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CASES OF SPONTANEOUS INTERBREEDING OF WOLF AND DOMESTIC DOG IN THE REGION OF SOUTHEAST BANAT (SERBIA)

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Abstract - The study presents the first documented data indicating the occurrence of spontaneous interbreeding of wolf and domestic dog in nature on the territory of Serbia, based on three specimens originating from the region of Southeast Banat. Some unique morpho-anatomical malformations of the cranium in two specimens are described. Based on complex morphological and craniometrical analysis of hybrid specimens and comparison with the corresponding material of authentic wolves from this region, it is possible to follow a local process of multiple wolf/dog hybridization and disturbance of the authentic genetic structure of wolf. The identification of wolf/dog hybrids is a subject of primary concern for the development of conservation and management strategies. Because of great vulnerability of the population of South-Carpathian wolves on the boundaries of their range in Serbia, there is a need for permanent and increased protection in order to maintain their adequately strong population in this region.

Key words: Interbreeding, *Canis lupus*, *C. familiaris*, hybridization, morphological and craniometrical analysis

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INTRODUCTION

The wolf (*Canis lupus* Linnaeus, 1758) is one of the most important of European predators. A highly mobile animal with a complex social structure, *Canis lupus* has evolved to survive in a variety of habitats – from coniferous forests and frozen tundra to arid deserts. In Serbia it preys primarily upon deer, wild boar, chamois, and livestock, but may take rabbits and rodents as well as dogs. Under these circumstances, the possibility of forming a pack with feral and stray dogs, as well as the likelihood of their interbreeding with wolves, is practically irrelevant.

Today there is great variation of wolf numbers in various European countries, but in most areas only small populations survive in close contact with increasing numbers of humans and domestic dogs (P r o m b e r g e r and S c h r ö d e r 1992). Strong negative anthropogenic influence on wolf populations in a great part of their distribution area has resulted in disturbance of the population structure, especially the sex structure, of this predator, making possible a new ecological succession. The vacant wolf's ecological niche has been filled by packs of feral and stray dogs, and the missing wolf-partners for couple formation have been replaced by dogs (M c K n i g h t, 1964; D e n n l e r, 1966; N o w a k, 1967; S o l d a t o v i ć *et al*., 1970; R y a b o v, 1973, 1978). The wolf is listed in the CITES Appendix I for India, Pakistan, Bhutan, and Nepal, and in Appendix II everywhere else. Conservation efforts are attempting to combat habitat destruction, competition with humans for livestock, hybridization with domestic dogs, and persecution because of public misunderstanding of the nature of the wolf. The problem of wolf/dog hybridization is considered in the Action Plan for the Conservation of Wolves in Europe (B o i t a n i, 1998, 1999, 2002).

All species in the genus *Canis* are closely related (W a y n e *et al.,* 1997) and can interbreed and produce fertile offspring (G r a y, 1954). Gray wolfs and dogs are the most closely related large canids. Interbreeding of wolf with dog, not only of an enforced type achieved in captivity, but also of a spontaneous type in the wild, has been known for a relatively long period of time. Occasional crossbreeding between wolves and dogs in the wild has been observed in Russia (R y a b o v, 1985; B i b i k o v, 1985, 1988), Ukraine (G u r s k i, 1975), Latvia

(K r o n i t, 1971), Israel (Z i m e n, 1991), Italy (B o i t a n i, 1983; R a n d i *et al.,* 1993) and Spain (V i l à *et al.,* 1997). Some recent studies involving nuclear markers have shown that natural hybridization rarely occurs in the wild (A n d e r s o n e *et al.,* 2002; R a n d i and L u c c h i n i, 2002). Field observation and genetic studies (B o i t a n i 1983; V i l à and W a y n e 1999) suggest that crossbreeding is very limited in Western European wolf populations, but may be more frequent in some parts of Eeastern Europe (B i b i k o v, 1985; R a n d i *et al.,* 2000).

Wolf biologists from all over the world agree that wolves do not naturally mate with dogs. V i l à and W a y n e (1995) have demonstrated that if domestication were a common event, dog and wolf haplotypes would be mixed to a much greater extent than they are. The analysis of mitochondrial DNA suggests that hybridization between wolves and dogs is uncommon, and there is no clear evidence of introgression of dog mitochondrial DNA into wolf populations (R a n d i *et al.,* 2000).

In the ex-Yugoslavia region, this phenomenon has been known for a very long time. Spontaneous mating between a male wolf and a female dog has deep folklore meaning in the popular belief (V u k o v i ć, 1985). So far, scientific and professional literature has not dealt with the phenomenon of spontaneous interbreeding between wolf and dog in the region of our country. Some authors generally accept that as a possibility (Ž i v a n č e v i ć, 1951), while others are quite reserved in regard to this occurrence (K n e ž e v i ć and K n e ž e v i ć, 1956).

MATERIAL AND METHODS

The first argumented data indicating interbreeding between wolf and dog for the territory of Serbia based on proof material pertain to the region of Southeast Banat. The proof material includes three skulls and two furs.

The first skull belongs to an adult hybrid female that was shot in the late autumn of 1985 between the villages of Gudurica and Markovac (in the area of Vršački Breg). The specimen is located in a private collection in Vršac. The next two skulls, as well as furs, belong to adult individuals: a mature female and a younger adult male, which were shot (18 May 1979 and 17 December 1980) in the region of Deliblatska Peščara. Both specimens are located in the Institute for Nature Conservation of Serbia in Novi Sad.

Analysis of the material was performed by morphological and morphometric procedures. The estimation of age of individuals was performed by classical procedure according to N o v i k o v (1956) and G e p t n e r *et al.* (1967). All the craniometric measurements were taken with a digital caliper accurate to 0.01 mm.

Descriptions, diagnoses, and keys for precise determination of wolf as a species known from the literature (M i l l e r, 1912; N o v i k o v, 1956; G e p t n e r *et al.,* 1967; M e c h, 1970; M i r i ć, 1970; B i b i k o v, 1985; P e t e r s, 1993) have a limited, mostly implicit value when applied to distinction of hybrids from pure wolves. Moreover, a few instructions and keys for distinction of wolf from dog based on morphological and morphometric characteristics (T i m a r a c, 1976; A s m e r a and B a b i č k a, 1983; K r y š t u f e k and J a n ž e k o v i ć, 1999), because of mixed characteristics of wolf and dog in this case, are not very useful. A different methodological approach was therefore applied in this study. Firstly, the forms and specific anatomical characteristics of the skulls in hybrid animals, as well as their fur's appearance, were described in detail. Relevant morphological and craniometrical parameters were their considered in comparison to descriptions and dimensions of typical wolves from the investigated region according to M i l e n k o v i ć (1997).

RESULTS

The appearance of the skull of the adult female at first glance deviates from a typical wolf's skull. This skull is slighter and has an appearance that is closer to a dog's. The condylobasal length (224.2 mm) and zygomatic width (116.3 mm) are clearly smaller than even the minimum values for adult female wolves from this region (Table 1). That, along with the generally smaller teeth and bones, indicates that this animal is more kindred to dog than to wolf. The lengths of P^4 and M_1, depth of the brain case and length of the full set of maxillary teeth are less than the minimum values measured in the wolf population of South Banat. On the other hand, some other craniometric characters of the hybrid specimen – like length of the lower M_2 (which is an important diagnostic character) and interorbital and postorbital width fall within the range of variation in this population and suggest a close relationship of the specimen with wolf.

The next two specimens were craniologicaly completely different. Caught in Deliblatska Peščara, they could be confidently identified as hybrids only on the ba-

Table 1. Minimal and maximal values (mm) for 12 cranial and dental characters in 18 pure wolf specimens and three hybrid specimens (female shot in the area of Vršački Breg, female and male shot in the region of Deliblatska Peščara) originating from the region of Southeast Banat (Serbia). (Cbl – Condylobasal length; Rd – Rostral depth behind canine; Rb – Rostral breadth over canines; Iob – Interorbital breadth; Pob - Postorbital breadth; Zyg – Zygomatic breadth; Bcd – Depth of brain case; Maxtr – Maxillary tooth row (M^2-C^1); LP^4 – Length of upper carnassial; BP^4 – Breadth of upper carnassial; M – Mandible; LM_1 - Length of lower carnassial).

	Males (10 adults)		Females (five adults)		Females (three subadults)		Hyb. female	Hyb. female	Hyb. male
	min	max	min	max	min	max			
Cbl	228.4	258.5	227.8	238.7	221.0	226.6	224.2	205.4	234.7
Rd	33.6	39.6	34.1	36.7	32.2	35.0	33.2	30.6	39.2
Rb	46.2	51.6	43.0	49.6	42.0	44.0	44.4	39.3	47.2
Iob	44.3	52.2	45.9	47.9	40.1	45.9	46.1	42.0	47.1.0
Pob	41.3	48.6	41.3	44.7	39.8	42.2	42.1	42.2	46.3
Zyg	135.9	154.6	132.2	139.3	117.9	129.0	116.3	124.0	136.7
Bcd	80.3	88.2	79.4	84.5	77.6	83.4	75.4	69.9	81.3
Maxtr	105.7	116.5	102.0	112.8	101.7	106.5	98.2	91.1	105.7
LP^4	24.0	27.1	24.5	26.2	24.1	24.7	24.0	23.4	26.2
BP^4	18.8	20.9	18.2	19.5	18.0	20.3	15.1	17.9	20.4
M	181.1	207.8	178.0	189.4	170.6	177.9	176.3	160.1	185.8
LM_1	27.9	30.3	26.1	28.1	26.4	28.4	29.7	25.2	29.6

sis of detailed mutual comparisons. These hybrids are kindred, but they arise from different generations (levels) of hybridization. Namely, the female's skull at first glance could be considered a dog's, contrary to the male's skull, which looked like a typical wolf's. However, the appearance and quality of furs of these specimens are specific, mutually almost completely identical and atypical of wolf generally. On the one hand, this indicates a close relation between these two specimens, while on the other it clearly separates them from typical wolves in this region.

The general color tone of the female's fur is clearly foxy-yellowish, especially on the head, sides, and thighs. A gray shade, which is generally characteristic of the wolves in Deliblatska Peščara, is completely absent in this specimen. On the back side of the fur, a distinctive black line from forehead to shoulder-blade is observed, developing into a well-expressed black cloak, which is atypical of wolves in this region. The ventral side is of a bright-coffee color. A white brim around the lips is in strong contrast with the yellowish muzzle and dark (atypical) brown-black cheeks and forehead. A black line on the forelegs is well developed. The hair is visibly shorter, denser, and softer than in wolves in this region.

The general shade of the male's fur is also clearly foxy-yellowish, without a gray shade. The cloak and edges of the cloak are not as prominent as in the female, but still better developed than in typical wolves in Deliblatska Peščara. The ventral side is of a bright-coffee color. A white brim around the lips is well-developed and in contrast with the foxy-yellowish and black muzzle and cheeks. The existence of a separate bright speck on the right cheek draws this specimen nearer to typical wolves in the region. A black line on the forelegs is well developed. The hair is somewhat longer than in the female, but it is also shorter, denser and softer than in wolves in Deliblatska peščara.

Comparative craniological and craniometric analysis additionally and completely affirms a kindred relationship of these two hybrid individuals. The female's skull is smaller, with slighter bones, tiny teeth, and a conspicuously flat forehead, similar to a jackal's forehead (Fig. 1). The muzzle is noticeably narrow. Nasal bones on the fore edge have an unprominent bony prolongation on

Fig. 1. Skull of hybrid female from Deliblatska Peščara

Fig. 2. Impacted lower premolar (P_1) in hybrid female from Deliblatska Peščara.

both sides of the nasal sutura (*sutura internasalis),* contrary to the nasal bones in typical wolves. The condylobasal length in this adult specimen's skull is noticeably smaller than this length in five adults and even two subadult female wolves from South Banat (Table 1). The values of zygomatic width, length of the upper carnassial molars, rostral breadth, interorbital breadth, and length of the lower carnassial molars in this hybrid specimen are also smaller than in typical female wolves. As in the specimen from Vršački Breg, certain characters in the female from Deliblatska Peščara – rostral depth, depth of the brain case, the maxillary tooth row, length of the upper carnassial, and breadth of the upper carnassial and mandible – are noticeably smaller than in adult female wolves in this region. In addition to this, the manner of the skull's reliance (without the mandible) on the flat surface gives an elevation of the rostrum which diverges from the usual elevation in wolves from South Banat (M i l e n k o v i ć, 1997).

It is especially important to emphasize the existence of two noticeable and atypical malformations on the skull of this specimen which were not registered in any of 210 examined wolf skulls from regions of ex-Yugoslavia (M i l e n k o v i ć, 1997). The first one involves incompletely developed (impacted) permanent teeth P_1 (*dex et sin*), which barely appear from the alveolus only with their distal part and show colossal parts of crowns in a horizontal position (Fig. 2). The second pertains to the *foramen infraorbitale.* While in examined wolves, the *foramen infraorbitale* is regularly completely passable, on the left side of the skull in this specimen it is filled with spongy bony tissue (Fig. 3).

Some other characteristics which are unusual for typical wolves are noticed in this hybrid. Semicircular lines of the hind part of the forehead in adult wolves usually reach each other approximately at the level of the *sutura coronalis*. In the hybrid female from Deliblatska Peščara Sands, this happens much farther back approximately at the middle of the *os parietale*. Also, the appearance of the *sutura frontalis* is atypical. The s*utura frontalis* in this specimen noticeably meanders at the joint of the *ossis frontales* and (especially) the *ossis parietales*, while in typical wolves it has the form of a slightly curving or sometimes interrupted, zigzag line.

Contrary to the female specimen, the skull of the male hybrid (Fig. 4), both in its appearance and on the basis of numerical values of basic craniometric parameters, does not deviate from the series of typical wolves from this region (Table 1). This skull, if analyzed separately, cannot be separated from the skulls of typical wolves or identified as hybrid in regard to any diagnostic or classi-

Fig. 3. *Foramen infraorbitale* filled with spongy bony tissue in hybrid female from Deliblatska Peščara

Fig. 4. Skull of hybrid male from Deliblatska Peščara

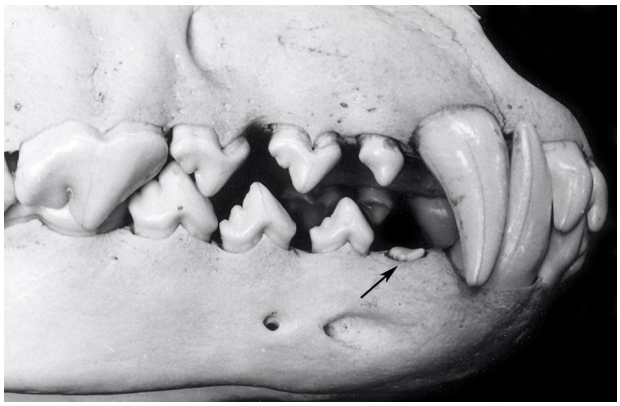

Fig. 5. Impacted lower premolar (P_1) in hybrid male from Deliblatska Peščara

cal morphological and morphometric parameters. However, its hybrid nature is revealed by two clearly recognizable morpho-anatomical malformations, identical to those noticed and described in the previous specimen from Deliblatska Peščara Sands. In the male hybrid, in the female, the lower premolars P_1 (*dex et sin*) are similary impacted, with their crowns barely appearing from the alveolus (Fig. 5). The *foramen infraorbitale* on the left side of the skull is noticeably filled with spongy bony

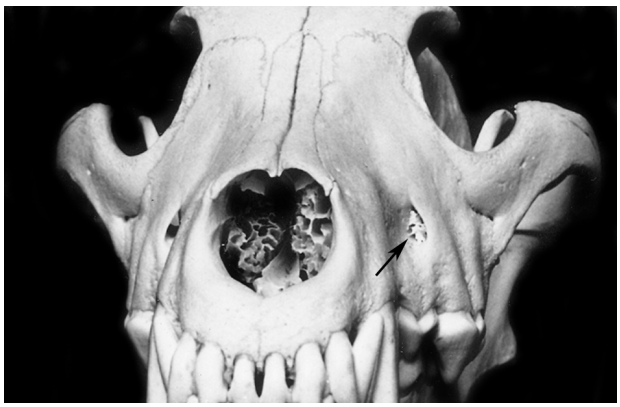

Fig. 6. *Foramen infraorbitale* filled with spongy bony tissue in hybrid male from Deliblatska Peščara

tissue (Fig. 6).

DISCUSSION

The obvious coincidences in the unique features of structure and appearance of the skull and fur in two specimens from the same locality can be interpreted only as a significant level of mutual relationship. On the other hand, differences in their appearance and different manifestations of wolf craniological characteristics in the two specimens could be interpreted as indicating their belonging to different generations and directions of hybridization. This conclusion in the concrete case is supported by the fact that the hybrid female, which was shot one year earlier than the male, was older. It could be the ancestor of the younger and later hunted male hybrid, whose male parent was a typical wolf. The survival of some successful hybrids in the wild and their preference for wolf packs in comparison to dog society is known from the literature (R y a b o v, 1985).

However, all these points require further research, above all combined use of mitochondrial DNA, autosomal, and Y chromosome genetic markers in order to analyze the identity of these specimens. According to V i l à *et al.* (2003), the combined use of autosomal markers and both paternally and maternally inherited markers makes it possible to determine the direction of hybridization events.

The wolves in the area of Vršački Breg and (especially) Deliblatska Peščara Sands belong to the westernmost population of South-Carpathian wolves. Both groups are to a great extent geographically isolated from other Balkan populations of the same species. The only potential communication occurs with wolves in the Romanian Carpathians, who occasionally immigrate to the region of South Banat, as well as with wolves in Southeast Serbia.

Periodically strong hunting pressure on this species in recent historical time and (especially) the appearance of endemic rabies have occasionally induced considerable reduction of wolf abundance in Southeast Banat. This has resulted in feeble natural mechanisms of population protection, enabled the infiltration of dogs, and significantly increased the possibility of occasional hybridization with them. Hybridization induced by human disruption of natural populations and their environment is a serious problem to wildlife.

Successful hybrid individuals, having a preference for authentic wolves, evidently were able to reproduce with them, producing new hybrid combinations. The case of the described male hybrid from Deliblatska Peščara Sands clearly demonstrates the process of further destruction of the genetic structure of authentic wolves, and this problem deserves further research. However, for now

there are no data on changes of behavioral characteristics (non-selective hunting of game, attacks on humans, etc.) in wolves from this region. There is no evidence of hybrid individuals forming their own autonomous pack, which would probably initiate noticeable changes in hunting and other activities of such individuals in comparison with the usual behavior of wolves.

The identification of wolf/dog hybrids is a subject of primary concern for the development of conservation and management strategies. Because of great vulnerability of the population of South-Carpathian wolves on the boundaries of their range in Serbia, there is a need for permanent and increased protection in order to maintain their adequately strong population in this region.

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СЛУЧАЈЕВИ СПОНТАНИХ УКРШТАЊА ВУКА И ДОМАЋЕГ ПСА У ЈУГОИСТОЧНОМ БАНАТУ, СРБИЈА

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У овој студији по први пут се презентују подаци о спонтаном парењу вука и домаћег пса у природним условима на територији Србије, засновани на три хибридна примерка југоисточног Баната.

На основу сложене морфолошке и краниолошке анализе хибрида и поређењем са "материјалом аутохтоних" вукова из тог региона, могуће је пратити процес локалне мултипне хибридизације са псима и поремећаја аутентичне генетичке структуре вука. Идентификација хибрида вука и пса јесте од нарочите важности у развићу конзервације, заштити и стратегији менаџмента.