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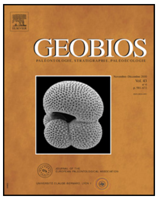

Original article

Villafranchian-Galerian mammal faunas transition in South-Western Europe. The case of the late Early Pleistocene mammal fauna of the Frantoio locality, Arda River (Castell'Arquato, Piacenza, Northern Italy)☆

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ABSTRACT

We investigated the fossil mammal assemblage from the late Early Pleistocene (early Galerian) site of the Arda River. Seven taxa were identified: one carnivore (*Ursus dolinensis*), five artiodactyls (*Sus strozzii*, *Pseudodama farnetesis*, *Praemegaceros* sp., *Bison* sp., and *Hippopotamus* sp.) and one perissodactyl (*Stephanorhinus hundsheimensis*). The Arda River faunal assemblage includes taxa already present in the Villafranchian, such as *Pseudodama* and *Sus strozzii.* The bear *U. dolinensis* and the bison, a more evolved form than *Bison* (*Eobison*), are taxa typical of the beginning of the Galerian mammal age. Paleontological, sedimentological and paleobotanical data point towards the presence of woodlands settled on an alluvial plain with patches of grassland dated around 1.0 Ma. The continental sediments of the Arda River represent one of the first steps of the forming of the alluvial Po valley.

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1. Introduction

The Arda River is a right tributary of the Po River flowing in Emilia-Romagna (Northern Italy; Fig. 1). Since 2006, investigations in the continental clay layers along its course have yielded several scattered bone remains of large mammals. The fossils, according to the field observations, come from the same stratigraphical level located at 247 m above the base of the studied stratigraphical section of the Arda River. Field taphonomic observations allow to infer that the carcasses, after being transported by the river, were deposited in a lagoon or a marsh where the decomposition took place without further transport. At that time, no field excavations were carried out and the remains were collected immediately after flood episodes. The mammal fossil remains of the Arda River represent a worth investigating sample of the Italian large mammal fauna during the late Early Pleistocene. The fossil assemblage comprises species of Villafranchian affinity alongside new forms announcing the imminent turnover of the Middle Pleistocene mammals, which will find its completion under the Slivia and Isernia Faunal Units (Masini and Sala, 2011) of the early Middle Pleistocene.

2. Stratigraphical section of the Arda River and age of the faunal assemblage

The Arda River geological section coincides with the upper part of the Castell'Arquato Formation; it consists of ~300 m of sediments. The basalmost 237 m are marine deposits dated from about 1.8 to 1.2 Ma (Crippa et al., 2016). The uppermost 63 m are made of mainly continental deposits organized in four main cycles, characterized by massive or slightly stratified fluvial gravels (1–4 m-thick each), which pass quickly to sands, silts and clays of the alluvial plain. In these very fine sediments are preserved the remains of large fossil mammals described herein, as well as roots of plants in life position, trunks, leaves, seeds (Pini et al., 2014) and freshwater molluscs (Bagattini, 2014), which document the existence of swamps and marshes (Bona et al., 2015; Monesi et al., 2016). The mammal remains were unearthed 247 m above the base of the Arda section (Fig. 2). According to magnetostratigraphic analyses (Monesi et al., 2016) the mammal-yielding level has been placed at the top of the Jaramillo subchron, at an age close to 0.99 Ma.

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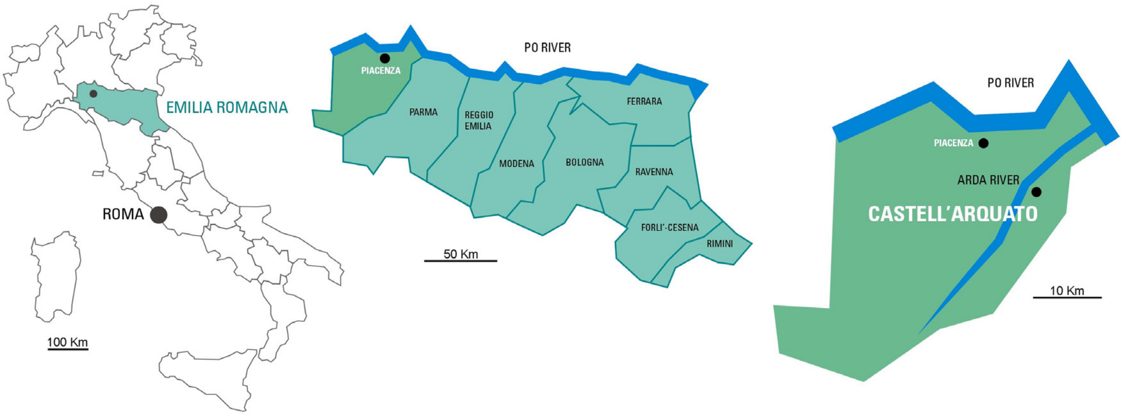

Fig. 1. Geographical position of the "Frantoio" locality, late Early Pleistocene, Arda River, Northern Italy.

3. Material and methods

The Arda River fossil mammal collection consists of 61 remains that have been collected in 2006–2015 from a continental clay layer in the locality called "Frantoio". The complete collection of fossils is housed at the local geological Museum "G. Cortesi" of Castell'Arquato (PC).

Measurements of the fossil bones, where not specified, are taken mainly according to Driesch von den (1976), Persico et al. (2015), and Mazza et al. (1993) for rhinoceros. Dental morphology is described according mainly to the terminology proposed by Heintz (1970) and Hillson (2005). The teeth were described using the following terminology: upper, M/x; lower, Mx/.

The fossil assemblage of the Arda River has been compared with those of late Early Pleistocene sites of Central and Western Europe, such as Untermassfeld in Germany (Guérin and Faure, 1997; Sher, 1997; Musil, 2001; Kahlke, 2007), Le Vallonnet (Moullé et al., 2006) and Bois-de-Riquet (Bourguignon et al., 2016) in France, Colle Curti, Redicicoli and Scoppito (Masini and Sala, 2007) in Italy, Trinchera Elefante, Fuente Nueva-3, Barranco Leon-5, Valparadís Estació (Madurell-Malapeira et al., 2010, 2014) in Spain, Megalopolis–Marathousa (Koufos, 2001) in Greece, and Het Gat (Post et al., 2001; Mol et al., 2003) in The Netherlands.

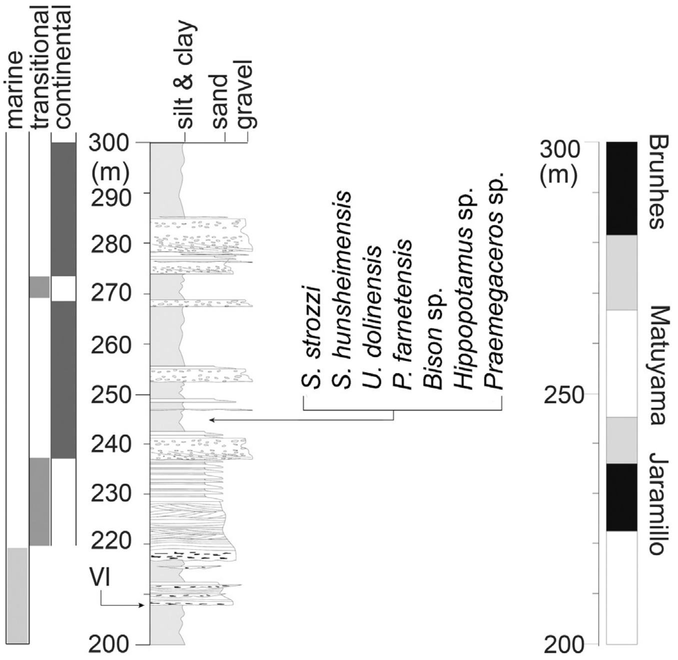

Fig. 2. Sedimentological evolution along the uppermost 100 m of the Arda River stratigraphic section at the "Frantoio" locality, indicating the mammal fossil-bearing level and presenting the magnetostratigraphic interpretation of the series (modified from Monesi et al., 2016).

4. Systematic paleontology

Order Carnivora Bowdich, 1821
Family Ursidae Gray, 1825
Genus ***Ursus*** Linnaeus, 1758
Ursus dolinensis García and Arsuaga, 2001
Fig. 3
2001. *Ursus rodei* – Musil.

Material: Vt081 (left half skull); Vt034-035 (complete lower jaw); Vt082 (fragment of right ulna); Vt151 (right M/2).

Measurements: See Table 1.

Description:

Skull. The skull (Vt081) is very poorly preserved; only the left side is present with P4/, M1/, M2/, the alveoli of P1/ and P3/, and probably P2/ (Fig. 3(3,4)). The skull shows a high degree of deformation but some traits are visible: the frontal bones do not form a typical speleoid "frontal angle", the sagittal crest is developed backward; overall, the skull belongs to a very large individual (condylo-basal length ≃390 mm).

The overall P4/ morphology is strange. The tooth has a quadrangular shape due to an enlargement of the paracone towards the lingual side. The wear marks on the paracone form a drop shape with the apex facing the metacone. The metacone shows a very small secondary cusp placed at 1/5 of the tooth length development. The metacone is the only cusp not deeply worn. The deuterocone is heavily worn and wear marks form an ovoidal dentine islet. A cingulum, even if not well developed, is present on the buccal side. Supplementary cones and ridges are absent.

The M1/ has a quadrangular profile. Paracone and metacone have similar dimensions. The occlusal surface is deeply worn but the small unworn areas are smooth without accessorial tubercles. The cingulum is well developed only on the metacone.

The M2/ is large with a very simple occlusal surface lacking crests and accessorial tubercles. The wear of the paracone has a trapezoidal shape; the ridge connecting the protocone and hypocone is deeply worn. The crown is low. The overall shape clearly shows the typical distal lengthening and constriction. The crown is very developed in mesio-distal direction.

Mandible. The mandible (Vt034-035) preserves canines, P/4, M/1 and M/3; both M/2 are absent; the alveoli of P/1 and P/3 are

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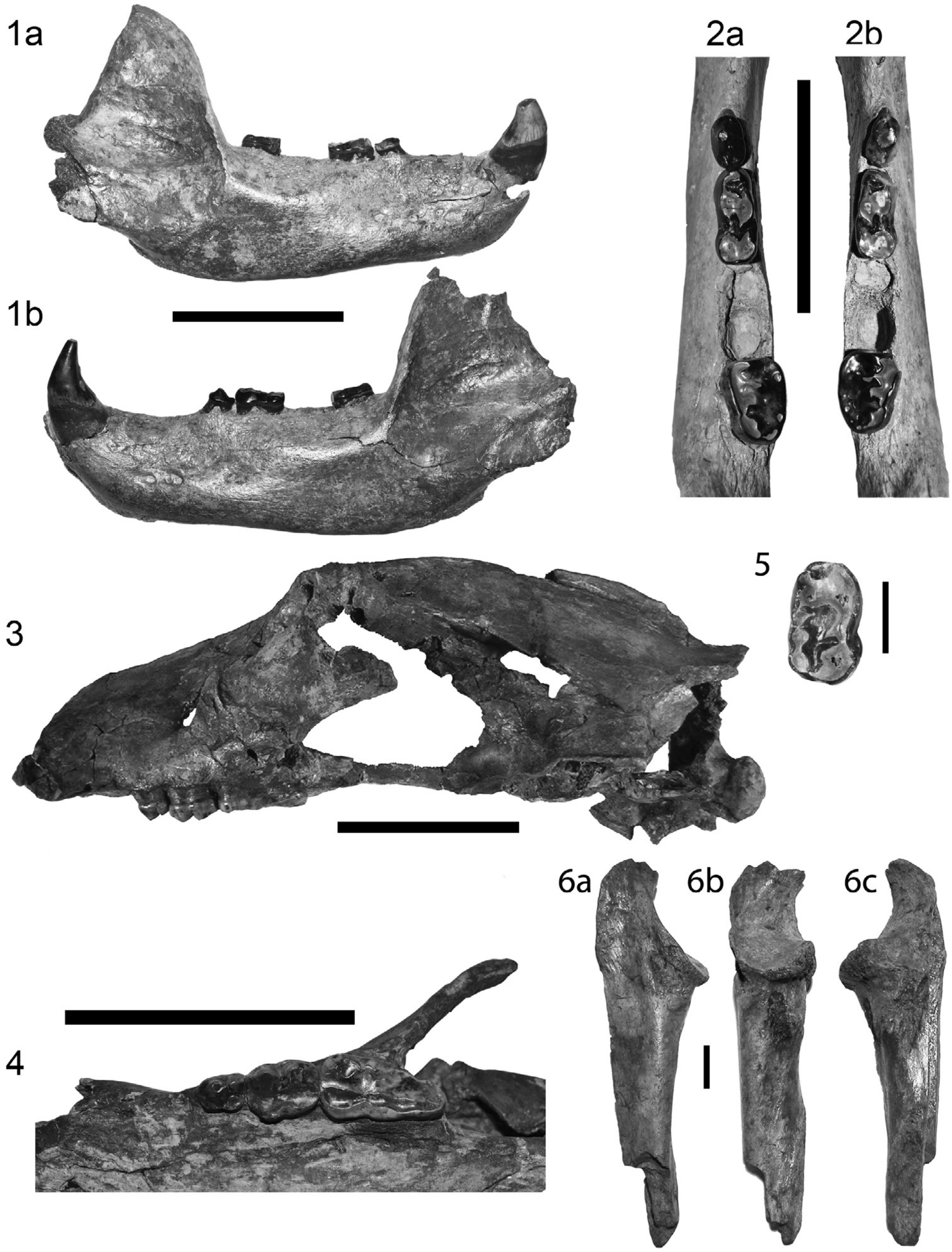

Fig. 3. *Ursus rodei* from the "Frantoio" locality, late Early Pleistocene, Arda River, Northern Italy. **1**. Mandible in buccal view; a, Vt035; b, Vt034. **2**. Mandible in occlusal view; a, Vt034; b, Vt035. **3**. Half skull, left view, Vt081. **4**. Left cheek teeth, detail of Vt081. **5**. Right lower second molar, Vt151. **6**. Right ulna fragment, Vt082; a, lateral view; b, dorsal view; c, medial view. Scale bars: 10 cm (1–4), 2 cm (5, 6).

present (the P/2 alveolus is also present, but only a small trace of it is visible) (Fig. 3(2)). The teeth are medium worn, testifying the adult age of the bear. The articular condyles are poorly preserved, as well as the coracoid processes. The overall morphology of the jaw is very robust, similar to that of the *U. deningeri*/*spelaeus* group, with a very high horizontal ramus and an expanded vertical ramus.

The P/4 is an ovoid tooth with a markedly developed protoconid. The talonid shows a modest height. On the lingual side, a slight cingulum is present.

The M/1 presents an elongated trigonid and a rounded talonid. The paraconid is clearly separate from the other cusps. On the buccal side, a depression between the protoconid and hypoconid is present; on the lingual side, the depression between the metaconid and entoconid is more developed, occupying two thirds of the transverse development of the tooth. It is possible to note the extreme simplification of the tooth despite the considerable wear.

The M/2 (Vt151) is sub-rectangular with a medial restriction that well divides the tooth into two sectors: the anteroconid and the talonid. The anteroconid is quadrangular while the talonid is more rectangular due to its enlargement on the buccal side. Both the lingual and the buccal walls of the tooth are inclined towards the middle part. The occlusal surface is simple, lacking accessorial tubercles and crests (Fig. 3(5)).

The M/3 is a sub-quadrangular tooth with a very smooth occlusal surface.

Postcranial material. Vt082 is a small proximal fragment of the right ulna of a bear of medium to large size. The olecranon and the anconea apophysis are not preserved. The semilunar recess and the sigmoid cavity make a heavy twisted articular surface (Fig. 3(6)).

Remarks: The total amount of information given by the cranial and mandibular features, the strong speleoid-like development of the bones accompanied by very simple arctoid-like teeth, and the

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Table 1
Measurements (in mm) of *Ursus dolinensis* remains from the "Frantoio" locality, late Early Pleistocene, Arda River, Northern Italy. Measures (Driesch von den, 1976): 1, total length; 2, length from angular process to infradentale; 3, length from the indentation between the condyle process to the angular process-infradentale; 4, length from the condyle process to the aboral border of the canine alveolus; 5, length from the indentation between the condyle process and the angular process – aboral border of the canine alveolus; 6, length from the angular process to the aboral border of the canine alveolus; 7, length from the aboral border of the alveolus of M/3 to the aboral border of the canine alveolus; 8, length of the cheek row from P/1 to M/3; 9, length of the cheek row from P/2 to M/3; 10, length of the molar row, measured along the alveoli; 11, length of the premolar row (P/1-P/4), measured along the alveoli; 12, length of the premolar row (P/2-P/4), measured along the alveoli; 13, length and breadth of the carnassial, measured at the cingulum; 14, length of the carnassial alveolus; 15, length and breadth of the M/2, measured at the cingulum; 16, length and breadth of the M/3, measured at the cingulum; 17, greatest thickness of the body jaw (below M/1); 18, height of the vertical ramus from the basal point of the angular process to the coronion; 19, height of the mandible behind M/1, measured on the lingual side; 20, height of the mandible between P/2 and P/3, measured on the lingual side.

	Vt081 – Skull			Mandible		
	P4/	M1/	M2/	Meas. #	Vt034	Vt035
Total length	17.3	25.8	45.7	1	–	–
Maximum width	12.9	–	–	2	–	–
Anterior lobe buccal length	–	12.6	–	3	293.0	–
Posterior lobe buccal length	–	13.4	–	4	–	253.0
Anterior lobe lingual length	–	–	–	5	254.0	–
Posterior lobe lingual length	–	–	–	6	–	–
Paracone length	–	9.5	14.5	7	146.3	–
Metacone length	–	9.3	7.5	8	139.9[a]	136.7[a]
Anterior lobe width	–	20.4	23	9	126.7[a]	123.6[a]
Posterior lobe width	–	20	14.6	10	80.2	79.7
Median narrowing width	–	19.4	–	11	60.3[a]	56.1[a]
Paracone-Metacone length	5.7	13.4[a]	–	12	45.7	–
Paracone height	9.8	9.0	–	13	27.7	–
Metacone height	8.3	8.8	–	14	26.6	26.8
Protocone-Hypocone length	–	16.7[a]	21.7	19	65.6	67.3
Protocone width	–	–	21.7	20	58.0	60.8
Paracone-Protocone length	–	–	11.4			

	C inf		P/4		M/1		M/3		M/2
	Vt034	Vt035	Vt034	Vt035	Vt034	Vt035	Vt034	Vt035	Vt051
Length			14.7	15.2	27.6	–	24.3	24.2	26.5
Width			9.6	9.6	–	–	–	–	–
Trigonide length			–	–	17.9	–	–	–	14.4
Talonide length			–	–	9.8	9.5	–	–	11.2
Trigonide width			–	–	11.2	11.3	18.4	18.4	15.1
Talonide width			–	–	12.2	12.5	16.4	16.3	16.0
Length (at the enamel edge)	26.3	26.6							
Width (at the enamel edge)	18.1	18.1							

[a] Estimated measurement.

medium to large size dimensions allow the attribution of the specimen to a very poorly known species of bear, *U. dolinensis*, first described by García and Arsuaga (2001) from the remains of Trinchera Dolina, Atapuerca (Spain). According to García (2004) and Kahlke (2007), *U. rodei*, described a few months later from Untermassfeld (Musil, 2001), is a junior synonym of *U. dolinensis*.

Order Perissodactyla Owen, 1848
Family Rhinocerotidae Gray, 1820
Genus ***Stephanorhinus*** Kretzoi, 1942
Stephanorhinus hundsheimensis (Toula, 1902)
Figs. 4–6,7(1),8

Material: Vt088 (skull); Vt089 (skull); Vt138 (skull); Vt086 (mandible); Vt092 (mandible); Vt085a (left ulna); Vt091 (right ulna); Vt085b (left radius); Vt169 (right radius); Vt083 (complete pelvis); Vt165 (left coxal bone fragment); Vt166 (left coxal bone fragment); Vt084 (left femur); Vt124 (left tibia).

Measurements: See Table 2.

Description:

Skull. In the Arda sample, rhinoceros remains are the best represented. Three incomplete skulls have been found: Vt088 is an almost complete dolichocephalic skull lacking a portion of the occipital bone (Fig. 4(1)). The teeth were collected near the skull but, apart from both the P2/, which were still in place, none of the teeth were inside the alveoli; the right P4/ is missing. The skull Vt088 is slightly deformed mainly due to a lateral compression. It is the only skull of the Arda River that preserves the strong and slightly directed forward processus postglenoideus but lacks the processi posttympanicus and paraoccipitalis. Loose (1975: fig. 5) presents some differences between the otic region of fossil and living rhinoceroses; unfortunately the otic area of Vt088 is not enough preserved to compare with them. The external auditory meatus is triangular and wide. The high level of tooth wear allows the attribution of the specimen to an old individual.

Vt089 is a half-preserved skull with all the teeth in place, lacking the brain case and the right side facial bones. It has been subject to a slight lateral compression that caused the fracture of the palatal bones. The Vt089 specimen is an old individual of about the same age as Vt088; it preserves partial left side with the complete dentition (Fig. 5(1)).

The Vt138 is the worst preserved skull: only small portions of the right premaxillary and maxillary bones are present with the P2/-P4/ in place. The right M2/ and M3/ were collected at a short distance from the cranial fragments and may be attributed to the same individual. The Vt138 shows a tooth wear stage similar to the one of Vt088 and Vt089 (same individual age).

The three skulls share important characters useful to separate the species of *Stephanorhinus* according to Fortelius et al. (1993) and Schreiber (2005):

- the nasal septum is partially fused;
- the posterior rim of the nasal incision is situated above P4/-M1/ and the anterior rim of the orbit reaching back above M2/ (Vt089). This condition is typical for *S. hundsheimensis*;

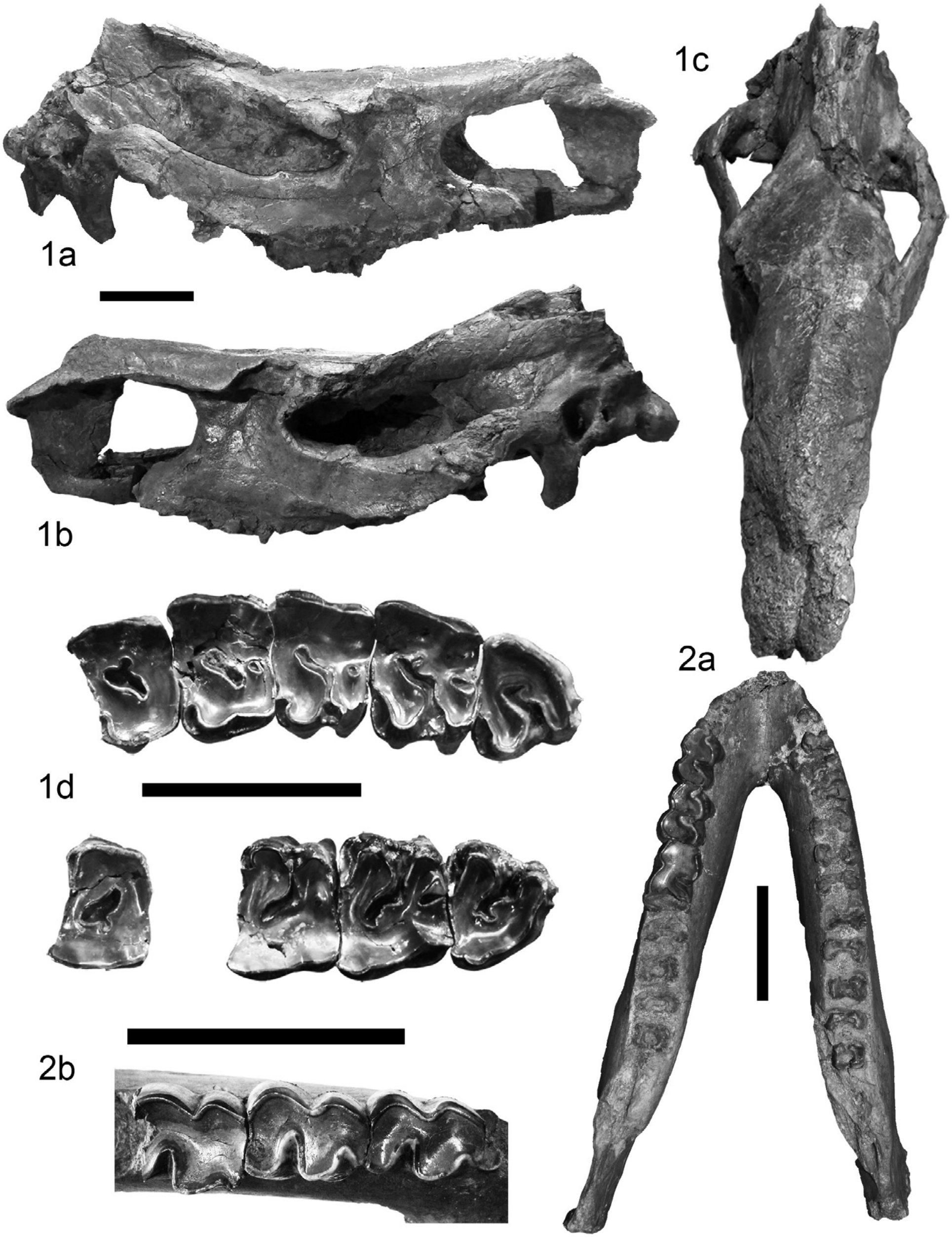

Fig. 4. *Stephanorhinus hundsheimensis* from the "Frantoio" locality, late Early Pleistocene, Arda River, Northern Italy. **1**. Skull, Vt088; a, right view; b, left view; c, dorsal view; d, cheek teeth series. **2**. Mandible, Vt092; a, occlusal view; b, detail of the teeth still in place. Scale bars: 10 cm.

- in dorsal view, the skulls present a narrow and elongated shape (Vt088 and Vt089 in part);
- in lateral view, the skulls are slender, the zygomatic arch is relatively thin, the frontal horn base rugosity is developed, but not well pronounced, instead the nasal horn base rugosity is well-developed. These features are reported for *S. hundsheimensis* (Fortelius et al., 1993);
- the teeth from P4/ to M2/ are approximately of the same dimensions. This situation has been reported for *S. etruscus* and *S. hundsheimensis*. On the contrary, in *S. hemitoechus* M2/ is significantly larger than M1/ and the reverse ratio is reported for *S. kirckbergensis*;
- the teeth are low-crowned.

Unfortunately, the teeth are very worn; as a result of this wear stage the lingual valley and the post-fossette frequently assume the shape of islets in the dentine occlusal surface and others features are impossible to be recognized. Teeth are described according to Ballatore and Breda (2013).

P2/: all the second premolars are very worn out. According to this state of wear, only the presence of a labial cingulum that not reached the distal end of the tooth can be recognized (Fig. 5(1c, 2b)).

P3/: the third premolars show a similar state of preservation than P2/, but in two of the three teeth, the presence of a single crochet and a single crista can be seen. In all teeth, a lingual cingulum that does not reach the distal end of the tooth is present (Figs. 4(1d), 5(1c, 2b)).

P4/: in Vt138, which is the less worn P4/, the crochet is present. All P4/ hold a well-developed lingual cingulum; also in this case, the cingulum does not reach the distal end (Figs. 4(1d), 5(1c, 2a)).

In the upper premolars, a discontinuous lingual cingulum is a typical *S. hundsheimensis* feature according to Schreiber (2005).

M1/: a simple crochet and simple crista are present. The lingual cingulum is always present and continuous. The angle between the

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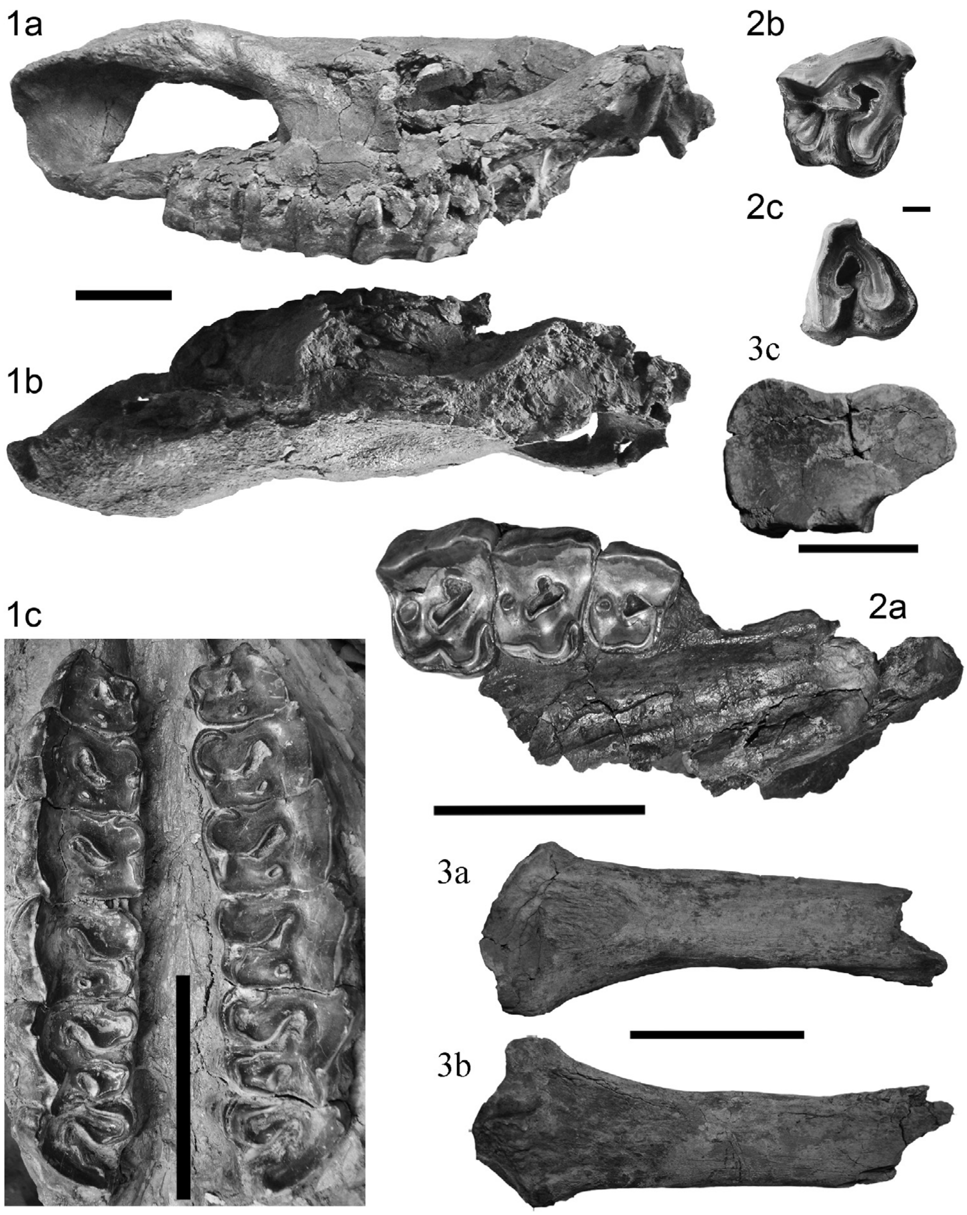

Fig. 5. *Stephanorhinus hundsheimensis* from the "Frantoio" locality, late Early Pleistocene, Arda River, Northern Italy. **1**. Skull, Vt089; a, left view; b, dorsal view; c, cheek teeth series. **2**. Right fragment of skull with isolated right M2/ and M3/, Vt138; a, occlusal view; b, M2/ occlusal view; c, M3/ occlusal view. **3**. Left radius, Vt169; a, dorsal view; b, palmar view; c, proximal end. Scale bars: 10 cm (1, 2a, 3a, 3b), 5 cm (3c), 1 cm (2b, 2c).

crochet and ectoloph is flat; the angle between the crochet and metaloph is obtuse. A strong paracone fold is present. The protocone constriction may vary from very light to light (Figs. 4(1d), 5(1c)).

M2/: the second molar shares the same features described for the first one. In Vt138, an anterocrochet is present (Figs. 4(1d), 5(1c, 2b)).

M3/: a single crochet is always present. The anterocrochet is present only in one tooth over five. The crista is generally absent but rarely present (1/5). The paracone fold is present and always strong. The lingual cingulum is present. The protocone constriction may vary from absent to light. The medisinus is generally open. The overall morphology of the tooth is similar to an isosceles triangle with lingual side smaller than the others. In *S. etruscus*, the M3/ shows a shape of an equilateral triangle; on the other hand, *S. hundsheimensis* presents an M3/ with an isosceles triangle shape (Figs. 4(1d), 5(1c, 2c)).

Mandible. Two nearly complete mandibles have been found. Vt086 lacks the mandibular symphysis and some portions of the vertical branches with the articular processes. The dentition is composed by the complete deciduous teeth dP/2-dP/4, M/1-M/2 and an erupting M/3. The two branches are still embedded in the original matrix. The eruption stage of the teeth allows attribution of the skull to a young rhino (Fig. 6).

Vt092 preserves the mandibular symphysis with the two branches still connected. Only three teeth are in their alveoli: P/3, P/4, and partly M/1 (Fig. 4(2)). On the other teeth, only the roots are preserved. The wear degree allows attribution of Vt092 to an old individual. The main features of the lower teeth are hereby reported.

The dP/2 is a very simple tooth that resembles P/2 of *Bos* with some substantial differences. The dimensions of P/2 are significantly higher than P/2 of *Bos*, and the roots are converging and parallel. A lingual valley is present, mesially developed, and proportionally larger than in *Bos*. In addition, the base of the lingual valley is farther away from the neck of the tooth so the lingual valley quickly disappears with wear (Fig. 6(2)).

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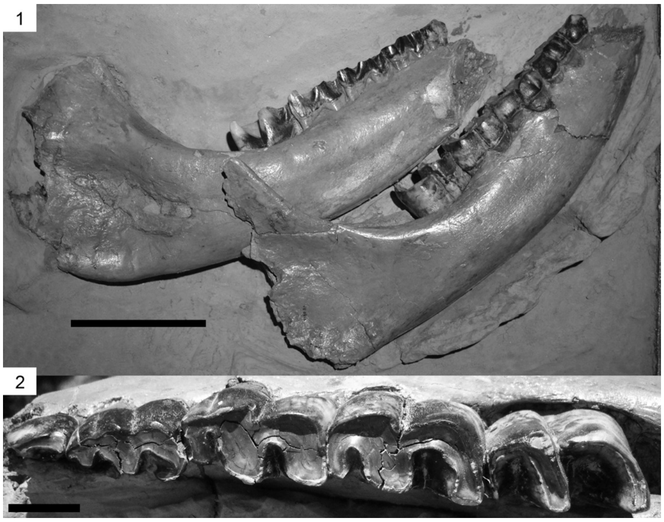

Fig. 6. Juvenile mandibule of *Stephanorhinus hundsheimensis* (Vt086) from the "Frantoio" locality, late Early Pleistocene, Arda River, Northern Italy. **1**. View of the juvenile mandible still preserved in the matrix. **2**. Right hemi-mandible in occlusal view. Scale bars: 10 cm (1), 2 cm (2).

The dP/3 presents a shape similar to the permanent teeth, but proportionally narrower; furthermore it has an additional mesial valley in a proximal position (Fig. 6(2)).

The dP/4 is very similar to permanent teeth but proportionally narrower (Fig. 6(2)).

The P/3 (Vt092) shows V-shaped distal and mesial valleys in lingual view. On the buccal side, the cingulum is continuous but thin, while on the lingual side, it is completely missing. The opening of the vestibular syncline is slightly obtuse, close to the right angle.

In the P/4 Vt092, distal and mesial valleys are V-shaped. The buccal cingulum is continuous but little developed while the lingual one is absent. The opening of the vestibular syncline is slightly obtuse, close to right angle.

M/1: in the young individual Vt086, the mesial valley has a narrow V-shape while the distal valley presents a broad V-shape. The old rhino Vt092 shows a worn out mesial valley and a V-shape distal one. For both teeth, no cingula or very few poorly developed cingula are present.

The M/2 Vt086 shows a broad and V-shaped mesial valley while the distal valley ranges from a broad V-shape to U-shape.

Postcranial material. *Ulna*. Two ulnae have been collected. Vt085a could be attributed to a young individual lacking the olecranon tuberosity (unfused epiphysis). Vt091, although fragmentary, shows a robust shape with strong muscle insertions typical of adult individuals. Overall, the two ulnae display a triangular cross section of the diaphysis and a sigmoidal (or trochlearis) incisure gently bending on lateral development (Figs. 7(1), 8). The synovial fossette is more developed in the ulnae of the Arda than that of *S. etruscus* from Upper Valdarno (Fortelius et al., 1993: pl. 3) and the overall dimensions testify that rhinoceroses of the Arda were slightly more robust than *S. etruscus*.

Radius. Vt169 is a 2/3 proximal adult right radius. The diaphysis is dorso-palmarly flattened. In the proximal epiphysis, there are two humeral cochleae, the medial one being larger than the lateral one. On the caudal side, there are two ulnar articulation surfaces, with the lateral one more developed (Fig. 5(3)).

Femur. Vt084 is a fragmented left diaphysis very poorly preserved. The femur shows a very strong and well-developed third trochanter (Fig. 8).

Remarks: During the late Early Pleistocene, a new small size species of rhinoceros appeared in Eurasia. This species, *S. hundsheimensis*, was recognized for the first time by Toula (1902). In the past, *S. hundsheimensis* was often misidentified as *S. etruscus* due their similarities (Ballatore and Breda, 2013). An example of very small *S.* cf. *hundsheimensis* comes from Pietrafitta (Italy) and dates ~1.5 M.a. (Mazza et al., 1993). *S. hundsheimensis* was stockier, with shorter and wider limb bones than *S. etruscus*. The *S. hundsheimensis* skull was more robust and elongate, with teeth similar in dimension and shape to those of *S. etruscus.* Overall, the Arda River rhinoceros remains show cranial (the position of posterior rim of the nasal incision, the position of the anterior rim of the orbit with respect to the teeth, and the presence of a strong nasal horn base) and dental (the shape of M3/ and the morphology of the lingual cingulum of upper premolars) features, as well as postcranial dimensions consistent with *S. hundsheimensis* (Fortelius et al., 1993; Mazza et al., 1993; Lacombat, 2006).

In Italy, rhinoceroses from the early Villafranchian (Late Pliocene) are referred to as *S. elatus* (also assigned to *S. jeanvireti*), documented in the Triversa FU in the type area of Villafranca d'Asti (Piedmont; Ambrosetti et al., 1996; Masini et al., 1996; Forno et al., 2015), in Tuscany at Gaville (Arezzo; Berzi, 1966; Rustioni, 1987), and at Bargo (Lucca; Kotsakis, 1986). The Dusino (Villafranca d'Asti) specimen, a complete skeleton of rhinoceros kept in the Regional Museum of natural Sciences of Turin, was studied by Guérin (1980) and assigned to "*Dicerorhinus jeanvireti*". These attributions are in contrast to Pandolfi and Marra (2015) who affirm that during the Early Pleistocene only *S. estruscus* was present.

In the Montopoli FU of the middle Villafranchian, *S. elatus* is identified at Montopoli (Pisa, Tuscany; De Giuli and Heintz, 1974; Masini et al., 1991). In the Saint-Vallier FU at Collepardo (Frosinone, Latium), cf. *S. elatus* is also present (Masini et al., 1991; Palombo et al., 2002).

The first *S. etruscus* is reported from the Coste S. Giacomo FU at the Quercia (Aulla, Massa Carrara, Tuscany; Masini et al., 1994). In the same FU a *S.* cf. *S. etruscus* is quoted at Ponte Naja (Abbazzi et al., 1997; Petronio et al., 2002). Later, *S. etruscus* is reported in several sites of the Olivola and Tasso FUs. Recently, Bourguignon et al. (2016) assigned to *S. etruscus* a small-sized rhinoceros from Bois-de-Riquet (Hérault, France), a site dated between 1.3 and 1.1 Ma.

At Pietrafitta (Perugia, Umbria), a late Farneta FU site, a small rhinoceros is signalized, with characters of both *S. etruscus* and *S. hundsheimensis* (Mazza et al., 1993), which was assigned to *S.* cf. *hundsheimensis* based mainly on the features of the postcranial skeleton. Made (2010, *fide* Pandolfi and Marra, 2015), Pandolfi and Petronio (2011), and Pandolfi et al. (2015) relate these small rhinoceroses to *S. etruscus*. Other specimens of a small-sized rhinoceros from Westerhoven (Brabant, The Netherlands), assigned to *S. etruscus* by Kolfschoten (1989), were later revisited and assigned to *S.* cf. *hundsheimensis* (Mazza et al., 1993).

S. aff. *hundsheimensis* is quoted at Madonna della Strada (Scoppito, l'Aquila, Abruzzo; Caloi and Palombo, 1995; Masini et al., 1991, 1996), *S.* cf. *hundsheimensis* at Lumena (Florence, Tuscany; Abbazzi et al., 1995), and *S. hundsheimensis* at Redicicoli (Rome, Latium; Caloi and Palombo, 1997; Palombo et al., 2002), three sites supposed to be late Villafranchian in age, but their chronology remains uncertain. At the end of the late Villafranchian, Italian authors (Gliozzi et al., 1997; Masini and Sala, 2007) signalize *S.* cf. *hundsheimensis* or *S. hundsheimensis*, in contrast with Pandolfi and Marra (2015) who report *S. etruscus*.

In the successive Colle Curti FU of the early Galerian (Epivillafranchian *sensu* Kahlke, 2007) at Colle Curti (Perugia, Umbria; Ficcarelli and Mazza, 1990), Imola (Bologna, Emilia-Romagna; Masini et al., 1995) and Castagnone (Giraudi et al., 2003; Siori and Sala, 2007), the remains of rhinoceroses are attributed to

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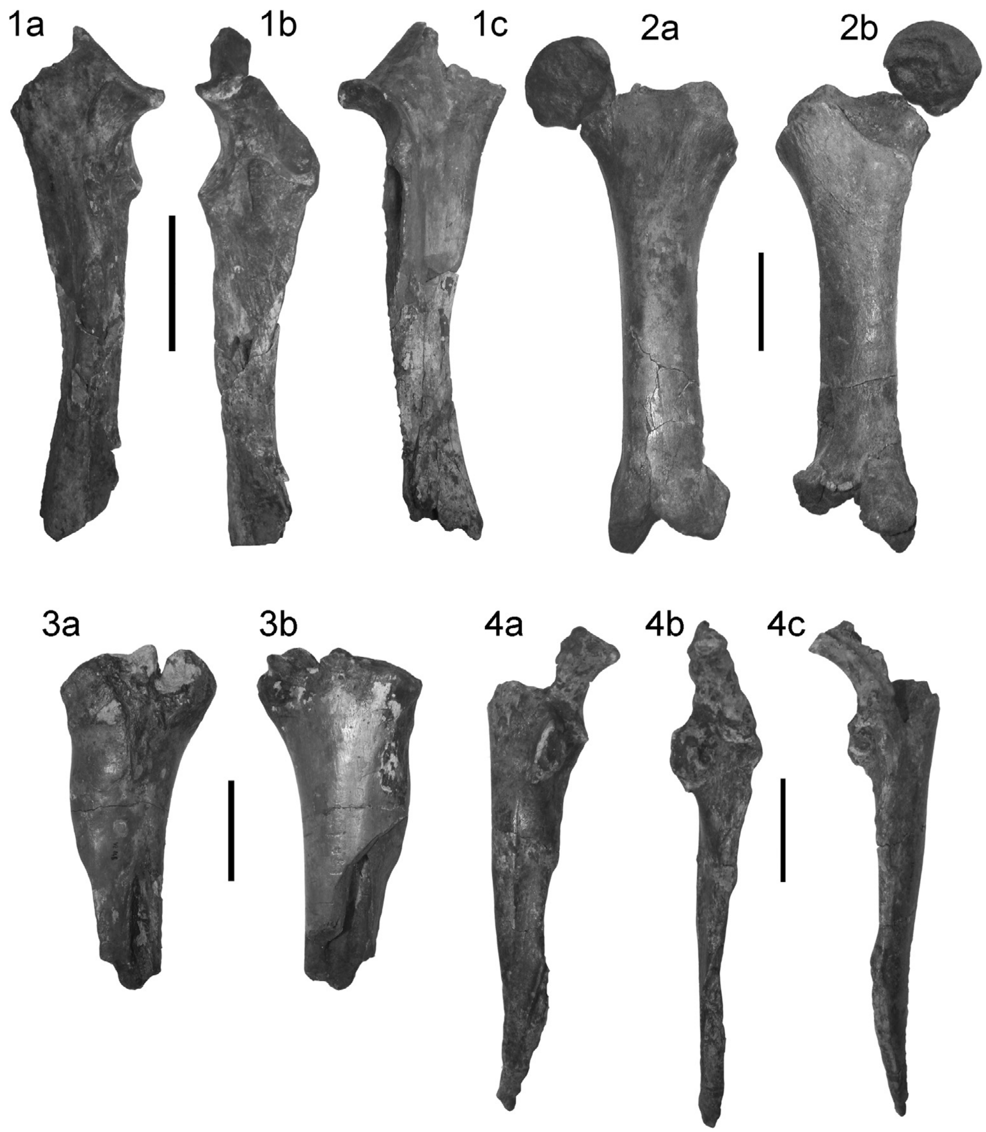

Fig. 7. Long bones from the "Frantoio" locality, late Early Pleistocene, Arda River, Northern Italy. **1**. *Stephanorhinus hundsheimensis*, right ulna, Vt091; a, lateral view; b, dorsal view; c, medial view. **2**. *Hippopotamus* sp., left femur, Vt157; a, cranial view; b, caudal view. **3, 4**. *Praemegaceros* sp. 3: Proximal fragment of right radius; Vt148; a, palmar view; b, dorsal view; 4: fragmented right ulna, Vt147; a, lateral view; b, dorsal view; c, medial view. Scale bars: 10 cm (1, 2), 5 cm (3, 4).

S. cf. *hundsheimensis* or to *S*. aff. *hundsheimensis*. In the following FUs of Slivia and Isernia, *S. hundsheimensis* is reported in several sites, and its precise disappearance in the successive Fontana Ranuccio FU is not well known.

Order Artiodactyla Owen, 1848
Family Hippopotamidae Gray, 1821
Genus ***Hippopotamus*** Linnaeus, 1758
Hippopotamus sp.
Fig. 7(2)

Material: Vt123 (left femur); Vt157 (left femur).

Description: The hippopotamus remains found so far consist of only two femur diaphyses of young individuals. In both elements, the epiphyses are missing with the exception of the *caput femuri* of Vt157. The diaphyses are large with a sub-circular section. The trochanteric fossa is developed and the supracondyloid fossa is wide and deep. The third trochanter is massive, like in the *Hippopotamus* sp. fragmentary femur described by Pandolfi et al. (2015).

Remarks: The femurs, as observable in Fig. 7(2), differ significantly from those of the rhinoceroses lacking the third trochanter; they may be attributed to young hippopotamuses. Although it is not possible to identify these remains at the species level, the only known hippopotamus present in Italy during the late Early Pleistocene is the *Hippopotamus* ex. gr. *antiquus* (Mazza, 1991; Masini and Sala, 2007); it is most likely that the Arda femurs belong to this taxon.

Family Suidae Gray, 1821
Genus ***Sus*** Linnaeus, 1758
Sus strozzii Forsyth Major, 1881
Fig. 9(1–3)

Material: Vt090 (mandible); Vt143 (left I1/).

Measurements: See Table 3.

Description:

Mandible. Vt090 is the lower jaw of a sub-adult male (Fig. 9(1)). The incisors and the right P/1 are absent; the symphysis is partially destroyed and fused and its posterior edge is placed at the level of P/2. The lower jaw is preserved only in its superior side until the M/3; its base is broken, lacking the distal half of the right M/3 and the two vertical branches. Overall, compared to the lower jaw of *S. scrofa*, Vt090 is stocky, strong, with massive mandibular

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Fig. 8. *Stephanorhinus hundsheimensis* from the "Frantoio" locality, late Early Pleistocene, Arda River, Northern Italy. Vt083, 084 and 085(a + b) still preserved in the matrix as they are displayed in the Museo Geologico G. Cortesi (Castell'Arquato – PC – Northern Italy) exhibition. Scale bar: 10 cm.

branches; the teeth are more closed and the diastema between P/1 and P/2 is short. Furthermore, all teeth show a swollen crown base. The teeth are poorly worn out; M/3 has no traces of wear. According to Grant's (1982) scheme on dental wear, M/1 can be attributed to stage g, M2 to stage b, and M/3 to stage a. Accordingly to Bull and Payne's (1982) ageing scheme for *S. scrofa*, Vt090 may have an age of 23–31 months.

Table 2
Measurements (in mm) of *Stephanorhinus hundsheimensis* from the "Frantoio" locality, late Early Pleistocene, Arda River, Northern Italy. Measures: Teeth (Mazza et al., 1993; Fortelius et al., 1993): BBL, basal buccal length; MBB, basal mesial width; BLL, basal lingual length; DBB, basal distal width; Bones (Driesch von den, 1976): DPA, depth across the Processus anconaeus; BPC, greatest breadth of the proximal articular surface; SDO, smallest depth of the olecranon for the ulna; Bp, greatest breadth of the proximal end; SD, smallest breadth of diaphysis; CD, smallest circumference of diaphysis; BFp, greatest breadth of the facies articularis distalis; LA, length of the acetabulum including the lip; LAR, length of the acetabulum on the rim; SH, smallest height of the shaft of ilium; SB, smallest breadth of the shaft of ilium; SC, smallest circumference of the shaft of ilium.

	Side	BBL	MBB	BLL	DBB
Vt 089 – Skull					
P2/	R	30.2	37.6	27.4	41.3
P2/	L	30.1	36.6	27.5	42.9
P3/	R	36.6	52.6	33.0	51.9
P3/	L	37.2	57.6	34.6	54.8
P4/	R	37.9	58.3	35.3	55.2
P4/	L	39.6	57.6	34.6	54.8
M1/	L	48.3	60.4	39.3	56.2
M1/	R	40.2	57.7	36.2	54.0
M2/	R	46.2	60.0	40.3	55.6
M2/	L	47.0	60.8	39.1	56.1
M3/	R	54.8	56.5	50.2	–
M3/	L	54.4	56.1	50.6	–
VT 138 – Skull					
P2/	R	31.0	35.4	31.3	44.1
P3/	R	34.9	48.7	31.3	44.1
P4/	R	35.4	54.2	35.4	48.9
M2/	R	49.2	60.2	40.8	50.9
M3/	R	–	50.3	46.1	–
VT 092 – Mandible					
P/3		32.4	31.4	24.5	25.1
P/4		37.1	34.4	27.5	30.9
M/1		39.5[a]	–	30.4	31.0
Vt 091 – Ulna		**Vt 166 – Coxale**		**Vt 169 – Radius**	
DPA	105.9	LA	81.2	Bp	91.2
BPC	76.5	LAR	91.5	SD	51.9
SDO	82.4	SH	59.7	CD	143.0
		SB	30.7	BFp	87.6
		SC	163.0		

[a] Estimated measurement.

The lower canine is a large tooth, thus pointing to a male individual. The canine has a typical "*S. verrucosus*" section (Azzaroli, 1954) where buccal and lingual sides have similar dimensions while the distal side is narrower; overall, the section of the tooth has the shape of an isosceles triangle (Fig. 9(2)). The presence of "*S. verrucosus*" section is a typical character of *S. strozzii* and never presents in *S. scrofa*. This character is very informative, therefore allowing the assignment of the Arda River suid rests to *S. strozzii*.

P/2 has the main and highest cuspid placed in the middle of the tooth, with two accessory cuspids of which the smallest is located in the mesial portion of the tooth. The second accessory cuspid, in the distal area, is more developed than the mesial one. On the lingual side, there is a bulge that forms a "cingulum" in the distal portion of the tooth.

P/3 is similar to P/2, with a strong mesial cuspid and a bulge forming a "cingulum" in the distal portion of the tooth.

P/4 is complex, with two central cuspids; the buccal one is situated more mesially than the lingual one. The mesial cingulum of P/4 is shallow, while the distal one is more developed but not significantly raised. The base of the tooth crown bulges distally and buccally. In comparison with *S. scrofa*, the P/4 Vt090 lacks the first mesial cuspid, which is replaced by a linear slope, and in mesio-lingual position, there is a small valley that, in *S. scrofa*, bisects the first half of the tooth in two parts.

Both M/1 are broken mesially and strongly constricted between the P/4 and the M/2. The wear level is at stage g *sensu* Grant (1982). The M/1 comprises two pairs of cuspids separated by a single median cuspid. The lingual cuspids are offset distally. The distal cingulum is developed.

M/2 is larger but similar to M/1 in shape. The wear level is at stage b of Grant's (1982) scheme.

M/3 has a trilobated crown. It is strongly elongated with a well-developed talonid. The protoconid, hypoconid, metaconid and entoconid have large dimensions. The basal cuspids of the first two lobes are placed posteriorly in comparison with the buccal ones. Between the second and third lobe, there is a large pillar with two other small cuspids, one mesial and another distal. Two strong tubercles and a sub-rounded posterior cuspid form the talonid. The buccal tubercle is larger than the labial one.

Upper dentition. The left I1/ (Vt143; Fig. 9(3)) is the only upper suid tooth available. Compared with the upper first incisor of *S. scrofa*, Vt143 shows substantial differences:

- the crown in occlusal view presents a simple V-shape notch whereas the *S. scrofa* one displays a more complex U-shaped notch with two accessory cusps in the distal-basal portion of the crown;
- in dorsal view, Vt143 shows a straighter development of the crown-root system in comparison with that of *S. scrofa* which is more curved;
- again, in dorsal view, the crown presents an enlargement on the buccal side that juts out from the profile of the root, whereas the same section in *S. scrofa* follows the root line.

Remarks: The Arda River suid remains have been attributed to *S. strozzii* based mainly on the presence of the canines with a "*S. verrucosus*" section; in addition, the P/4 and I1/ also show features typical of *S. strozzii* and never observed in the modern *S. scrofa*.

The faunal renewal that occurred during the transition from the Villafranchian to the Galerian mammal Age happened progressively (Gliozzi et al., 1997; Kahlke, 2007). During this time, suids faced significant changes. At Untermassfeld, Guérin and Faure

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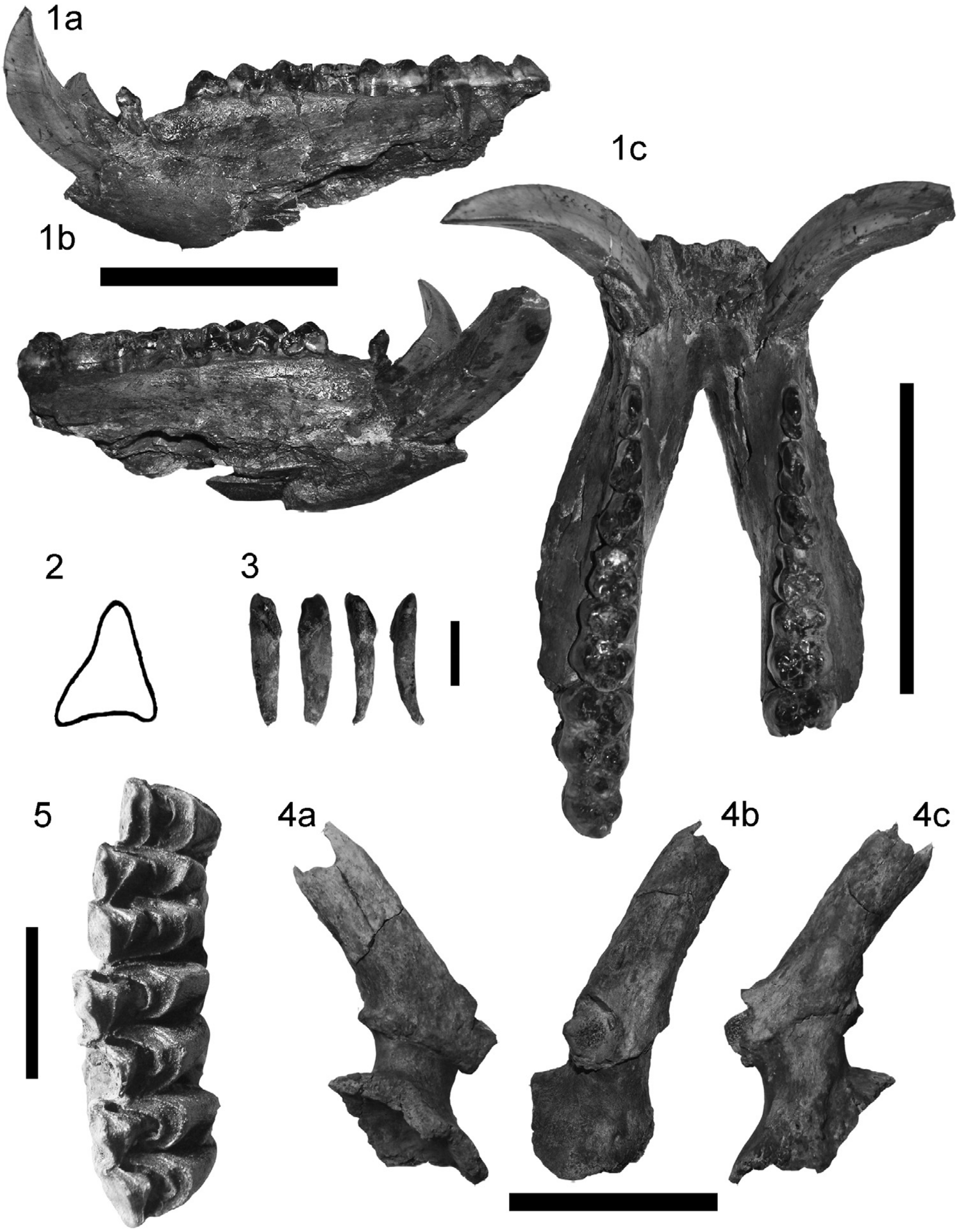

Fig. 9. *Sus strozzii* and *Pseudodama farnetensis* from the "Frantoio" locality, late Early Pleistocene, Arda River, Northern Italy. **1–3**. *Sus strozzii.* 1: Mandible, Vt090; a, left view; b, right view; c, occlusal view; 2: transversal section of the Vt090 canine (not to scale); 3: left I1/, Vt143. **4, 5**. *Pseudodama farnetensis.* 4: Left frontal bone fragment with first portion of the antler, Vt162; a, mesial view; b, frontal view; c, lateral view; 5: left maxillary fragment in occlusal view with P4/, M1/, M2/ and M3/, Vt128. Scale bars: 10 cm (1, 4), 2 cm (3, 5).

Table 3
Measurements (in mm) of *Sus strozzii* remains from the "Frantoio" locality, late Early Pleistocene, Arda River, Northern Italy. Measures of the mandible are taken following Driesch von den (1976).

				P/1	P/2		P/3		P/4		M/1		M/2		M/3		C	
Vt090 – Mandible	dex	sin		sin	dex	sin	dex	sin	dex	sin	dex	sin	dex	sin	dex	sin	dex	sin
6		165.0	Length	8.6	15	15.1	16	16.1	16.6	16.2		17.1[a]	25.7	25.2		47		
7		158.0	Length 1													29.2		
7a (P2–M3)		133.5	Width	4	6.5	6.8	9.3	9.5	12	12								
8		88.2	W (anteroconid)			8.3	8.2	10	10			17.3	16.7	21.8	22			
9		67.9	W (median)													20.7		
9a	46.1	44.4	W (talonid)								14.4	14.2	19.1	18.9		17.3		
21	20.5	20.3	W (distal)														16	15.6
P2–P4	46.5	45.7	W (buccal)														20.5	20.1
M1–M3		87.8	W (lingual)														22.8	22.5
Vt143 – I1/																		
Length	10.5																	
Width	6.2																	

[a] Estimated measurement.

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(1997) identified a large suid as a more robust form or subspecies (*S. scrofa priscus*) of the living *S. scrofa*. The Untermassfeld suid also represents the first occurrence of this species in Europe. On the other hand, the same authors state the presence of last residual populations of *S. strozzii* in Europe during the same period (late Early Pleistocene). At the coeval site of Vallonnet, Moullé et al. (2006) identified a *Sus* sp. that had some affinities with *S. strozzii* and tentatively affirmed that the pigs from Vallonnet could be linked to the northern Chinese species *S. lydekkeri*, the presence of which is documented from the Early to the Middle Pleistocene in China (Dong, 2008; Dong et al., 2013). *S. lydekkeri* was a large suid that shared some important features, for example the "*S. verrucosus*" section of the lower canine, with *S. strozzii* and another southern Chinese species, *S. peii*. According to Dong (2008) and Dong et al. (2013), in these three species, the common traits outnumber the differences so that it may be possible to consider them either as distinct subspecies or as closely related species. In our view, the occurrence in Europe during the last part of the Early Pleistocene of *S. lydekkeri* is unlikely and it is more reasonable to think that populations of *S. strozzii* were still present at the end of the Early Pleistocene in the first Galerian faunas of the Colle Curti FU (Gliozzi et al., 1997; Masini and Sala, 2011).

In conclusion, the Arda suid represents the most recent occurrence of *S. strozzii* in Italy, as well as being one of the youngest evidences for this species in Europe. In Italy, the appearance of *S. strozzii* is related to the Costa San Giacomo FU (Cassoli and Segre Naldini, 1993, 2000; Bellucci et al., 2014a, b), while its last occurrence, before data from the Arda assemblage were available, was attributed to the Farneta FU or, tentatively, to the Pirro FU (Masini and Sala, 2007).

Family Cervidae Gray, 1821
Subfamily Cervinae Baird, 1857
Tribe Cervini Goldfuss, 1820
Genus ***Pseudodama*** Azzaroli, 1992
Pseudodama farnetensis Azzaroli, 1992
Fig. 9(4, 5)
1986. "*Dama*" cf. *nestii* – De Giuli, Masini and Torre.
1988. *Cervus* s.l. *nestii vallonnetensis* – de Lumley, Kahlke, Moigne and Moulle.
1998. Dama "nestii" vallonnetensis – van der Made.
1998. *Euraxis* – Di Stefano and Petronio.

Material: Vt162 (Left frontal bone fragment with proximal portion of the antler); Vt128 (fragment of right upper maxilla).

Measurements: See Table 4.

Description: Vt162 is a left frontal bone fragment with the proximal ten centimetres of the antler still preserved (Fig. 9(4)). The antler has a broken brow tine inserted near the base of the beam. The base of the beam is obliquely inserted on the burr. In lateral view, the antler shows a latero-posterior orientation. The antler is laterally compressed so that the beam presents an oval section. The specimen belongs to a non-fully developed animal as testified by the well-defined frontal suture; in fact, according to Azzaroli (1992), in *Pseudodama*, the narrower basal bifurcation is typical of juvenile individuals. Vt128 is a fragmentary right maxilla with P4/ and M1-3/. All teeth are low-crowned and at a very early wear stage (the four cones of the molars are not yet completely connected). The lingual ridge of the P4/ infundibulum is U-shaped and slightly bent in the middle.

In the M1/ and M2/, the mesial lobe is compressed mesio-distally, forming a V-shaped column; on the contrary, the distal lobe is well developed, forming a U-shaped column. In M3/, the two lobes have the same size and U-shape. All the molars show a well-developed mesostyle, while the parastyle and metastyle are less developed (Fig. 9(5)).

Remarks: On the evolution and classification of this late Early Pleistocene *Dama*-like deer, opinions differ widely as there is no agreement about their generic and sometime specific name (Azzaroli, 1992; Kahlke, 1997; van der Made, 1998; Di Stefano and Petronio, 2003; Croitor, 2006; Breda and Lister, 2013). In any case, an evolutionary trend is documented from the oldest species (*P. lyra*) up to the youngest known species (*P. farnetensis* = *Cervus* s.l. *nestii vallonnetensis*), first proposed by De Giuli et al. (1986), and characterized by:

- the insertion of the brow tine becoming more basal;
- the brow tine becoming strongly curved upwards and forming a very wide angle with the beam;
- the progressive reduction of ante-molar teeth.

The overall teeth morphology and dimensions of Arda specimens (Table 4) allow to consider these remains as belonging to a medium-sized cervid of the *Pseudodama* group (*sensu* Azzaroli, 1992). The position of the brow tine, close to the burr, allows the attribution of

Table 4
Measurements (in mm) of cervid remains from the "Frantoio" locality, late Early Pleistocene, Arda River, Northern Italy. Measures of the limb bones are taken following Driesch von den (1976).

Preamegaceros sp.										
Vt129–P4/		Vt130–M1/		Vt132	P/4	M/1	Vt147		Vt148	
Length	19.3	Length	28	Length	22.4	22.4	DPA	69.4	Bp	78.9
Width	22.6	Width	29	Length at the neck	21.2	21	BPC	39.2	Bfp	79.3
				L (Anterocon.)		14.3				
				L (Talon.)		8.1				
				Width	14.1	17.2				
Pseudodama farnetensis										
Vt128 - Maxilla	**P4/-M3/**	**M1/-M3/**	**P4/**	**M1/**	**M2/**	**M3/**				
Length	64.6	53.0	11.8	17.3	18.4	18.5				
Width			16.6	18.1	21.8	20.5				
Vt162 – Skull with antler fragment										
Circumference at the top of the pedicle	120.0									
Antero-posterior (maximum) diameter at the top of the pedicle	35.7									
Transverse (minimum) diameter at the top of the pedicle	29.5									
Beam circumference just above basal tine	103.0									
Antero-posterior (maximum) diameter of the beam just above basal tine	38.1									
Transverse (minimum) diameter of the beam just above basal tine	29.5									

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the remains to *P. farnetensis*. The Arda *Dama*-like remains show a highly evolved degree in the beam development and seem to be similar to that of the middle-sized cervids of Le Vallonnet (de Lumley et al., 1988) and Untermassfeld (Kahlke, 1997).

Tribe Megacerini Viret, 1961
Genus ***Praemegaceros*** Portis, 1920
Praemegaceros sp.
Figs. 7(3, 4), 10
1828. *Megaloceros* – Brooks
1914. *Megaceroides* – Joleaud
1956. *Orthogonoceros* – Kahlke H.-D.

Material: Vt129 (P4/ right); Vt130 (M1/ right); Vt131 (P2/ or P3/ right); Vt132 (poorly preserved left horizontal branch with P/4 and M/1 badly preserved); Vt147 (left ulna); Vt148 (left radius); Vt150 (fragmented frontal bone).

Measurements: See Table 4.

Description: Vt150 is a badly preserved portion of frontal bone with the intact peduncles of a male. The estimate angle of the antler divergence is about 90° (Fig. 10(4)).

Upper dentition. The teeth are brachydont and low-crowned. The P4/ is compressed mesio-distally; the infundibulum is divided into two parts at a medium wear stage, the distal one being about one quarter of the mesial one; the lingual portion of the infundibulum is mainly U-shaped but a fold in the middle forms two small second order U-shaped structures (Fig. 10(1)).

The mesial lobe of the M1/ is more compressed in mesio-distal direction than the distal one. Both lobes are V-shaped. On the lingual side, a continuous cingulum is present. On the buccal side, the cingulum is divided into two cingula, connecting respectively the parastyle to the mesostyle and the mesostyle to the metastyle, one at the base of the paracone and the other at the base of the

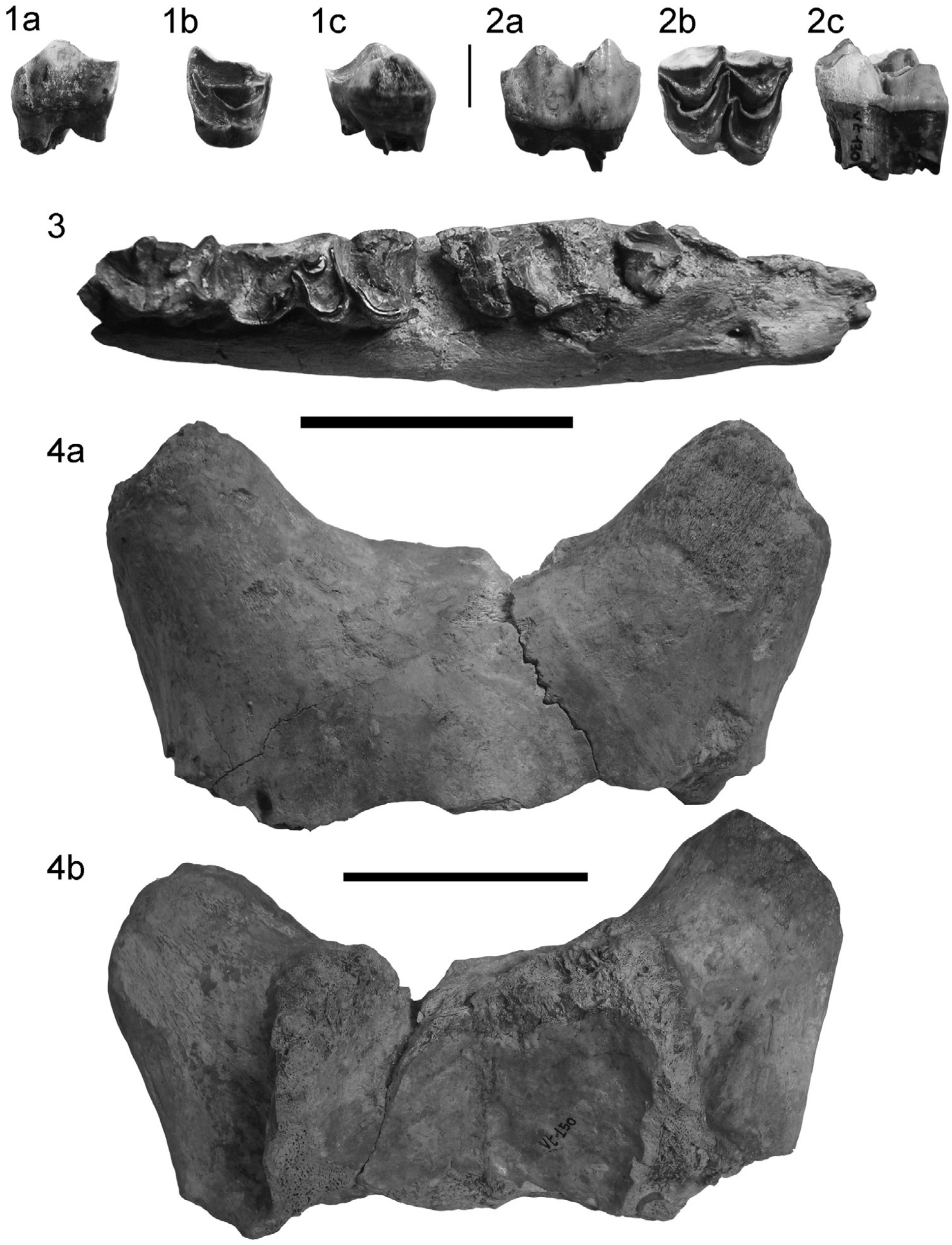

Fig. 10. *Praemegaceros* sp. From the "Frantoio" locality, late Early Pleistocene, Arda River, Northern Italy. **1.** Right P4/, Vt129; a, buccal view; b, occlusal view; c, lingual view. **2.** Right M1/, Vt130; a, buccal view; b, occlusal view; c, lingual view. **3.** Left fragmented and worn hemi-mandible, occlusal view. **4.** Incomplete frontal bone, Vt150; a, frontal view; b, caudal view. Scale bars: 1 cm (1, 2), 5 cm (3, 4).

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metacone. The mesostyle is well developed, the parastyle is evident and the metastyle is worn out due to attrition with M2/ (Fig. 10(2)).

Lower dentition. The only lower teeth available in the collection belong to a highly fragmented and badly preserved right lower jaw (Vt132; Fig. 10(3)). The teeth are: a fragmented and worn out P/4, the morphology of which is comparable to that of megacerine deers (Kostopoulos, 1997); a very worn out M/1 which lacks, due to the wear and to the bad preservation, the lingual wall cement and has an anteroconid that is almost twice as long as the talonid. Due to the poor state of preservation, it is not possible to describe more characters on these specimens.

Postcranial skeleton. The only two bones attributed to *Praemegaceros* are a complete proximal articulation of the forearm (Vt147 and Vt148), constituted by a fragmented radio-ulna complex (Fig. 7(3,4)). The overall features and dimensions allow attributing the above-described bones to a large deer.

Remarks: The systematics of large-sized deers – *Megaceroides*, *Megaloceros*, and *Praemegaceros* – is not so clear and there is no common agreement between researchers about their nomenclature. In this paper, in accordance with Delpech and Guérin (in Guérin and Patou-Mathis, 1996) and Abbazzi (2004), we consider that the oldest giant deers belong to *Praemegaceros*. This genus characterizes the European Mammal assemblages from the middle Early Pleistocene (late Villafranchian Mammal age) to the Middle Pleistocene (Galerian Mammal age) (Masini and Sala, 2007). Its oldest representative is *P. obscurus* from the Farneta FU, followed by *P. verticornis* which marks the transition between Villafranchian and Galerian Mammal ages; the last known is *P. solilhacus*. *P. dawkisi* is a close relative of the latter species but it is recognized as an endemic species from Great Britain (Abbazzi, 2004). The *Praemegaceros* species are so closely related that they are usually referred to the so-called *verticornis* group (Kahlke, 1956; Abbazzi, 2004). The evolution of *Praemegaceros* concerns in particular the morphology of the antlers (Abbazzi, 2004):

- shortening of the proximal part of the beam;
- increasing angle of antler divergence;
- simplification of the basal tract of the beam with a reduction of the number of tines.

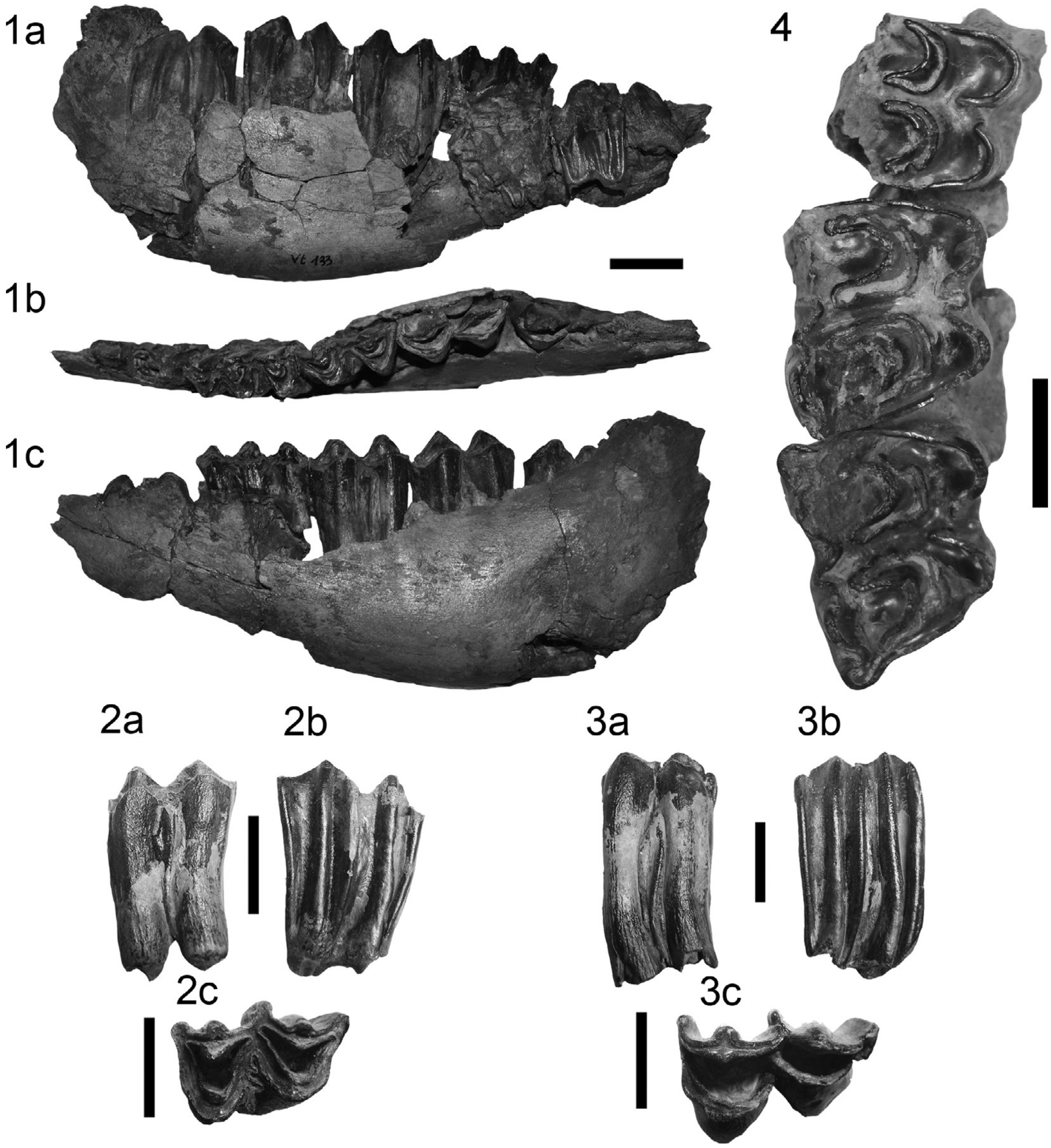

Fig. 11. *Bison* sp. From the "Frantoio" locality, late Early Pleistocene, Arda River, Northern Italy. **1.** Hemi-mandible, Vt133; a, lingual view; b, occlusal view; c, buccal view. **2.** M3/, Vt139; a, lingual view; b, buccal view; c, occlusal view. **3.** M3/, Vt140; a, lingual view; b, buccal view; c, occlusal view. **4.** Right maxillary fragment in occlusal view with M1/, M2/ and M3/. Scale bars: 2 cm.

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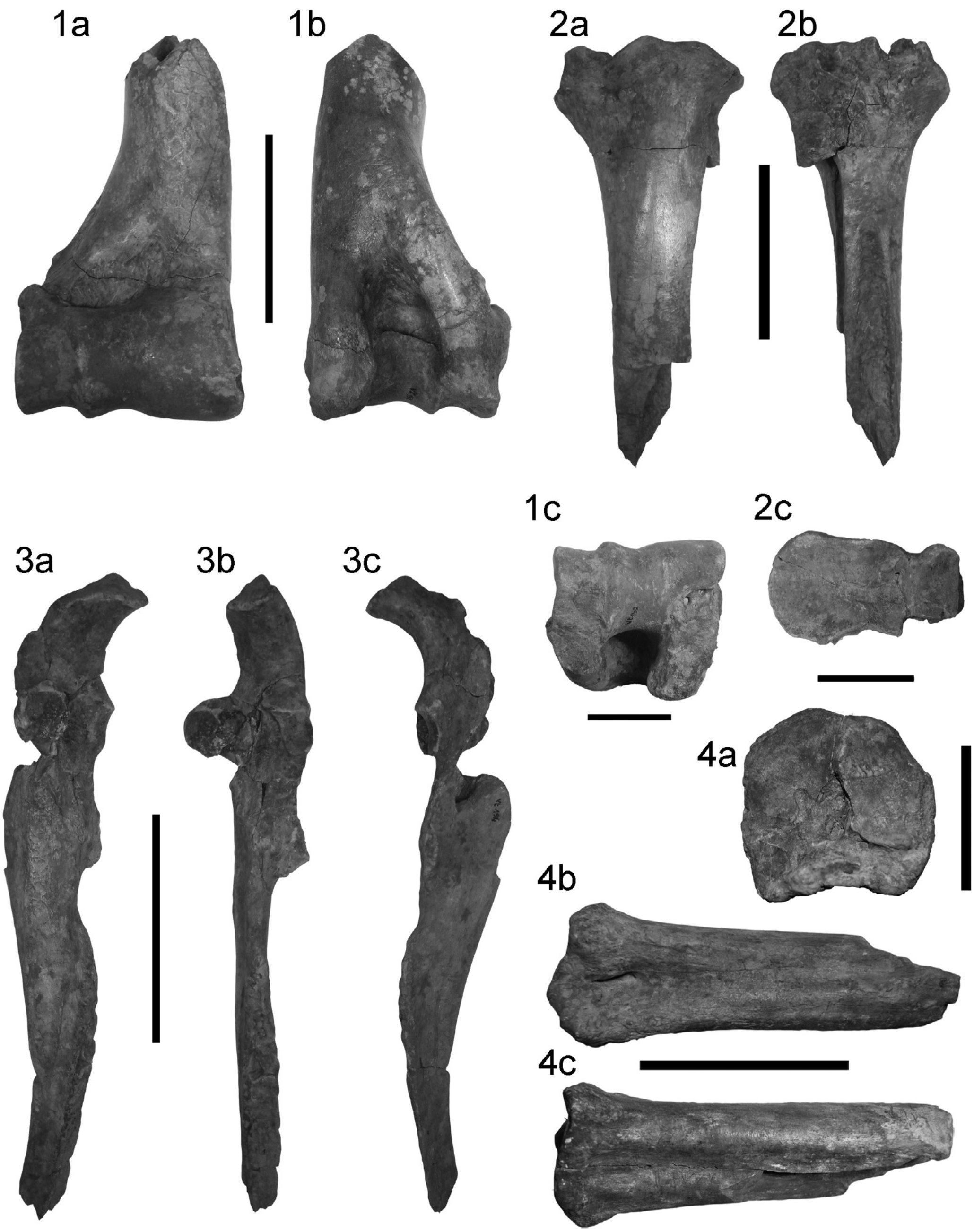

Fig. 12. *Bison* sp. From the "Frantoio" locality, late Early Pleistocene, Arda River, Northern Italy. **1.** Right humerus, distal half fragment, Vt152; a, cranial view; b, caudal view; c, distal end. **2.** Right radius, proximal half fragment, Vt153; a, dorsal view; b, palmar view; c, proximal end. **3.** Right ulna, Vt154; a, lateral view; b, dorsal view; c, medial view. **4.** Right metatarsal, Vt163; a, proximal end; b, palmar view; c, dorsal view. Scale bars: 10 cm (1a,b, 2a,b, 3, 4b,c), 5 cm (1c, 2c, 4a).

As for the fallow deer group, the giant deer sample from the Arda River lacks useful elements for a specific identification, above all the antlers. The state of preservation of Vt150 does not permit to identify the remains at a specific level, but the direction of the peduncles, which form an angle of antler divergence of ~90°, discards any attribution to *Cervalces* and *Eucladoceros* (the angle of divergence usually reaches about 180° and less than 90°, respectively; Azzaroli and Mazza, 1992; Kostopoulos, 1997). Dental dimensions further point to *Praemegaceros*.

Family Bovidae Gray, 1821
Tribe Bovini Gray, 1821
Genus ***Bison*** Smith, 1827
Subgenus *Bison* Smith, 1827
Bison (Bison) sp.
Figs. 11 and 12

Material: Vt133 (horizontal ramus of a left hemi-mandible); Vt134 (vertical ramus of a left hemi-mandible); Vt139 (right M2/); Vt140 (right M2/); Vt149 (fragmented left hemi-mandible); Vt152 (right humerus); Vt153 (right radius); Vt154 (right ulna); Vt156 (right maxilla); Vt163 (right proximal half metatarsus).

Measurements: See Table 5.

Description: The bison remains are very scanty and badly preserved in Frantoio. Vt133 is a horizontal ramus of a left hemi-mandible with dP/2-dP/4 (only dP/4 is preserved enough to be described), M/1-M/2 on the occlusal surface, P/2-P/4 and M/3 in eruption (Fig. 11(1)). According to the sequence of teeth eruption, the specimen could have had an age of 18 months at death (Hillson, 2005). Vt149, a left fragment of hemi-mandible with P/3 and P/4 and M/1 erupting, is worse preserved than Vt133.

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Table 5
Measurements (in mm) of *Bison* sp. remains from the "Frantoio" locality, late Early Pleistocene, Arda River, Northern Italy. Measures of the limb bones are taken following Driesch von den (1976).

Specimen	Dimension	
	Length	Width
Vt 133		
D/4	34.9	14.4
M/1	32	14.9
M/2	35.2	14.6
Vt 149		
M/1	27.3	14.3
Vt 139		
M3/	36.7	24.5
Vt 140		
M3/	33.1	24.7
Vt 156		
M1/	21	/
M/2	27.2	27.6[a]
M/3	31.4	26.1

Vt 054	**BPC**
Ulna	56.4

Vt 152	**Bd**	**BT**
Humerus	98.4	94.6

Vt 153	**Bp**	**BFp**
Radius	111.3	91.2

Vt 163	**Bp**	**Dp**	**SD**
Mt	63.6	63	43.4[a]

[a] Estimated measurement.

Lower dentition. dP/4 is a typical trilobate artiodactyl fourth milk premolar. The first column is V-shaped, the protoconid and the hypoconid are U-shaped. The parastylid and entostylid are well developed. In all two buccal valleys a well-developed ectostylid are present.

M/1 is a hypsodont tooth with cement. The two columns are V-shaped. The base of the crown is slightly swollen. The parastylid and the entostylid are well developed. The ectostylid is high and stout.

M/2 (Vt133) is almost unworn; it shows the same features of M/1 apart from its larger dimensions.

Upper dentition. M2/ (Vt156, poorly preserved; Fig. 11(3)) is a hypsodont tooth with slightly swollen crown base. The cement is present. The entostyle is present and, in a high degree of wear, rounded; the infundibula are U-shaped with pleating. Mesostyle and metastyle are present.

M3/ (Vt139, Vt140, Vt156; Fig. 11(2, 3)) is a hypsodont tooth with a slightly swollen crown base. The enamel is rough. The cement also is present. The parastyle and metastyle are developed. The entostyle is high, stout and pleated in mesial side (Fig. 11(2c)).

Postcranial skeleton. Vt152, Vt153 and Vt154 compose a complete elbow bone articulation of an adult specimen. Only the distal portion of the humerus (Vt152; Fig. 12(1)) is present with a well-preserved articular surface. By comparing the morphology of the humerus with the drawings and description proposed by Sher (1997: 120–121), it is easy to recognize in the Vt152 specimen some diagnostic bisontine features: a well-developed lateral part, a smooth protrusion of the trochlea, and a sharp-oval *fossa olecrani*. The trochlea dimensions are comparable with those of a female *Bison menneri* from Untermassfeld (Sher, 1997). The radius (Vt153; Fig. 12(2)) is an almost complete proximal half. The lateral tuberosity is poorly developed. The dimensions of the proximal end fall in the variability range of a large *Bison* (Sher, 1997: 127). The ulna (Vt154; Fig. 12(3)) is very poorly preserved with the olecranon completely missing; the articular surface and the diaphysis are quite complete. The metatarsus (Vt163; Fig. 12(4)) preserves the half proximal portion. The plantar surface is flattened in the upper third portion. On the dorsal surface of the diaphyses, the furrow is well shaped. The Schertz's angle measures ~40°. The overall dimensions fall in the range of *B. menneri* (Sher, 1997).

Remarks: The large dimension of the specimens, the degree of hypsodonty and the slightly swollen base of the teeth crown allow the attribution of the Arda River bovine remains to a bison. The lack of skulls with horns and the fragmentary condition of the distal bones do not allow the identification of the features that distinguish *B. menneri* from *B. schoetensacki*. Although the dimensions of the Arda River bison fall in the range of *B. menneri* (Sher, 1997) they are not very different from those of *B. schoetensacki* (Sala, 1996) and *Bison* sp. from England (Breda et al., 2010).

Some authors (Moullé et al., 2006) argue that *B. menneri* and *B. schoetensacki* may have been for some time coeval, even though they lived in very different environments – the slender and gracile-legged *B. menneri* lived in lowlands and forested areas, while the stocky *B. schoetensacki* preferred a rugged terrain with patchy vegetation. Sala (1986: 163), on the other hand, suggests that *B. schoetensacki* "could have lived in open environments, steppes and prairies as well as in closed environments, forests and woods".

5. Discussion

5.1. Paleoenvironmental considerations

The presence or absence of some taxa, according to their feeding habits and morphological features, permits to make inferences about the past environment. The occurrence of animals typical of wooded areas, such as bears, cervids, suids, and of a brachydont rhinocerotid (browser), indicate the presence of a forest in the area. On the other hand, the occurrence of a bison points towards the presence of open areas for grazers. The hippopotamus indicates the presence of prairies nearby the river where it lived. Similar paleoenvironmental conditions are given by the sedimentological, freshwater molluscs and paleobotanical data (Pini et al., 2014; Bagattini, 2014) that together point towards the presence of inundated woodlands settled on an alluvial plain with patches of grassland.

5.2. Biochronological considerations

In Italy, biochronology has a certain tradition thanks mainly to the studies on large mammals which, from the work of Azzaroli (1977) onward, produced a lot of data, permitting to carry out a detailed biochronological scansion of Plio-Pleistocene Mammal Ages (Villafranchian, Galerian, and Aurelian) and Faunal Units (Gliozzi et al., 1997). The proposed subdivision of the large mammal faunas is used in Italy and sometime also in other countries, but commonly in Eastern Europe the Holarctic biochronological scale, based on the small mammals (principally voles), is used. Recently, Masini and Sala (2011) proposed an integrated scale of the Italian Quaternary large and small mammals.

In order to facilitating international correlations, Palombo and Valli (2004) inserted the Italian Faunal Units into Mein's (1975, 1990, 1998) MN zones and Guérin's (1982, 1990) MNQ zones. However, the MNQ zones of Guérin were not used later on as they are not suitable to the more detailed subdivisions of the Italian biochronology. Here we follow the biochronological scale proposed by Masini and Sala (2011) (Fig. 13).

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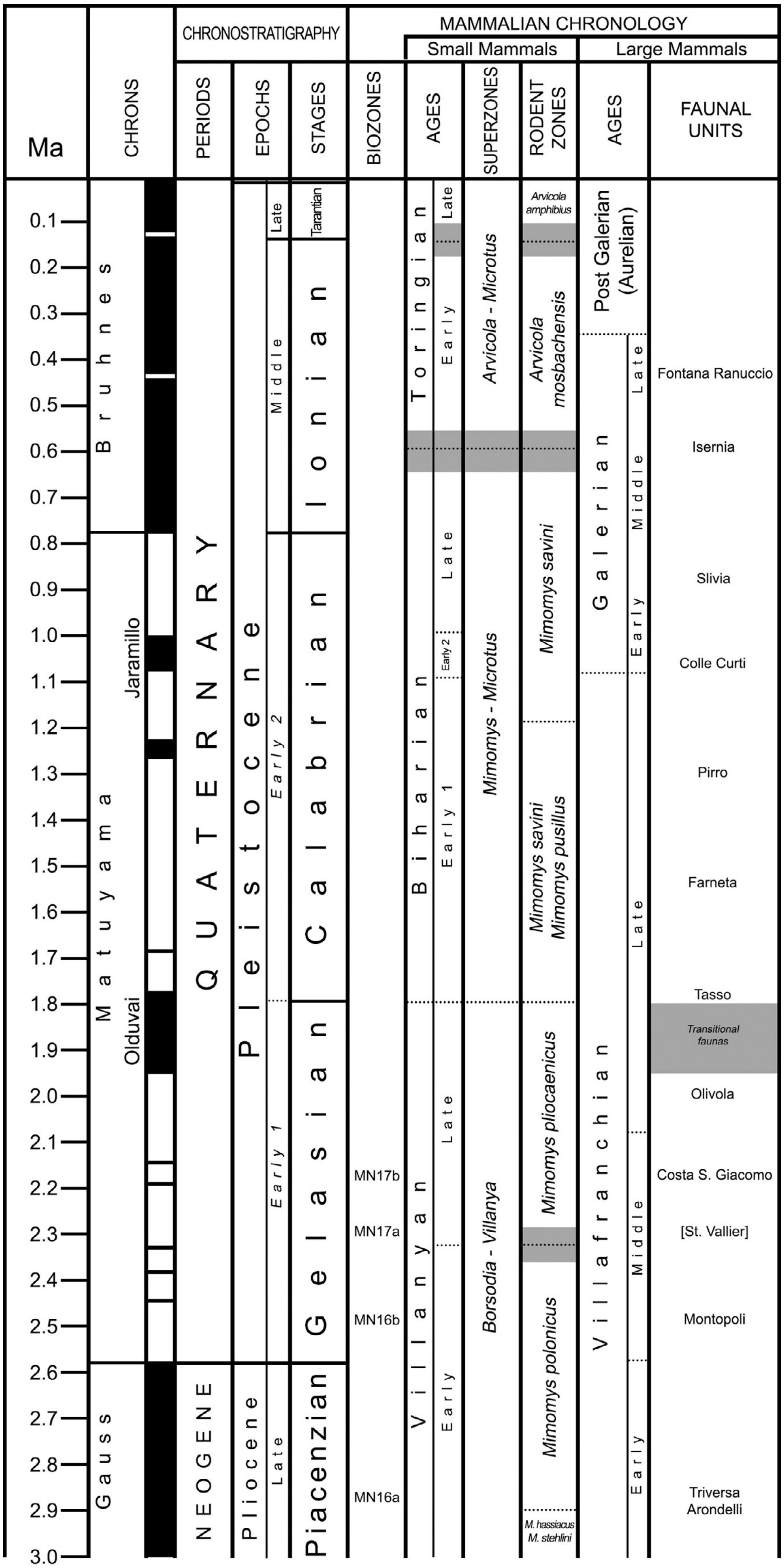

Fig. 13. Chronological scheme for the last 3 m.a. (Late Pliocene–Present) with small and large mammal-based chronology, Italian faunal Units (Gliozzi et al., 1997; Sala and Masini, 2007), and selected Italian and European localities.

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The Arda River faunal assemblage includes taxa originated in the Villafranchian, such as *Pseudodama* and *S. strozzii*. The large cervid attributed to *Praemegaceros* is first signalized at Pietrafitta in the Farneta Faunal Unit of the late Villafranchian. *Praemegaceros veriticornis* is the cervid that marks the beginning of the Galerian mammal age (Gliozzi et al., 1997). The bear *U. dolinensis* is a post-Villafranchian taxon, dated from the beginning of the Galerian. *Bison* sp. and *Hippopotamus* sp. are not useful age indicators because the former has not been identified at a sub-generic (*Eobison* or *Bison*) or specific level and the latter belongs to a genus that had a wide distribution over time.

In the late Early Pleistocene of Central and Western Europe, the fossil assemblages preserve a mixture of late Villafranchian and early Galerian elements. The selected sites of this period, cited for example by Bellucci et al. (2014a, b), are Untermassfeld in Germany, Le Vallonet, Soleilhac, Saint Prest, Bois-de-Riquet and Durfort in France, Colle Curti, Redicicoli and Scoppito in Italy, Trinchera Elefante, Fuente Nueva-3, Barranco Leon-5, Valparadís Estació in Spain, Megalopolis–Marathousa in Greece, and Het Gat in The Netherlands. As far as concerns some Italian sites, care is recommended in considering the sites of Redicicoli and Scoppito because the chronology of both is still debated (Palombo et al., 2002). For these transitional European faunas, Kahlke (2007, 2009) re-proposes the term "Epivillafranchian" previously coined by Bourdier (1961) as a provisional biochron. Even Bellucci et al. (2014a, b) brace the use of the term Epivillafranchian and suggest considering the FOs of *Praemegaceros verticornis-B. menneri* and *Crocuta crocuta* as indicators for the lower limit of this biochron, making away from the Galerian the first two FUs (Colle Curti and Slivia) and re-propose Ponte Galeria as first FU of the Galerian Age (Petronio and Sardella, 1999).

In Gliozzi et al. (1997) the faunal assemblage of the early Galerian was clearly described as "characterized by the presence of *Megaceroides verticornis* and by the persistence of forms with Villafranchian affinities". These are characteristics that are also typical of the Epivillafranchian, therefore considered as the first part of the Galerian Mammal Age.

If the term "Epivillafranchian" were to be accepted for designating the beginning of the early Galerian, then the first part of the Aurelian Mammal Age should also be similarly renamed as "Epigalerian" because some species from such assemblages present a variety of features which are not easily assignable to the Galerian and rather point towards the Aurelian. Therefore, we do not agree with the proposal of a new Mammal Age made up of only two FUs (Colle Curti and Slivia) and prefer maintaining the current division referring to this time span as the first part of the Galerian. Moreover, we are against reviving the Ponte Galeria FU, a faunal unit rarely considered by the scientific community (for instance Kotsakis et al., 2003) because the Ponte Galeria 2 assemblage, coinciding with the oldest fauna of this locality, may be encompassed in the Slivia FU due to its similar faunal composition (Palombo et al., 2002). The Arda River faunal assemblage is therefore assignable to the Colle Curti FU within the Galerian Mammal Age and it is correlated to the late Early Pleistocene (Fig. 13).

6. Concluding remarks

The Arda River mammalian faunal list currently consists of seven taxa: one carnivore (*U. dolinensis*), five artiodactyls (*Hippopotamus* sp., *S. strozzii*, *P. farnetensis*, *Praemegaceros* sp., and *Bison* sp.) and one perissodactyl (*S. hundsheimensis*). The poor preservation of the remains has enabled identification at species level for only three taxa: the bear *U. dolinensis*, the rhinoceros *S. hundsheimensis*, and the suid *S. strozzii*.

Stratigraphic and paleomagnetic data indicate an age for the mammal-bearing level of the sequence corresponding to the end of the Jaramillo subchron, ~0.99 Ma (Monesi et al., 2016). On the other hand, foraminifera and nanofossils may give an age near to 1.1 Ma (Crippa et al., 2016). The study of the Arda mammal fauna places the assemblage at the beginning of the Galerian in the Colle Curti FU, probably between MIS 34 and MIS 26 (Gliozzi et al., 1997; Masini and Sala, 2007). This period is marked by important environmental changes that highly affected the composition of the European mammal fauna. During the same period, significant climate changes took place, leading to prolonged glacial periods that triggered major changes in vegetation composition in response to colder and more arid conditions, and consequently also drove a significant faunal turnover (Masini and Sala, 2007, 2011).

The mammalian fossil fauna of the Arda River brings together species of Villafranchian affinity and new incomers that testify to the imminent Middle Pleistocene mammal turnover, which will find its completion under the Slivia and Isernia Faunal Units. The presence of *S. strozzii* in the Arda River assemblage is likely to account for an older age than that of the Slivia FU, where *S. scrofa* appears for the first time (Gliozzi et al., 1997; Sala and Masini, 2007); to date, the two species have never been found associated. At the same time, the occurrence of new taxa, represented by a large-sized bison (not belonging to *Bison* (*Eobison*)) and by *U. dolinensis*, signal the start of a major faunal turnover, which is well attested in the early Galerian fossil record. This faunal change anticipates the large increase in migration flows that will be characteristic of the Middle and Late Pleistocene time interval.

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