

THE FOSSIL RECORD OF THE GENUS *CANIS* (CANIDAE, CARNIVORA, MAMMALIA) FROM THE UPPER VALDARNO: A CRITICAL REVISION IN THE FRAME OF THE EARLY AND MIDDLE PLEISTOCENE CANIDS OF EURASIA

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ABSTRACT: The outstanding fossil record of the Upper Valdarno Basin is renowned since the XV century. Its Early Pleistocene sample of canids, characterized by the large sized *Lycaon falconeri* and the medium-sized *Canis arvensis* and *Canis etruscus*, has laid the basis for the study of the evolution of the genus *Canis* in Western Eurasia. In recent years, several discoveries tend to modify our conception on this subject, e.g. the lineage that leads to modern wolves or the inter/intraspecific variability of fossil species, but the record of UV Basin remains one of the most extensive and important of its age.

KEYWORDS: Upper Valdarno, Pleistocene, Canidae, taxonomy, evolution

1. INTRODUCTION

In the international panorama of continental Quaternary sites, the Upper Valdarno Basin is historically renowned from the Renaissance for its outstanding record of large mammals (Rook et al., 2013), and since the 18th century naturalists and early palaeontologists, above all G. Cuvier (Cuvier, 1812; 1821-1824), have studied the mammals recovered from this basin (Cioppi & Dominici, 2010). For the scholars who study the family Canidae, the significance of this basin emerged by the end of the 19th and the beginning of the 20th century (Forsyth Major, 1877; Del Campana, 1913) with the description of the medium-sized *Canis arvensis* Del Campana, 1913 and the large *Lycaon falconeri* (Forsyth Major, 1877). These two species, together with *Canis etruscus* Forsyth Major, 1877 also recovered from the other Tuscan locality of Olivola, represented the earliest species of the genus to be described in Western Eurasia. The faunal assemblage of these localities suggested a correlation to the beginning of the Calabrian (i.e., at that time, the Plio-Pleistocene boundary) (Azzaroli, 1977), as confirmed by some magnetostratigraphic calibrations (e.g. Napoleone et al., 2003). The appearance of *Canis etruscus* came to be known as the “Wolf event” (Azzaroli, 1983; Azzaroli et al., 1988; Rook & Torre, 1996). Other findings, e.g. those of Coste San Giacomo (2.1 Ma, Bellucci et al., 2012) and Vialette (disputed 3 Ma, Lacombat et al., 2008), have shown the diachronic state of the arrival of *Canis* taxa in Europe (Sotnikova & Rook, 2010 for further discussion). Nevertheless, the record of *Canis* the Upper Valdarno still has to be regarded with great interest by international researchers for the implication its fossil have. For instance, *C. etruscus* is generally considered as the an-

cestor of the lineage that leads to the modern wolf (Sotnikova, 2001; Brugal & Boudadi-Maligne, 2011). Moreover, several sites across Eurasia indicate the occurrence of *C. etruscus*-like canids (see Cherin et al., 2014 and reference therein). On the contrary, *C. arvensis* seems limited to sites of “Tasso FU” faunal components (Torre et al., 1992). Interestingly, the former argued that this species could be the European representative of a holoarctic coyote-like population, with *Canis lepophagus* as American correspondent. During the Early Pleistocene the diversity of species of *Canis* is not limited to these two as *Canis senezensis* Martin, 1973 was described from Senèze (Massif Central, France; ca. 2 Ma) whereas in Spain, *Canis accitanus* Garrido & Arribas, 2008 is reported from Fonelas P-1 (Guadix Basin, Granada ca. 1.9-1.7 Ma). Around 1.5-1.4 the first representatives of *Canis mosbachensis* Soergel, 1925 appears in Spain and in Italy. Lastly, from the site of Apollonia comes the disputed *Canis apollonensis* Koufos & Kostopoulos, 1997. This variability of species decreases around the Epivillafranchian (ca 1 Ma) as only *C. mosbachensis* remained in Western Europe (Sotnikova & Rook, 2010). In Asia, the pattern of decrease in diversity is similar. During the Early Pleistocene several medium- to large-sized species were present [*Canis chihliensis* Zdansky, 1924 and *Canis palmidens* (Teilhard de Chardin & Piveteau, 1930) from Nihewan Basin; *Canis teilhardi* Qiu et al., 2004, *Canis longdanensis* Qiu et al., 2004 and *Canis brevicephalus* Qiu et al., 2004 from Longdan] but in the Middle Pleistocene the medium-sized and mesocarnivorous niche of canids was occupied by *C. mosbachensis variabilis* Pei, 1934 (Jiangzuo et al., 2018).

This short review aims to resume past knowledge in the light of recent discoveries with unpublished material



Fig. 1 - Geographic localization of the sites considered in this study. 1, Venta Micena, Spain; 2, Cueva Victoria, Spain; 3, Vallparadís Estació-Cal Guardiola, Spain; 4, Olivola, Italy; 5, Upper Valdarno, Italy; 6, Pirro Nord, Italy; 7, Gerakarou, Apollonia-1, Petralona, Greece; 8, Dmanisi, Georgia; 9, Vértesszölös II, Hungary.

that has significant implications for the phylogeny of this group of Carnivora.

2. MATERIAL AND METHODS

The material considered for the present research is housed at the Museum of Natural History of the University of Florence. Comparative fossil and extant sample studied comes from various European sites (Fig. 1) and it is held in different European and North American institution as the Montevarchi Paleontological Museum; La Specola Zoology section of the Museum of Natural History of the University of Florence; the American Museum of Natural History (New York); the Georgian National Museum (Tbilisi); the Aristotle University of Thessaloniki; the Hungarian Museum of Natural History and the Geological Society of Hungary (Budapest); Earth Science department of the Université Claude Bernard Lyon-1. Furthermore all the relevant literature on fossil *Canis* has been reviewed. The morphometric analyses used in this study include log ratio diagrams (Simpson, 1941), box plots, and biplots. Those analyses were performed with PAST ver. 3.14 (Hammer, 2016). The measurements were taken to nearest of 0.1 mm following Driesch (1976).

3. RESULTS

The morphometric and morphological comparison of the Tuscan material of *C. etruscus* and that of *C. etruscus* from Dmanisi showed important difference both in dental proportions and, more importantly, in cranial features e.g., the elongation of the skull in ros-

trocaudal sense; the length of the nasal (Fig. 2); the height of the skull; the anteroposterior divergence of the medial wall of the tympanic bullae. The morphology of these characteristics in *C. "etruscus"* from Dmanisi are more similar to the other Early Pleistocene canid *C. mosbachensis* as well as to extant and more derived species e.g. *C. lupus* rather to the coeval *C. etruscus* or *C. arnensis*. Similar characteristics have been recognized in the sample of Gerakarou (Greece). Although the size is intermediate between *C. arnensis* and *C. etruscus*, the greek specimens show the same morphologies that characterize the material of *Canis* sp. from Dmanisi.

The analyses on several samples taxa from Early and Middle Pleistocene sites across Europe such as Venta Micena, Pirro Nord, Apollonia, Petralona, Vértesszölös II (Fig. 1) have revealed a wide range of variability in size but a general morphology shared by all these samples, all referable to *C. mosbachensis*-like canids.

4. DISCUSSION AND CONCLUSIONS

The fossils of *C. arnensis* and *C. etruscus* of the Olivola and Tasso FU represent one of the most extensive record of the genus *Canis* of the early Quaternary and among the earliest record in Western Europe. These samples remain pivotal basis for comparison in the attempt to resolve the intricate scenario of Early Pleistocene canids across Eurasia. The morphometric and morphological characteristics found in the Georgian *Canis "etruscus"* greatly contrast with the peculiarities of *C. etruscus*. Moreover, the *Canis* from Dmanisi presents

several cranial affinities to Eurasian *C. mosbachensis* and to other modern wolf-related species, for instance the antero-posteriorly divergent medial walls of the tympanic bullae, as also noticed by Sotnikova & Rook (2010). Relevance of this feature stands in the fact that only some extant species but no fossil taxa present it, with the exception of *C. mosbachensis* (Bartolini Lucenti et al., 2017; Jianzuo et al., 2018). Altogether this evidence leads us to consider this taxon as *Canis* sp. nov. The new information on the Dmanisi *Canis* sp. has strong implications on the evolutionary history of the Late Villafranchian canids, because it changes the widely accepted *C. etruscus*-*C. mosbachensis*-*C. lupus* lineage.

Although the status of *C. mosbachensis* is questioned by some authors (for an updated resume see Mecozzi et al., 2017), the slight morphological differences found in samples of Early to Middle Pleistocene sites attributed to *C. mosbachensis*-like canids should definitely be regarded as results of the intraspecific variability. Surely, such little variations are not sufficient to erect new species. Likewise, it would be misleading to interpret this diversity as part of the variability of the modern *C. lupus*. In this sense, the ascription of the Chinese taxon *C. variabilis* as a subspecies of *C. mosbachensis* in Jiangzuo et al. (2018) offers an interesting solution to the issue.

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REFERENCES

- Azzaroli A. (1977) - The Villafranchian stage in Italy and the Plio-Pleistocene boundary. *Giornale di Geologia*, 41, 61-79.
- Azzaroli A. (1983) - Quaternary Mammals and the End-Villafranchian Dispersal event - a turning point in the history of Eurasia. *Palaeogeography, Palaeoecology, Palaeoclimatology*, 44, 117-139.
- Azzaroli A., De Giuli C., Ficarelli G., Torre D. (1988) - Late Pliocene to early mid-Pleistocene mammals in Eurasia: faunal succession and dispersal events. *Palaeogeography, Palaeoecology, Palaeoclimatology*, 66, 77-100.
- Bartolini Lucenti S., Alba D.M., Rook L., Moyà-Solà S., Madurell-Malapeira J. (2017) - Latest Early Pleistocene wolf-like canids from the Iberian Peninsula. *Quaternary Science Review*, 162, 12-25.
- Bellucci L., Mazzini I., Scardia G., Bruni L., Parenti F., Segre A.G., Naldini E.S., Sardella R. (2012) - The site of Coste San Giacomo (Early Pleistocene, central Italy): palaeoenvironmental analysis and biochronological overview. *Quaternary International*, 267, 30-39.
Doi: 10.1016/j.quaint.2011.04.006

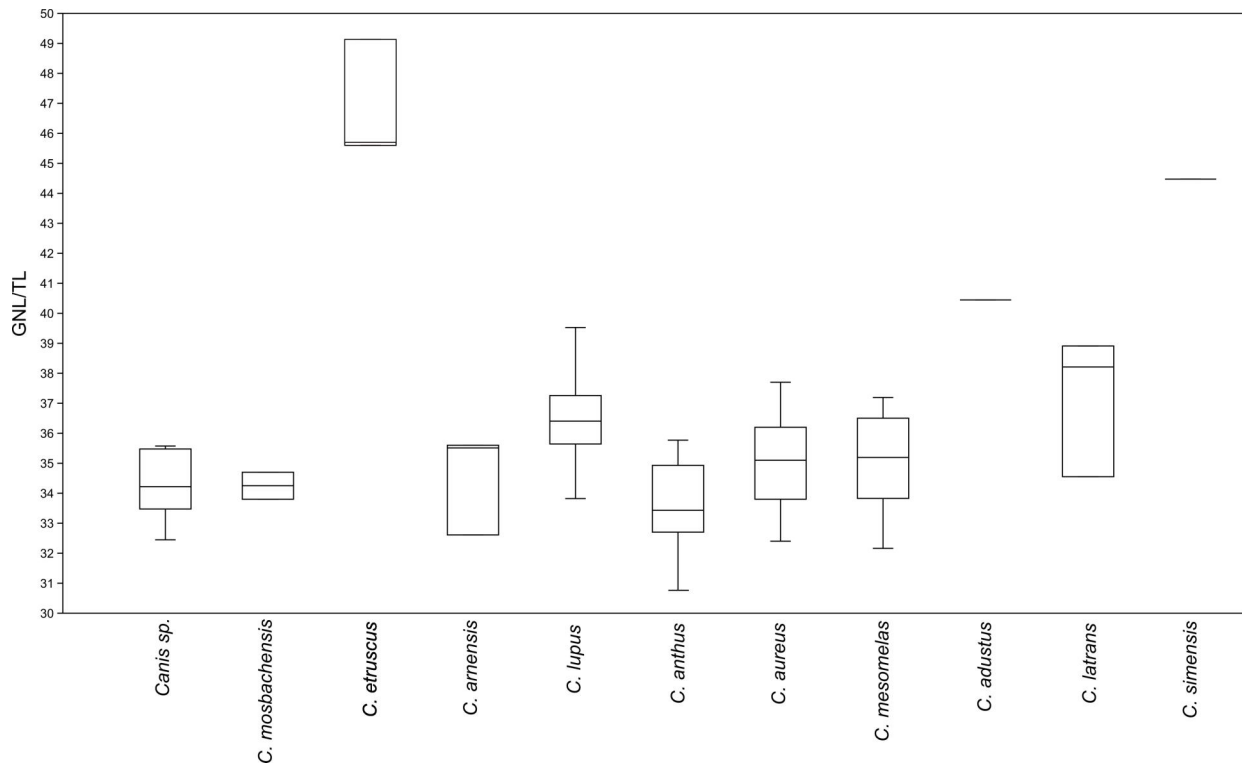


Fig. 2 - Boxplot resumming the variability of the ratio GNL/TL (greatest nasal length/total length of the cranium) in Early Pleistocene taxa (as *C. etruscus*, *C. amensis*, *C. mosbachensis*, and *Canis* sp. from Dmanisi) and in extant species of the genus *Canis*.

- Brugal J.P., Boudadi-Maligne M. (2011) - Quaternary small to large canids in Europe: taxonomic status and biochronological contribution. *Quaternary International*, 243, 171-182.
Doi: 10.1016/j.quaint.2011.01.046
- Cherin M., Bertè D.F., Rook L., Sardella R. (2014) - Redefining *Canis etruscus* (Canidae, Mammalia): a new look into the evolutionary history of Early Pleistocene dogs resulting from the outstanding fossil record from Pantalla (Italy). *Journal Mammalian Evolution*, 21, 95-110.
- Cioppi E., Dominici S. (2010) - Origin and development of the geological and palaeontological collections. In: Monechi S. & Rook L. (eds.), *Il Museo di Storia Naturale dell'Università di Firenze. Le collezioni geologiche e paleontologiche*, 3, 19-55.
- Cuvier G. (1812) - Recherches sur les ossemens fossiles, où l'on rétablit les caractères de plusieurs animaux dont les révolutions du globe ont détruit les espèces. Atlas 1-2. Deterville, Paris.
- Cuvier G. (1821-1824) - Recherches sur les ossemens fossiles, où l'on rétablit les caractères de plusieurs animaux dont les révolutions du globe ont détruit les espèces. Five volumes. Dufour et d'Ocagne, Paris.
- Del Campana D. (1913) - I cani pliocenici di Toscana. *Tipografia successori fratelli Nistri*.
- Driesch von den A. (1976) - A guide to the measurement of animal bones from archaeological sites. *Peabody Mus. Bulletin* 1, 1-137.
- Forsyth Major C.I. (1877) - Considerazioni sulla fauna dei Mammiferi pliocenici e postpliocenici della Toscana. *Memorie della Società Toscana di Scienze Naturali*, 3, 202-227.
- Garrido G., Arribas A. (2008) - *Canis accitanus* nov. sp., a new small dog (Canidae, Carnivora, Mammalia) from the Fnelas P-1 PlioePleistocene site (Guadix basin, Granada, Spain). *Géobios*, 41, 751-761.
- Hammer Ø. (2016) - PAST. PAleontological Statistics. Version 3.14. Reference Manual. Natural History Museum, University of Oslo. <http://folk.uio.no/ohammer/past/past3manual.pdf>.
- Jiangzuo Q., Liu J., Wagner J., Dong W., Chen J. (2018) - Taxonomical revision of fossil *Canis* in Middle Pleistocene sites of Zhoukoudian, Beijing, China and a review of fossil records of *Canis mosbachensis variabilis* in China. *Quaternary International*.
- Koufos G.D., Kostopoulos D. (1997) - New carnivore material from the Plio-Pleistocene of Macedonia (Greece) with a description of a new canid. *Münchener geowissenschaftliche Abhandlungen*, 34, 33-63.
- Lacombat F., Abbazzi L., Ferretti M.P., Martínez-Navarro B., Moulle P.E., Palombo M.R., Rook L., Turner A., Valli A.M.F. (2008) - New data on the Early Villafranchian fauna from Viallette (Haute-Loire, France) based on the collection of the Crozatier Museum (Le Puy-en-Velay, Haute-Loire, France). *Quaternary International*, 179, 64-71.
- Linnaeus C. (1758). *Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis*. In: *Synonymis, Locis, Editio Decima, Tomus I. Laurentius Salvius, Stockholm. reformata*.
- Martin R. (1973) - Trois nouvelles espèces de Caninae (Canidae, Carnivora) des gisements Plio-Villafranchiens d'Europe. *Documents du laboratoire de géologie de la Faculté des sciences de Lyon*, 57, 87-96.
- Mecozzi B., Iurino D. A., Berte D. F., Sardella R. (2017) - *Canis mosbachensis* (Canidae, Mammalia) from the Middle Pleistocene of Contrada Monticelli (Putignano, Apulia, southern Italy). *Bollettino della Società Paleontologica Italiana*, 56 (1), 72.
- Napoleone G., Albianelli A., Azzaroli A., Bertini A., Magi M., Mazzini M. (2003) - Calibration of the upper Valdarno basin to the Plio-Pleistocene for correlating the Apennine continental sequences. *Il Quaternario*, 16, 131-166.
- Pei W.C. (1934) - A Preliminary report on the late-palaeolithic cave of Choukoutien. *Acta Geologica Sinica (English Ed.)*, 13 (1), 327-358.
- Qiu Z.B., Deng T., Wang X. (2004) - Early Pleistocene Mammalian Fauna from Longdan, Dongxiang, Gansu, China. *Palaeontologia Sinica, New Series C*, 27, 1-198.
- Rook L., Torre D. (1996) - The wolf-event in Western Europe and the beginning of the Late Villafranchian. With 2 figures in the text. *Neues Jahrbuch für Geologie und Paläontologie*, 8, 495-501.
- Rook L., Croitor R., Delfino M., Ferretti M.P., Gallai G., Pavia M. (2013) - The Upper Valdarno Plio-Pleistocene vertebrate record: an historical overview, with notes on palaeobiology and stratigraphic significance of some of important taxa. *Italian Journal of Geosciences*, 132, 104-125.
Doi: 10.3301/IJG.2012.16.
- Sotnikova M.V. (2001) - Remains of Canidae from the lower Pleistocene site of Untermassfeld. In: Kahlke, R.D. (Ed.), *Das Pleistozän von Untermassfeld bei Meiningen (Thüringen)*, Teil. 2. Habelt Verlag, Bonn, 607-632.
- Sotnikova M.V., Rook L. (2010) - Dispersal of the Canini (Mammalia, Canidae: Caninae) across Eurasia during the late Miocene to early Pleistocene. *Quaternary International*, 212, 86-97.
- Simpson G.G. (1941) - Large Pleistocene felines of North America. *American Museum Novitates*, 1136, 1-27.
- Teilhard de Chardin P., Piveteau J. (1930) - Les mammifères fossiles de Nihewan (Chine). *Annales de Paleontologie*, 19, 1-134.
- Torre D. (1967) - I cani villafranchiani della Toscana. *Paleontographia Italica*, LXIII, 113-138.
- Torre D., Ficcarelli G., Masini F., Rook L., Sala B. (1992) - Mammal dispersal events in the early Pleistocene of Western Europe. *Courier Forschungsinstitut Senckenberg*, 153, 51-58.
- Zdanksy O. (1924) - Jungtertiäre Carnivoren Chinas. *Palaeontologia Sinica, New Series C, Geological Survey of China*. pp.223.