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THE MORPHOMETRY AND THE OCCURRENCE OF *CERVUS ELAPHUS* (MAMMALIA, CERVIDAE) FROM THE LATE PLEISTOCENE OF THE ITALIAN PENINSULA

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Abstract. The evolutionary trends and adaptations of the red deer from the Middle Pleistocene to the present day are well documented in Eurasia. These are generally explained by the high capability of this deer to adapt to different enviromental and climatic conditions. The large number of subspecies attributed to *Cervus elaphus*, often limited to specific paleogeographical areas above all during the late Middle Pleistocene, can be explained by this characteristic. The abundant remains of red deer collected from Late Pleistocene and older Holocene fossiliferous localities in Italy has allowed a detailed analysis of morphometric features in different areas of the Italian Peninsula and also some interesting paleoecological discussion. The variation and differences observed in the size of the red deer show close relationships with the latitude and the paleoclimate.

Introduction

Among artiodactyls, cervids are the faunal elements which best characterize several mammal assemblages during the Pleistocene in the Italian Peninsula (Di Stefano & Petronio 1992; Gliozzi et al. 1997; Petronio et al. 2011).

The presence of *Cervus elaphus* is often well documented with numerous remains in almost all the faunal deposits from the Galerian Mammal Age and it has a considerable importance both from the biochronological and paleoecological points of view (Gliozzi et al. 1997; Petronio et al. 2011). Moreover, living *C. elaphus* shows high genetic flexibility and remarkable and fast capability to adapt, also linked to an "intermediate" herbivore feeding strategy (it is considered a mixed feeder and not a purely browsing or grazing ruminant) (Hofmann 1989). These characteristics, and also the human impact, guarantee the widespread presence of this cervid across continents and in almost all climatic zones (Nowak & Paradiso 1991).

The capability of *C. elaphus* for fast adaptation and the morphological variability allowed this species to differentiate during the climatic phases of the Pleistocene into numerous populations and subspecies which often have an important significance from the biochronological point of view (Di Stefano & Petronio 1993, 2002; Petronio et al. 2011, and references therein).

The large number of red deer remains and data also allow a careful analysis of the more important morphometric features and the size, above all in the postcranial skeleton. This analysis allows to draw a sketch of the evolutive pathways of *C. elaphus* in Italy, but also to suggest the paleogeographical boundaries and the relative biochronological importance of the various forms.

One of the simplest and most useful feature for the morphometric investigation is size: for example, the body size of the European red deer populations decreases from East to West and from North to South, but this cline has only been established since the Middle Age (see Hornberger 1970; Riedel 1976a). The presence of numerous microclimates in the Italian Peninsula and the capability for fast adaptation of the red deer led us to predict size variation through time, above all from

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the Late Pleistocene to the Holocene, when the climatic and enviromental conditions were particularly changeable. Moreover, the variations in size due to changing climatic conditions are testified in many mammals (Conti et al. 2010; Desantis et al. 2011; Pandolfi et al. 2011; Mazza & Bertini 2013; Prost et al. 2013; Meache et al. 2014; O'Keefe et al. 2014; Sansalone et al. 2015). The main goal of this paper is to verify if variations in size are observable in *C. elaphus* and particularly in the Late Pleistocene populations from Italy. The study is restricted to the Late Pleistocene because the abundance of fossil remains and fossiliferous localities. Moreover, during the considered time span, only a subspecies of *Cervus elaphus* was recorded according to several authors (Abbazzi 1995; Gliozzi et al. 1997; Petronio et al. 2011); so, the possible influence of subspecies differences on size would be excluded.

Overview on *Cervus elaphus* in the Pleistocene of Italy

The first subspecies referable to the red deer in Italy, as in Eurasia as a whole, is *C. elaphus acoronatus*. The fossil evidences show that deer probabily evolved in Asia and it is characterized by large size, five-pointed antler with a typical terminal fork perpendicular to the sagittal axis of the body and rather robust limb bones (Beninde 1937; Di Stefano & Petronio 1992, 2002).

The first occurrence of this subspecies in the Italian Peninsula, with few remains, is recorded in faunal assemblages referable to the Slivia Faunal Unit (FU), corresponding to the post-Villafranchian faunal renewal (Early – Middle transition: Gliozzi et al. 1997; Petronio et al. 2011). However, the acoronate deer is well documented in the mammal deposits referable to the subsequent Galerian Mammal Age, above all to its early and middle parts (latest Early – late Middle Pleistocene: Petronio et al. 2011; Marra et al. 2014). In fact, a complete skeleton of *C. elaphus acoronatus* has been recently recorded from the lacustrine deposits of Pianico-Sèllere (Bergamo, northern Italy) just after the chronological interval of the Slivia FU (Paganoni & Sala 2011).

A fragmentary skull with both antlers showing the typical features of *C. elaphus acoronatus* comes from the "lower gravels" of Ponte Molle (the ancient name of Ponte Milvio in Rome) (Di Stefano & Petronio 1992). From the deposits of Vitina (near Rome), referable to the Ponte Galeria Formation, some antler remains have been discovered (Caloi et al. 1981). Some bone remains and many teeth collected from Casal Selce (near Rome) in the levels above the "*Venerupis senescens* Clay" of Ponte Galeria (Rome) have been referred to *C. elaphus acoronatus* by Petronio & Sardella (1999). Numerous antler fragments, some skull remains, teeth and limb bones referable to the acoronate deer have been collected from the so-called "Brecce Veronesi" (this generally comprises the continental deposits from some localities in northeastern Italy, such as Domegliara, Soave Castello, Cava Sud, Monte Tenda, Viatelle and Romagnano) (Di Stefano & Petronio 1992).

C. elaphus aconoronatus occurs also in the Isernia FU (ca. 0.6-0.55 Ma), in particular in the locality of Isernia La Pineta (Molise, central Italy: Sala 1996). However, these remains are scarce and lacking peculiar features, just like those from slightly younger deposits (for example the remains from Venosa Notarchirico, Venosa, southern Italy: Cassoli et al. 1999; Di Stefano & Petronio 2002), and thus further data would be necessary to better clarify their attribution.

A red deer different from *C. elaphus acoronatus* occurs in Italy in the Late Galerian faunal assemblage (Fontana Ranuccio FU, Middle Pleistocene: Marra et al. 2014); this cervid is referred to the subspecies *C. elaphus eostephanoceros* and it is the first red deer with a crowned antler in Europe (Di Stefano & Petronio 1993). This subspecies has been collected in numerous mammal deposits from central Italy (Cava Nera Molinario, Fontignano, S. Cosimato, Fontana Ranuccio; see Di Stefano & Petronio 1993; Marra et al. 2014) but it has been recorded also in Bristie (Trieste, northern Italy) and in some deposits from Western Europe, like Hundsheim (Austria) and Tautavel (France) (Di Stefano & Petronio 1993).

C. elaphus eostephanoceros is a medium sized red deer, smaller than the acoronate one, but the most important and peculiar features are in the antler morphology which is, as mentioned, the first to show a fairly developed crown (Di Stefano & Petronio 1993). The antler is rather stout with the beam laterally flattened for almost all its length; the b span is very short because the well developed brow tine arises just above the rose that has a typical elleptical diameter. The bez tine is usually well developed, it is always present and forms a characteristic angle with the beam, almost always of 90° or lower, drawing a sort of bisector between the brow tine and the beam. The trez tine is in a very high position, close to the terminal crown, it is large sized and laterally flattened. This last tine and the terminal ones form a primitive cup-shaped crown, where the original terminal fork and some supernumerary tines seem to be placed posteriorly, almost perpendicular to the beam.

C. elaphus eostephanoceros does not seem to occur in faunal assemblages younger than the Late Galerian and thus the biochronological range of this deer is particularly useful not only for the Italian Peninsula but it seems also for a wide area of western Europe (Di Stefano & Petronio 1993, 2002; Marra et al. 2014).

The red deer populations occurring in Italy and, generally, in Eurasia during the Middle Pleistocene are characterized by high variability which, as already said, is still present today and can be referred to the genetical variation of this cervid and its capability to adapt to most of the enviromental conditions of the boreal zone (Di Stefano & Petronio 1993, 2002). These characteristics cause great difficulty, both in the fossil and living forms, to recognize populations and/or subspecies.

Red deer populations characterized by large crowned antlers occur in some areas of Italy during the late Middle Pleistocene (corresponding to the Torre in Pietra and Vitinia FUs), as *C. elaphus aretinus* from Val di Chiana (Tuscany) (Azzaroli 1948). In the same period, red deer populations characterized by stout and crownless antlers also occur, as the subspecies *C. elaphus rianensis* from Riano (Rome) (Leonardi & Petronio 1974). Some remains from other deposits of central Italy have been referred to this last subspecies, like the fragmented skull from Via Flaminia (Rome) (Kotsakis et al. 1978) and, more doubtfully, the remains from the lower levels of Torre in Pietra (Caloi & Palombo 1978).

In the latest Middle Pleistocene (Vitinia FU), red deer forms with longer and more slender beam and tines occur in Italy: these forms seem more similar to the Late Pleistocene and living red deer but the remains are too scarce and lacking of diagnostic features for a taxonomical attribution (Caloi & Palombo 1978). The characteristics of these red deer populations seem strongly related to the abundance of trophic resources and with regional environments, as testified by the living *C. e. barbarus* in northern Africa or by the subspecies of Mediterranean islands (*C. e. tyrrhenicus* or the living *C. e. corsicanus*) (see Caloi et al. 1986; Geist 1998; Sommer et al. 2008).

According to Petronio et al. (2007) the modern-like subspecies of red deer occurs from the beginning of the Late Pleistocene. In fact, since that period until the Holocene, the red deer remains are rather abundant, often with high percentages in the faunal assemblages (Wilkens 1989; Minieri et al. 1995; Petronio et al. 2011). These remains are generally fragmented, above all in the deposits of anthropic origin where the anatomical parts are often selected by man (Wilkens 1989). Most authors therefore just referred these remains to *C. elaphus* or *C. elaphus* ssp., sometimes indicating that their size fit into the range of the Late Pleistocene red deer.

The red deer is well known in the continental deposits of southern Italy in the first part of the Late Pleistocene (Petronio et al. 2007). In the continental deposits above the Thyrrenian level of Grotta Romanelli (MIS 5; Lecce, Apulia), in the so-called "red clays", the most abundant mammals are the fallow deer and the rabbit, some large-sized mammals also occur and the presence of man is well documented, but the red deer is rather scarce (Blanc 1920, 1928; Bologna et al. 1994). The same faunal assemblages have been discovered in other coastal caves between Castro Marina and Otranto (Lecce, Apulia) and in many "funnel-like" deposits in the area between Melpignano and Maglie (both in southern Apulia): these faunas have been correlated to the "red clays" of Grotta Romanelli and they are dominated by the presence of fallow deer among the cervids while the red deer is represented by scarce bones, teeth and antler fragments (De Giuli 1983; Di Stefano et al. 1992; Bologna et al. 1994; Barbera et al. 2006). Some red deer remains have been also collected from Avetrana (Taranto, Apulia); the features of the antler fragments allow us to refer these remains to a modern form of red deer (Petronio et al. 2008; Pandolfi et al. 2013). The same considerations have been made for the remains collected from Ingarano (near the city of Apricena, northern Apulia): in fact, the morphological features are referable to an advanced red deer, different from the other populations occuring in the previous part of Late Pleistocene (Capasso Barbato et al. 1992; Petronio et al. 1995; Petronio & Sardella 1998).

The red deer is the most frequent mammal in the latest Pleistocene "brown clays" from Grotta Romanelli (MIS 2) with many fragmented remains where only those more compact or not utilised by humans (such as carpal and tarsal bones, teeth, etc.) are well preserved; antler parts are rather numerous but they are represented only by tines or beam fragments (Blanc 1920, 1928; Tagliacozzo 2003).

Red deer with large antlers showing a sort of distal palm and elliptical section of the beam occur during the latest Pleistocene and also in some localities referable to the first part of Holocene. These peculiar features in the antler lead De Stefano (1911) to establish the subspecies *C. elaphus palmidactyloceros*; however, the palmated antlers have almost always been collected together with unpalmated ones with circular section of the beam: therefore, that particular features may be referred to individual variations, perhaps influenced by feeding stress linked to environmental conditions, the health or the ontogenetic age of the animal (Billamboz 1979; Angelelli 1981; Abbazzi 1995) or, finally, to the increasing hunting pressure of man (Wilkens 1989). These red deer populations then are not considered as a subspecies.

Material and Methods

A large number of post-cranial remains collected from several Late Pleistocene and early and middle Holocene (thereinafter older Holocene) Italian deposits were considered for the morphometric analysis of the red deer. Some measurements have been taken directly by the Authors, following the methodology introduced

Tab. 1 - Late Pleistocene and older Holocene localities of Italy considered in this work.

Site	Region	Geographic area	Age	Reference
Isorella	Lombardy	Northern Italy	Holocene	Bon et al. 2005
Santorso	Venetian	Northern Italy	Holocene	Cassoli & Tagliacozzo 1989
Fimon	Venetian	Northern Italy	Holocene	Riedel 1948
Val Liona	Venetian	Northern Italy	Holocene	Riedel 1948
Isolone della Prevaldesca	Lombardy	Northern Italy	Holocene	Riedel 1975
Ledro	Trentino Alto Adige	Northern Italy	Holocene	Riedel 1976a
Barche di Solferino	Lombardy	Northern Italy	Holocene	Riedel 1976b
Colombare di Negrar	Venetian	Northern Italy	Holocene	Riedel 1976c
Pozzuolo Friuli	Friuli Venezia Giulia	Northern Italy	Holocene	Riedel 1983
Colognola ai Colli	Venetian	Northern Italy	Holocene	Riedel 1984a
Cladrecis	Friuli Venezia Giulia	Northern Italy	Holocene	Riedel 1984b
Appiano	Trentino Alto Adige	Northern Italy	Holocene	Riedel 1985
Grotta d'Ernesto	Trentino Alto Adige	Northern Italy	Holocene	Riedel 1991
Canàr Polesine	Venetian	Northern Italy	Holocene	Riedel 1998
Vadena	Trentino Alto Adige	Northern Italy	Holocene	Riedel 2002
Ancona - Cappuccini	Marche	Central Italy	Holocene	Wilkens 1989
Bachero	Marche	Central Italy	Holocene	Wilkens 1989
Capo d'Acqua	Abruzzi	Central Italy	Holocene	Wilkens 1989
Conelle	Marche	Central Italy	Holocene	Wilkens 1989
Grotta Continenza	Abruzzi	Central Italy	Holocene	Wilkens 1989
Grotta dei Piccioni	Abruzzi	Central Italy	Holocene	Wilkens 1989
Ortucchio	Abruzzi	Central Italy	Holocene	Wilkens 1989
Ripoli	Abruzzi	Central Italy	Holocene	Wilkens 1989
S. Maria in Selva	Marche	Central Italy	Holocene	Wilkens 1989
Grotta S. Angelo	Abruzzi	Central Italy	Holocene	Wilkens 1996
Osimo	Marche	Central Italy	Holocene	Wilkens 1997
Coppa Nevigata	Apulia	Southern Italy	Holocene	Siracusano 1995
Torre Mordillo	Calabria	Southern Italy	Holocene	Tagliacozzo & Curci 2001
Latronico	Basilicata	Southern Italy	Holocene	Wilkens 1989
Punta delle Terrare	Apulia	Southern Italy	Holocene	Wilkens 1989
Bari - S. Maria	Apulia	Southern Italy	Holocene	Wilkens 1991
Arene Candide	Liguria	Northern Italy	MIS 2	Cassoli & Tagliacozzo 1994
Riparo Tagliente	Venetian	Northern Italy	MIS 2	Rocci Ris et al. 2005
Palidoro	Latium	Central Italy	MIS 2	This work
Grotta delle Mura	Apulia	Southern Italy	MIS 2	Bon & Boscato 1993
Grotta La Cala	Campania	Southern Italy	MIS 2	Boscato et al. 1997
Grotta della Serratura	Campania	Southern Italy	MIS 2	Boscato et al. 2005
Grotta Romanelli	Apulia	Southern Italy	MIS 2	Tagliacozzo 2003, and this work
Riparo di Fumane	Venetian	Northern Italy	MIS 3/2	Cassoli & Tagliacozzo 1991, and this work
Grotta del Fossellone	Latium	Central Italy	MIS 3/2	This work
Botro ai Marmi	Tuscany	Central Italy	MIS 3	Boscato 1995
Grotta di Parignana	Tuscany	Central Italy	MIS 3	Caterini 1921; Farina 2009
Grotta S.Agostino	Latium	Central Italy	MIS 4/3	Tozzi 1970
Ingarano	Apulia	Southern Italy	MIS 4/3	This work
Sora -Valle Radice	Latium	Central Italy	MIS 5	This work
Avetrana	Apulia	Southern Italy	MIS 5	This work

by Driesch (1976), but many have been provided by literature: in these cases, we pay a careful attention to verify that our data are consistent with the others (Tab. 1; Appendix).

Due to the condition of the fossil remains, size variation index (SVI) was used to study the size variation of red deer during the Late Pleistocene and older Holocene. This method enables us to compare the size of the whole skeleton and has commonly been used in archaeozoology and, recently, in palaeontology (Uerpmann 1982, 1986; Meadow 1986, 1999; Eisemann & Kuznetsova 2004; Lacombat 2009). Moreover, this index is particularly useful when the fossil remains are numerous but fragmented.

In our analysis we utilized the following bones: radius, metacarpal, tibia, metatarsal and astragalus because they are the most abundant bones collected from deposits. Mean (M) and Standard Deviation (SD) were calculated for each measurement considered and for each locality. The following formula was used for comparisons: $SVI = 25\,(x-M)/SD$ where "x" is the measurement of a specimen to compare, "M" is the mean of the measurement of the standard sample (the standard sample is in this case the population from Mosbach 2), "SD" is the standard deviation of the measurement of the standard sample. The values obtained were plotted on histograms graduated in several standard deviations from the standard. The standard dimension is set at zero and a measurement one standard deviation larger than the standard dimension is plotted at 25, one standard deviation smaller at -25 (Meadow 1986) (Fig. 1).

The postcranial material of *Cervus elaphus acoronatus* from Mosbach 2 (Appendix; Di Stefano & Petronio 1992) was used as standard sample. This choice has been made because that population is large, homogeneous and far from the other remains considered from the geographical and chronological point of view. To better observe the size variations at a regional level, we divided the localities into three groups representing three different geographical areas: northern Italy (local-

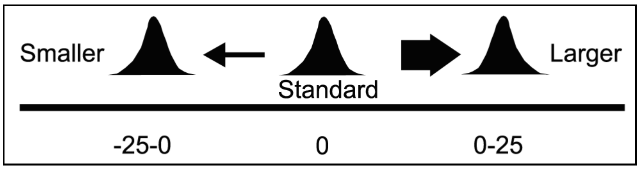

Fig. 1 - Illustrative example of SVI. The standard dimension is set at zero; a measurement one standard deviation or more larger than the standard dimension will be plotted at 25, 50 or more, one standard deviation smaller at -25.

ities northern than the Emilian-Tuscany Apennines), central Italy (localities from the Emilian-Tuscany Apennines to the southern Latium) and southern Italy (localities in Apulia, Basilicata and Calabria) (Tab. 1).

The variation of SVI has been represented for every area for four chronological intervals corresponding to MIS 5, MIS 4/3 (MIS 4 and MIS 3), MIS 2 and to older Holocene. A few deposits chronologically referred between the end of MIS 3 and the beginning of the MIS 2 are included into the group of MIS 2. The age of the localities has been taken from literature, sometimes reviewed by the authors on the basis of the information available from the faunal list, new geological data and more recent analyses.

In addition, following Lister (1993) and Lister et al. (2010), the deviations of different postcranial elements from the corresponding elements of the standard are used as a variable in a Mann-Whitney U-test.

Results

The SVI, calculated for all the considered samples reported in Tab. 1, shows a slight variation in size of the Late Pleistocene populations of red deer from Italian Peninsula (Fig. 2). For population collected in localities of MIS 5 age the maximum frequency (more than 60 observations) is between -75 and -50 (three standard deviation smaller than the standard dimension). From MIS 4/3 to the older Holocene the maximum frequency is between -50 and - 25 (two standard deviations smaller than the standard dimension). The results of U-test among the considered time spans are not statistically significant for the group MIS 4/3-MIS 2 (Tab. 2).

The SVI calculated for the samples grouped according to their geographic position reveals different patterns of variation in size.

In northern Italy, the maximum frequency is between 0 and 25 during MIS 2 and between -50 and -25 during the older Holocene (Fig. 3). The difference between the two groups is statistically significant (Tab. 2). This testifies a decrease in size of the northern Italian populations of red deer at the end of the Pleistocene (the maximum frequencies of MIS 2 and older Holocene are three steps apart). Unfortunately, specimens collected from localities chronologically related to MIS 5 and MIS 4/3 are poorly or not documented.

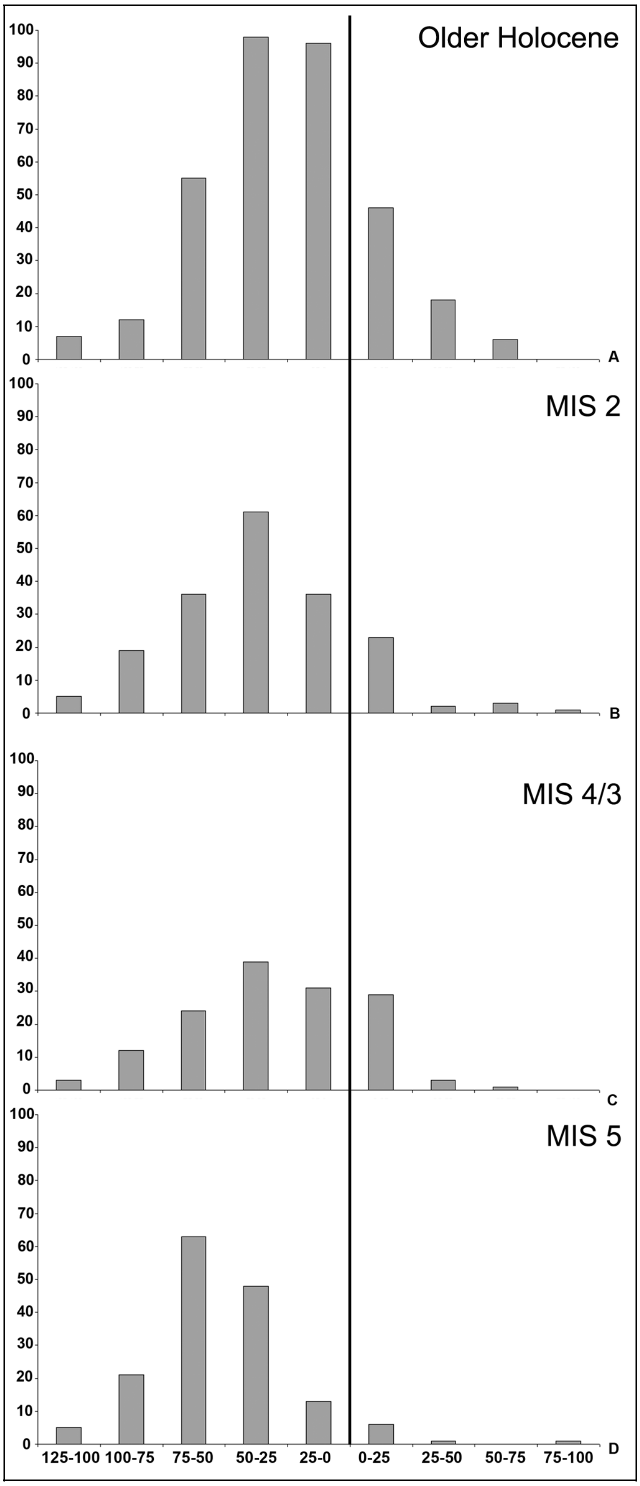

Fig. 2 - Size Variation Index of the red deer populations from Italy during the older Holocene (A), MIS 2 (B), MIS 4/3 (C), and MIS 5 (D).

In central Italy, the maximum frequency is between -75 and -50 during MIS 5, between -25 and 0 during MIS 4/3, between -75 and -50 during MIS 2 and between -25 and 0 during the older Holocene (Fig. 4). The maximum frequencies during the consid-

Italy	MIS 4/3 (142)	MIS 2 (274)	Holocene (347)
MIS 5 (164)	0.0009877	6.461E-0.9	3.73E-18
MIS 4/3 (142)		0.1695	0.000509
MIS 2 (274)			0.005596
northern Italy	MIS 4/3	MIS 2 (38)	Holocene (94)
MIS 2 (38)			5.457E-0.9
central Italy	MIS 4/3 (43)	MIS 2 (58)	Holocene (194)
MIS 5 (107)	2.12E-05	0.003103	1.67E-17
MIS 4/3 (43)		0.0004904	0.1268
MIS 2 (58)			0.0003295
southern Italy	MIS 4/3 (99)	MIS 2 (165)	Holocene (59)
MIS 5 (57)	0.445	0.2665	5.094E-0.8
MIS 4/3 (99)		0.9482	1.934E-0.5
MIS 2 (165)			3.995E-0.9

Tab. 2 - Significance testing of red deer postcrania among considered time spans in Italian Peninsula and in the three subareas. For each time span, the number of specimens is reported in brackets; values are *p*-values obtained using U-tests, with a $p<0.05$ the difference is significant, with a $p<0.01$ the difference is very significant, with a $p<0.001$ the difference is highly significant.

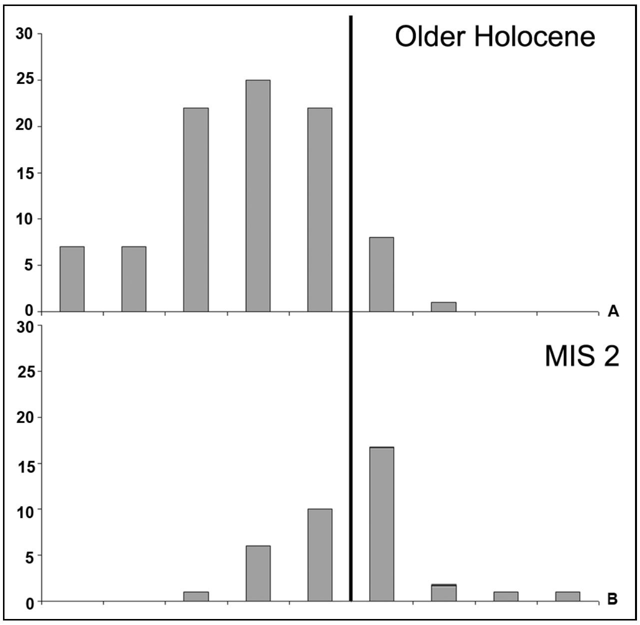

Fig. 3 - Size Variation Index of the red deer populations from northern Italy during the older Holocene (A) and MIS 2 (B). Data from MIS 4/3 and MIS 5 are not available. Details on localities and their ages are reported in Tab. 1.

ered time spans show a fluctuation in size of *Cervus elaphus* in central Italy. The smaller size is during MIS 5 and MIS 2, whereas the larger size is during MIS 4/3 and older Holocene. The differences among the groups are statistically significant through time (Tab. 2).

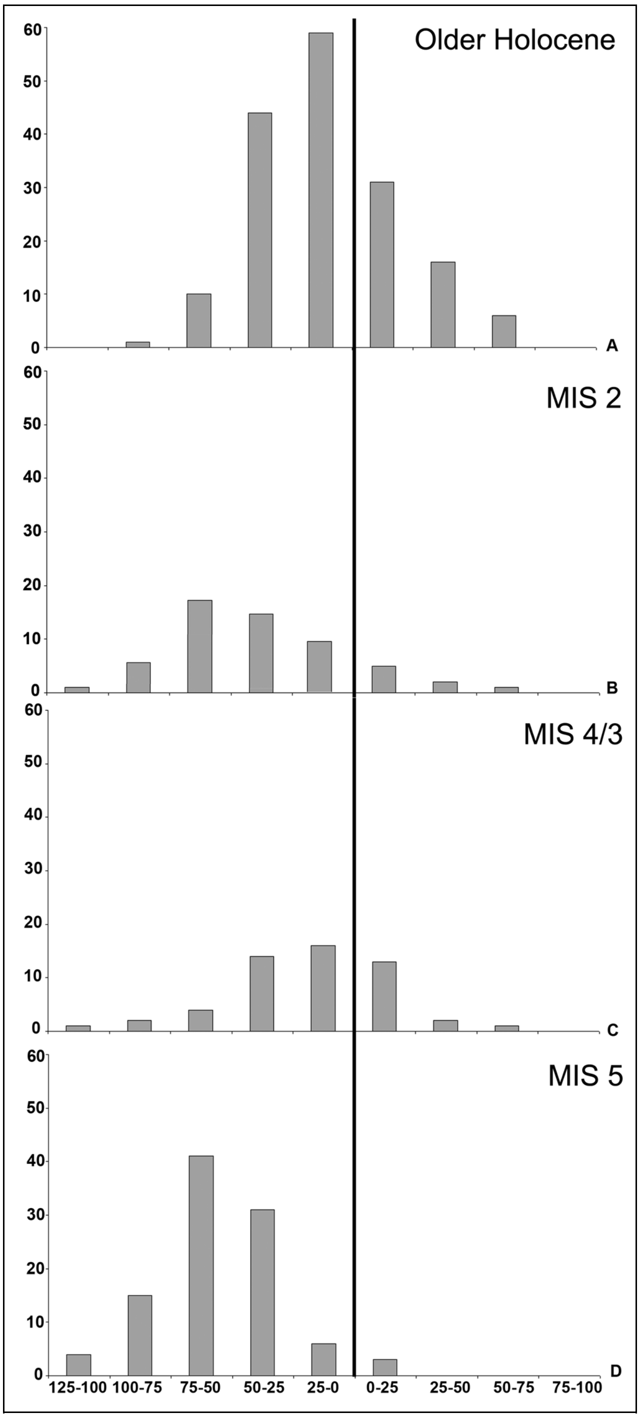

Fig. 4 - Size Variation Index of the red deer populations from central Italy during the older Holocene (A), MIS 2 (B), MIS 4/3 (C), and MIS 5 (D). Details on localities and their ages are reported in Tab. 1.

In southern Italy, the maximal frequency during MIS 5 is between -75 and -50 as in central Italy (Fig. 5). During MIS 4/3, the maximum frequency is between -50 and -25; the same result is obtained for MIS 2 and older Holocene (Fig. 5). The histograms show a size increase of *C. elaphus* in southern Italy from MIS 5 to MIS 4/3 and a stasis during MIS 2 and older Holocene. Nevertheless, the differences among the considered groups are not statistically supported for MIS 5-MIS 4/3, MIS 5-MIS 2, MIS 4/3-MIS 2 (Tab. 2). The older Holocene sample is statistically different from the Pleistocene ones (Tab. 2).

The red deer has similar size in central and southern Italy during MIS 5 (same maximum frequency between -75 and -50 and statistically supported: Tab. 3). The red deer is larger in northern Italy (maximum fre-

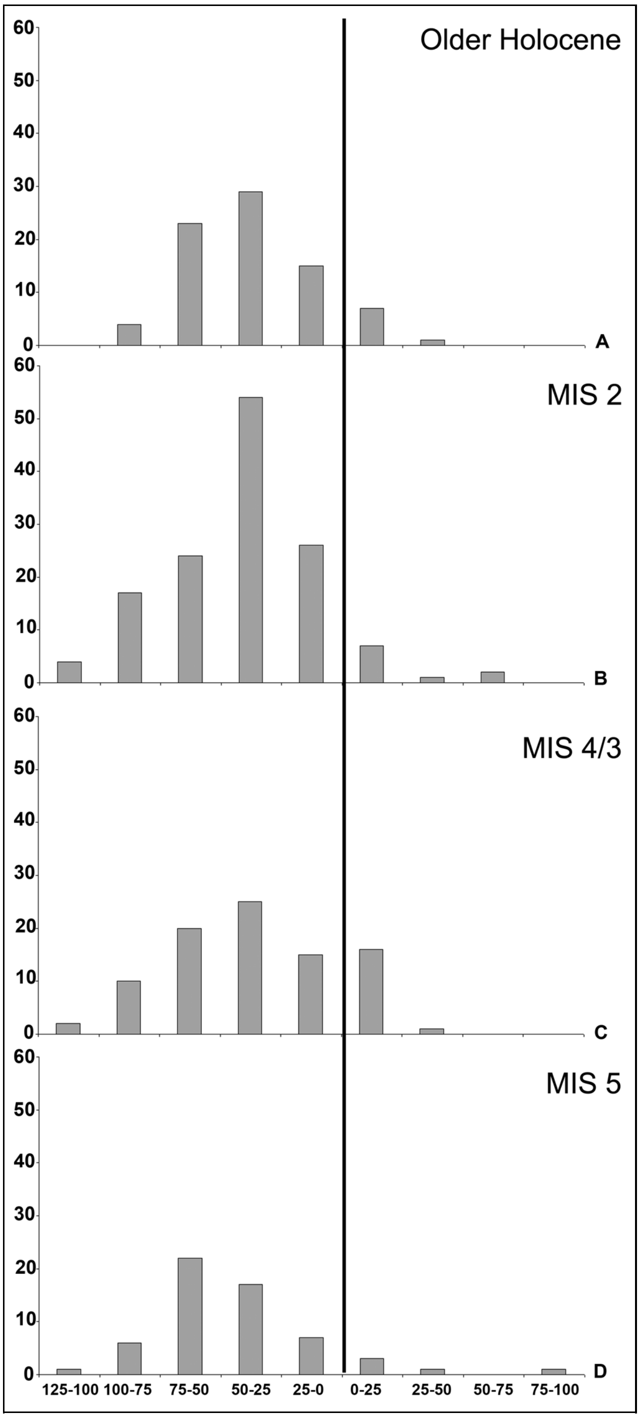

Fig. 5 - Size Variation Index of the red deer populations from southern Italy during the older Holocene (A), MIS 2 (B), MIS 4/3 (C) and MIS 5 (D). Details on localities and their ages are reported in Tab. 1.

quency between 0 and 25) than the other two areas during MIS 2 (between -75 and -50 in central Italy and between -50 and -25 in southern Italy). The northern Italian sample is statistically different from the central and southern Italian ones (Tab. 3). During the older Holocene, the species appears larger in central Italy (between -25 and 0) than in northern and southern Italy (both between -50 and -25). Nevertheless, U-test reveals that the northern Italian sample is statistically different from the central and southern Italian samples, whereas the central Italian sample is not statistically different from the southern Italian one (Tab. 3).

MIS 5	northern Italy	central Italy	southern Italy
central Italy			0.2222
MIS 4/3	northern Italy	central Italy	southern Italy
central Italy			0.08293
MIS 2	northern Italy	central Italy	southern Italy
northern Italy		3.56E-07	1.20E-10
central Italy			0.5431
Holocene	northern Italy	central Italy	southern Italy
northern Italy		4.347E-0.6	3.005E-0.6
central Italy			0.2569

Tab. 3 - Significance testing of red deer postcrania among considered subareas for each time span. Values are p-values obtained using U-tests, with a $p<0.05$ the difference is significant, with a $p<0.01$ the difference is very significant, with a $p<0.001$ the difference is highly significant.

Discussion

Based on our results, the red deer shows an increase in size during MIS 4/3 in central Italy. The histogram also suggests an increase in size in southern Italy but this is not statistically supported. This increase may be referred to the altered feeding conditions or to the spread of red deer populations from central Europe to the glacial refugia of southern Europe, like the Iberian, Balkan and Italian Peninsulas, due to the expansion of ice caps (Sommer et al. 2008; Banks et al. 2008). The few data referable to MIS 2 suggest the presence of large sized red deer in northern Italy; unfortunately, a trend cannot be confirmed for this area due to the scarcity of data. The decrease of the ice caps during the latest Pleistocene enabled the species to spread again from the glacial refugia to central and northern Europe. In this period, the red deer populations reached central Europe from the Iberian Peninsula and from the Balkans (Ludt et al. 2004; Sommer et al. 2008; Skog et al. 2009; Meiri et al. 2013). The two haplogroups living in Italy at the present day (one genetically closer to the Western European populations living in central Italy, and another one closer to the Balkan populations living in northern Italy) seem to develop during this period (Sommer et al. 2008). The presence of two haplogroups could explain the presence of populations with different size during the older Holocene in northern and in central Italy, although there is no direct evidence for this. Northern Italian population is, however, statistically different from both central and southern Italian populations referred to the same time span. In northern Italy red deer expanding from the Balkan area (the populations from which are genetically related with them: Sommer et al.

2008) could spread into the Po Valley. In central Italy, populations originated from Central Europe were still present (these populations could be represented at present days by the red deer from Mesola, which are considered, even though not definitively, as the only autochthonous red deer in Italy) (Sommer et al. 2008; Hmwe et al. 2006). The red deer from southern Italy show instead a stasis in size through the Late Pleistocene. These populations, represented above all by remains collected from Apulia, do not seem to be influenced by the dispersal events at the end of Last Glacial. Indeed, during MIS 2 the southern Italian sample is statistically different from both central and northern Italian samples (Tab. 3); on the contrary, during MIS 5 and MIS 4/3 southern Italian sample is statistically similar to that from central Italy (Tab. 3).

Red deer shows size variations also in other areas of Europe during the Late Pleistocene. According to Prat & Suire (1971) the red deer from Wurm I (MIS 5) seem to be smaller and have narrower teeth than those from Wurm II (MIS 4/3): according to Prat & Suire (1971) these differences could the recognition of two subspecies. Guadelli (1996) considers the smaller form to be distinct at specific rank as, *C. simplicidens*, on the basis of the size (*C. simplicidens* is considerably smaller than *C. elaphus* both in the teeth and in the bone remains) and some morphological differences in the teeth but also some ecological differences (*C. simplicidens* is associated with more temperate environments) (see Guadelli 1996). This species is not widely accepted and Steele (2004) considers the holotype of *C. simplicidens* as *C. elaphus*, maintaining that the two forms are morphologically very similar and that significant ecological differences have to be demonstrated.

The presence of small red deer populations during MIS 5 also occurs in Italy; these populations show a normal distribution with the dominant class between -75 and -50 and occur both in central and southern Italy (Figs 3, 4). These size distributions are not present in the SVI histograms after MIS 5.

Conclusions

The red deer is a typical species of European temperate and boreal faunal assemblages since the Middle Pleistocene and shows a capability for fast adaptation; during the climatic phases of the Pleistocene it differentiated into several populations with different body size (Lister 1984).

Variability of the body size does not have a valuable taxonomic significance if not corroborated by other morphological and morphometric characters. In fact, during the Middle Pleistocene the Italian red deer populations show peculiar morphological features (Di Stefano & Petronio, 1992, 1993, 2002 and references therein) allowing us to distinguish different subspecies which may have biochronological value.

Since the end of the Middle Pleistocene and during the Late Pleistocene, the remains of the red deer populations in Italy do not show any important morphological changes. However, the morphometric analysis of these remains shows interesting results that may help to explain the presence of the different haplogroups living in Italy at the present day. Variations in the SVI index of red deer can be observed across the considered time span and the geographical areas, but they do not appear synchronous in the three areas.

The populations of red deer in northern Italy were probably less influenced by geographic isolation and could have experienced gene flow with the populations of Central Europe due to the presence of the Adriatic corridor (in the East) and of the mountain passes in the West. Populations further south in Italy may have been more isolated and effectively refugial.

Therefore, in Italy the differences in body size during the Late Pleistocene are likely to have been influenced both by climatic changes and paleogeography. The attribution of the different Italian populations to different subspecies during the considered time span is very difficult, however additional useful material, including ancient genetic data, are needed to clarify this aspect.

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Appendix

Measurements of the post-cranial remains of red deer from the Middle Pleistocene of Mosbach 2 (Germany) stored at the Naturhistorisches Museum of Maintz and from the Late Pleistocene Italian sites of Ingarano and Avetrana (stored at the Department of Earth Science, La Sapienza University of Rome), Sora, Fossellone, Palidoro, Grotta Romanelli and Riparo Fumane (stored at the Museo Nazionale Preistorico Etnografico Luigi Pigorini, Rome).

L = maximum length; PTD = proximal transversal diameter; PAPD = proximal antero-posterior diameter; MTD = transversal diameter of the shaft; MAPD = antero-posterior diameter of the shaft; DTD = distal transversal diameter; DAPD = distal antero-posterior diameter; Hl = lateral height; Hm = medial height; TD = maximum transversal diameter.

Radius

Site	Specimen	L	PTD	PAPD	MTD	MAPD	DTD	DAPD
Mosbach	MM 1949/61	281.0	53.0	30.0	38.0	21.0	50.0	31.0
Mosbach	MM 1949/248	288.0	56.0	29.0	34.0	21.0	48.0	33.0
Mosbach	MM 1956/358	281.0	55.0	29.0	34.0	19.0	46.0	30.0
Mosbach	MM 1964/529	308.0	60.0	33.0	39.0	25.0	56.0	39.0
Mosbach	MM 1955/1136	319.0	60.0	31.0	37.0	22.0	54.0	40.0
Mosbach	MM 1958/42	335.0	65.0	36.0	41.0	23.0	60.0	43.0
Mosbach	MM 1973/299	302.0	57.0	30.0			51.0	32.0
Mosbach	MM 1961/69		66.0	35.0	34.0	24.0		
Mosbach	MM 1966/192	323.0	65.0	35.0	39.0	22.0	58.0	41.0
Mosbach	MM 1959/217		62.0	33.0	41.0	23.0		
Mosbach	MM 1958/355		54.0	29.0	32.0	18.0		
Mosbach	MM 1962/1233		69.0	36.0	39.0	25.0		
Mosbach	MM 1961/292	324.0	69.0	35.5	39.0	27.0	61.0	40.0
Ingarano	I1	268.5	56.0	32.0	32.0	24.0	51.0	37.5
Ingarano	I2		53.5	29.0				
Ingarano	I3						56.0	34.0
Ingarano	I4		57.0	32.5	34.0	21.0		
Avetrana	A1		46.0	24.0	27.5	16.0		
Avetrana	A2		52.0	30.0				
Avetrana	A3		55.0	31.0				
Avetrana	A4		53.0	29.0				
Avetrana	A5				30.0	20.0		
Sora - Valle Radice	P4215		49.0	25.5				
Sora - Valle Radice	P4217						45.2	33.0
Sora - Valle Radice	sn		48.4	25.5				
Sora - Valle Radice	sn		45.8	27.5				
Sora - Valle Radice	sn		53.1	27.7				
Sora - Valle Radice	sn		49.0	25.4				
Sora - Valle Radice	sn		44.4	22.7				
Sora - Valle Radice	sn						42.5	31.0
Sora - Valle Radice	sn						44.9	31.9
Sora - Valle Radice	sn						45.3	31.3
Sora - Valle Radice	sn						39.7	29.2
Grotta Romanelli	P1691		54.0	30.0				
Grotta Romanelli	P1692		50.0	27.0				
Grotta Romanelli	P1696						45.0	32.0
Grotta Romanelli	P1698						45.0	33.0
Grotta Romanelli	P1690		50.0	28.5				
Grotta Romanelli	P1694		52.0	29.5				
Grotta Romanelli	P1699						46.0	32.0
Grotta Romanelli	P1700						46.5	31.0
Grotta Romanelli	P1697						46.0	30.0
Grotta Romanelli	R54V		54.2	30.6				
Grotta Romanelli	sn						45.5	31.0
Grotta Romanelli	sn						44.4	30.9
Grotta Romanelli	sn						45.9	32.4

Metacarpal

Site	Specimen	L	PTD	PAPD	MTD	MAPD	DTD	DAPD
Mosbach	MM 1954/441	294.0	47.0	35.0	28.0	27.5	48.0	27.0
Mosbach	MM 1954/442	286.0	41.5	32.0	27.0	26.5	46.5	27.5
Mosbach	MM 1961/534	277.0	45.0	31.0	25.5	26.0	42.5	26.0
Mosbach	MM 1961/1308	278.0	47.0	35.5	29.0	28.5	48.5	28.0
Mosbach	MM 1961/1059	279.0	45.0	31.0	27.0	26.0		
Mosbach	MM 1962/684		46.0	34.0	28.0	24.0		
Mosbach	MM 1956/559		45.5	32.0	29.0	28.0		
Mosbach	MM 1955/306	268.0	38.5	29.5	25.0	24.0	43.0	25.0
Mosbach	MM 1957/528	271.0	39.0	30.5	22.5	25.0	40.0	26.0
Mosbach	MM 1955/968	290.0	47.0	33.5	27.5	28.0	47.0	29.0
Mosbach	MM 1951/103	277.0	43.0	31.0	25.5	25.0	45.0	26.0
Mosbach	MM 1954/324	298.0	47.0	34.5	29.0	26.0		
Mosbach	MM 1957/956				25.5	28.0	46.5	27.5
Mosbach	MM 1958/354		52.0	36.0	35.0	25.0		
Mosbach	MM 1958/290				29.0	27.0	46.0	28.0
Mosbach	MM 1965/281		45.5	33.0	29.5	24.0		
Mosbach	MM 1959/214	288.0	46.0	33.0	30.0	27.0	47.0	28.0
Mosbach	MM 1956/359	278.0	47.0	32.0	27.0	27.0	45.0	27.0
Mosbach	MM 1958/353	264.0	40.0	29.0	24.5	24.0		
Mosbach	MM 1959/581		43.0	32.0	25.0	24.0		
Mosbach	MM 1959/580		46.0	32.0	27.0	25.0	47.0	27.0
Mosbach	MM 1952/360		52.0	36.0				
Mosbach	MM 1955/1359		49.0	36.0	28.0	29.0		
Mosbach	MM 1963/638		45.0	33.5	27.0	27.0		
Mosbach	MM 1959/132		45.0	33.0	26.5	27.0		
Mosbach	MM 1956/706		45.0	32.0	26.0	25.5		
Mosbach	MM 1962/971		44.0	33.0				
Mosbach	MM 1952/352	294.0	49.0	35.0	29.0	27.0	48.0	30.0
Mosbach	MD Mb 665	272.0	46.0	33.0	26.5	27.0	48.0	28.0
Mosbach	MD Mb 389	282.0	44.0	31.0	27.0	27.0	46.5	27.0
Ingarano	I5	245.0	40.5	31.0	24.0	23.5	40.5	27.5
Ingarano	I6	247.0	40.5	33.0	23.5	23.5	41.0	27.5
Ingarano	I7		37.5	27.0				
Ingarano	I8							29.0
Ingarano	I9						42.0	27.0
Ingarano	I10				23.0	22.0		
Avetrana	A6		39.0	28.0				
Avetrana	A7			31.0				
Avetrana	A8		36.0	25.5				
Avetrana	A9		40.5	29.0				
Avetrana	A10		36.0	26.0	21.5	21.0		
Avetrana	A11				25.0	28.0	44.0	32.0
Avetrana	A12						40.0	28.0
Grotta del Fossellone	P90.1	265.0	44.0	34.0	30.0	30.0	46.0	28.5
Grotta del Fossellone	P90.1	256.0	42.0	31.0	24.0	26.0	43.0	29.0
Grotta del Fossellone	P10.58						39.0	26.0
Sora - Valle Radice	P4230	244.0	36.0	27.0	20.5	22.0	38.5	26.0
Sora - Valle Radice	sn		36.7	25.8				
Sora - Valle Radice	sn		41.2	29.6				
Sora - Valle Radice	sn		35.7	27.0				
Sora - Valle Radice	sn		36.4	27.5				
Sora - Valle Radice	sn		40.0	28.6				
Sora - Valle Radice	sn		39.8	28.2				
Sora - Valle Radice	sn						41.0	26.5
Sora - Valle Radice	sn						41.5	27.8
Grotta Romanelli	P1724	244.5	38.0	28.0	22.0	22.5	38.5	27.0

Metacarpal

Site	Specimen	L	PTD	PAPD	MTD	MAPD	DTD	DAPD
Grotta Romanelli	P1732						46.0	29.0
Grotta Romanelli	P1725		44.0	30.0				
Grotta Romanelli	P1737						38.5	27.0
Grotta Romanelli	P1735						37.0	25.2
Grotta Romanelli	P1733						45.8	31.0
Grotta Romanelli	sn						37.5	25.4
Grotta Romanelli	sn						39.2	27.3
Grotta Romanelli	sn						42.8	28.7
Grotta Romanelli	sn						41.1	28.0
Grotta Romanelli	sn						44.5	29.8
Grotta Romanelli	sn						38.4	25.6
Grotta Romanelli	sn						41.2	27.7
Grotta Romanelli	sn						46.7	27.6
Grotta Romanelli	sn		39.7	27.9				
Grotta Romanelli	sn						45.4	28.5
Grotta Romanelli	sn						43.4	26.7
Grotta Romanelli	sn						40.3	26.1
Grotta Romanelli	sn						42.7	27.5
Grotta Romanelli	sn						36.9	25.0
Grotta Romanelli	sn						40.1	26.4
Grotta Romanelli	sn						36.6	25.4
Grotta Romanelli	sn						42.5	26.8

Tibia

Site	Specimen	L	PTD	PAPD	MTD	MAPD	DTD	DAPD
Mosbach	MM 1972/135	409.0		95.0	40.0	35.0	55.0	
Mosbach	MM 1957/587						48.0	35.5
Mosbach	MM 1954/68						49.0	38.0
Mosbach	MM 1959/137						48.5	38.0
Mosbach	MM 1961/1118						60.0	42.0
Mosbach	MM 1962/1772						50.5	37.0
Mosbach	MM 1961/201				37.0	30.5	55.0	42.5
Mosbach	MM 1956/186				30.0	28.0	50.0	35.0
Mosbach	MM 1957/357				33.0	29.0	45.0	34.0
Mosbach	MM 1957/181				43.0	37.0	61.0	47.0
Mosbach	MM 1954/519				37.0	28.0	55.0	43.0
Mosbach	MM 1961/76						55.0	43.0
Mosbach	MM 1955/377	411.0	92.0		36.0	31.0	58.0	42.0
Ingarano	I11	336.5	76.0	71.5	32.5	32.0	50.5	40.0
Ingarano	I12				31.5	27.0	51.0	42.0
Ingarano	I13						57.0	42.0
Ingarano	I14	375.0	85.0	78.0	25.0	30.0	51.0	41.0
Avetrana	A13				32.0	27.0	51.5	41.0
Avetrana	A14						50.0	40.0
Grotta del Fossellone	P1065						50.0	40.0
Riparo di Fumane	A10V75						56.0	44.5
Sora - Valle Radice	P4235	325.0	64CA	68.0	25.0	27.0	48.0	36.0
Sora - Valle Radice	sn			63.2	67.0			
Sora - Valle Radice	sn						41.7	34.0
Sora - Valle Radice	sn						41.7	32.1
Sora - Valle Radice	sn						40.0	32.6
Sora - Valle Radice	sn						53.6	42.3
Sora - Valle Radice	sn						42.4	35.0
Sora - Valle Radice	sn						41.8	33.8
Sora - Valle Radice	sn						43.1	33.5

Tibia

Site	**Specimen**	**L**	**PTD**	**PAPD**	**MTD**	**MAPD**	**DTD**	**DAPD**
Sora - Valle Radice	sn						40.5	30.2
Sora - Valle Radice	sn						42.6	33.5
Grotta Romanelli	P1755		71.0	62.5				
Grotta Romanelli	P1765						45.0	34.0
Grotta Romanelli	P1759						47.0	39.0
Grotta Romanelli	P1754		78.2	75.0				
Grotta Romanelli	P1756		62.0	61.0				
Grotta Romanelli	P1766						50.0	41.0
Grotta Romanelli	P1760						49.0	37.0
Grotta Romanelli	P1764						47.0	37.0
Grotta Romanelli	P1758						47.0	36.0
Grotta Romanelli	P1762						47.2	37.5
Grotta Romanelli	sn						45.8	32.7
Grotta Romanelli	sn						46.4	35.4
Grotta Romanelli	sn						45.2	36.4

Metatarsal

Site	**Specimen**	**L**	**PTD**	**PAPD**	**MTD**	**MAPD**	**DTD**	**DAPD**
Mosbach	MM 1961/324	316.0	41.0	46.0	29.0	30.0	45.0	30.0
Mosbach	MM 1956/667	312.0			26.0	30.0	44.5	
Mosbach	MM 1955/459		40.0	41.0	25.0	30.0		
Mosbach	MM 1962/847	329.0	42.0	45.5	28.0	31.5	49.0	30.0
Mosbach	MM 1957/324	302.0	34.0	40.0	25.0	30.5	41.5	25.5
Mosbach	MM 1961/535		35.0	40.0	24.0	27.0		
Mosbach	MM 1951/355	303.0		41.0	24.0	28.0	44.5	29.0
Mosbach	MM 1955/1021		40.0	42.0	26.0	29.0		
Mosbach	MM 1961/126	316.0	42.0	42.0	26.0	30.0		
Mosbach	MM 1955/1134		40.0	43.0	26.5	33.0		
Mosbach	MM 1957/703	302.0	38.0	43.0	24.0	32.0	42.0	28.0
Mosbach	MM 1957/806	318.0	44.0	48.0	27.5	34.0	49.0	29.0
Mosbach	MM 1957/569		39.0	43.5	26.5	28.0		
Mosbach	MM 1957/991		47.5	50.0	29.0	35.0		
Mosbach	MM 1958/807		44.0	47.0				
Mosbach	MM 1971/34		36.5	40.0	24.5	26.0		
Mosbach	MM 1957/759		37.5	43.0	25.0	27.0		
Mosbach	MM 1967/50		43.0	47.0	26.0	29.5		
Mosbach	MM 1957/758		36.5	41.0	24.0	29.0		
Mosbach	MM 1958/122	312.0	44.0	47.5	26.5	29.0	48.5	30.0
Mosbach	MM 1958/502	312.0	41.0	44.5	25.0	30.0	44.0	30.0
Mosbach	MM 1958/121	335.0	48.0	51.0	32.0	36.0	58.0	34.5
Mosbach	MM 1959/353	321.0	42.0	45.5	28.0	29.5		28.0
Mosbach	MM 1954/222						48.0	29.0
Mosbach	MM 1962/571		39.5	42.0				
Mosbach	MM s. n.		41.0	44.0				
Mosbach	MM 1970/123				27.0	30.5	47.0	30.0
Mosbach	MM 1969/130				27.0	31.5	47.0	31.0
Mosbach	MM 1961/824						48.0	29.0
Mosbach	MM 1962/970						46.0	28.5
Mosbach	MM 1961/127				29.0	31.5	49.5	30.0
Mosbach	MM 1959/756				27.0	28.0	53.0	29.0
Mosbach	MM 1962/419						49.5	32.5
Mosbach	MM 1961/718						48.0	30.0
Mosbach	MM 1970/122						47.5	30.5
Mosbach	MM 1957/244		36.0	38.0	25.5	28.0		
Mosbach	MM 1956/764		40.0	44.0	25.5	27.5		

Metatarsal

Site	Specimen	L	PTD	PAPD	MTD	MAPD	DTD	DAPD
Mosbach	MM 1953/393		39.0	41.0	26.0	27.0		
Mosbach	MM 1961/604		39.0	44.5				
Mosbach	MM 1962/1376		37.0	39.5	25.0	25.5		
Mosbach	MM 1961/1057		38.0	41.5	25.5	27.0		
Mosbach	MM 1957/581		38.0	40.0				
Mosbach	MM 1968/76		40.0	43.0	24.0	27.0		
Mosbach	MM 1949/379	321.0	44.0	47.0	28.0	31.0	52.0	32.0
Mosbach	MD Mb 372	317.0		47.0	29.0	32.0	52.0	33.0
Mosbach	MD Mb 371		47.0	46.0	28.0	29.0		
Ingarano	I15	276.0	39.5	42.0	28.0	27.0	40.5	30.0
Ingarano	I16		35.5	36.0	18.5	25.5		
Ingarano	I17		36.5	36.5				
Ingarano	I18		40.0	46.0	28.0	33.0		
Avetrana	A15		29.0	31.0				
Avetrana	A16		34.0	37.0				
Avetrana	A17		32.0	33.0	20.5	23.5		
Avetrana	A18				21.0	24.0		
Avetrana	A19		34.0	37.0	21.0			
Avetrana	A20		35.0	38.0	22.0	28.0		
Grotta del Fossellone	P1061						42.0	27.5
Grotta del Fossellone	P90.3	279.2	39.0	41.0	24.5	28.5	45.0	29.5
Grotta del Fossellone	P1059		34.0	37.5				
Grotta del Fossellone	P1062						46.0	29.0
Sora - Valle Radice	P4246	282.0	39.0	39.0	23.5	28.0	42.0	27.0
Sora - Valle Radice	sn		36.7	38.3				
Sora - Valle Radice	sn		36.3	37.2				
Sora - Valle Radice	sn		33.4	34.6				
Sora - Valle Radice	sn		36.6	40.2				
Sora - Valle Radice	sn						39.8	25.6
Sora - Valle Radice	sn						39.2	25.1
Sora - Valle Radice	sn						34.7	24.7
Sora - Valle Radice	sn						38.6	26.5
Grotta Romanelli	P1796						40.2	28.0
Grotta Romanelli	P1788		35.0	37.0				
Grotta Romanelli	P1795						42.0	27.0
Grotta Romanelli	sn		33.7	35.1				
Grotta Romanelli	sn						39.0	26.8

Astragalus

Site	Specimen	Hl	Hm	TD
Mosbach	MM 1957/518	62.0	57.0	40.0
Mosbach	MM 1955/318	62.0	57.0	38.0
Mosbach	MM 1950/585	69.0	63.0	46.0
Mosbach	MM 1955/1150	65.0	62.0	40.0
Mosbach	MM 1954/642	64.0	60.0	42.0
Mosbach	MM 1957/48	63.0	59.5	40.0
Mosbach	MM 1954/770	60.0	57.0	39.0
Mosbach	MM 1956/587	58.0	55.0	38.0
Mosbach	MM 1959/799	60.0	55.0	38.0
Mosbach	MM 1954/619	64.0	60.0	40.0
Mosbach	MM 1955/978	60.0	55.0	
Mosbach	MM 1955/975	65.0	61.0	42.0
Mosbach	MM 1959/856	63.0	57.0	41.0
Mosbach	MM 1955/1250	61.0	57.0	37.0

Astragalus				
Site	**Specimen**	**Hl**	**Hm**	**TD**
Mosbach	MM 1961/512	63.0	57.0	40.0
Mosbach	MM 1961/901	65.0	61.0	40.0
Mosbach	MM 1960/61	64.0	59.5	41.0
Mosbach	MM 1959/745	69.0	65.0	45.0
Mosbach	MM 1960/51	65.0	63.0	42.0
Mosbach	MM 1961/598	66.0	61.0	44.0
Mosbach	MM 1961/58	62.0	57.0	40.0
Mosbach	MM 1957/533	64.0	59.0	42.0
Mosbach	MM 1968/253	63.0	60.0	41.5
Mosbach	MM 1958/575	63.0	57.0	41.0
Mosbach	MM 1961/131	62.0	58.0	38.0
Mosbach	MM 1959/668	63.0	59.0	38.0
Mosbach	MM 1957/590	80.0	76.0	47.0
Ingarano	I19	55.0	52.0	37.0
Ingarano	I20	49.0	47.0	32.0
Ingarano	I21	54.0	49.5	37.0
Ingarano	I22	54.0	48.0	38.0
Ingarano	I23			35.0
Ingarano	I24	53.0	49.0	34.0
Ingarano	I25	53.0	49.5	36.0
Ingarano	I26		46.0	
Ingarano	I27		47.0	
Ingarano	I28		49.0	34.0
Ingarano	I29		51.5	
Ingarano	I30		45.0	
Ingarano	I31	50.0	44.5	32.0
Ingarano	I32	49.5	45.0	32.0
Avetrana	A21		49.0	
Avetrana	A22	53.5	51.0	35.0
Avetrana	A23	52.0	47.5	34.0
Avetrana	A24	57.5	54.0	38.0
Grotta del Fossellone	P1069-1	53.5	49.0	35.0
Grotta del Fossellone	P1068	49.0	45.0	31.1
Grotta del Fossellone	P1071	57.0	53.0	36.0
Grotta del Fossellone	P1070	54.0	51.0	37.8
Sora - Valle Radice	P4242	48.7	45.2	30.5
Sora - Valle Radice	sn	48.0	42.8	31.3
Sora - Valle Radice	sn	51.9	47.2	33.5
Sora - Valle Radice	sn	53.2	49.5	34.3
Sora - Valle Radice	sn		49.0	33.0
Sora - Valle Radice	sn	47.5	45.9	28.6
Palidoro	PAL59	55.3	50.7	34.0
Palidoro	PAL59	53.5	49.3	34.7
Palidoro	PAL59	55.1	50.7	34.6
Palidoro	PAL59	55.4	52.5	35.6
Palidoro	PAL59	50.0	47.0	30.3
Grotta Romanelli	P1774	51.0	48.0	33.0
Grotta Romanelli	P1769-2	52.5	49.5	33.0
Grotta Romanelli	P1769-1	54.0	50.0	33.0
Grotta Romanelli	P1770-1	48.0	46.0	29.0
Grotta Romanelli	P1772-2	54.0	52.0	34.0
Grotta Romanelli	P1772-1	55.2	51.5	33.0
Grotta Romanelli	P1771-1	51.2	49.0	28.0
Grotta Romanelli	P1771-2	52.0	48.5	31.0
Grotta Romanelli	P1770-2	52.0	48.5	32.0
Grotta Romanelli	P1773	45.0	42.0	28.0

Astragalus				
Site	**Specimen**	**Hl**	**Hm**	**TD**
Grotta Romanelli	sn	54.8	53.3	33.0
Grotta Romanelli	sn	49.9	47.5	30.3
Grotta Romanelli	sn	52.1	48.7	32.5
Grotta Romanelli	sn		53.0	37.5
Grotta Romanelli	sn	58.3	52.4	32.3
Grotta Romanelli	sn	55.0	50.6	35.0