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DEER FAUNA FROM THE AULLA QUARRY (VAL DI MAGRA, NORTHERN APENNINES). BIOCHRONOLOGICAL REMARKS

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Riassunto. Viene riportata la presenza nei sedimenti continentali di Cava Aulla, di cervidi tipici della fauna del Villafranchiano Inferiore, attribuiti a *Procapreolus cusanus* e *Pseudodama* ex gr. *pardinensis-lyra*. Questi rinvenimenti mettono in discussione la correlazione della successione sedimentaria al Pliocene Inferiore, effettuata sulla base del contenuto pollinico riconosciuto nei sedimenti.

Abstract. The occurrence in the continental deposits of Aulla quarry of deer characteristic of Early Villafranchian fauna, referred to *Procapreolus cusanus* and *Pseudodama* ex gr. *pardinensis-lyra*, is reported. These finds make questionable the correlation of the sedimentary succession to the Early Pliocene, based on the pollen assemblage.

Introduction.

The discovery of the remains of medium to small sized deer referable to *Procapreolus cusanus* (Croizet & Jobert, 1828) and *Pseudodama* ex gr. *pardinensis-lyra* in the Aulla quarry allows the examination of the chronological position of the sediments exposed in this site. Bertoldi (1988) used the floral content of the Aulla deposits to define the Macriana pollen phase, which correlates with the Early Pliocene (following the division of the Pliocene into Early and Late), and with the Ruscinian Mammal Age. The association of *Pseudodama pardinensis-P. lyra* and *Procapreolus cusanus* is characteristic, in Western Europe, of the mammal assemblages of the Early Villafranchian (the Triversa, and possibly the Montopoli faunal assemblages, referred respectively to biozones MN16a and MN16b after Mein, 1990). The occurrence of these taxa in the sediments of the Aulla quarry therefore contrasts with the attribution of the sedimentary succession to the Early Pliocene. The floral assemblage from the Aulla succession contains elements characteristic of a subtropical climate, which allow us to rule out the possibility that the fossil remains belong to the Montopoli faunal assemblage. Indeed, the Montopoli assemblage correlates with the Praetiglian pollen phase, which coincides with a generalized cooling marked by the spread of steppe vegetation in Southern Europe (cf. Bertoldi et al., 1989).

In Italy, fossils referable to the base of the Villafranchian (Triversa faunal unit) are relatively common. Various sites around Asti (S. Martino Unit, cf. Masini et al., 1994) have yielded *Pseudodama pardimensis* remains associated with mastodonts (*Anancus arvernensis, Zygolophodon borsoni*), *Sus minor, Dicerorhinus jeanvireti*, and *Leptobos stenometopon*. The lignites and clays at the base of the succession of the S. Barbara quarry (Upper Valdarno) contain remains referred to *Ursus minimus, Tapirus arvernensis, Dicerorhinus* sp., *Leptobos* sp. The Lower Valdarno has yielded *Tapirus arvernensis* (Dominici et al., in press), *Pseudodama lyra* (Azzaroli, 1992), and *Nyctereutes megamastoides* (Del Campana, 1917). Finally *Anancus arvernensis, Zygolophodon borsoni*, and *Tapirus arvernensis* have been reported from Umbria-Sabina localities in the Tiber basin (cf. Di Stefano et al., 1994).

Paleontological, radiometric, and paleomagnetic lines of evidence show that the Villafranchian began during the Gauss chron, between 3.0 and 3.6 Ma (cf. Albianelli et al., in press). In the Spanish locality of Layna, the fossil remains, which represent a transitional phase between the Ruscinian and the Villafranchian, come from sediments with a positive magnetization that correlates with the Gauss chron, thus excluding an age earlier than 3.6 Ma for the fossiliferous horizon (cf. Baksi, 1993). At Vialette and Les Etouaires (French Central Massif), radiometric studies have yielded age between 3.3 and 2.6 Ma (Bandet et al., 1978; Couthure & Pastre, 1983; Savage & Curtis, 1983) for the mammal

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assemblages characteristic of the Triversa faunal unit. In Italy, the sediments of the Fornace RDB quarry (Villafranca d'Asti, Northern Italy), bearing the type fauna of the Triversa unit, show a positive magnetic interval interlayered between two negative intervals that correlate with the Kaena and Mammoth events of the Gauss chron (Lindsay et al., 1980). The recent paleomagnetic analyses of the succession exposed in the S. Barbara quarry have yielded analogous results (Albianelli et al., in press). Indeed, the part of the Gauss normal magnetochrone, with the reversed Kaena event dated as 3.10-3.17 Ma, has been identified in the fossiliferous lignites and clays at the base of the deposit.

In Fig. 1 a chronological scheme where radiometrical ages, paleomagnetical scale, geochronological units, mammal ages, faunal units, and pollen phase are correlated, is shown.

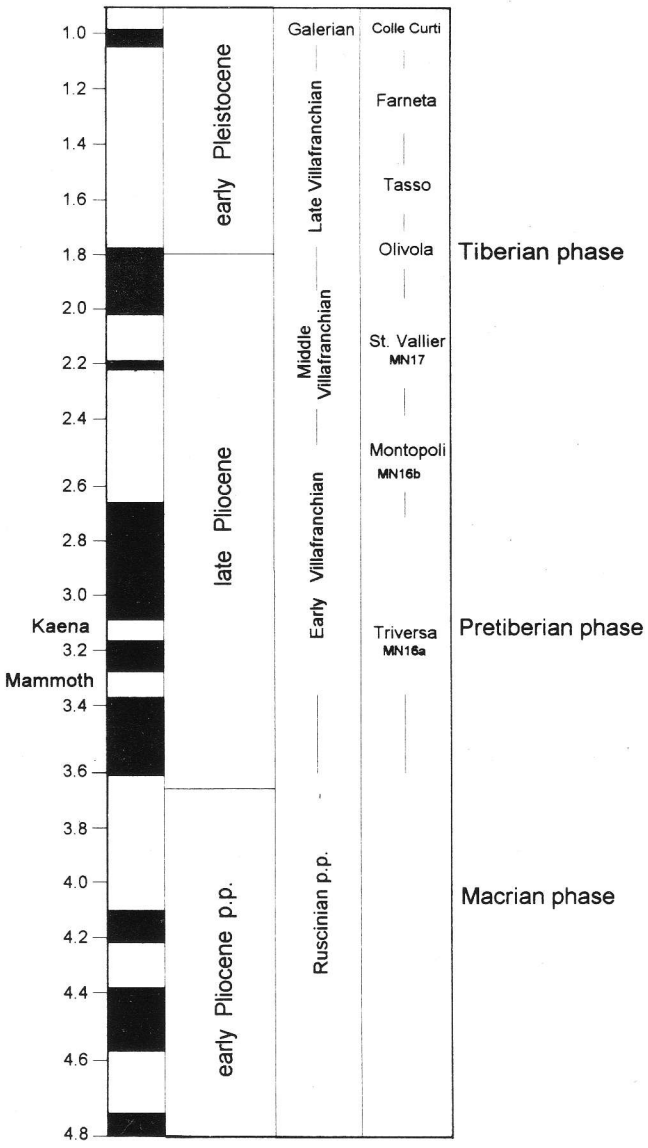

Fig. 1 - Correlation scheme of Mammal ages, Faunal units, Pollen phases (according to Lona & Bertoldi, 1972; Bertoldi, 1988).

Geological setting and chronology of the Aulla quarry.

The Aulla quarry, located north of the town of Aulla, lies within the Aulla-Olivola basin (Fig. 2), which contains a 250 m succession of continental deposits subdivided in 3 units (Federici et al., 1982). From bottom to top, the first unit consists of lacustrine silts and clays, the second of alternating fluvio-lacustrine silts and clays, and gravels, and the third of prevalently fluvial pelitic sands and conglomerates ("Olivola Conglomerates"), marking the final infilling of the basin. A Middle Villafranchian assemblage characterized by *Pseudodama nestii, Sus strozzii, Stephanorhinus etruscus, Canis etruscus* (Azzaroli, 1950; Azzaroli et al., 1988; Masini et al., in press) has been recovered in clay outcropping near Quercia and Vaccareccia (Fig. 2) referable to the second unit (Federici et al., 1982).

The Olivola Conglomerates yielded mammal remais upon which the Olivola faunal unit is defined, marking the beginning of the Late Villafranchian (Azzaroli, 1977).

The sediments exposed in the Aulla quarry (Fig. 3) are referable to the first unit, and have been the object of a palynological study carried out by Bertoldi (1988), who showed that throughout the succession arboreal taxa predominated over non-arboreal ones. Predominant among the forest taxa are the so-called Tertiary elements, such as *Taxodium, Sequoia, Magnolia, Symplocos,* Sapotaceae, and on the whole the pollen assemblages indicate a temperate to warm climate. The predominance of archaic plants at Aulla has chronological significance, in that in Europe these plants are generally confined to the pre-Pleistocene. At Pietrafitta (Perugia, Central Italy), the sharp decrease in the Tertiary Taxodiaceae group that occurs at the base of the sedimentary succession has in fact been used to locate the base of the Tiberian, which correlates with the Plio-Pleistocene boundary (Lona & Bertoldi, 1972). The presence of ele-

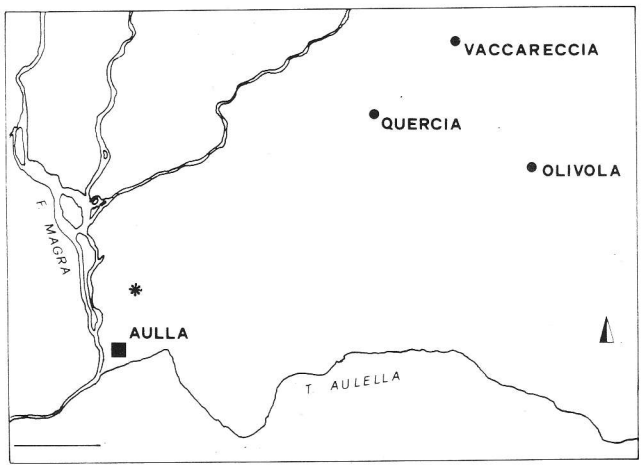

Fig. 2 - Location map of the Aulla quarry (*) in the Aulla-Olivola basin. The scale is 1 km.

ments such as *Symplocos* and *Magnolia* makes the Aulla assemblage even more primitive than the assemblages referred to the Pretiberian phase. Indeed, in some European successions, some elements (e.g. *Symplocos*) appear to be limited to the Early Pliocene, and only reach the Pleistocene with a few forms. According to Bertoldi (1988), the palynological sequence of Aulla therefore records a floral phase characterized, throughout its duration, by a pollen assemblage distinct from those of the Pretiberian and Tiberian phases. For this reason it was chosen to define the Macriana pollen biozone (Early Pliocene, Ruscinian Mammal Age).

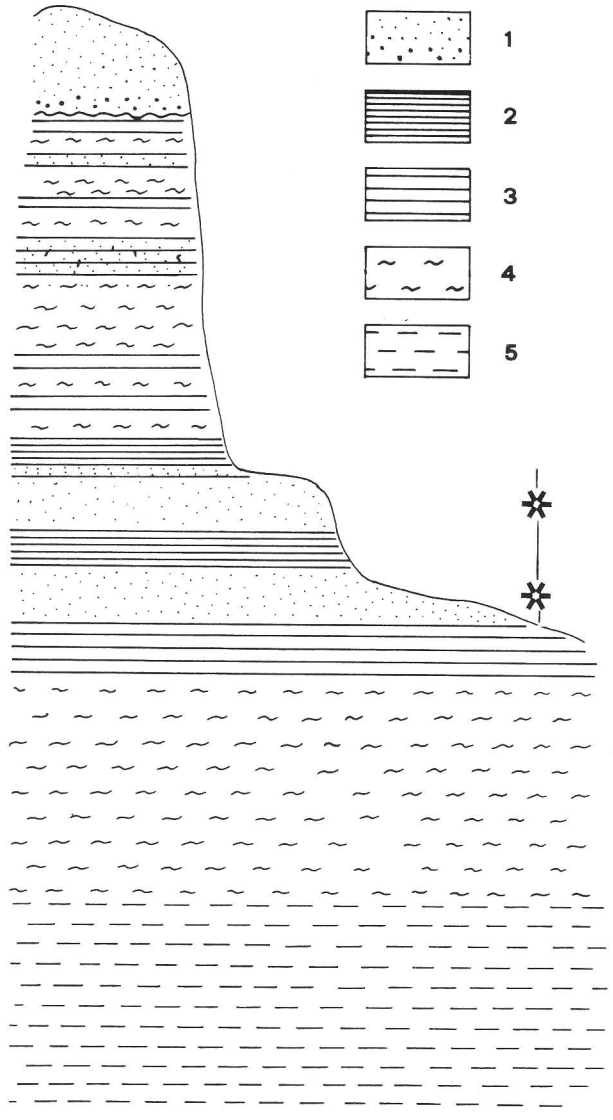

Fig. 3 - Stratigraphical section of Aulla quarry (from Bertoldi, 1988, modified). On the right the zone where the deer remains have been recovered is shown. It is not possible to indicate on the section reported by Bertoldi the precise provenance of the fossils, because at the present the outcrop is somewhat modified by erosion. Legend: 1) gravels and/or sands; 2) silty-sandy clays; 3) silty clays; 4) clays with limonitic nodules; 5) lignitiferous clays. The scale is 1 m. The ondulating line in the upper part of the succession indicates the erosion of the lacustrine sediments.

The pre and infra-Pliocene elements typical of the Aulla succession are poorly represented in the sediments of the RDB quarry, which are referable to the Late Pliocene. The analysis of the pollen content of the succession exposed in this locality (Bertoldi, 1988; Bertoldi, 1994) showing that it contains few elements that presently have a sub-tropical distribution (e.g. *Symplocos*, Clethraceae/Cyrillaceae, and Sapotaceae), allows the pollen sequence to be attributed to the Pretiberian phase, which was dominated by the Taxodiaceae group.

A floral assemblage indicative of a hot humid subtropical climate, with Sapotaceae, Clethraceae-Cyrillaceae, and *Taxodium*, has recently been found in the lignites and basal clay of S. Barbara (Albianelli et al., in press), bearing the Triversa mammal assemblage. This shows that the Tertiary elements whose substantial occurrence had been thought to be limited to the pre-Pliocene or Early Pliocene, are also well represented in assemblages dated to subsequent intervals.

The Ruscinian and Villafranchian transition in the deer fauna.

The climatic and environmental variations that occurred during the Neogene had a profound influence on the Cervidae family, favoring its radiation and diversification. One of the bioevents that affected this family occurred at the transition from the Ruscinian to the Villafranchian, which seems to have been marked by a brief cold interval, and has been set near the limit between the Early and Late Pliocene. With the beginning of the Villafranchian, in addition to the more derived species of genera present in the Ruscinian (*Procapreolus, Croizetoceros*), medium to large sized deer such as *Arvernoceros* and "*Cervus*" spread into Europe (Vislobokova, 1992; Vislobokova et al., 1993). In Western Europe there was an assemblage characterized by the presence of *Croizetoceros ramosus, Procapreolus cusanus, Pseudodama pardinensis, Pseudodama lyra, Arvernoceros ardei,* and *Cervus perrieri.* These taxa have also been found in Early Villafranchian localities of Central Europe, such as Weze 2 (Poland, cf. Kowalski, 1990).

At the beginning of the Villafranchian there was, in addition to the dispersal of forms larger than those present in the Ruscinian assemblages, an increase in the complexity of the antlers, with the development of distal ramifications, and the appearance of a true basal tine, a few cm from the burr. The tendency towards an increase in the morphological complexity of the distal portion of the antler was, however, already observable in the preceding evolutionary phases (middle-late Turolian, Ruscinian), with the genera *Procapreolus, Pliocervus,* and *Croizetoceros* (Azanza et al., 1989). In the Ruscinian *Croizetoceros ramosus* the distal tines are especially numerous (Heintz, 1970, 1974).

The basal tine was also present from the beginning of the Early Pliocene. Azanza et al. (1989) report deer (Cervinae gen. and sp. indet.) with basal tines in the Spanish locality of Fonelas (early Ruscinian, biozone MN14). Czyzewska (1968) describes *Cervus warthae*, from Weze 1 (Poland, biozone MN15), underlining the presence of a basal tine. As occurred with the distal ramifications, this tine became common and widespread, in both simple small sized forms such as *Pseudodama pardinensis* and *P. lyra*, and more complex, larger sized forms such as *Cervus perrieri*, only at the beginning of the Villafranchian.

The fossil remains from the Aulla quarry.

Provenance. The fossil deer found at Aulla comes from sandy sediments in the middle of the sedimentary succession (Fig. 2).

Systematics.

Procapreolus cusanus (Croizet & Jobert, 1828).

At Aulla, this species is represented by a few proximal fragments of shed antlers (Pl. 1, fig. 1a, b), and by a specimen that lacks the basal section, and displays a marked flattening of the beam and a short ramification (Fig. 4). A few fragments of isolated teeth can also be attributed to this species.

P. cusanus was erected by Croizet and Jobert (1828) on material from Les Etouaires. It has also been found at Vialette (Heintz, 1970), and in Italy it has been reported from the Montopoli locality (Masini et al., 1994).

The antlers attributed to this species display strong transversal flattening, and, at least in the adults, from three to five tines oriented along the same anterior-posterior plane.

Procapreolus cusanus is typical of the Early Villafranchian of Western Europe (Heintz, 1970; Triversa and Montopoli faunal units), even though it was known from the beginning of the Ruscinian (Vislobokova, 1990). Representatives of the genus *Procapreolus* are known from throughout Eastern Europe beginning in the Late Miocene (Vislobokova, 1990), in faunal assemblages referable to the Vallesian (biozone MN10).

The genus is closely related to *Capreolus*, whose earliest known representatives referred by Vislobokova et al. (1995) to *C. costantini*, have been found at Udunga, an Early Villafranchian (biozone MN16) locality in Transbaikalia (Vislobokova et al., 1993; Vislobokova et al., 1995).

Pseudodama ex gr. *pardinensis-lyra.*

A right antler fragment with an incomplete basal tine branching off an anterior position is attributed to this taxon (Pl. 1, fig. 2a, b). Unfortunately, the specimen is heavily encrusted by well cemented sands (Pl. 1, fig. 3), which alter its size, though not its morphology.

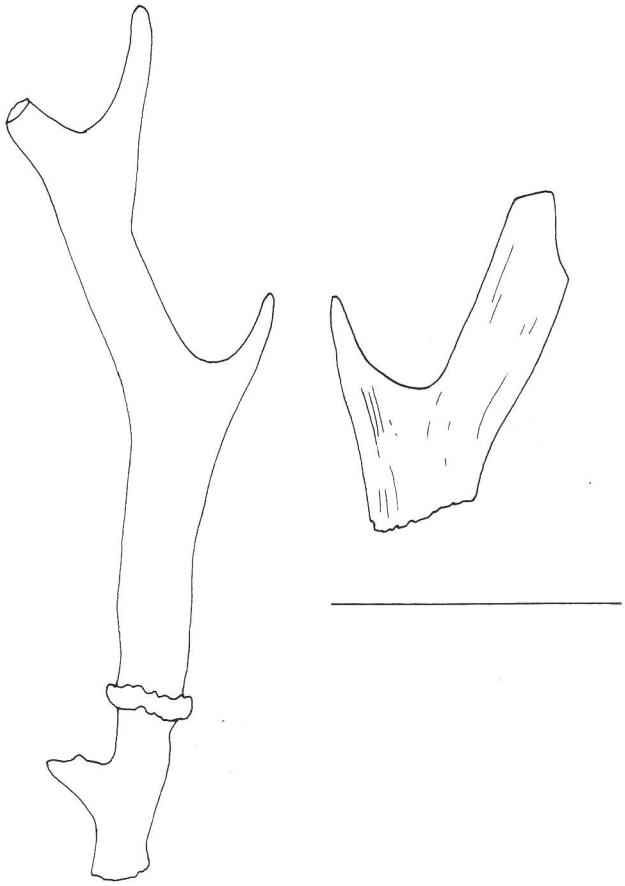

Fig. 4 - Comparison between one remain of *Procapreolus cusanus* from Aulla quarry (on the right) and the neotype from Les Etouaires (from Heintz, 1970, redrawn). The scale is 10 cm.

The beam presents a faint concavity at the insertion of the basal tine, which forms an angle of about 50° with the beam and is located about 90 mm from the burr. The proximal curvature of the beam indicates that the antlers were fairly slanted backwards from the skull. The beam is circular in cross section. These characters together with the size (taking into account the encrustation that covers it completely) agree with the attribution to *Pseudodama.* As a matter of fact the distance separating the first tine from the burr and the angle that the first tine forms with the beam in the specimen from Aulla are observed in the most archaic forms of *Pseudodama.* Among of the major evolutionary changes undergone by this genus are the positioning and orientation of the basal tine, which, in the most derived forms (*P. nestii* and *P. farnetensis*) branches off closer to the burr, and at an open angle with respect to the beam (Azzaroli, 1992; Colucci et al., in progress).

On the contrary the Aulla specimen differs from the European Ruscinian cervids such as *Paracervulus australis* de Serres (Montpellier, biozone MN14) in that the latter has a laterally compressed shaft, and has the

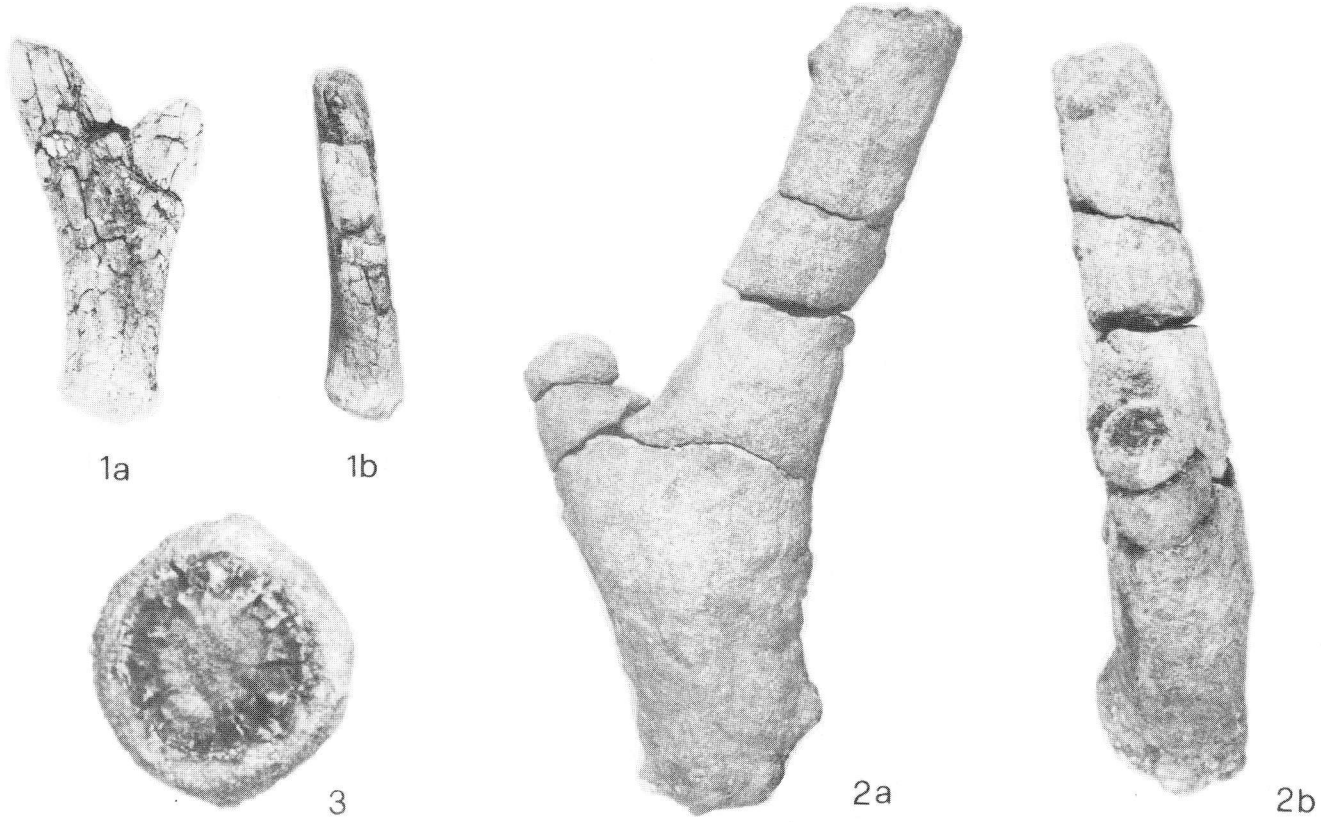

PLATE 1

Fig. 1 - *Procapreolus cusanus* (Croizet & Jobert). Right shed antler from Aulla quarry. a) Lateral view; b) frontal view. 1/2 natural size.
Fig. 2 - *Pseudodama* ex gr. *pardinensis-lyra*. Right shed antler from Aulla quarry. a) Frontal view; b) lateral view. 1/2 natural size.
Fig. 3 - *Pseudodama* ex gr. *pardinensis-lyra*. Cross section of the shed antler. The cemented sands envelopping the remain are shown. Natural size.

first tine far from the burr. This second characteristic is also observable in the antlers of *Croizetoceros ramosus*, whose basal tine has a very wide insertion angle (Heintz, 1970), wider than that observed in the Aulla specimen.

The genus *Pseudodama* has been recently erected by Azzaroli (1992) to group the medium sized deer widespread in the Late Pliocene-Early Pleistocene, previously referred to *Dama* (Azzaroli, 1947) and to *Cervus* (Heintz, 1970). According to Azzaroli (1992), this genus includes six species that represent two distinct phyletic lines. The former, including *P. pardinensis, P. rhenanus* and *P. pereolensis* (probably a synonym of *P. nestii*), seems to be widespread in more northern regions than the latter, which includes *P. lyra, P. nestii* and *P. farnetensis.* This line is recorded in the mediterranean area.

P. lyra, which is the species of more recent erection (Azzaroli, 1992), is well represented in the sediments of the Lower Valdarno (Early Pliocene), where it occurs in association with mammals of the Triversa and Montopoli faunal units. According to Azzaroli *P. lyra* can be distinguished from *P. pardinensis* found at Les Etouaires and Vialette, because its morphological characters are more derived, both in the antlers (incipient third distal bifurcation and greater curvature of the shaft), and in the dentition (lesser development of the cingulum in the upper teeth). Though the phylogenetic relationships between the two species are not clear yet, *P. lyra* could be derived from *P. pardinensis*, or they could be sister species (Azzaroli, 1992).

The characters upon which the distinction between the two species is made cannot be observed in the antler of Aulla because of its fragmentary nature. Therefore this specimen is referred to *Pseudodama* ex gr. *pardinensis-lyra.*

Conclusions.

The presence of *Procapreolus cusanus* in the sediments of the Aulla quarry has not a precise biochronologic significance, in that though the species is typical of the Early Villafranchian, it has also been found in Ruscinian localities. The identification of a primitive form of *Pseudodama* is on the other hand more important. The occurrence of this taxon in fact seems to be characteristic of Post-Ruscinian faunas. The association

of *P. cusanus* and *P.* ex gr. *pardinensis-lyra* would limit the age of the Aulla deposit to the Late Pliocene, a conclusion that contrasts with the results obtained from the pollen study, which indicates an Early Pliocene age (Bertoldi, 1988).

The recent identification of Tertiary subtropical elements in the Late Pliocene sediments of the S. Barbara quarry (Albianelli et al., in press) suggests however that the stratigraphic distribution of these taxa covers a time longer than that which had previously been thought. The abundance of elements whose present distribution is tropical-subtropical in the sediments of the Aulla quarry could be due to the development, in that area, of a microclimate that supported a distinctive floral assemblage.

In conclusion in the Olivola-Aulla basin faunal assemblages referred to Early Villafranchian (Triversa faunal unit), to Middle Villafranchian (Seneze faunal unit) and to Late Villafranchian (Olivola faunal unit) occur from W to NE. The lacking of the Montopoli faunal unit could be attributable to an erosive phase, recognizable at the top of the Aulla succession.

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