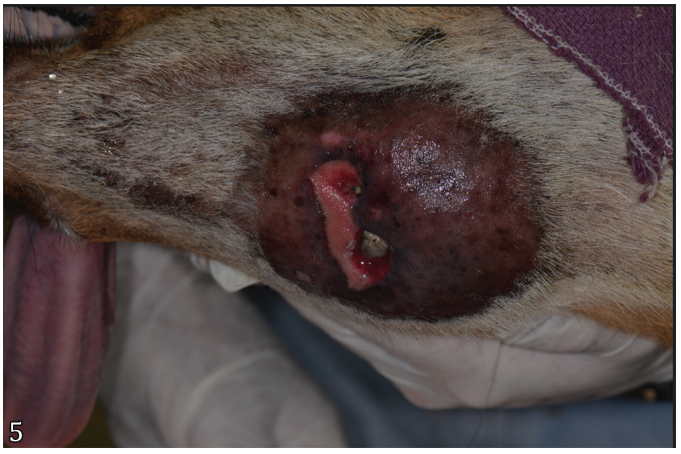

Fig.5. Submandibular cutaneous fistula, resulting from multiple abscesses of odontogenic infection in an adult marsh deer.

(Miller et al. 1975). In the present study, the increase in facial volume with evolution to abscess formation was the main observation in CCCP squad files, affecting 32 (65.3%) of the total number of marsh deer that presented some oral affection. Detecting oral lesions in captive deer occurs more frequently when they present evident manifestations. A detailed examination of the oral cavity demands risks owing to the need for chemical containment and a trained professional. However, the absence of clinical signs, as evident from facial bulging, does not indicate the absence of disease, which can go unnoticed if not properly investigated.

Periodontitis, a particular manifestation of the periodontal disease group, has previously been described as an important cause of mortality in wild animals, both wild and in captivity (Gual-Sill & Suárez-de-Gual 1996). In the present study, periodontitis was directly identified in only four marsh deer (8.2%) out of the total investigated. However, a high frequency of tooth loss (22.4%), accumulation of food in the oral cavity (36.7%), oronasal fistulas (22.4%), and tooth root exposure (18.3%) suggest a high occurrence of periodontitis in the herd animals. The incidence of periodontitis in CCCP marsh deer described in this survey may be underestimated, probably owing to the difficulty in carrying out a thorough inspection of the oral cavity and the lack of knowledge of the clinical signs of the disease. In addition, clinical care aimed at oral health and the performance of complementary examinations that help diagnose periodontal diseases are still not routine among wild ruminants.

In the present study, osteomyelitis was reported in only two marsh deer (4.08%). Chronic osteomyelitis has already been identified in large proportions in other free-living deer species (Konjevic et al. 2011). At the time, the authors associated the high prevalence of the disease and tooth wear with the ingestion of abrasive substances. However, in a recent study, dental wear was described in goats kept in confinement in pens without contact with soil (Campello et al. 2019). This study was contrary to the hypothesis suggested by some authors that the etiology of this disease would be related to the ingestion of soil and sand components in food (Healy & Ludwig 1965, Glaze et al. 1982). The CCCP deer is soft food-fed, which does not justify the high prevalence of tooth wear among the marsh deer.

Several studies have reported a well-established association between periodontal diseases and systemic disorders in cattle (Ramos et al. 2019) and sheep (Anderson & Bulgin 1984, Baker & Britt 1990). It is known that oral bacteria and bacterial products from untreated periodontal disease and peri-apical infection can reach circulation and cause distant diseases such as subacute bacterial endocarditis (Kumar 2017). Cardiorespiratory and osteoarticular disorders, diabetes, kidney disease, and premature births are closely associated with human periodontitis (Kornman 2008, Kuo et al. 2008). Little is known about the possible associations between periodontal diseases and systemic changes in deer. However, some of the observations recorded in CCCP deer diagnosed with dental affections are starvation, apathy, progressive emaciation, and predisposition to infestations by ectoparasites. In autopsy forms, the occurrence of sinusitis with evolution to sepsis in individuals with oral-sinus communication resulting from orofacial lesions was highlighted. Unfortunately, it was impossible to confirm this hypothesis in the present study.

The results of this retrospective study in marsh deer indicate that age plays an important role in the occurrence of periodontal diseases in the species since the change in age category predisposes the deer to lesions up to eight times the normal. As reported in cattle recently, this is likely due to the animal's exposure to risk factors for a longer period of life (Borsanelli et al. 2021). However, adult deer in the full reproductive stage is also severely affected by oral affections, an event observed in the results of this study.

In previous studies, the genus was a factor associated with mandibular lesions in different species of deer in North America and Europe (Doerr & Dieterich 1979, Azorit et al. 2012). However, in the present study, sex was not a significant predisposing factor for the onset of oral affections in marsh deer (p=0.213).

The hypothesis that dietary factors are an important component that would act on dental conditions and systemic health has been reported in studies involving different animal species (Dutra et al. 1993, Gawor et al. 2006, Borsanelli et al. 2017b, Campello et al. 2019), including deer (Pérez-Barbería & Gordon 1998, Stimmelmayr et al. 2006, Mackenzie et al. 2011). In domestic ruminants, newly reformed pastures and new opening areas for livestock are recognized as risk factors for the prevalence of periodontal diseases (Döbereiner et al. 1975, Dutra et al. 1993, Ramos et al. 2019). Ramos et al. (2019) described the occurrence of periodontal diseases (gingivitis and necrotizing gingivitis) in cattle kept under grazing in areas of newly reformed pastures.

In deer, the feeding behavior in nature differs from that of animals in captivity. The diet at CCCP includes the supply of cultivated forages such as hibiscus (*Hibiscus*) and blackberry (*Morus alba*), or native (*Paspalum conspersum*), and fed with high protein content. Generally, feed is purchased from commerce as products formulated for other animal species (horses). In this approach, it is plausible to consider the possibility that the diet's composition has consequences on dysbiosis in the oral ecosystem and, by extension, on the occurrence of periodontal diseases. To the limits of our knowledge, we found no evidence or association between flooding and the occurrence of diseases associated with oral diseases in deer. However, in flooded ecosystems, changes in chemical, physical and biological processes occur in the soil (Ponnamperuma 1984). In addition, plants grown in flooded soils exhibit changes in their metabolic and physiological processes (Crawford 1992, Baruch 1994).

Mackenzie et al. (2011) suggested that Canadian moose exposed to deficient diets may have impaired the amelogenesis of permanent teeth, predisposing them to dental fractures during natural wear. In the retrospective study of clinical records, the occurrence of dental fractures in five marsh deer (10.2%) with oral affections was reported. Factors associated with the occurrence of this finding may be associated with tooth wear, compromised tooth formation, trauma, or other unknown causes.

The results of the present study showed a high occurrence of oral diseases in *Blastocerus dichotomus* kept in captivity and revealed the need to consider diseases, whether infectious or not, that may affect stomatognathic structures and systemic health, as they represent important causes of mortality in these deer. Logistic regression analysis showed that age probably represents a risk factor in the development of oral diseases in marsh deer; however, other important factors, such as diet, should be investigated as a possible agents in the etiology and etiopathogenesis of oral affections in the species.

CONCLUSIONS

Oral affections are a recurrent problem in marsh deer (*Blastocerus dichotomus*) kept in captivity, especially among older deer.

The practice of clinical and oral examinations and information on dental and periodontal affections were not documented in all marsh deer that were part of the CCCP, which may have contributed to underreporting of the relevant information.

Logistic regression analysis showed that age was significantly associated with dental affections and that older deer were eight times more likely to manifest oral diseases.

The results of the present study allow us to infer that deer kept in captivity are susceptible to triggering dentoalveolar and bone diseases of the mandible and maxilla and implementation of diagnostic methods, as well as standardization of the clinical record of the oral cavity in live and necropsied deer can contribute to early detection or intervention of such diseases.

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