

# **Prevalence and risk factors for dental disease in captive Central bearded dragons (*Pogona vitticeps*) in the UK**

## Abstract

Background Despite periodontal disease being recognized as a common condition in captive bearded dragons, there is a lack of data regarding the prevalence. A soft diet has previously been cited as the main risk factor linked to the disease, although there has been little research conducted into the etiology since the disease was first described. The aims of this study were to investigate the prevalence of dental abnormalities and disease in captive Central bearded dragons in the UK, and to begin to investigate the risk factors affecting the presence and increased severity of disease in this species.

Methods Data collection was conducted from 20 veterinary practices across the UK from March to October 2018. All bearded dragons presented to participating practices during this time period were assessed for the presence of dental disease, and for each animal a standardized data collection form was completed to provide information concerning the animal's signalment, diet and health status. Severity of any dental disease was also graded in a subset of bearded dragons (n=147) by two of the authors using a grading system from 0-5.

Results The prevalence of dental abnormalities and disease was 50% in the sampled population of 304 bearded dragons. Increasing age, an abnormal body condition score, presence of concurrent disease, as well as presence of fruit in the diet were all significant risk factors for the presence of dental abnormalities and disease.

Conclusions and clinical relevance Contrary to previous reports, neither presence of different live foods in the diet, nor presence of vegetable matter in the diet had any significant associations with dental abnormalities and disease, challenging some of the assumptions made to date about the etiology of dental disease in Central bearded dragons. This study instead found that fruit could be the main dietary risk factor for dental disease and should be excluded from the captive diet of these animals. This study has found a strong association between increasing age and presence of dental abnormalities and disease, and stresses the importance of a thorough oral exam, especially in older individuals.

## Keywords

Bearded dragons; lizard; acrodont dentition; periodontal disease; dental disease; dentition

## Abbreviations

Body Condition Score: BCS

Central bearded dragon: bearded dragon

## Introduction

Central bearded dragons (*Pogona vitticeps*) are diurnal agamid lizards [1] and are one of the most popular pet reptiles kept in captivity [2][3]. Native to central Australia, they inhabit rocky desert regions, arid and semi-arid woodland [4], with an omnivorous diet in the wild which has been reported to include a variety of arthropods, small rodents, flowers, and plant matter [2][4]. In captivity they are typically fed mass-produced feeder insects such as crickets and locusts, and a variety of leafy greens, vegetables and fruits [5].

Similar to other agamids, chameleons and the tuatara, bearded dragons possess acrodont dentition, which is unique to these groups [6][7][8]. Acrodont dentition is comprised of laterally compressed triangular teeth directly ankylosed to the mandibles and maxillae [9], forming a single functional unit of teeth [10]. During development, the pulp of the teeth is replaced with a mineralized matrix that fuses the teeth to the bone [10], so that unlike the pleurodont dentition of other lizards, the teeth are permanent and are not replaced throughout life [11]. As the animal grows, further teeth are added caudally [11]. The gingiva of acrodont dentition attaches lower on the buccal and lingual aspects of the mandibles and maxillae, not at the base of the teeth as in other reptiles and mammals [7]. This lower attachment exposes strips of mandibular and maxillary bone, overlaid only with a thin layer of stratified squamous epithelium [12][13], which is predisposed to bacterial colonization [14]. Periodontal disease is widely recognized as a common condition in lizards with acrodont dentition [15][16].

Periodontal disease in captive bearded dragons was first described in 1994 in animals displaying clinical signs comparable to periodontal disease in domestic companion animals [17]. Periodontal disease is defined as a progressive and irreversible inflammatory disease of

the periodontal ligament and alveolar bone that results in attachment loss [18][19]. Periodontal disease in animals possessing acrodont dentition is comparable to that observed in the earlier stages in mammals [17], although the pathogenesis is different, and end-stage disease is characterized by osteomyelitis and bone necrosis rather than tooth loss [8][20]. The term 'periodontal disease' is often used to describe all stages of dental disease in reptiles with acrodont dentition [7], despite a lack of a periodontal ligament in these animals [10]. The authors therefore suggest the term 'dental disease' instead of 'periodontal disease' for animals with acrodont dentition.

Initial stages of acrodont dental disease are characterized by staining of the teeth and the exposed mandibular and maxillary bones, gingival erythema and accumulation of calculus [17][21]. This then progresses to further calculus accumulation, gingival recession and gingival pocket formation, which can accrue calculus, food and purulent material [4]. The final stage of acrodont dental disease is osteomyelitis, leading to necrosis of the mandibular and maxillary bones and pathological fractures, occasionally leading to systemic disease and septicemia [4][14]. The disease is often subclinical and only detected upon oral examination [15].

Periodontal disease is extremely prevalent in both domestic companion animals and humans [22][23], and has been linked with many etiological factors, including diet, advanced age and concurrent disease [22][24]. Although many factors have been proposed, exact causes of dental disease in bearded dragons are unknown [7]. The disease has been suggested to be a syndrome of captivity [25], and factors such as trauma to the mouth [17], a soft diet rich in fruit [4][7][15][26], increased age [7], concurrent disease and poor husbandry [12][27] have all been suggested to be linked to dental disease.

Wild bearded dragons have not been reported to suffer from dental disease [17] and many have suggested that feeding a more abrasive diet could help prevent dental disease [12] as this is thought to be more representative of a natural diet [20][26]. There is little published literature on the natural diet of wild bearded dragons; however, they are reported to consume mostly hard-bodied termites, ants and locusts as well as other arthropods and plant matter [2]. Harder food items are also thought to encourage mastication to physically debride plaque from the teeth and prevent bacterial colonization of the exposed bone [7].

Both fungal [28] and bacterial pathogens [29] have been implicated in dental disease of acrodont dentition, but the most common isolates are gram-positive and -negative aerobes,

anaerobes and spirochetes [13][17]. This is comparable to mammalian periodontal disease [17], in which a predominant aerobic flora is replaced with anaerobic bacteria and spirochetes [13][24]. Treatment of dental disease includes analgesia and antimicrobials after culture and sensitivity [29]. Radiographs of the skull should be taken to identify any involvement of the mandibular or maxillary bones, and dental scaling and curetting of infected bone can be undertaken under general anesthesia [29].

Despite dental disease having been recognized in this species for over twenty years [17], there is no known prevalence of the disease in bearded dragons in the UK, and only one study has attempted to measure prevalence and severity of disease anywhere in the world [20]. The aims of this study were to investigate the prevalence of dental abnormalities and disease in captive Central bearded dragons in the UK, and to begin to investigate the risk factors affecting the prevalence of dental abnormalities and disease.

### Materials and Methods

The prevalence of dental disease in bearded dragons in the UK would ideally be obtained by assessment of a randomized sample of the entire captive bearded dragon population. Unfortunately, there are no robust data available on this population from which an unbiased sample could be taken, so in order to try and obtain a measure of the prevalence, veterinarians throughout the UK were invited to participate in the study. Veterinary practices listed on the RCVS website [30] as treating exotic pets, and veterinarians listed on the British Veterinary Zoological Society website [31] as having an interest in exotic pets and reptiles were all contacted by email. A total of 35 veterinarians at different practices responded, and 20 agreed to undertake data collection. Standardized tick-box data collection forms were sent out to participants for them to record data from all bearded dragons presented to them during the study period of March to October 2018. Each participating practice was also provided with information sheets to aid in discerning normal from diseased dentition. The information sheets contained photographs of normal and diseased dentition at different grades, as well as providing information on how to conduct data collection.

Participating veterinarians were asked to record presence or absence of dental disease for each animal, in addition to any clinical signs of the disease based on history and physical examination. These were specified as bleeding from the mouth, loss of appetite, loss of teeth or surrounding bone, mandibular or maxillary swellings, pain upon chewing, ptyalism and weight loss. Details on the animal's age, sex and body condition score (BCS) were also

recorded. As there is no standardized BCS system for bearded dragons, animals were visually categorized by participating veterinarians as underweight, healthy or overweight. In cases where exact age was unknown, veterinarians were asked to categorize animals into the appropriate age group of juvenile, adult or elderly, based on estimated age. Each bearded dragon's current diet was recorded in as much detail as possible and any concurrent disease affecting each animal was also recorded. Incomplete data collection forms were included in the analysis where possible, which accounts for discrepancies in numbers across risk factors.

Prior experience with diagnosing dental disease was not assumed for participating vets, and determining truly diseased dentition from dental abnormalities and normal acrodont dentition can be challenging. Therefore, animals recorded as having dental disease by participating vets were classified as having dental abnormalities and disease to allow for any over-diagnosis in animals with dental abnormalities.

For analysis, bearded dragons were categorized into five age groups: 0 up to 1 year old, 1 year to up to 3 years old, 3 years up to 5 years old, 5 years up to 8 years old and 8 years and older. Animals of unknown age that were categorized as adults were excluded from analysis of age, as there was potential for them to be included in several categories. Those categorized as juveniles were included in the 0 to 1 year old category.

Veterinarians at participating practices were not asked to grade any dental disease encountered during their data collection. Instead, a subset of bearded dragons (n=147) were graded by two of the authors (RM & SP) according to a 0-5 grading system [20] (**Fig. 1**). At the start of the data collection period, both assessors jointly recorded and graded 40 individuals to attain an estimate of agreement on scoring the different grades of the disease, ensuring subjectivity was kept to a minimum as both assessors were in total agreement regarding grading scale. For the remainder of the data collection period all subsequent grading of bearded dragons was conducted individually: one author recording and grading all bearded dragons presented to their practice during the data collection period, and the other author personally visiting five practices across the UK to record and grade all bearded dragons presented during their visit.

Data was analyzed using commercially available software (SPSS® Statistics, Version 26) and a P value of <0.05 was taken to indicate statistical significance. A Chi-squared test and binary logistic regression was used to evaluate the potential risk factors for occurrence of dental disease. Risk factors with P<0.1 in the univariable binary logistic regression analysis were included in a multivariable model and manual backward elimination method was used to

derive the final model. Odds ratio and its 95% confidence intervals (CI) were reported for the logistic regression analysis.

## Results

Data were obtained from a total of 304 bearded dragons presented to participating veterinary clinics during the data collection period, consisting of 129 females (42.4%), 170 males (55.9%), and five of unknown sex (0.17%). The bearded dragons ranged in age from 3 months to a reported 16 years. In total, 153 (50.3%; 95% confidence interval 44.74-55.91) bearded dragons were observed to have dental abnormalities and disease (**Table 1**).

A statistically significant association was found between increasing age and presence of dental abnormalities and disease ( $p < 0.024$ ) and 86.8% of bearded dragons 8 years and older had dental abnormalities and disease (**Fig. 2**). There was a significant association between having an abnormal BCS and presence of dental abnormalities and disease ( $p < 0.022$ ), with 71.4% of underweight and 62.9% of overweight bearded dragons having dental abnormalities and disease, compared to 41.3% of bearded dragons with a normal BCS. Concurrent disease was also significantly associated with presence of dental abnormalities and disease, with the odds of having dental abnormalities and disease being higher at 1.68 (1.07-2.66) for animals with concurrent disease recorded.

Looking at dietary factors, there was a significant association between presence of fruit in the diet and presence of dental abnormalities and disease, with the odds of having dental abnormalities and disease being higher at 2.68 (1.61-4.46) for animals with fruit present in the diet. There were no significant associations between the presence of dental abnormalities and disease and the amount of vegetable matter in the diet, individual dietary items or sex of the bearded dragons.

Carrying out a multivariable model with all the variables in Table 1 where  $p < 0.1$  (sex, age group, BCS, concurrent disease, presence of fruit in diet, crickets, morio worms) resulted in age, low BCS and presence of fruit in the diet remaining in the final model as independent predictors of abnormalities and disease (**Table 2**).

A subset of 147 bearded dragons were graded for dental disease, of which 81 (55.10%; 95% confidence interval 47.03-62.91) had any stage of the disease (grade 1 and above). Of these, 33 had advanced dental disease (grades 3 and above) (**Table 3**). Only 11.8 % of 0 to 3 year

old bearded dragons had advanced disease, compared to 64.3% of bearded dragons aged 8 years and older. Looking at body condition, 60.9% of bearded dragons with advanced dental disease were underweight, compared to 39.5% having a normal BCS, and only 13.3% were overweight.

## Discussion

Dental disease is recognized as a common condition affecting reptiles with acrodont dentition [14]; however, there has been little research conducted in this area since the disease was first described [17]. This study has found a prevalence of 50.3% of dental abnormalities and disease among bearded dragons in the UK. Previous studies have proposed a soft diet rich in fruit as one of the main risk factors in the etiology of the disease [15,17], along with increased age [7], concurrent disease [20] and poor husbandry [33]. This study supports that there are significant associations between increasing age, an abnormal body condition score and presence of fruit in the diet with the presence of dental abnormalities and disease in bearded dragons.

Prevalence of dental abnormalities and disease was found to be 50.3% across all bearded dragons in the study, although the smaller subset of 147 graded bearded dragons had a slightly higher prevalence of 55.1%. This difference in prevalence could be due to the difference in sample size, and due to multiple contributors to the larger data set. The only other study to date to attempt to gain an estimate of prevalence of dental disease in bearded dragons, sampled 62 Central bearded dragons presented to a veterinary practice in Australia and reported a prevalence of 35% [20]. The small sample size of the previous study may explain the lower prevalence found, and it is not mentioned whether any wild-caught individuals were included, which may also have influenced the results.

An inappropriate diet has been linked with periodontal disease in both humans and domestic companion animals [19][34][35] and the acidity of fruit is recognized as being linked with dental erosion and disease in humans [36]. McCracken and Birch [17] suggested that inappropriate diet was the main factor in the development of dental disease in agamids, and attributed a decrease in incidence of dental disease in their collection to the substitution of a soft, fruit-rich diet with a firmer diet containing less fruit. The findings of this study suggest that the presence of fruit in the original diet could be more of a contributing factor to the presence of dental disease in these animals than the softness of the diet. This contrasts sharply with the vegetable component of the diet, with no significant association between presence or

amount of vegetable matter in the diet and dental abnormalities and disease. This lack of significant association suggests that the high sugar content and acidity of fruit may play an important role in the etiology of dental disease. Fruits are recommended as part of the bearded dragon's diet in much of the literature [4][5]. There has however, been no recorded incidence of fruit as a component of wild bearded dragons' diet [2], and more research needs to be conducted in wild Central bearded dragons to determine if fruit is truly a natural part of their diet. This study suggests that fruit could be the main aspect of the diet linked with dental disease in Central bearded dragons.

Bearded dragons with an abnormal BCS, whether underweight or overweight, were more likely to have dental abnormalities and disease. Owners often overestimate bearded dragon's energy requirements, as reptiles have a lower metabolic rate than that of mammals [37]. This results in obesity, which has been linked to periodontal disease in both domestic companion animals and humans [22][38][39]. A lower BCS has also been correlated with increased levels of periodontal disease in dogs [18], and this study suggests that this may also be a risk factor for bearded dragons. Other factors may be confounding this association, as both underweight and overweight animals are likely to have underlying disease [40]. Increased age and concurrent disease can both contribute to weight loss and a reduced BCS [32] and both were found to be significant risk factors for dental abnormalities and disease in bearded dragons in this study.

Clinical signs were only present in 24.8% of cases, which correlates with reports of dental disease often being an insidious disease [15][41]. Although many animals with dental disease displayed no clinical signs, in the subset of animals which were graded, all bearded dragons that presented with clinical signs had advanced disease (grade 3 and above), suggesting that clinical signs only appear as the disease advances. Bearded dragons are a prey species in the wild [42] and it would follow that they would attempt to hide signs of disease as seen in other prey species. This highlights the importance of checking the mouth and teeth at every clinical examination, so that dental disease can be detected and treated at an early stage.

Previous research reports an absence of dental disease in wild-caught specimens, although only eight adult animals were assessed, and the ages were not recorded [17]. More research needs to be undertaken to determine if dental disease in Central bearded dragons is truly only a product of captivity, or if their wild counterparts also suffer from the disease. This information can help inform our understanding of the etiology and prevention of the disease, as attempts to closely mimic a naturalistic diet as a form of prevention of the disease will be



ineffective if wild bearded dragons are also found to be susceptible to dental disease. There is also scope for further research into the effects of a harder, naturalistic diet on the presence of dental disease, as other risk factors such as increasing age and concurrent disease may also influence any dental disease found in wild bearded dragons.

While there was a good representation of healthy animals sampled, with 43% being reported as healthy with no concurrent disease, many bearded dragons were presented at participating practices due to owners' concerns about their health. This overrepresentation of unhealthy animals may have affected the results, as both the literature [20][23] and this study suggests that there is an association with the presence of concurrent disease and presence of dental disease.

As part of this study, two assessors graded bearded dragons on their level of dental disease. The scale is subjective, so any potential bias was kept to a minimum by only two assessors grading dental disease.

There were some other limitations to the current study. The practices contributing data may not be representative of all veterinary practices in the UK. The large number of veterinary practices and veterinarians involved in this study may also have led to some variation in data recording and assessment of dental disease. Information sheets were provided to aid in discerning normal dentition from dental disease, although discerning normal healthy dentition from diseased can be challenging, and there is the possibility of over-diagnosis by participating veterinarians. To mitigate this, animals that were recorded by participating veterinarians as having dental disease were classified as having dental abnormalities and disease to allow for any animals with dental abnormalities being recorded as having dental disease. Several bearded dragons had missing or incomplete data concerning diet, and data that was recorded related only to current diet due to the nature of this study. Historic problems which could have predisposed an individual to dental disease would therefore have been missed. There is scope for further research in in this area to attain a true estimate of each grade of dental disease in the UK Central bearded dragon population.

## Conclusion

This study represents the first large-scale investigation of the risk factors and prevalence of dental disease in captive Central bearded dragons. Of the 304 bearded dragons sampled, dental abnormalities and disease were present in just over 50% of individuals. Although

dental disease can be treated [29], importance must be placed upon prevention of the disease. While ageing effects are unavoidable, this study suggests that addressing causes of weight gain or loss and cutting fruit from the diet may help to reduce the risks of developing dental disease. This study has tested the long-held assumptions of the etiology of dental disease in bearded dragons, and while no evidence has been found to link other aspects of the diet with dental disease, this study suggests that increased age, concurrent disease, fruit in the diet, and abnormal BCS have significant associations with dental disease.

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