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Case Report

Turk. J. Vet. Anim. Sci.
2011; 35(4): 277-280
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doi:10.3906/vet-1004-275

Polydactyly in Arctic foxes (*Vulpes lagopus*)

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Received: 14.04.2010

Abstract: Seven Arctic fox puppies were found to have an extra claw (resembling a canine dewclaw) on their thoracic limb. These individuals came from 2 litters born of 2 different females. The "dewclaw" comprised a claw loosely connected with the limb by soft tissue, and it had the third phalanx (PIII) and a vestigial phalanx. Our results show that the presence of an extra claw on one or both hands in some Arctic fox puppies may, but does not have to, be a dominant trait. The differences between the 2 analyzed litters support the hypothesis that the mode of inheritance of the investigated trait in Arctic foxes could be more complex.

Key words: Polydactyly, thoracic limb, Vulpes lagopus

Introduction

Numerous anatomical abnormalities of the limb have been described in mammals. The most common congenital limb abnormalities are finger and toe deformities, including polydactyly (the presence of more than the normal number of fingers or toes), oligodactyly (the presence of fewer than the usual number of fingers or toes), syndactyly (a condition where 2 or more digits are fused together), and ectrodactyly (a condition where the middle finger or the middle toe is missing). Digital bones may also be deformed; the condition in which fingers and/or toes are abnormally long is referred to as arachnodactyly, while the condition of having unusually short fingers and/or toes is termed brachydactyly. The above malformations may affect one or more limbs (1-4).

Polydactyly is the most frequently observed congenital limb malformation. The occurrence of polydactyly has been reported in many breeding and wild-living species, as well as in primates including humans (5-8). In this paper, we report for the first time the occurrence of polydactyly in Arctic foxes (*Vulpes lagopus*). Our results may provide a new insight into the occurrence of polydactyly in animal species and could contribute to a better understanding of the inheritance of this trait.

Case history

The study was carried out on a group of Finnish Arctic foxes raised on a farm in northeastern Poland. The polydactyl individuals came from 2 litters born of a shadow female (litter S) and a blue female (litter B). The females were maternal half-siblings. The litters born of these females consisted of animals with extra digits on both hands or on one of the hands, as well as animals with the normal number of digits. Polydactyl foxes were both shadow- and blue-colored.

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The shadow female gave birth to 15 puppies, of which 14 survived until the end of the rearing period. The female was mated to 3 different blue males (farm signatures were K3, P10, and K10). The blue female gave birth to 16 puppies, of which 10 survived. The female mated with the male K10. It is recommended to mate shadow (Ss) individuals to blue (ss) partners, as the dominant gene S responsible for the shadow color type has a recessive lethal effect (9). Neither the females nor the males used for reproductive purposes had extra digits. The number of polydactyl individuals was not observed among newborns but among weaned animals, indicating their gender and color type as well as the affected limbs. All animals were subsequently slaughtered using electric current in the course of the normal production cycle. The procedure was approved by the local Ethics Committee in accordance with the relevant EU regulations. We monitored the development of the puppies from their birth, and we noticed the presence of extra claws on their thoracic limbs. Since we had never encountered such a phenomenon in foxes, we decided that the polydactyl feet of slaughtered animals should be brought to our clinic for analysis. Photographs and radiographs (2.5 mAs, 65 kV) documenting the described cases of polydactyly in foxes and showing the type of claw-hand connection were taken at the Department of Clinical Sciences, Surgery and Roentgenology Unit of the University of Warmia and Mazury in Olsztyn.

Results and discussion

The Table shows the number of polydactyl foxes by gender and color.

Seven young animals were found to have an extra claw in their forelimb, on the outer (ulnar) side in the abaxial aspect. An anatomopathological and radiographical analysis (Figure 1) revealed the presence of an extra digit, which comprised a claw, the third phalanx (PIII), and a vestigial phalanx, in all analyzed cases. The extra claw was attached to the limb by skin only; therefore, it is possible that young animals could lose it due to injury, which could lead to untypical inheritance patterns of this trait.

Based on the results in Table 1, the occurrence of polydactyly cannot be associated with only gender or color. It is also impossible to determine whether the mode of its inheritance is dominant or recessive, monogenic or polygenic. The absence of extra claws in the parents and their presence in the offspring can suggest that the origin of this disorder has a recessive or polygenic character. However, previous studies of the family *Canidae* reported a dominant mode of inheritance for polydactyly. This would imply that the parents of the examined puppies must have lost their extra digits at a young age, and that carriers of the mutated dominant gene were male K10 or, alternatively, both females (half-siblings).

According to reference data, polydactyly is an autosomal dominant trait, in both animals and

Table. Occurrence of polydactyly in Arctic fox puppies.

Litter					
	S			B	
	Right thoracic limb	Left thoracic limb		Right thoracic limb	Left thoracic limb
B ♂(2)	+	+			
S ♂ (1)	+	+			
B ♂ (1)	+	-			
B ♂ (1)	-	+	B ♂ (5)	-	-
B ♂ (2)	-	-	B ♂ (1)	-	+
S ♂ (1)	-	-	B ♀ (4)	-	-
B ♀(2)	-	-			
S ♀ (1)	-	+			
S ♀ (3)	-	-			

S – shadow color type, B – blue color type, + presence of the extra claw (polydactyly), - absence of the extra claw, (...) the number of animals is given in brackets

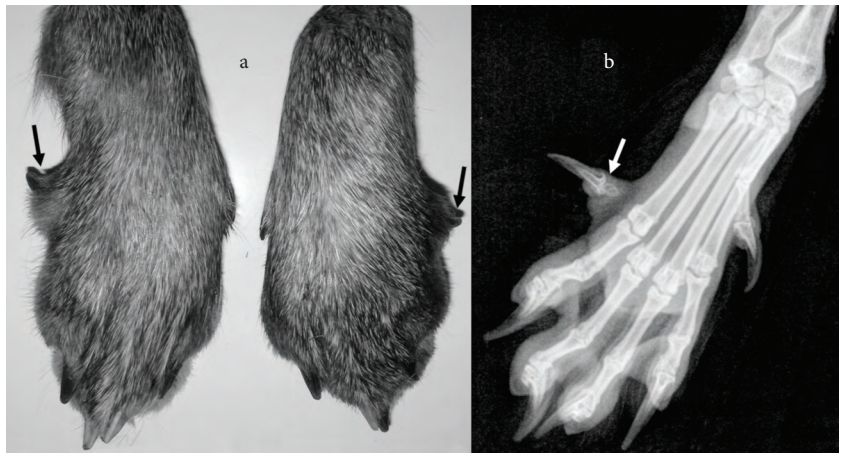

Figure 1. Photograph (a) and radiograph (b) in dorsoventral view of a sample polydactyl hand of an Arctic fox. The extra claws are marked by arrows.

humans. This anomaly is often considered to result from mutations in HOX genes, which control the expression levels of the Sonic Hedgehog (SHH) gene, whose product is responsible for the regulation of organogenesis (10). Representatives of the family *Canidae*, including Arctic foxes, normally have 5 digits in hand and 4 in foot (11). However, domestic dogs (*Canis familiaris*) often have dewclaws which are loosely connected to their hind limbs, usually by a flap of soft tissue and skin. In most cases, pelvic limb polydactyly in dogs is inherited, and the mutation responsible for this malformation is probably dominant (12). In selected breeds, such as Beauceron, Briard, Catalan Sheepdog, and Icelandic Sheepdog, dewclaws are desirable and required by the FCI (13). However, according to the majority of breed standards dewclaws may cause health problems in adult dogs and therefore they should be removed in puppies at 3-5 days of age (14). To the best of our knowledge, the literature reports no cases of forelimb polydactyly reported in the *Canidae* family. The only exception is the Norwegian Lundehund breed whose representatives have dewclaws on the front and hind limb, all of them fully formed, jointed, and muscled (15). The genetic background of this trait in the above-mentioned breed remains poorly understood yet.

It would be difficult to extrapolate the results obtained in dogs to foxes, as in the former polydactyly has the form of dewclaws that occur on the hindlimb while in the latter it manifests as the presence of extra digits (claws) on the forelimb. It should be stressed that no cases of polydactyly in Arctic foxes have been described to date. Jakubczak et al. (16) observed various changes in farm-raised animals of the family *Canidae*, but they did not note deformations of the above type. Our results show that the presence of an extra claw on one of the hands in some Arctic fox puppies may, but does not have to, be a dominant trait. If we assume that the trait for polydactyly is dominant in Arctic foxes, and that the father or both mothers (half-siblings) were carriers of the dominant gene, then half of the puppies in both litters would have extra claws. In our experiment, in litter S approximately half of the puppies (6 of 14) did have an extra claw on one or both thoracic limbs, but in litter B only one pup of 10 was polydactyl. The animals were kept in cages with a wire-mesh floor, which could contribute to the losing of the extra claws, which were poorly connected to the leg. We noted at weaning that several puppies from both litters had scars at places where extra claws could have been attached, thus suggesting that their parents could also had extra claws at a young age. However, if the mutation is dominant, why did so many puppies from the second litter lose their claws? The differences between the analyzed litters support the hypothesis that the mode of inheritance of the investigated trait in Arctic foxes may be more complex. It should be stressed that among 7 polydactyl puppies as many as 6 were male. Unfortunately, the number of puppies was

insufficient to perform a reliable statistical analysis.

We could not continue our study because the farm was closed and the animals were sold. We have never again found any other polydactyl Arctic foxes. Since the malformation has no negative effects on the health condition of animals and it is not considered a fault or defect, it might have simply been ignored by breeders in other farms.

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