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MORPHOLOGY AND ANOMALY OF THE SCULL OF ZOO *LYNX LYNX* (CARNIVORA: FELIDAE): ECOLOGICAL ASPECTS FOR FURTHER REINTRODUCTION

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Abstract

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Two skulls of zoo lynxes and one lynx skull with unknown origin have been studied. One of the lynx was male and seven years and six months old, imported from Russia and lived in the zoo in Stara Zagora. The second one was two years and six months old, imported from Czech Republic. The third lynx was from osteological collection and was with unknown origin. A comparative morphological investigation was conducted, using native and radiological study. After the osteological treatment of one skull, it was found that there was a bone defect in the caudal part of the frontal bones, which motivated our study. According to us, it was a bone anomaly, resulted by the inbreeding of the animal, often leading to the occasional appearance of asymptomatic bone defects. We suggest the origin of the lynxes to be studied carefully in their reintroduction in order to prevent the displacement of inbreeding animals. Thus, we propose that it is better to be studied the lynx ancestor for future reintroductions of the animal, which is of great importance for its ecology and surviving.

Key words: lynx; skull; morphology; reintroduction; malformations

Introduction

The Eurasian lynx (*Lynx lynx*, Linaeus, 1758) is the biggest representative of the family *Felidae* in Europe. Smaller representatives of the family *Felidae* are the Iberian lynx (*Lynx pardinus*, Temminck, 1827) and the wild cat (*Felis silvestris*, Schreber, 1877).

In the past the lynx has been spread throughout Europe. In 19th and 20th century the lynx disappeared in many of the European countries. In Germany the last lynx was observed in 1850, in France in 1900 and in Switzerland in 1915. Nowadays, the most significant lynx populations are reported in Finland – 2000 animals, Sweden – 1400 animals, Norway – 420 animals. In Central Europe, the lynx population is the most numerous in the Romanian Carpathians region. It is similar to that in Finland, while in Poland it is just over 100 individuals (Bieniek et al., 1998; Bego, 2001; Breitenmoser-Würsten and Breitenmoser, 2001; Hristovski, 2001; Paunović et al., 2001; Soldo, 2001; Spassov et al., 2001; Panayotopoulou, 2001; Zlatanova et al., 2001; Zlatanova et al., 2009; Spassov et al., 2015).

To restore the biological diversity, the Slovenian part of the Carpathians from Czechoslovakia former was important donor for the reintroduction of freely living lynxes in

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the neighboring countries in the seventies of the 20th century (Ryser-Degiorgis et al., 2004; Breitenmoser-Würsten and Obexer-Ruff, 2007; Gomerčić et al., 2010). In all projects in this aspect, the reintroduced lynxes belong to the same population – the Carpathians of Slovakia. The reintroduced animals are often related – brothers and sisters, mothers and generation. As a result, in Switzerland have occurred cases of congenital skeletal malformations in reintroduced animals and decreasing of the genetic diversity (Ryser-Degiorgis et al., 2004; Breitenmoser-Würsten and Obexer-Ruff, 2007).

Regarding the Harz Lynx Project program Pace (2010) reports the reintroduction of lynxes born in zoo and in rescue centers in the Harz national park – Germany. Von Arx et al. (2009) report that for the period from 1992 to 1999 in the Kampinoski National Park, Poland were introduced thirty-one lynxes, born in captivity. Fourteen lynxes were male, and seventeen were female. According to Von Arx et al. (2009) the reintroduced lynxes born in captivity in Harz National Park in Germany since 2000 have been twenty-eight.

In Bulgaria, the lynx was accepted as missed at the beginning of the 1940s and was included in the Red Book of Bulgaria (1985) as an extinct species. It has been protected species since 1986 (Spiridonov and Spassov, 2015). According to Zlatanova et al. (2001), the last official reports for killed lynxes are from 1935 in Pirin, around Melnik and from 1941 in the Parangalitsa Reserve in Rila. Since 1985 there have been reports of its occurrence in Central Stara Planina, Rila, Western Rhodopes (Dobrostan and Dabras), Danube Plain and Ludogorie, Ropotamo, Strandzha, Western Border Mountains. Lynx was observed in 2000s south to Stakevzi village, Western Stara Planina. In the same region its presence was proved in 2004-2005s and in Ossogovo – in 2009. Obviously, these lynxes are part of the population of Carpathian self-migrated animals of thirty individuals in the last 20-25 years in Eastern Serbia (Spiridonov and Spassov, 2015).

In ecological, morphological and evolutionary aspect, the scull characteristics of the lynx have been studied by many authors (Andersen and Oystein, 1984; Garcia-Perea, 1996; Gomerčić et al., 2010; Mihaylov and Dimitrov 2010; Yom-Tov et al., 2010), but only Ryser-Degiorgis et al. (2004) report scull and other bone anomalies.

Nowadays, in Bulgaria can be observed only in some zoos in the country. A couple of lynxes live in Sofia Zoo, as the male is imported from Canada and the female – from Russia. Stara Zagora zoo bought from Russia in 2007 two male lynxes. They were born in the same year. One of them died in September 2014 after suffering a severe anaphylactic reaction due to wasp stinging on the tongue. Kenana Zoo in Haskovo bought two lynxes – male and female in 2014, born in the same year. The male died in August 2016, as a result of fatty liver dystrophy. After the osteological treatment of the skull, it was found that there was a bone defect in the caudal part of the frontal bones. That provoked us to conduct this study.

Materials and Methods

The sculls of three lynxes were studied. One lynx was male and seven years and six months old, imported from Russia and lived in Stara Zagora zoo with cadaver weight 21 kg. The second lynx was male and two years and six months old, imported from Czech Republic, lived in Haskovo zoo with cadaver weight 25 kg. The third lynx scull was from the osteological collection of Animal morphology Unit, from the Department of Morphology, Physiology and Animal Nutrition, Faculty of Agriculture, Trakia University, Stara Zagora. It was with unknown origin.

The bone objects were treated by the method of Sarma (2006) – maceration, removing of soft tissues, degreasing, bleaching and drying.

The results were documented with digital camera Canon Legria HF R16E (Canon Inc. Japan).

The radiological study was performed with X-ray machine TUR 800 D-1 (Röntgenbelichtungsautomat – 20029), Dresden with digitizing camera- iQ-CR ACE, which was a CR reader to digitize X-ray imaging. Radiograms were in dorsoventral and lateral projections with focus-film distance of 100 cm, Kilovolt peak of 65 kV and Milliampere per seconds of 10 mAs. The used cassette was DICOM 3.0 (24x30 cm; 14``x17``) with matrix size 2328 x 2928 px and 18 x 24 cm (14``x17``) with matrix size 1728 x 2328 px. The spatial resolution was 10 px/mm, the scanning depth was 20 bit/px and the depth after processing was 16 bit/px. The used operation system was Windows XP SP3. The used software for radiograms' investigation was iQ-VIEW Version 2.7.0 BETA INT EN 002R; Copyright© 2006-2011 IMAGE Information Systems Ltd.

Results

The native image of the scull of the male lynx, aged seven years and six months, lived in Stara Zagora zoo (St Z Zoo), showed specifics of the bone structure, proper for this age. Crista sagittalis externa was well defined and ascended dorsally to the connecting suture between both external laminas of the parietal bones. Temporal lines diverged rostrally from crista sagittalis externa and reached the caudal edge of the frontal bones' temporal process. The rostral end of crista sagittalis externa followed its way and separated the caudal parts of both squamae of the frontal bones (Figure 1).

In the scull of the lynx, with finished growth and unknown origin (Unknown) from the osteological collection

Fig. 1. Native images of lynx sculls (St Z Zoo), H Zoo and Unknown

asterisk* – caudal end of the right squama of the frontal bone; arrowheads – transversal fissure in the rostral end of crista sagittalis externa, which extended on the right as an oblique craniolateral bone finding, comprising the beginning of temporal line; two asterisks** – caudal end of the right squama frontalis

of Animal Morphology Unit from the Department of Morphology, Physiology and Animal Nutrition, Faculty of Agriculture, Trakia University, Stara Zagora there was a different topography of the rostral end of crista sagittalis externa. The rostral end of crista sagittalis externa reached the caudal parts of both squamae of the frontal bone, but it did not separate each other (Figure 1).

In the male lynx, aged two years and six months, owned by Haskovo zoo (H Zoo) crista sagittalis externa was well defined and high. In its rostral end there was a transversal fissure, which extended on the right as oblique rostrolateral finding. It comprised a small part of the beginning of the right temporal line (Figure 1 and Figure 2).

Fig. 2. Scull of male lynx – H Zoo

arrowheads – transversal fissure in the rostral end of crista sagittalis externa, which extended on the right as an oblique craniolateral bone finding comprising the beginning of temporal line

The observed transversal bone fissure decreased its depth, after its extension in rostrolateral direction, which followed initially the way of the right temporal line (Figure 2).

In the radiological study of the lynx scull (H Zoo), in dorsoventral (DV) projection, we found alterations in the bone structure in the zone of the caudal end of both frontal bones' squamae and in the rostral end of the external lamina of both parietal bones' dorsomedial parts. The found bone alterations were with increased X-ray attenuation of the bone plate, widened and right dislocation of the caudal end of septum of frontal sinuses, close to the parietal bones. In the lateral part of the right squama of the frontal bones, close to the right orbital border was observed increased X-ray attenuation, thickening of the external bone plate and medial dislocation of the bone portion (osteosclerosis). The X-ray finding confirmed the found bone fissure in this region, shown in the native image (Figure 3).

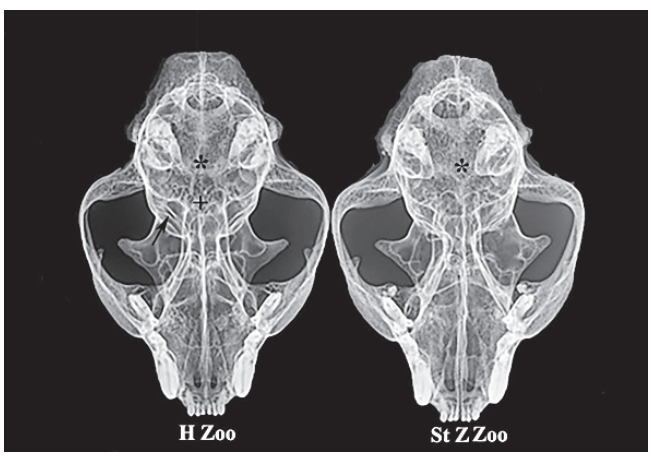

Fig. 3. Radiological image of lynx scull (H Zoo) and (St Zoo); (dorsoventral projection – DV)

arrowhead – osteosclerosis; + – dislocation of septum of frontal sinuses; asterisk * – alterations of the bone structure in the zone of the caudal end of the squama of the frontal bones

In the radiological study of the lynx scull (St Z Zoo), in dorsoventral projection (DV) we observed normal findings of the bone density and continuity in the region of the rostromedial transition between the parietal and frontal bones. The septum of frontal sinuses showed normal bone contours, specific for this age. The lateral parts of both squamae of the frontal bones shoed symmetric normal radiological findings (Figure 3).

In the radiological study in laterolateral projection of the male lynx scull (St Z Zoo) there weren't pathological X-ray findings. In the radiological study in laterolateral projection of the male lynx scull (H Zoo), there was a finding

with increased X-ray attenuation in the region of the medial parts of the frontal squama's internal part together with the ventral end of septum of frontal sinuses. The image of the frontal sinus in the lynx H Zoo was smaller than the same in the lynx St Z Zoo. The internal lamina was with double contours, it was thickened and laminated. Dorsally the caudal part of the external lamina of the frontal bones' squama was with increased X-ray attenuation and too thickened. The same finding was observed in the caudal end of the septum of the frontal sinuses, at the border with the parietal bones. The findings were specific for osteosclerosis and periosteal growth, being characteristic for chronic inflammatory process (osteitis). The X-ray finding confirmed the bone fissure in this region, shown in the native image (Figure 4).

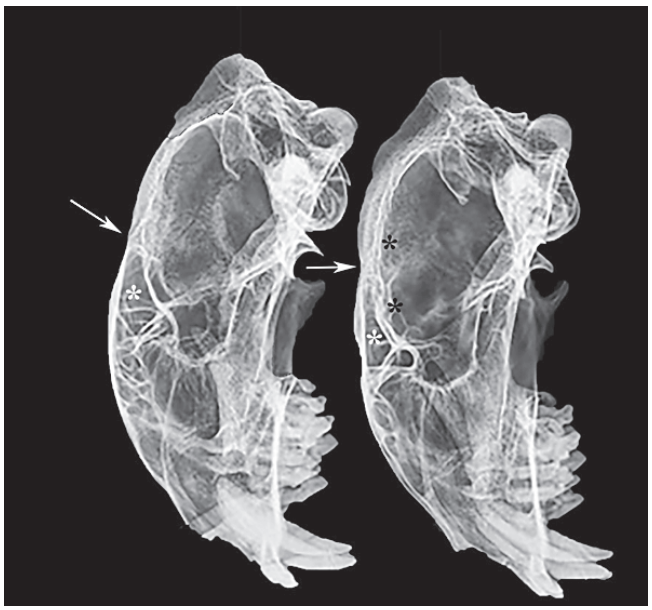

Fig. 4. Radiological image of male lynx scull (H Zoo) and (St Z Zoo) (laterolateral projection – LL)
white arrowhead – H Zoo – osteological alterations close to the superficial contours of the bone defect; white arrowhead – St Z Zoo – it showed the normal status of the bone structure from the same region; white asterisk – frontal sinus; black asterisk – osteological alterations in the region of the internal lamina of the frontal squama and the internal surface of the external sagittal crest

Discussion

In the comparative study of the dorsal surface of the three lynx skulls the results show that in the lynx – H Zoo this surface is with normal structure, compared to the same in the other two lynxes. There have not been neurological symptoms in the lynx – H Zoo before its death, which could accompany it if the bone defect had been caused by a shock, caused this fissure. The fissure was surficial, but the process of ossification had been developed. The conclusions of the pathological anatomical protocol show that the cause of the death is hepatic dystrophy, not the bone defect in the region, investigated by us. The fact that lynx – H Zoo is aged two years and six months old and cadaver weight 25 kg and the lynx – St Z Zoo is aged seven years and six months and with cadaver weight 21 kg suggests that the lynx – H Zoo is well nourished and the deficits are missed. If the observed bone defect in the lynx – H Zoo is only a result of a fracture, it has to heal without visible consequences, regarding the age (a young animal). The mentioned above and the fact that the lynx – H Zoo originates from Czech Republic support the thesis of Ryser-Degiorgis et al. (2004), according to which the lynxes, reintroduced in countries, close to Czech Republic are prone to congenital malformations (multiple skeletal deformities: scoliosis, kyphosis and fusion of two vertebrae in the thoracal area; deformity of the ribs (with indications of old factures); and pronounced symmetrical deformity of the anterior extremities at the level of the elbow that prevented a normal extension of the limbs). We assume in this case that it is a bone anomaly, a result of this animal inbreeding, leading often to occasion appearance of asymptomatic bone defects.

In connection to the mentioned above, and to eliminate the difficulties in the future reintroduction of the lynxes, related to different programs we propose a careful study of the lynx origin in their reintroduction in order to be eliminated the population of inbreeding animals.

We do not agree the description of Nankinov (1968), according to which the body weight of the lynx in Bulgaria is approximately 45 kg, because the cadaver weight of the lynx – St Z Zoo is 21 kg and this of the lynx – H Zoo is 25 kg, which is normal weight of the lynx.

Conclusion

We assume that this is a pathological osteological finding, resulted by the inbreeding of the lynx – H Zoo. Thus, we suggest it is better to be studied the lynx ancestor for future reintroductions of the animal, which is of great importance for its ecology and surviving.

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