

Late Pleistocene-Holocene mammals from “Canale delle Acque Alte (Canale Mussolini)” (Agro Pontino, Latium)

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ABSTRACT - The classification of the fossil mammalian remains from the “Canale delle Acque Alte” collection is here revised. The stratigraphical provenance of the fossil material has now been reconstructed based on paleontological and sedimentological evidence derived from analyzes of the faunal assemblage and the sediment residue that specimens still preserve within bone cavities. Many species such as *Hippopotamus amphibius*, *Dama dama dama*, *Megaloceros giganteus*, *Ursus spelaeus*, *Vulpes vulpes*, *Bos taurus longifrons* and *Capra hircus* are recognized for the first time within the material sampled from this locality. The data obtained allowed assessment of the relative abundance of taxa based on calculation of the minimum number of individuals present. Hypotheses regarding the environmental conditions under which the fauna lived are also proposed based on the results and the ecology of the species identified. The fauna is attributed to a time interval between the end of the MIS 5a and MIS 3, while the specimens within the topmost level are Holocene in age.

RIASSUNTO - [Mammiferi del tardo Pleistocene-Olocene del “Canale delle Acque Alte (Canale Mussolini)” (Agro Pontino, Lazio)] - Vengono presentati i risultati dello studio paleontologico della collezione storica del Canale delle Acque Alte conservata presso il Museo di Storia Naturale e del Territorio dell'Università di Pisa. Il lavoro ha consentito una revisione sistematica dei resti fossili e la ricostruzione della provenienza stratigrafica dei reperti, sia mediante considerazioni paleontologiche, sia attraverso l'analisi dei sedimenti ancora reperibili all'interno delle cavità delle ossa.

Numerose le specie riconosciute, fra le quali alcune mai citate in precedenza in questo sito, come *Hippopotamus amphibius*, *Dama dama dama*, *Megaloceros giganteus*, *Ursus spelaeus*, *Vulpes vulpes*, oltre a forme domestiche come *Bos taurus longifrons* e *Capra hircus*. La fauna è dominata da *Bos primigenius* seguito da *Cervus elaphus* ed *Equus ferus*, ma significativa è anche la presenza di *Equus hydruntinus*, *Mammuthus primigenius* e *Stephanorhinus hemitoechus*. La collezione include anche alcuni esemplari di molluschi gasteropodi e bivalvi e tre frammenti di legno fossile. I dati raccolti hanno permesso di calcolare il numero di individui per una valutazione delle abbondanze relative dei taxa. Vengono inoltre avanzate ipotesi sull'ambiente e sulle condizioni climatiche in cui viveva l'associazione, basate sui risultati ottenuti e sulle caratteristiche ecologiche delle specie determinate. Si ipotizza che la fauna sia riferibile ad un intervallo cronologico compreso tra la fine dello stadio isotopico 5a e lo stadio 3, e che gli esemplari del livello più alto siano invece olocenici.

INTRODUCTION

Italy has provided rich collections of Late Pleistocene mammal remains, thus contributing substantially to our knowledge of the faunas of this time. The peninsula wedges between the cooler northern regions and the temperate-warmer southern ones. It has often shown microzonation of the climate and of its faunal communities (Petronio et al., 2005).

The late Middle to Late Pleistocene fossil remains of mammals from the so-called “Campagna Romana” are so tremendously abundant and varied to represent the Aurelian Mammal Age (35000-13000) proposed by Italian paleontologists which includes four Faunal Units: Torre in Pietra and Vitinia according to Gliozzi et al. (1997), and the recently proposed Faunal Units of Melpignano and Ingarano (Petronio et al., 2007).

The mammal assemblage of “Canale delle Acque Alte” or “Canale Mussolini” (Blanc et al., 1957) (Agro Pontino) is a Late Aurelian fauna which was collected from an uninterrupted stratigraphical sequence. Though abundant, the fossils were unfortunately collected without taking into account their stratigraphical provenance. This caused the loss of a great deal of valuable stratigraphical information.

The Acque Alte Channel was excavated in 1935; details were given by Blanc in a number studies (Blanc, 1935a, 1935b, 1935c, 1936; Blanc et al., 1957). Blanc reported the presence of: *Canis lupus*, *Canis sp.*, *Crocota crocota spelaea*, *Sus scrofa*, *Cervus elaphus*, *Capreolus capreolus*, *Bos primigenius*, *Equus ferus*, *E. hydruntinus*, *Stephanorhinus hemitoechus*, *Elephas antiquus* and *Mammuthus primigenius*. In his first publication Blanc (1935a) cited also the genus *Hippopotamus*, but he then removed it from his later lists (Blanc, 1935b).

Blanc (1935a, 1936) identified eleven layers in the Acque Alte channel sequence (Fig. 1). He named them alphabetically from the bottom upwards:

H - Marine sandy clays. In a nearby site (Grottaacce, Nettuno) similar clays contain *Plicatula*, *Brocchia*, *Isocardia*, etc., and have been attributed to the Sicilian (Blanc et al., 1957).

G - Volcanic lithoid tuffs pierced by lithodomes with *Taxus baccata*, *Ruscus aculeatus*, *Smilax pontina*, *Vitis vinifera*.

F - Shallow sea sand. This layer outcrops in the whole Pontine region. It yielded large amounts of molluscs, among which *Eastonia rugosa*, *Pectunculus bimaculatus* and *Spondylus gaederopus*. Blanc referred this layer to the Tyrrhenian II correlating it with the stratigraphical

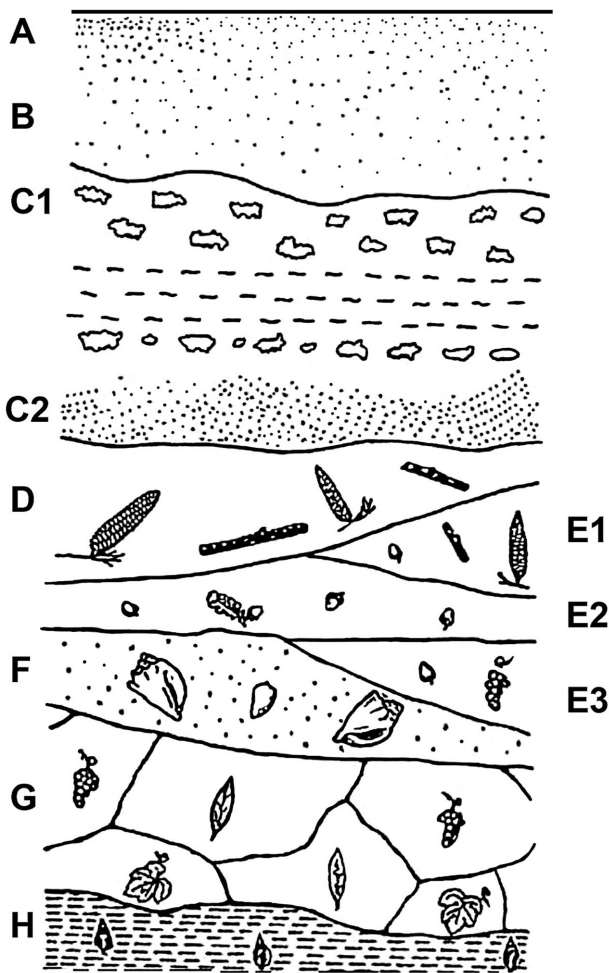


Fig. 1 - Stratigraphy of "Canale delle Acque Alte" (Blanc et al., 1957, mod.). A: Red sands; B: Yellow reddish sands; C1: Grey-green sands; C2: Reddish cross-bedded sands; D: Peat and floated trunks of *Abies alba*; E1: Peat with *Carpinus betulus*, *Abies alba*, *Taxus baccata*; E2: Peat bearing remains of *Quercus robur* subsp. *sessiliflora*, *Carpinus betulus*, *Fagus silvatica*; E3: Peat containing *Vitis vinifera*, *Cornus mas*, *Prunus spinosa*; F: Marine sand; G: Volcanic lithoid tuffs; H: Marine sandy clays.

sequence published by Clerici (1922) and with Nettuno's coastal Quaternary formations (Blanc, 1935c). Later on, as the channel was widened and deepened, Blanc found an abundant marine fauna at "Borgo Sabotino" containing

Strombus bubonius and *Conus testudinarius* (Blanc, 1935b). This evidence confirmed the attribution of this layer to the Tyrrhenian II.

E - Originally, this layer was described as grey-green sand with plant remains. Later on, Blanc (1936) and Tongiorgi (1936) recognized three different plant associations and thus divided the layer into three sub-layers:

E3 - Peat with *Vitis vinifera*, *Cornus mas*, *Prunus spinosa* etc.

E2 - Peat with *Quercus robur* subsp. *sessiliflora*, *Carpinus betulus*, *Fagus silvatica* ecc.

E1 - Peat with *Carpinus betulus*, *Abies alba*, *Taxus baccata*, etc.

In these sub-layers Blanc found also Mousterian industry of the Pontinian type.

D - Peat and floated woods. The woods were studied by Tongiorgi (1936) who reported rich amounts of *Abies*, *Corylus* and *Quercus pedunculata*.

An excavation was carried out in 1957 in the "Gnif Gnaf" area. It was aimed at collecting wood and peat samples from Blanc's layers D-E3 (Blanc et al., 1957). The samples were all radiocarbon-dated. A tree trunk of *Quercus robur* L. var. *sessiliflora* Salisb., said to be "older than 55000 years" by Prof. Hl. De Vries, was found in a dark grey sand lying in direct contact with the marine sands (F layer) (Blanc et al., 1957). Moreover, *Abies alba* from the layers E1 or E2 was given a date of 58000 years (Vogel & Zagwyn, 1967). More recently, Cocchi-Genick (1994) gave a radiocarbon date of 55000 and 58000 ± 5000 years to the lower peat of the Acque Alte channel. The age of the trunks are consistent with the MIS 4.

C - This layer had been originally (Blanc, 1935a) described as yellow sands (probably of eolian origin). Afterwards, Blanc (1936) divided it into two sub-layers:

C2 - Reddish cross-bedded sands with mammals and Mousterian industry.

C1 - Grey-green sands with mammals, Mousterian industry and calcareous concretions attesting to a climatic change towards more continental conditions. Late Paleolithic artefacts appear here for the very first time (Blanc et al., 1957).

B - Yellow reddish sands with mammals and Late Paleolithic industry.

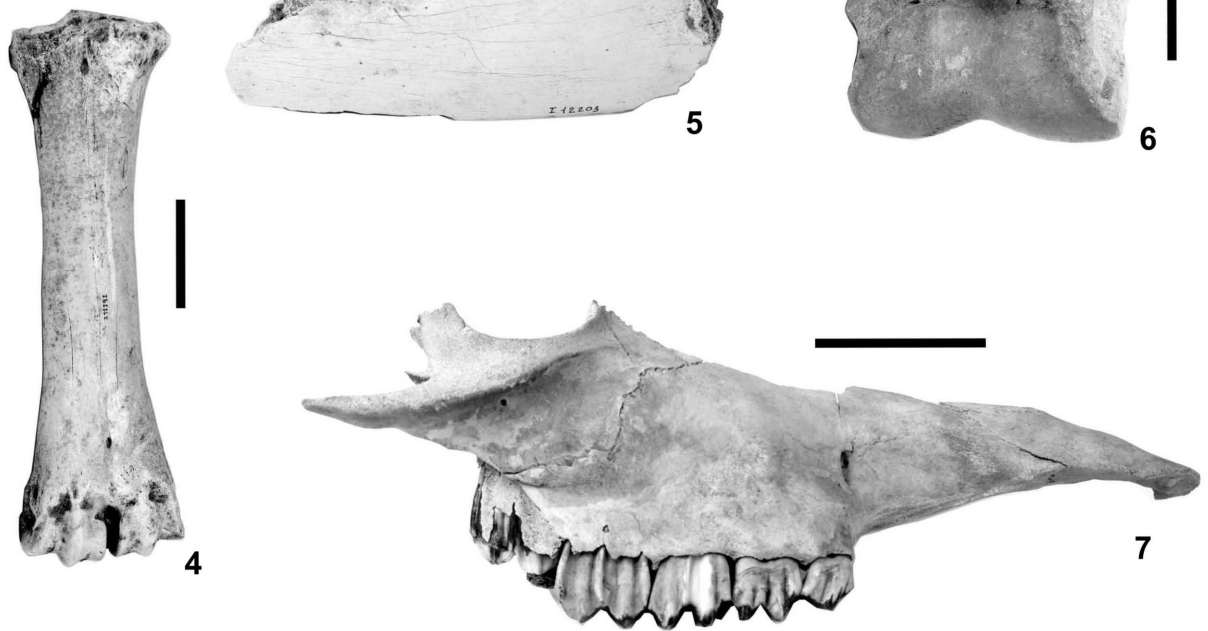
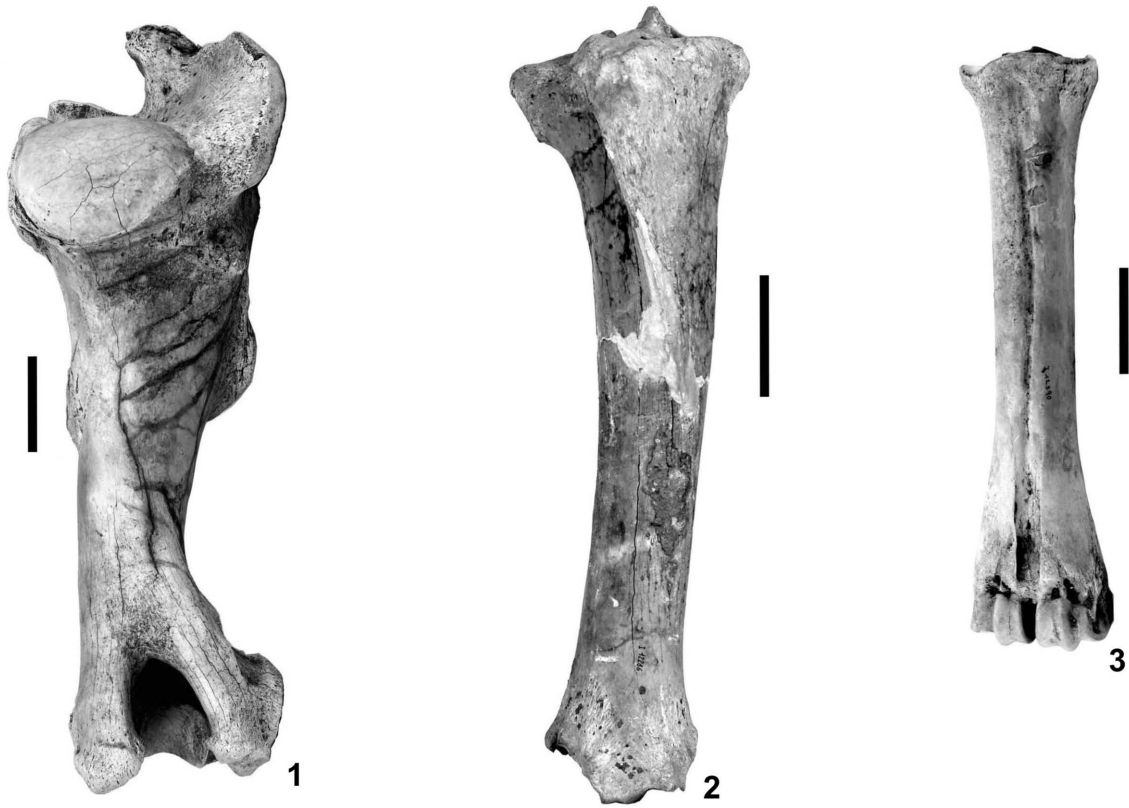
A - Red sands with Late Paleolithic industry and mammals; Bronze Age flints and pottery in the very upper portion and Roman pottery on surface (Blanc et al., 1957).

EXPLANATION OF PLATE 1

Figs 1-7 - *Bos primigenius* Bojanus.

- 1 - Right humerus, posterior view.
- 2 - Right tibia, anterior view.
- 3 - Left metatarsal, anterior view.
- 4 - Right metacarpal, anterior view.
- 5 - Fragmental left mandible, lateral view.
- 6 - Left astragalus, anterior view.
- 7 - Right jaw, lateral view.

Scale bar = 5 cm.



n° inv	class	species
I12372	Bivalvia	<i>Ostrea lamellosa</i>
I12275	Bivalvia	<i>Pecten opercularis</i>
I12229	Bivalvia	<i>Venus verrucosa</i>
I12265	Bivalvia	<i>Acanthocardia</i> sp.
I12253	Bivalvia	<i>Pecten jacobaeus</i>
I12276	Bivalvia	<i>Acanthocardia tuberculata</i>
I12341	Bivalvia	<i>Spondylus</i> sp.
I12364	Bivalvia	<i>Spondylus</i> sp.
I12361	Bivalvia	<i>Spondylus</i> sp.
I13778	Bivalvia	<i>Acanthocardia</i> sp.
I12256	Bivalvia	<i>Acanthocardia tuberculata</i>
I12365	Bivalvia	<i>Ostrea lamellosa</i>
I12272	Gastropoda	<i>Nassarius</i> sp.
I12270	Gastropoda	<i>Nassarius</i> Cfr. <i>mutabilis</i>
I13777	Gastropoda	<i>Strombus bubonius</i>

Tab. 1 - Mollusc fauna of “Canale delle Acque Alte”.

MATERIALS AND METHODS

The paleontological collection of the Acque Alte channel, which is now housed at the “Museo di Storia Naturale e del Territorio dell’Università di Pisa”, consists of about 500 specimens. Once determined both anatomically and taxonomically, all the specimens have been categorized, level by level, using the standard taphonomic parameters: NISP (Number of Identified Specimens), MNE (Minimum Number of Elements) and MNI (Minimum Number of Individuals) (Chaplin, 1971; Grayson, 1984). These parameters have then been used to calculate the relative frequency of the taxa. MNE and MNI have been assessed primarily on post-cranial specimens (cranial remains have been tallied only when there was nothing else of a given taxon). The MNE and MNI assessment accounted for age, size, and, where possible, sex.

Blanc (1935b) and Blanc et al. (1957) affirm that part of the fossils were recovered in situ, while others were found in the channel. More precisely, 159 bear a tag stating a generic provenance from “Canale Mussolini”. Other tags, in contrast, report the layer of find, i.e., “Canale Mussolini F” (4 specimens), “Canale Mussolini D” (9), “Canale Mussolini C1” (9) and “Canale Mussolini C2”

Species	NISP	MNE	MNI
<i>Elephas antiquus</i>	16	3	3
<i>Mammuthus primigenius</i>	4	3	3
<i>Crocota crocata spelaea</i>	1	1	1
<i>Ursus spelaeus</i>	2	2	2
<i>Canis lupus</i>	3	3	3
<i>Vulpes vulpes</i>	1	1	1
<i>Equus ferus</i>	33	32	22
<i>Equus hydruntinus</i>	5	4	4
<i>Stephanorhinus hemitoechus</i>	1	1	1
<i>Sus scrofa</i>	6	2	2
<i>Hippopotamus amphibius</i>	5	5	5
<i>Dama dama dama</i>	14	6	6
<i>Cervus elaphus</i>	61	42	35
<i>Megaloceros giganteus</i>	18	16	15
<i>Capreolus capreolus</i>	2	2	2
<i>Capra hircus</i>	1	1	1
<i>Ovis</i> vel <i>Capra</i>	2	2	2
<i>Bos primigenius</i>	147	121	99
<i>Bos taurus longifrons</i>	18	17	16
total values	340	264	223
anatomically determined specimens	42	33	15
total determined specimens	382	297	238

Tab. 2 - NISP, MNE and MNI values of the Acque Alte channel fauna.

(17). Features in common with the specimens collected in situ (i.e., state of conservation, kind of fossilization, colour and concretions) allowed a tentative stratigraphical repositioning of the untagged specimens.

The least fossilized specimens have been placed in the topmost and most recent layers A and B. The peaty beds E1-E2-E3, which are distinguished only on the basis of their plant content and which are barren in fossil bones, have been grouped up with the layer D (D-E3).

FAUNA

The material is fairly well preserved. Apart from the mammal remains, the collection includes also 3 fossil wood fragments as well as 27 molluscs (gastropods and bivalves). The latter comprise a *Strombus bubonius* shell and a few specimens of *Spondylus*, *Acanthocardia* and

EXPLANATION OF PLATE 2

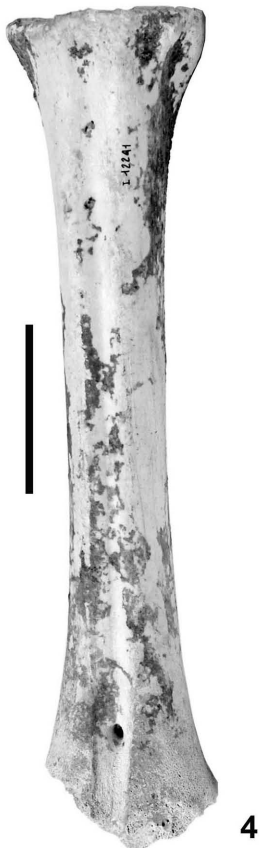
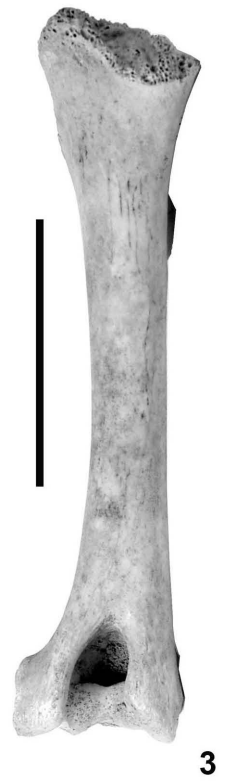
Figs 1-2 - *Hippopotamus amphibius* Linnaeus.
1 - Fragmental left tibia, anterior view.
2 - Fragmental left tibia, anterior view.

Fig. 3 - *Capra hircus* L Linnaeus. Left humerus, posterior view.

Figs 4-5 - *Bos taurus longifrons* Owen
4 - Left metatarsal, anterior view.
5 - Right astragalus, anterior view.

Fig. 6 - *Sus scrofa* Linnaeus. Left mandible, lingual view.

Scale bar = 5 cm.



Pecten (Tab. 1) which Blanc (1935a, 1935b) attributed to the Tyrrhenian, 2 gastropods and 4 bivalves from the “Le Grottae” blue marl, which Blanc (1935c) attributed to the Sicilian and some indeterminate fragments.

Alongside the mammalian species reported by Blanc (1935b), which include *Canis lupus*, *Crocota crocuta spelaea*, *Sus scrofa*, *Cervus elaphus*, *Capreolus capreolus*, *Bos primigenius*, *Equus ferus*, *Equus hydruntinus*, *Stephanorhinus hemitoechus*, *Elephas antiquus* and *Mammuthus primigenius*, the following have been recognised during the present analysis: *Ursus spelaeus*, *Vulpes vulpes*, *Hippopotamus amphibius*, *Dama dama dama*, *Megaloceros giganteus*, *Bos taurus longifrons* (syn.= *brachyceros*), *Capra hircus*, *Ovis vel Capra*. Blanc (1935b) reported also *Canis* sp.

RESULTS

Of the 500 specimens examined in this study, 42 could be determined only anatomically, and 19 of them are ribs, while 74 fragments are completely undetermined. The total NISP from “Canale delle Acque Alte” (inclusive of the specimens determined only anatomically) is 382 (Tab. 2). The faunal assemblage and the values of NISP, MNE and MNI from the fossiliferous layers of the Acque Alte Channel are reported in Tabs 3-8.

The macromammals are dominated by *Bos primigenius* (NISP=147, MNI=99); the red deer (NISP=61, MNI=35) and horse (NISP=33, MNI=22) are much less abundant, while the other faunal components are rarer. Significant occurrences are those of the steppe ass, mammoth and pachyderms, which include hippopotamus and steppe rhinoceros.

The presence of the modern fallow deer (NISP=14, MNI=6) is attested to by two fragments of antler, an incomplete right humerus, a left upper jaw and an incomplete right metatarsal from layer D, three fragments of antler, a left lower jaw and a left incomplete metacarpal from layer C2, an incomplete left metacarpal and an incomplete right metatarsal from layer C1 and a fragment of right radius from layer A, while a fragment of antler is from an unspecified level.

The giant deer (NISP=18, MNI=15) is represented by an incomplete left femur from layer D and a fragment of tooth, two complete radius, a left complete and a right

Layer	Order	Species	NISP	MNE	MNI
F	Proboscidea	<i>Elephas antiquus</i>	1	1	1
		<i>Bos primigenius</i>	2	2	2
	total	3	3	3	

Tab. 3 - Faunal assemblage from layer F and its NISP, MNE and MNI values.

Layer	Order	Species	NISP	MNE	MNI
D-E3	Proboscidea	<i>Elephas antiquus</i>	6	1	1
		<i>Mammuthus primigenius</i>	1	1	1
	Carnivora	<i>Crocota crocuta spelaea</i>	1	1	1
		<i>Canis lupus</i>	2	2	2
	Perissodactyla	<i>Equus ferus</i>	10	10	7
		<i>Equus hydruntinus</i>	1	1	1
	Artiodactyla	<i>Sus scrofa</i>	5	2	2
		<i>Dama dama dama</i>	5	2	2
		<i>Cervus elaphus</i>	8	7	5
		<i>Megaloceros giganteus</i>	1	1	1
		<i>Bos primigenius</i>	40	34	27
	total	80	62	50	

Tab. 4 - Faunal assemblage from layers D-E3 and its NISP, MNE and MNI values.

Layer	Order	Species	NISP	MNE	MNI
C2	Proboscidea	<i>Elephas antiquus</i>	6	1	1
		<i>Mammuthus primigenius</i>	2	1	1
	Carnivora	<i>Ursus spelaeus</i>	2	2	2
		<i>Canis lupus</i>	1	1	1
	Perissodactyla	<i>Equus ferus</i>	19	19	12
		<i>Equus hydruntinus</i>	2	2	2
		<i>Stephanorhinus hemitoechus</i>	1	1	1
	Artiodactyla	<i>Hippopotamus amphibius</i>	5	5	5
		<i>Dama dama dama</i>	5	1	1
		<i>Cervus elaphus</i>	27	14	12
		<i>Megaloceros giganteus</i>	7	6	6
		<i>Capreolus capreolus</i>	1	1	1
<i>Bos primigenius</i>		69	56	45	
total	147	110	90		

Tab. 5 - Faunal assemblage from layer C2 and its NISP, MNE and MNI values.

incomplete femur and two left incomplete tibias from layer C2. This species has been recognized also amongst the fossil remains from layer B with three incomplete radii, a fragment of metacarpal and an incomplete right metacarpal, two incomplete left tibias and a complete left calcaneus. Other giant deer material is of unknown stratigraphical provenance. This cervid material is perhaps

EXPLANATION OF PLATE 3

Figs 1-2 - *Megaloceros giganteus* Blumenbach.

- 1 - Left femur, anterior view.
- 2 - Left radius, anterior view.

Figs 3, 5 - *Cervus elaphus* Linnaeus.

- 3 - Fragmental left tibia, anterior view.
- 5 - Left calcaneus, anterior view.

Fig. 4 - *Dama dama dama* (Linnaeus). Fragmental right humerus, anterior view.

Fig. 6 - *Mammuthus primigenius* Blumenbach. Fragmental tusk.

Scale bar = 5 cm.



included among the specimens that Blanc (1935b) ascribed to *Cervus elaphus*.

An incomplete left humerus of *Capra hircus* has been recognized amongst the fossils from layer B, while *Ovis* vel *Capra* is attested to by a left scapula from layer B and a complete right metatarsal from layer A.

A left lower jaw, a fragmental left radius, a fragment of left pelvis, an incomplete right calcaneus, two complete right astragalus, three fragmental metatarsals, a complete first phalanx and a complete third phalanx from layer A are ascribed to the domestic *Bos taurus longifrons* (NISP=18, MNI=16). Other domestic cattle material, also present in the “Canale delle Acque Alte” sample, is of unknown stratigraphic provenance.

A fragmental right humerus, a fragmental right radius, two incomplete left tibias and a fragment of left pelvis of *Hippopotamus amphibius* (NISP=5, MNI=5) have been recognized amongst the fossil remains from C2.

The most representative specimen is an incomplete left tibia (Pl. 2, Fig. 1) which is represented by the distal epiphysis and a part of the diaphysis. The epiphysis is depressed dorso-ventrally and the measure of the breadth of the distal epiphysis (BD=107 mm) is in line with those reported by Mazza (1995) for *Hippopotamus amphibius*.

Vulpes vulpes is present in layer B with a complete right tibia, while *Ursus spelaeus* occurs in layer C2 represented by two third upper left incisors.

DISCUSSION

The present analysis led primarily to an updating of the classification of the paleontological collection of “Canale delle Acque Alte” (Farina, 2006). Collecting the fossils without stratigraphical backing caused the loss of substantial chronological and palinologic information; this seriously impacts on the paleoclimatic and paleoenvironmental significance of the assemblages. Despite these limits, the tentative stratigraphical repositioning of the specimens, the paleoecologic inferences, as well as the relative frequencies of the taxa, allows assumptions on the past habitats of the different assemblages. Moreover, a clearer definition of Canale delle Acque Alte’s biochronology is proposed.

Temperate-warm conditions are attested to in the sequence’s bottom-most bed F. Here *Elephas antiquus* and *Bos primigenius* are associated with shelf molluscs accumulated during the Tyrrhenian II regression (Blanc,

Layer	Order	Species	NISP	MNE	MNI
C1	Proboscidea	<i>Mammuthus primigenius</i>	1	1	1
	Perissodactyla	<i>Equus ferus</i>	4	3	3
		<i>Equus hydruntinus</i>	2	1	1
		<i>Dama dama dama</i>	2	2	2
	Artiodactyla	<i>Cervus elaphus</i>	5	3	3
		<i>Bos primigenius</i>	30	24	20
		total	44	34	30

Tab. 6 - Faunal assemblage from layer C1 and its NISP, MNE and MNI values.

Layer	Order	Species	NISP	MNE	MNI
B	Carnivora	<i>Vulpes vulpes</i>	1	1	1
	Artiodactyla	<i>Cervus elaphus</i>	10	10	7
		<i>Megaloceros giganteus</i>	8	7	6
		<i>Capra hircus</i>	1	1	1
		<i>Ovis</i> vel <i>Capra</i>	1	1	1
total	21	20	16		

Tab. 7 - Faunal assemblage from layer B and its NISP, MNE and MNI values.

Layer	Order	Species	NISP	MNE	MNI
A	Artiodactyla	<i>Sus scrofa</i>	1	1	1
		<i>Dama dama dama</i>	1	1	1
		<i>Cervus elaphus</i>	6	4	4
		<i>Ovis</i> vel <i>Capra</i>	1	1	1
		<i>Bos taurus longifrons</i>	11	10	9
total	20	17	16		

Tab. 8 - Faunal assemblage from layer A and its NISP, MNE and MNI values.

1935a, 1935c). During this low-stand of the sea, the peaty layers E1-E3 formed upon the newly emerged territories in swamps scattered amongst the coastal dunes (Blanc, 1936).

From layer D upwards the faunal assemblage is dominated by *Bos primigenius* (NISP=40, MNI=27), *Equus ferus* (NISP=10, MNI=7) and *Cervus elaphus* (NISP=8, MNI=5), followed by *Elephas antiquus* (NISP=6, MNI=1), *Sus scrofa* (NISP=5, MNI=2) and *Dama dama dama* (NISP=5, MNI=2). *Equus hydruntinus* and *Mammuthus primigenius* are “cold” indicators, but are rare (only one specimen each). The proportional abundances of the taxa from these basal levels of the “Canale delle Acque Alte” succession are in line with an increasing climatic cooling suggested by the occurrence of the fir forest flora from layer D.

The abundance of temperate-indicating fauna, the colonization of the coastal dunes by fir forest (Tongiorgi,

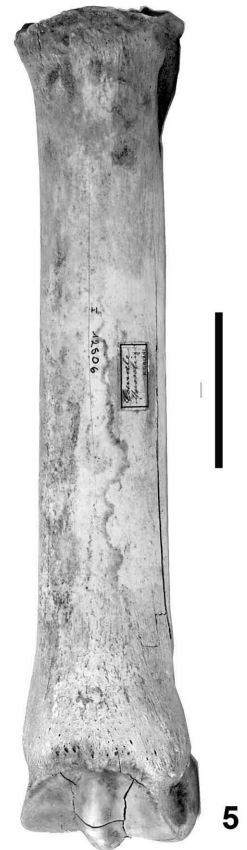
EXPLANATION OF PLATE 4

Fig. 1 - *Stephanorhinus hemitoechus* Falconer. Fragmental right scapula, lateral view.

Figs 2, 4-5 - *Equus ferus* Boaddaert.
2 - Left tibia, anterior view.
4 - First phalanx, anterior view.
5 - Left metatarsal, anterior view.

Fig. 3 - *Equus hydruntinus* Regalia. First phalanx, anterior view.

Scale bar = 5 cm.



1936), together with the presence of the rare cold-indicating faunal components, suggest that this is a time-averaged portion of the succession, long enough to embrace a relatively warmer period followed by the onset of cooler-humid (oceanic) conditions. Trunks from the E2-E1 layers in fact gave a radiometric date of 58000 years (Vogel & Zagwyn, 1967), which correlates these levels with the MIS 4.

In C2 there is a proportional increase of *Bos primigenius* (NISP=68, MNI=45), *Cervus elaphus* (NISP=27, MNI=12), *Equus ferus* (NISP=19, MNI=12) and *Megaloceros giganteus* (NISP=7, MNI=6), *Elephas antiquus* shows unvaried abundances, compared with the underlying layers, while *Equus hydruntinus* and *Mammuthus primigenius* are still rare (NISP=2). *Stephanorhinus hemitoechus* (NISP=1) and *Hippopotamus amphibius* (NISP=5, MNI=5) add to the temperate component of the fauna. *Hippopotamus* is a helpful environmental marker, which normally indicates temperate-humid settings. A plentiful amount of hippopotamus remains of the same age as those of the Acque Alte Channel have been recovered from the Latium coast (e.g., “Cava della Catena” near Terracina: Blanc, 1935b; Grotta Guattari: Taschini, 1979; in caves at Monte Circeo: Blanc et al., 1957). Hence, in C2 temperate and cooler indicators are mixed together again confirming that the MIS 4 glacial cycle was relatively mild over the Latium coast. The increasing abundances of *Megaloceros giganteus*, *Bos primigenius* and *Equus ferus*, however, indicate that a gradual environmental-climatic transition is under way from the top of the layer C2 on. It will peak in layer C1, where much cooler and arid climatic conditions are reached. In fact, in C1 the disappearances of *Elephas antiquus*, *Ursus spelaeus*, *Crocota crocota spelaea*, *Canis lupus*, *Stephanorhinus hemitoechus*, *Hippopotamus amphibius* and *Megaloceros giganteus*, matched with the decline of *Bos primigenius* (NISP=30, MNI=20), *Cervus elaphus* (NISP=5, MNI=3) and *Equus ferus* (NISP=4, MNI=3), indicate a very strong change towards cold climatic conditions (continental climate). Blanc et al. (1957) referred layer C1 to the “Würm II” (MIS 3).

In layer B there is return of *Megaloceros giganteus* (NISP=8, MNI=6). *Cervus elaphus* here increases its frequency (NISP=10, MNI=7), while *Mammuthus primigenius* and *Equus hydruntinus* disappear. These

bioevents indicate a new transition towards temperate climatic conditions, which persist in layer A.

CONCLUSIONS

The “Canale delle Acque Alte” mammalian assemblages show changes through time and these changes are seemingly a response to the latest Pleistocene/earliest Holocene’s climatic events. Starting from the low sea-stand in the succession’s basal layer F, which can be chronologically referred to the last part of the Eemian interglacial (i.e., end of MIS 5a), the ecologically mixed faunas from the peaty layers D-E3 and from C2 provide information about the conditions existing in coastal Latium at the time of the MIS 4. In fact, the species that Blanc had not recognized in his studies, especially the modern fallow deer from layer D, as well as the hippopotamus and cave bear at the base of layer C2, add further ecological information, confirming the attribution of the E3-C2 layers to the onset of the MIS 4.

The relatively colder conditions suggested by the disappearance of the large temperate mammals from the C1 fauna are likely referable to the most severe phases of the MIS 4 glacial. At this time the coastal Latium landscape turned into a cold steppe.

Declining glacial conditions are suggested by the layer B mammals, which show a new increase of the temperate-indicators. This fauna likely lived at the end of MIS 3.

The fossil mammalian remains from “Canale delle Acque Alte” reveal a palaeontological gap at the time of the Last Glacial Maximum (MIS 2). In fact, the absence of cold indicators, associated with the findings of Late Paleolithic industry in layer B, indicate an older age than the L.G.M., while the temperate features of the mammals from the topmost layer A, in addition to their state of conservation and kind of fossilization, points to an attribution to a Holocene age.

In conclusion, the Acque Alte Channel succession presents an almost uninterrupted stratigraphical succession covering the chronological interval from the last part of the Eemian interglacial, which is represented by the Tyrrhenian fossil beach at the end of MIS 5a, to the late MIS 3, while the topmost level can be dated to the Holocene.

EXPLANATION OF PLATE 5

Fig. 1-2 - *Canis lupus* Linnaeus.

1 - Left mandible, lateral view.

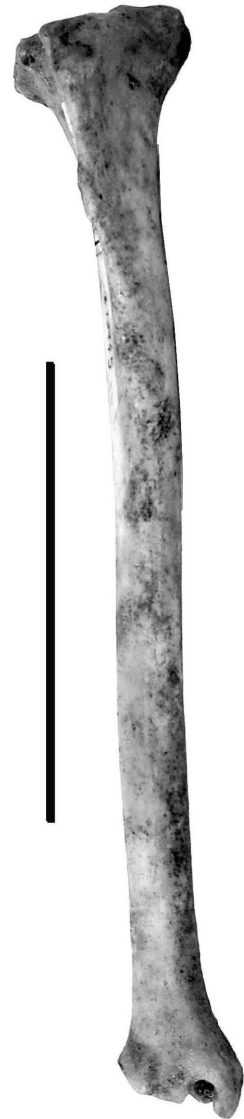
2 - Fragmental left mandible, lateral view.

Fig. 3 - *Vulpes vulpes* (Linnaeus). Right tibia, anterior view.

Fig. 4 - *Ursus spelaeus* Rosenmuller & Heinroth. Upper left third incisor.

Fig. 5 - *Crocota crocota spelaea* Goldfuss. Lower right first molar, lingual view.

Scale bar = 5 cm.



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