

Measurement of hip laxity by distraction radiography in young crab-eating foxes (*Cerdocyon thous*)

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[*Mensuração da frouxidão da articulação coxofemoral por radiografia de distração em cachorros-do-mato (Cerdocyon thous) jovens*]

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ABSTRACT

This study aimed to measure hip laxity using distraction–stress radiography in young crab-eating foxes. Eight free-ranging crab-eating foxes (*Cerdocyon thous*), six males and two females, with a mean age of 4 months and weighing from 3.5 to 4.0 kg were used. Under deep sedation and analgesia, the animals were submitted to a radiographic ventrodorsal hip extended standard view and extended distraction radiographic view. Distraction radiography was performed three times for each animal to determine repeatability. The standard deviation (SD) recorded in the distraction index (DI) between the three examinations of each animal ranged from 0.02 to 0.05, with a mean of 0.03 ± 0.01 . The DI of the worst joint ranged from 0.08 to 0.37, with a mean of 0.21 ± 0.09 . The mean DI on the right and left sides was similar. In conclusion, the crab-eating fox preserves normal hip development without a predisposition to hip dysplasia. However, monitoring of the species' hips is recommended, given the small sample size of this study and the occurrence of an animal with a DI > 0.30.

Keywords: distraction index, dysplasia, hip joint, radiography, wild animal

RESUMO

Este estudo teve como objetivo mensurar a frouxidão da articulação coxofemoral por meio de radiografia com distração-estresse em cachorros-do-mato jovens. Foram utilizados oito cachorros-do-mato (*Cerdocyon thous*) de vida livre, seis machos e duas fêmeas, com idade média de quatro meses e peso entre 3,5 e 4,0kg. Sob sedação profunda e analgesia, os animais foram submetidos à radiografia padrão ventrodorsal das articulações coxofemorais e à projeção radiográfica sob distração. A radiografia por distração foi realizada três vezes para cada animal para determinar a repetibilidade. O desvio padrão (DP) registrado no índice de distração (ID) entre os três exames de cada animal variou de 0,02 a 0,05, com média de $0,03 \pm 0,01$. O ID da pior articulação variou de 0,08 a 0,37, com média de $0,21 \pm 0,09$. O ID médio nos lados direito e esquerdo foi semelhante. Foi possível concluir que o cachorro-do-mato preserva o desenvolvimento normal da articulação coxofemoral sem predisposição ao desenvolvimento da displasia coxofemoral. No entanto, o monitoramento da articulação coxofemoral dessa espécie é recomendado, dado o pequeno tamanho da amostra deste estudo e o surgimento de um animal com ID > 0,30.

Palavras-chave: índice de distração, displasia, articulação coxofemoral, radiografia, animal selvagem

INTRODUCTION

Hip dysplasia is a common developmental disorder in domestic dogs identified radiographically because of hip subluxation, hip osteoarthritis, or both (Reagan, 2017; Hayward and Todhunter, 2023). Hip laxity is recognized as an important factor in the development of the disease since it leads to femoral head subluxation, which is a precursor to degenerative joint disease (Adams, 2000; Hayward and Todhunter, 2023). The early detection of canine hip dysplasia may help for treatment purposes, screening of at-risk breeds before breeding, and avoiding dog training investment, among others (Smith *et al.*, 1990; Adams, 2000; Butler and Gambino, 2017; Hayward and Todhunter, 2023). The presence or suspected hip dysplasia in non-domestic Canidae has occasionally been reported, such as in an exemplar of timber wolf (Douglass, 1981), red fox (Lawler *et al.*, 2014), and saber-toothed cat *Smilodon fatalis*, which is an extinct species (Balisi *et al.*, 2021). In addition, in a study with museum skeletons of raccoon dogs, 78% of hip joints (25/32) had signs compatible with hip dysplasia (Lawler *et al.*, 2012). Therefore, the assessment of hip health in non-domestic canid patients requires the establishment of reference data for normal hip laxity in each species.

Distraction–stress radiography techniques, such as the PennHip method, have been used to estimate the degree of dislocation of the femoral head from the acetabulum through the distraction index (DI) and susceptibility to hip osteoarthritis (Smith *et al.*, 1990; Adams, 2000; Butler and Gambino, 2017; Hayward and Todhunter, 2023). The PennHip method used in 4-month-old puppies was shown to be more sensitive than the Orthopedic Foundation for Animals method (standard extended hip radiographic view) in 2-year-old dogs for detecting coxofemoral instability (Adams, 2000). A PennHip DI ≥ 0.3 in dogs ≥ 16 weeks of age indicates an increased risk of osteoarthritis development (Butler and Gambino, 2017).

Among the wild canids, the crab-eating fox (*Cerdocyon thous*) is considered a medium-sized animal, with adults weighing from 3.7 to 11.1 kg (Cheida *et al.*, 2006). This canid is distributed in several countries in South America, with crepuscular and nocturnal habits, and an

omnivorous diet (Cheida *et al.*, 2006; Beisiegel *et al.*, 2013). The hip joint laxity of these animals has already been evaluated, including the Norberg angle on radiography, the dorsolateral subluxation score, the center distance index, the lateral center edge angle, and the dorsal acetabular rim angle on computed tomography (Castilho *et al.*, 2021). However, all these hip parameter analyses were conducted in adult animals. Knowledge of the normal conformation of the hip joints at different ages is fundamental for identifying abnormalities that may compromise normal biomechanics and understanding the differences between domestic and wild canids that may predispose them to diseases such as hip dysplasia.

Therefore, this study aimed to measure hip laxity using distraction–stress radiography in young crab-eating foxes. The hypothesis is that the animals had a DI similar to the non-dysplastic hips of domestic dogs (DI < 0.3). To the best of the authors' knowledge, DI has not been measured in young crab-eating foxes.

MATERIALS AND METHODS

This study was approved by the Institutional Ethics Committee on Animal Use (CEUA: 0575/2023). Eight free-ranging crab-eating foxes, six males and two females, with a mean age of 4 months and weighing from 2.1 to 4.2 kg (mean $\pm$ SD: 3.43 kg $\pm$ 0.8) were used. These animals were rescued by the environmental police and received at the Centre for Medicine and Research Wild Animals (CEMPAS), where they were kept in an area (3.3 m wide x 3.3 m long x 3.0 high) and fed a canine commercial diet, fruits, and water *ad libitum*. Four animals were from the same litter, and two from another litter. The other two were not related. The animals were numbered from 1 to 8.

Before the study, all crab-eating foxes had undergone a general clinical examination and were considered healthy based on physical and orthopedic exams. Body condition scoring (BCS) was evaluated according to a nine-point scale (Ferro *et al.*, 2024). The body length (from the cranial aspect of the scapulohumeral joint to the caudal aspect of the ischial tuberosity) and height (from the dorsal scapular border to the paw) were measured with a measuring tape in each animal (Fig. 1).

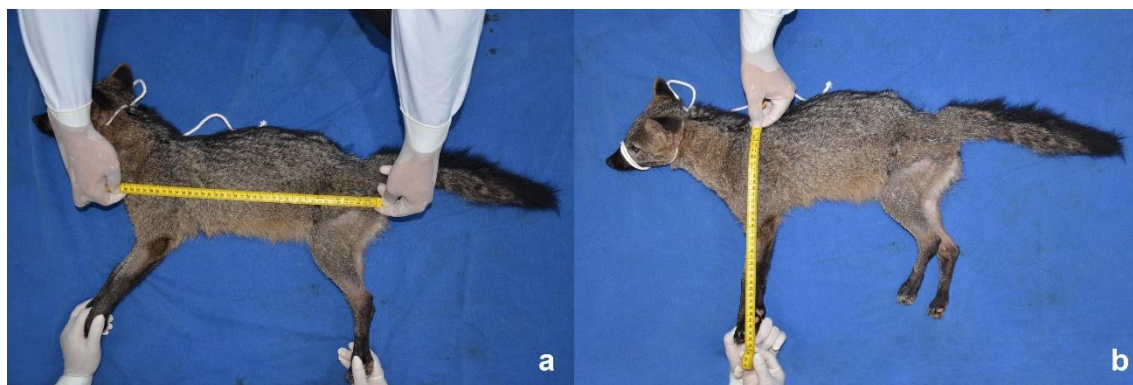


Figure 1. Measurements of body length (a: from the cranial aspect of the scapulohumeral joint to the caudal aspect of the ischial tuberosity) and height (b: from the dorsal scapular border to the paw) in a young crab-eating fox.

The radiographs were performed with the animals under deep sedation and analgesia. After 6 hours of fasting, each animal received a combination of butorphanol (0.2mg/kg), midazolam (0.3mg/kg), and ketamine hydrochloride (10mg/kg) intramuscularly in the hind limb.

The animal was positioned in dorsal recumbency with the back under a soft V-trough with no rotation of the spine and pelvis. For the ventrodorsal hip extended standard view, the hind limbs were extended, the femurs were internally rotated and maintained parallel to one another, and the patella centered within the trochlear groove. For the distraction radiographic view, as previously described (Smith *et al.*, 1990), the PennHIP distractor rods were placed parallel to the ventral abdomen and pelvis, maintaining the rods parallel to one another. The femurs were adducted in a neutral position against the distractor, and a firm downward force onto the pubis was applied holding the distractor at each end (Fig. 2). The first author (GR Cassanego) performed distraction radiography three times for each animal (as the examiner had little experience) to determine the repeatability. A standard DI deviation under 0.05 between the three examinations is considered an acceptable repeatability (Antech, 2015). Digital radiographs (SR 8100 SIUI) were taken at 8mAs, 57 kV, and 1-meter focus detector distance.

The Dys4Vet software was used by MMD Ginja to measure the distraction index (DI). Two circles were drawn on each coxofemoral joint, one to delineate the femoral head and the other to the cortical margin of the acetabulum, along with the geometric centers. The DI was then calculated by dividing the distance between the centers of the femoral head and the acetabulum by the radius of the femoral head. A DI of 0 indicates no subluxation, while a DI of 1 indicates complete hip joint luxation (Smith *et al.*, 1990; Butler and Gambino, 2017).

The Spearman correlation test was used to assess the relationship between body mass, body length, height, and ratio (length/height). For DI, the statistical analysis was performed at the individual animal level. The DI of reference for each joint was the mean value of the three examinations. When there was a laxity difference between the two hip joints, the dog was classified by the DI of the worst hip joint. A descriptive statistical analysis was used to characterize the DI. The paired t-test was used to compare DI means between the right and left sides. All statistical analyses were considered significant for $P < 0.05$ and were performed with standard computer software (SPSS® Version 27.0).



Figure 2. Distraction radiographic view in a crab-eating fox positioned in dorsal recumbency and the PennHIP distraction device (1) positioned between the hind limbs.

RESULTS

Two animals had a BCS of 3 and six had a BCS of 4. The body length and height were 35.5cm (± 4.34) and 33.12cm (± 2.35), respectively. Spearman's correlation analysis revealed a significant relationship between morphometric measurements and body mass, with correlation coefficients of 0.668 ($p < 0.05$) for height and 0.608 ($p < 0.05$) for length.

The exception was a litter with two animals. Sedation lasted about 30 minutes, and no

complications were observed. The hip joints were radiographically normal on ventrodorsal hip-extended view. The standard deviation (SD) recorded in the distraction index for the three examinations of each animal ranged from 0.02 to 0.05 (mean of 0.03 ± 0.01), and the 95% confidence interval had a lower limit of 0.03 and an upper limit of 0.04. The DI of the worst joint ranged from 0.08 to 0.37, with a mean of 0.21 ± 0.09 (Fig. 3). The mean DI on the right and left sides was similar ($P < 0.05$ in paired t-test).



Figure 3. Distraction radiograph views in a young crab-eating fox. Bilateral distraction index of 0.15 N. Note the delimitation of femoral head, acetabulum, and the measurement distance between femoral head center (FC) and acetabulum center (AC).

DISCUSSION

The DI of the crab-eating foxes showed values comparable to normal hips of domestic dogs ($DI < 0.30$). Although free-ranging animals, most of them (6/8) had a similar size pattern based on the correlation between morphometric measurements and body mass, which helps to uniform The SD between the three distraction examinations was in all cases under 0.5, with a mean of 0.3 (Antech, 2015).

The present study used an original PennHip distraction device to evaluate the hip laxity of crab-eating foxes, and the DI measurements were performed with the Dys4Vet software. A previous study showed that the Dys4Vet computer software can be used for DI measurements with repeatability and reproducibility (Ginja *et al.*, 2006). Other studies have developed novel techniques and distractors to quantify the laxity of the canine hip to avoid the requirements imposed for the use of the PennHip and expand its use beyond the United States (Broeckx *et al.*, 2018; Santana *et al.*, 2020).

The PennHIP method is based on three ventrodorsal radiograph views, including a standard hip-extended view to evaluate evidence of osteoarthritis, a compression view to verify joint congruency, and a distraction view to calculate femoral head subluxation (Butler & Gambino, 2017). Besides the standard extended hip radiographic view, the hip joint evaluation in the present study was based on the distraction view because two studies with distractors different from PennHIP showed that this view allowed similar DI (Broeckx *et al.*, 2018; Santana *et al.*, 2020).

The hypothesis that we put forward at the beginning of the study was confirmed, the mean DI of 0.21 ± 0.09 is typical of breeds that are not predisposed to developing hip dysplasia (Smith *et al.*, 1990). Dogs that develop normal hips typically have $DI < 0.30$ at young ages (Smith *et al.*, 1990). However, the $DI > 0.30$ in an animal in the sample may be indicative of some risk for the development of hip dysplasia in some animals of this species. Some breeds, such as Maine Coon cats, are highly affected by hip dysplasia (Low *et al.*, 2019). Conversely, some pure canine breeds improved for musculoskeletal

functionality, such as greyhounds (Loder and Todhunter, 2017), or wild animals in which orthopedic functionality is essential for their survival, the predisposition to the development of hip dysplasia seems uncommon. However, it must be considered that hip dysplasia was already described or suspected in some non-domestic Canidae (Douglass, 1981; Lawler *et al.*, 2014; Balisi *et al.*, 2021). Thus, more study needs to be done using a large number of captive animals since they are subject to other influences that may contribute to disease development.

The crab-eating foxes in the present study had a BCS considered ideal or too thin. In domestic dogs' hip dysplasia has a genetic basis with environmental influences and factors such as body mass, excessive exercise, nutrition, and fast growth rate may influence the development of the disease (King, 2017). The free-ranging crab-eating foxes are omnivores and opportunists with short and robust limbs that facilitate locomotion in dense forests (Berta, 1982). Additionally, the animal is one of the most frequently reported in roadkill (Beisiegel *et al.*, 2013). These elements may contribute to the absence of hip dysplasia reports in the species until this moment.

CONCLUSIONS

Based on this study we can conclude that the crab-eating fox maintains normal hip development without a predisposition to hip dysplasia. However, monitoring of the species' hips is recommended, given the small sample size of this study and the occurrence of an animal with a $DI > 0.30$.

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