

## Controversies of Origin of Domestic Dog - II - References of Fossil Dogs

Orhan Yilmaz

Ardahan University, Vocational High School of Technical Sciences, 75000, Ardahan, Turkey

### Review Article

#### \*Corresponding author

Orhan Yilmaz

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**Abstract:** The dog family or *Canidae* is a group of carnivore mammals in which the dog, *Canis familiaris*, is the only member to have been domesticated, although the red fox and the raccoon from time to time have been bred for their fur. The origin of the dog is always a popular argument subject because of place and time of domestication. To solve this question there are plenty analysis not only in modern breeds, but also ancient dog remains. First the Middle East was suggested as an origin of dog based on archaeological remains. Later than regions of Europe and Southeast Asia were also proposed as candidates of origin place. It is sure that there will be unearthed much more archaeological canid remains, which will ease the solution or not. It seems to be that those debates will continue for a while until whole or at least majority of scientists are gathered around a round table and get consensus.

**Keywords:** ancient dog, *Canis familiaris*, *Canis lupus*, DNA analysis, domestication

### INTRODUCTION

Dogs always have been a part of the history of human. The people had deep ties with their dogs in civilization of China, Egypt, Greece, India, Mesoamerica, Mesopotamia, Rome, and Turk [1, 2]. This history contained a close partnership between dogs (*Canis familiaris*) and humans. That partnership could be based on human needs either for help with herding and hunting or an early alarm system, or a source of food or a companionship [3]. Although 80 % of dog breeds were modern breeds that evolved in the last few hundred years, some dog breeds had ancient histories that go back thousands of years [4].

The archaeological sites or old remains from history can inform us about canids. Archaeological evidence of domestication, such as representations of scenes of husbandry or remains of objects linked with husbandry, for instance yokes, are rare and often ambiguous. Hence, the best way to investigate early domestication consists of studying archaeological skeletal remains which means archaeozoology [5]. The biologists, archaeologists and genetics study the mtDNA of the dogs and wolves which are abundant in ancient sites and remains [6]. For example ancient DNA proved that New World Dogs were derived from Old World gray wolves. Some fossil dog remains were found in Alaska, Mexico and South America that showed us that humans who crossed the Bering land bridge about 12-14.000 years ago brought dogs with them as they populated the New World [7]. According to a MSc thesis completed by Magda Nassef who graduated from University of Leeds, the Egyptian jackal (*Canis aureus lupaster*) was more similar to a grey wolf than to any jackal [8]. Also a multi-national group of researchers claimed that the Ethiopian highland jackals were in fact Egyptian jackals. More importantly the research team concluded that the *C. A. lupaster*,

whether found in Egypt or Ethiopia, was a type of grey wolf [9]. Another example the largest dog necropolis was found in Cattle of Yoncatepe, in Van Province of Turkey. In the necropolis there were unearthed fossil bones about 79 dogs. Dogs were buried with human in same grave because dogs used to seem a family member in Urartians and buried with human [10]. Until Epipalaeolithic period, animals were killed by direct impact but in the Epipalaeolithic, hunting strategies changed as humans started to use arrows armed with tiny stone blades. The success of this new strategy would have enhanced a new partnership between hunters and predomesticated dogs, which would help track and bring back wounded animals [11]. Belli, the Turkish archaeologist, also found some rock art in Calli Village of Kagizman County of Kars Province of Turkey. Belli reported that hunting seen with dog was about 15.000 years ago rock art. Belli revealed that the rock carving showed that dogs used to use to hunt deer and/or wild goats in ancient times [12, 13].

According to scientists relationship between the fossil remains of wolves and humans had been unearthed from sites as old as 500,000 years before the

present, but there was no evidence that these wolves were domesticated or even tamed [14]. Germonpré et al. published a paper related with Palaeolithic dog skulls at the Gravettian Predmosti site in the Czech Republic. Dogs skulls were dated to 27-26.000 years BP. The one of the skull had a hole made by an arrow [15, 16]. This proved that European people had contact to Palaeolithic

dogs in those dates and moreover they hunt and eat those dogs.

This paper aims to brief the present situation of knowledge collected by archaeology and archaeozoology of studying dog domestication supported by DNA analysis since middle of 20<sup>th</sup> century.

**Table-1: Some fossil canid places in the World**

Site	Culture	Years B.P.	Species	Reference
Tabun B (Israel)	Mousterian	45.000	Dog or Wolf	[17]
Kebara E (Israel)	Aurignacian	30-25.000	Dog or Wolf	[18]
Goyet (Belgium)	Aurignacian	30-25.000	Dog	[15]
Predmosti (Czech)	Gravettian	28-20.000	Dog	[15]
Avdevo (Czech)	Gravettian	28-20.000	Dog	[15]
Chauvet (France)	Aurignacian	26.000	Dog	[11]
Kostenski (Czech)	Early Upper Palael.	18-12.800	Dog	[15]
El-Wad C (Israel)	Levantine Aurign.	20.000	Dog or Wolf	[17]
Kebara C (Israel)	Kebaran	24-14.000	Dog or Wolf	[18]
Eliseevichi 447 (Russia)	Epigravettian	20-8.000	Dog	[19]
Eliseevichi 23781 (Russia)	Epigravettian	20-8.000	Dog	[19]
Mezin 5490 (Ukraine)	Epigravettian	20-8.000	Dog	[20]
Mezhirichi (Ukraine)	Epigravettian	20-8.000	Dog	[21]
Eliseyevichi (Russia)	Upper Paleolithic	17-13.000	Dog or Wolf	[14]
Kesslerloch (Switzerland)	Magdalenian	14.6-14.100	Dog	[22]
Bonn-Oberkassel (Germany)	Upper Paleolithic	14.000	Dog	[14]
Neve David (Israel)	Geometric Kebaran	13.000	Dog or Wolf	[23]
Kebara B (Israel)	Lower Natufian	12.000	Dog or Wolf	[18]
EinMallaha (Israel)	Early Natufian	12-11.000	Dog	[24]
Saint-Thibaud (France)	Epipaleolithic	12-9.000	Dog	[25]
Senckenberg (Germany)	Mesolithic	12-9.000	Dog	[26]
Bedburg (Germany)	Mesolithic	12-9.000	Dog	[27]
El-Wad B (Israel)	Natufian	11-11.500	Dog or Wolf	[17]
Shukbah B (Israel)	Upper Natufian	11.000	Dog or Wolf	[28]
Jericho (Israel)	Proto Neolithic	10.000	Dog or Wolf	[29]

### Literature of Ancient *Canidae*

Until 1997 the complete nucleotide sequences of mitochondrial genomes of 24 mammalian species had been published except the dog and wolf. American opossum (*Didelphis virginiana*), armadillo (*Dasypus novemcinctus*), blue whale (*Balaenopterus musculus*), Bornean orangutan (*Pongopygmaeus*), cat (*Feliscatus*), common chimpanzee (*Pan troglodytes*), cow (*Bostaurus*), donkey (*Equus asinus*), fin whale (*Balaenoptera physalus*), gorilla (*Gorilla gorilla*), grey seal (*Halichoerus grypus*), guinea pig (*Caviaporcellus*), harbour seal (*Phocavitulina*), hedgehog (*Erinaseuseuropaeus*), horse, (*Equuscaballus*), human (*Homo sapiens*), Indian rhinoceros (*Rhinoceros unicornis*), mouse (*Mus musculus*), platypus (*Ornithorhynchusanatinus*), pygmy chimpanzee (*Pan paniscus*), rat (*Rattus norvegicus*), Sumatran orangutan (*Pongoabelii*), wallaroo (*Macropus robustus*), and white rhinoceros (*Ceratotherium simum*) [30-50] were published but not domestic dog and wolf.

Per cell contains about 50 to 100 mitochondria and each mitochondrion contains about 50 to 100 copies of its genome. As a potential total of 2,500 to 10,000 copies of mitochondrial DNA (mtDNA) is in each animal cell. Hence a true way to investigate of the DNA from domesticated dogs and wild wolves is the mtDNA. On the other hand, analysing ancient DNA is not so simple, fast and easy, because several effects should be considered during analysing. The archaeological remains (Table 1) are usually incomplete and do not include all chain links of the evolutionary or domestication process. In additional, the amount of each archaeological sample is usually very limited and also being a very precious sample that sometimes is not amenable for analyses requiring destructive analytical methodologies. Special care should be taken to prevent the contamination of the ancient samples with modern DNA, which may jeopardize the subsequent downstream analyses. Moreover, the ancient DNA (aDNA) of archaeological remains may be absent, chemically changed and too physically degraded, which

may block or at least challenge its downstream processing [51].

#### **The Probable Origin of Middle East (Until 1990)**

A study was reported from Denmark that among the oldest and best-known skeletal material of the domestic dog were found in the Maglemosian settlements from the bogs at Mullerup, Svaerdborg, Holmegaard, Lundby and Aamosen near Halleby river, all in Zealand. Although tens of thousands of bones had been unearthed from these settlements, very few dog bones were found. The fossil dog bones were very fragmentary, and several showed marks where they had been cut which demonstrated that like those of other animals they were used as food by human [26]. In 1970 a dog skeleton unearthed at Rodgers Shelter, Benton County, Missouri, came from a zone dating at approximately 7.500 BP. The animal was buried in a shallow pit beneath a tumulus of limestone rocks and it was one of the earliest instances of canid burial to be recorded for North America [52]. A group of scientists worked on fossil canid bones which were supplied from several Archaeological Museums in Israel. The canid bones were from Natufian age dated 12.000 years ago. According to bones scientists thought wolves domesticated in Israel were of a large breed which was the contrary of previous theories on. Moreover, they decided that the dog was domesticated at a period earlier than the Natufian age [53]. In 1997 a group of Israeli scientists searched domestication by using fossil dogs which came from Late Natufian period dated about 11.000 BP. Those Natufian remains compared with all Natufian remains and the results suggested that genuine dogs were already living around and within human habitations during this period [54].

#### **The New World Dogs (2001-2005)**

Tito *et al.* surveyed a DNA study on American Holocene dogs. They suggested that the oldest genetically identified dog in the Americas directly dated to 9,260±170 Cal. BP and there was no evidence of local interbreeding with wolves. They also claimed that the domestic dog bone in a human paleofecal sample provided the earliest direct evidence for human consumption of dogs in the New World. These data supported the hypothesis that dogs had been a food source for early Paleoamericans [55]. A team studied on ancient DNA evidence for Old World origin of new world dogs by analysing mtDNA. Observed analysis data from ancient dog remains from Latin America and Alaska showed that native American dogs originated from multiple Old World lineages of dogs that accompanied late Pleistocene humans across the Bering Strait. Among mtDNA sequences especially one clade of dog sequences was unique to the New World, which was consistent with a period of geographic isolation. This special clade was absent from a large sample of modern dogs, which implied that European colonists systematically discouraged the breeding of native American dogs [7].

Sharma *et al.* fished ancient wolf lineages in India by using 45 *Canis lupus pallipes* from subcontinent of India and 23 *C. L. Chanco* from western and central Himalayas. All 45 lowland Indian wolves had one of four closely related haplotypes that form a well-supported, divergent sister lineage to the wolf-dog clade and this lineage might have been independent for more than 400 000 years. On the other hand, although seven Himalayan wolves from western and central Kashmir were within the widespread wolf-dog clade, one from Ladakh in eastern Kashmir, nine from Himachal Pradesh, four from Nepal and two from Tibet form a very different basal clade. This lineage contained five related haplotypes that probably diverged from other canids more than 800 000 years ago. They could not find no evidence of current barriers to admixture [56]. Verginelli *et al.* examined ancient European wolves and dogs by using a worldwide sample of 547 purebred dogs and 341 wolves. They analysed a 262-bp mitochondrial DNA control region fragment retrieved from five prehistoric Italian canids ranging in age from about 15,000 to 3,000 years ago. The results provided a-DNA support for the involvement of European wolves in the origins of the three major dog clades. Genetic data also suggested multiple independent domestication events. East European wolves could still reflect the genetic variation of ancient dog-founder populations [57].

#### **The Probable Origin of Europe (2006-2010)**

A year later Verginelli investigated another experiment for origins of dogs. The research team provided mitochondrial DNA sequences from Italian fossil bones attributed to three Late Pleistocene-Early Holocene wolves dated from about 15.000 to 10.000 years ago and two dogs dated to about 4.000 and 3.000 years ago respectively. By taking paleogeography into account, the phylogenetic data pointed to a contribution of European wolves to the three major dog clades, in agreement with archaeozoological data. The obtained phylogeographic data also suggested genetic differentiation of dogs and wolves related to isolation by geographic distance, supporting multicentric origins of dogs from wolves throughout their vast range of sympatry [58]. Pluskowski investigated European grey wolf (*Canis lupus lupus*) remains in medieval archaeological contexts and he pointed that there was a difficulty in distinguishing between the skeletal elements of wolves and dogs, accentuated by poor preservation and fragmentation [59]. Belli reported that hunting seen with dog about 15.000 years ago rock carving in village of Calli, county of Kagizman, province of Kars, Turkey. Belli revealed that the rock carving showed that dogs used to use to hunt deer and/or wild goats in ancient times [12]. A Swedish research group perused 24 mtDNA sequences in ancient Scandinavian dogs. The breeds originating in northern Europe were characterized by having a high frequency of mtDNA sequences belonging to a haplogroup D

which was rare in other populations but this haplogroup was not presented in central or northern Europe samples. As a result, the Swedish team could not find no evidence for local domestication and also interpretation of the processes responsible for current domestic haplogroup frequencies should be carried out with caution if based only on contemporary data, but they also pointed out the East Asia for dog domestication [60]. A multinational research team led by Germonpré analysed both fossil and modern dogs and wolves by using multivariate molecular techniques. The fossil bones were provided from sites in Belgium, Ukraine and Russia. They were examined to look for possible evidence of the presence of Palaeolithic dogs. The fossil large canid from Goyet (Belgium), dated at circa 31,700 BP is clearly different from the recent wolves, resembling most closely the prehistoric dogs. This demonstrated that dog domestication had already started during the Aurignacian period. Selected Belgian examples were analysed for mtDNA and stable isotopes. All fossil samples delivered unique DNA sequences, indicating that the ancient Belgian large canids carried a substantial amount of genetic diversity. Moreover, there was little evidence for phylogeographic structure in the Pleistocene large canids, as they did not form a homogenous genetic group. Even though significant variation was observed in the fossil canid isotope signatures between sites, the Belgian fossil large canids preyed in general on horse and large bovids [15].

#### **Challenges between Germonpré and Crockford (2011-2014)**

A multinational research team who were from Russia, Canada, UK, USA, and the Netherlands reported a 33,000-year-old dog-like canid remains found in Razboinichya Cave, Altai Mountains of southern Siberia, Russia. The dog-like canid remains were very well preserved including skull, mandibles (both sides) and teeth. A radiocarbon dating of the skull and mandible of the Razboinichya canid proved that the canid was ca. 33,000 years old [61]. Some Early Neolithic dog and wolf burials were unearthed in Cis-Baikal, Siberia, Russia. The Samanka cemetery was located at the south-western end of Lake Baikal. At least 154 individuals from 96 graves were unearthed and human bone was dated about 7,000 to 6,1000 years BP. The second cemetery was located 75 km northeast of Shamanka. The canid and human remains were dated about 7-8,000 BP by using radiocarbon method [62].

A crowded search team analysed 49,024 autosomal SNPs in 1,375 dogs from 35 breeds and 19 wolves. They combined the observed data with previously published data and contrasted the genetic signatures of 121 breeds with a worldwide archaeological assessment of the earliest dog remains. According to results, first none of the ancient breeds derived from regions where the oldest archaeological remains have been found. Secondly three of the ancient breeds of Basenjis, Dingoes, and New Guinea Singing

Dogs came from regions outside the natural range of *Canis lupus* which was accepted as the dog's wild ancestor [63]. Germonpré et al. researched some Palaeolithic dog skulls unearthed from Gravettian Predmosti site in the Czech Republic. The research team studied three complete skulls which were identified as Palaeolithic dogs. The short skull lengths, short snouts, and wide palates and braincases indicated that they were relative to wolves. As a result, modifications by humans of the skull and canine remains from the large canids of Predmosti indicated a specific relationship between humans and large canids [16].

Some fossil remains were found in Kesslerloch Cave in Switzerland which was one of the major Magdalenian sites in Central Europe. Analysis results demonstrated that the large maxillary fragment was directly dated to c. 14,100-14,600 BP. The scientists decided that sizes of maxillary fragment were metrically well below the natural variability of wolves from both Palaeolithic and recent times and even show slight morphological differences to the wild wolves from the site. At conclusion the maxilla fragment could be considered as the earliest indisputable directly dated evidence of a domestic dog [22]. To against to opinions of Germonpré *et al.* [15, 16], a paper was published by Crockford and Kuzmin as a counter opinion about Palaeolithic dog skulls [64]. Crockford and Kuzmin claimed that the 'Palaeolithic dogs' described by Germonpré *et al.* [15, 16] and the 'putative incipient dog' described by Ovodov *et al.* [61] could simply be rather 'short-faced' wolf individuals that lived within a population of typical wolves that interacted in various ways with human hunters. In additional while the dog-like morphology of some Late Pleistocene wolves could have arisen due to persistent interactions with people over varying lengths of time, it was misleading to call this relationship 'domestication' [64]. The year after Germonpré issued a reply against to counter opinion of Crockford and Kuzmin [16]. He answered to Crockford and Guzman that they made some errors, misunderstandings and misrepresentations that he remedied there. According to Germonpré the early wolf domestication must have been regarded as an intimate relationship between humans and canids including the breeding of the latter by prehistoric people, resulting in the European Palaeolithic dogs [64].

A study perused to detect mtDNA genomes of ancient canids by suggesting a European origin of domestic dogs. The search team analysed the mitochondrial genomes of 18 prehistoric canids from Eurasia and the New World, along with a comprehensive panel of modern dogs and wolves. The results suggested that the mitochondrial genomes of all modern dogs were phylogenetically most closely related to either ancient or modern canids of Europe. Moreover, the molecular dating recommended an onset of

domestication there 18,800 to 32,100 years ago. Those observed data also meant that domestic dogs were the culmination of a process that initiated with European hunter-gatherers and the canids with whom they interacted. They also agreed with the opinion of that the geographic and temporal origins of the domestic dog remain controversial, as genetic data proposed a domestication process in East Asia starting 15,000 years ago, whereas the oldest doglike fossils were unearthed in Europe and Siberia and date to circa 30,000 years ago [65].

A group of scientists achieved a study to test two purposes. The first purpose of this study was to search temporal patterns in ancient dog burials in the Lake Baikal region of Eastern Siberia and the second purpose was to define whether the practice of dog burial here could be correlated with patterns in human subsistence practices, in particular a reliance on terrestrial mammals. According to direct radiocarbon dating of a suite of the region's dog remains demonstrated that those animals were given burial only during periods in which human burials were common. Dog burials of any kind were most common during the Early Neolithic dated 7–8000 BP and rare during all other time periods. In addition only foraging groups seemed to have buried canids in this region, as pastoralist habitation sites and cemeteries generally lack dog interments, with the exception of sacrificed animals. Stable carbon and nitrogen isotope data proved that those dogs were only buried where and when human diets were relatively rich in aquatic foods, which here most likely included river and lake fish and Baikal seal (*Phocasibirica*). Human and dog diets commonly emerged to have been similar across the study sub regions, and this was important for interpreting their radiocarbon dates, and comparing them to those obtained on the region's human remains, both of which likely carry a freshwater old carbon bias. Slight offsets were observed in the isotope values of dogs and humans in their samples, particularly where both had diets rich in aquatic fauna. This could result from dietary differences between people and their dogs, perhaps due to consuming fish of different sizes, or even different tissues from the same aquatic fauna. The paper also ensured a first glimpse of the DNA of ancient canids in Northeast Asia [66]. Boudadi-Malignea and Escarguel proposed that the recent genetic, morphological and radiometric analyses of relevant skeletal material apparently proved the presence of canids on Eurasian Early Upper Palaeolithic sites to be more widespread than previously envisaged. They also recommended that the further highlights needed for caution when considering species attributions and, more particularly, accurately identifying dog rather than wolf remains in archaeological assemblages. In addition a combination of biometric and morphological data provided a reliable basis for critiquing a series of recent publications purportedly demonstrating the presence of

dogs alongside humans during the Early Upper Palaeolithic [67].

## CONCLUSION

There were at least seven different origins of agriculture at seven different places and times. Maybe the origin of wheat cultivation was the oldest, but rice, corn and others were also cultivated on various places and times [68] which effects dog domestication. Archaeologists reported that burial of dogs first appeared in Eurasia during the late Pleistocene. During the Holocene era in Eurasia relationships between humans and dogs had been characterized as friendship and mutual respect, burials as evidence of the animals being considered persons or companions. The reason of animal bodies put with human corpses after death in Northern Eurasia was to concern for bodies of the human dead. Both were persons and possessed souls-proper treatment after death helped to ensure regeneration of their souls and the formation of new persons. Hence especially in Eurasia there were plenty of human-dog burials [62]. Researching the origin of dogs based on ancient canid remains was started in the 1990s by scientists. First Dayan [53] claimed that the origin of dog was Israel because of Natufian culture dog remains. After three years Tchernov and Valla [54] rejected his theory and suggested Levant culture for dog domestication. In the 2000s Verginelli [57, 58] proposed multicentric origins of dogs including regions of East Asia, Southeast Europe, and Middle East based on archaeological canid remains. In the late 2000s Germonpré *et al.* [15] claimed that the origin of dog was Europe by suggesting based on Palaeolithic dog of Aurignacian culture but the same year Malmström *et al.* [60] recommended a controversial opinion. Malmström a person who supposed to have a strong sense of humour explained her theory by choosing an interesting title of "Barking up the wrong tree". She and her team suggested an origin for dogs for East Asia rather than northern Europe. In the 2010s some scientists revealed that there were strong evidences of ancient dog remains from Central Asia even dated up to 33,000 years ago [61, 62, 66]. On the other hand, the same year Galibert *et al.* insisted on defending the Middle East origin of dogs [11]. It was also highly remarkable argument between two teams led by Germonpré and Crockford about Palaeolithic dog skulls. Recently Napierala and Uerpman [22] and Thalman *et al.* [65] exhibited also new evidences about the European origin of dogs. Although one of the last published opinions was claimed by Boudadi-Malignea that the presence of canids on Eurasian Early Upper Palaeolithic sites was much more widespread than previously imagined. But Boudadi-Malignea also declared that the timing of wolf and dog domestication remained a subject of intense debate as we thought [67].

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