

**THE CAVE BEARS FROM SAMBUGHETTO VALSTRONA (PIEDMONT,
NORTHERN ITALY) REVISITED. NEW DATA ON THE TEETH AND METAPODIA
INDICES WITH OBSERVATIONS ON THE EVOLUTIONARY STEP**

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ABSTRACT

Cave bears had a wide distribution in Northern Italy occupying an area from west (Liguria and Piedmont regions) to east (Friuli Venezia Giulia region). Moreover, some gaps in the knowledge of their distribution are still present in Piedmont in which only the fossils of *Ursus* gr. *spelaeus* from Grotta del Bandito (Cuneo Province), have been studied. In order to partially fill this gap, herein the teeth and metapodia of cave bears from Grotta delle Streghe (Sambughetto Valstrona, Verbano-Cusio-Ossola Province) are morphometrically and morphodynamically (teeth) studied and some indices for the metapodia are also calculated. From these analyses it is difficult to define a species for the bears, therefore we have assigned them a generic *Ursus* gr. *spelaeus*, and within the evolutionary picture they probably occupy an intermediate position along with the main part of the cave bear populations in Northern Italy.

INTRODUCTION

In Europe, the Middle-Late Pleistocene was characterized by a megafauna of which the cave bear *Ursus spelaeus* Rosenmüller, 1794 is one of the best-known components (Kurtén, 1955, 1976; Musil, 1980; Rabeder, 1999; Withalm, 2001; Tsoukala et al., 2006; Rabeder et al., 2009; Stiller et al., 2014; Gimranov et al., 2021 and so on).

Until the beginning of the 20th century *U. spelaeus* and *U. deningeri* Von Reichenau, 1906 (Kurtén, 1976; Torres, 1988; Rabeder, 1999) were considered the only species of European cave bears. Presently, with more modern techniques of investigation, and the use of genetics in particular, the phylogenetic picture has changed profoundly; in fact, new species and

subspecies have been identified: *Ursus ingressus*, *Ursus spelaeus spelaeus*, *U. s. ladinicus*, *U. s. eremus* (Rabeder et al., 2004). In many cases the scarcity of genetic and chronologic data of cave bears from Northern Italy prevents the identification of one or more of these new species. Despite these challenges, some of them have been identified: *Ursus s. ladinicus* for the bears from Conturines (Tyrol) and *Ursus ingressus* for Paina and Trene (Vicenza Province, Veneto region) populations (Rabeder et al., 2004; Terlato et al., 2018). A gap in the analyses of many populations with the consequence of an incomplete database, is evident (Santi and Rossi, 2001, 2007, 2014, 2018, 2020; Rossi et al., 2006; Rossi and Santi, 2013, 2015; 2018; Stoppini et al., 2007; Santi et al., 2011). In order to partially fill this gap, in this study the population of cave bears from Sambugetto Valstrona (a locality in the region of Piedmont near Lombardy) was analyzed (Fig. 1). Sambugetto Valstrona is a locality near Fontana Marella and Mount Generoso (Western Lombardy) (Perego et al., 2001; Bona, 2004) a locality in which a “reverse evolution” was hypothesized and tested. The focus of our study, after the preliminary analysis by De Carlis et al. (2005) and Santi et al. (2005), is to improve the knowledge of the Sambugetto area population by analyzing the teeth and metapodia which are the most important components of the skeleton necessary for an evolutionary pathway. Following this publication, our goal will be to focus deeper on the metapodia in the next study.

THE CAVE BEARS DISTRIBUTION IN NORTHERN ITALY

Since the Middle Pleistocene the Italian side of the Alps was deeply colonized by cave bear populations, until their extinction about 24,000 years ago (Terlato et al., 2018). However we need to clarify some aspects: often the morphometry, the morphodynamic of teeth and the metapodial indices, all useful tools for the identification of the species and of a possible evolutionary step (Rabeder, 1999; Gužvica and Radanović-Gužvica, 2000; Withalm, 2001; Robu, 2016; Robu et al., 2011), collide with the conclusions of genetic studies (mtDNA) which also characterize the different species of cave bears (Rabeder et al., 2004; Dabney et al., 2013; Bocherens et al., 2011, 2014; Alberti et al., 2018; Terlato et al., 2019; Hofreiter et al., 2004; Barlow et al., 2019, 2020).

At present using “non genetic” parameters like fossil documentation to identify the true or presumed ancestor of the *U. spelaeus*, *U. deningeri*, inside the different sectors of the Alps is often quite difficult; in fact its presence is documented only in the Cerè Cave (Verona Province,

Veneto region) (Rossi and Santi, 2007, 2011). The *U. deningeri* population should consist of a few elements that lived in a very restricted area of Italy but currently it is still debated when and where the *U. deningeri* arrived in Northern Italy.

Ursus gr. spelaeus is the great ruler of the Italian Alps which inhabited a large area from the Liguria region to the eastern sector of Friuli Venezia Giulia regardless of the altitude. However this is a very simplified view. In fact there are some “anomalies”. For example,

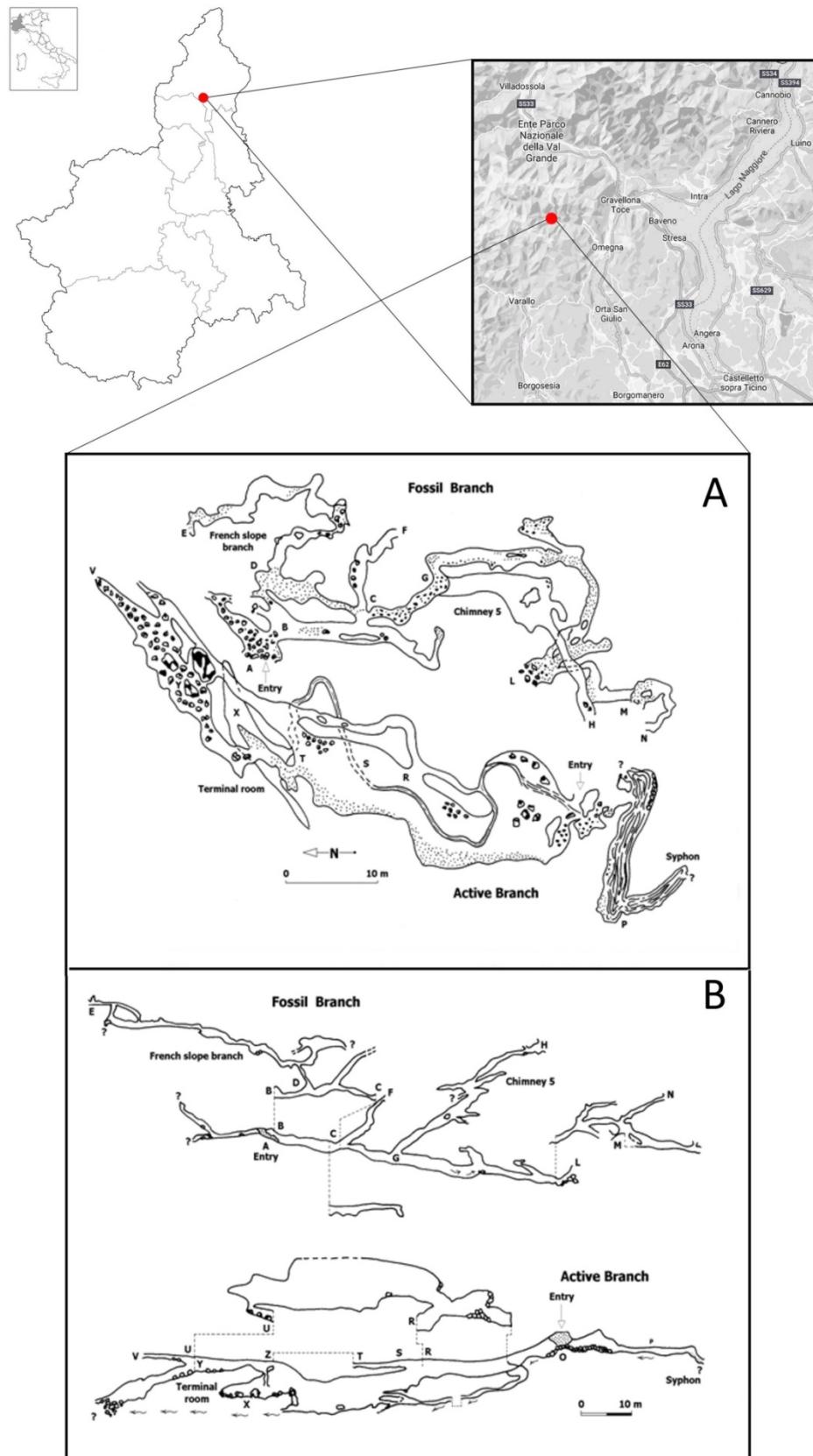


Figure 1. Geographical position of the Grotta delle Streghe. A – planimetry of the cave, B – the most important profiles of cave (from Cella, 1993, redrawn).

morphodynamic index for P4/p4 that show higher values for bears from Basura locality (Liguria region) (Quiles, 2004); or the chronological distribution (“reverse evolution”) in the Grotta Generosa (Bona, 2004) which is absolutely out of range for the general Italian populations of cave bears. On the contrary the genetic studies on mtDNA revealed that the picture of the *U. spelaeus* evolution is even more complicated. In fact, the subspecies *spelaeus ladinicus* (a bear of high altitude and confined to the Conturines, a type-locality near 2800 m, in Tyrol) (Rabeder et al., 2004) is flanked to “gr. *spelaeus*”. *Ursus s. ladinicus* disappeared about 44.000 years ago, yet *Ursus s. ladinicus* and *Ursus ingressus* together have been identified in the fossils found in the Paina and Trene villages (Vicenza Province, Veneto region), and dated about 24,000 years ago (Terlato et al., 2018). For the other Italian populations, the lack of genetic data together with the incompleteness of the chronological ones prevent the identification of the presence or absence of the different species of cave bears and their probable distribution within this alpine area.

THE GROTTA DELLE STREGHE IN SAMBUGHETTO VALSTRONA

Fossils of cave bears were found inside the biggest of the caves placed in the Cava Sambughetto locality: the Grotta delle Streghe that opens about 700 m a.s.l. (Fig. 1). This cave is composed of a dry sector and an active sector excavated by a river. As for the other caves, the Grotta delle Streghe is excavated in a big lens of the so-called “Marmo Valstrona” built in between the gneiss and micaschists of the “Kinzigitica-Sillimanitica Serie” of Valstrona. The osteological material is found together with yellow clays on the floor of the cavities; this sediment is often covered by a stalagmitic thick crust (about 15-20 cm); there follows a thin micaceous gray sand level without fossils, with some short lens of tiny gravel. The good state of conservation of the fossils is proof that these sediments deposited in situ, or were only lightly rearranged.

MATERIAL AND METHODS

This study has been carried out on the teeth and metapodia, that are the components of the skeleton that only indicatively characterize the possible evolutionary step of the Grotta delle Streghe bears (Fig. 2). These fossils are stored in the Museo Civico di Storia Naturale in Milan and, utilizing the parameters codified by Tsoukala and Grandal d'Anglade (2001) they have been morphometrically analyzed; for the teeth the morphodynamic indices (*sensu*

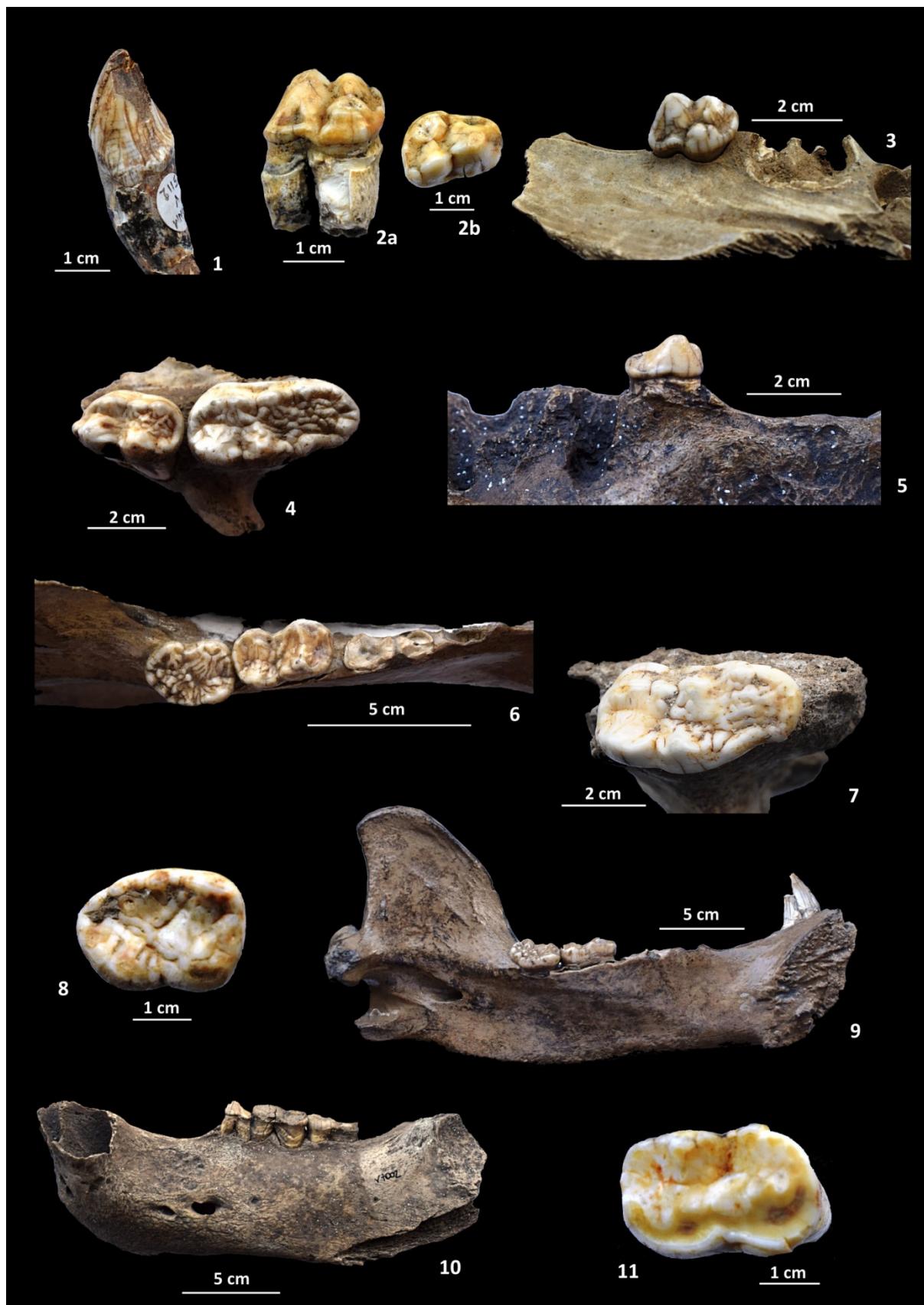


Figure 2. Incisor V5112 distal view. 2a. p4 S.N. lingual view. 2b. p4 S.N. occlusal view. 3. p4 V5088 lingual view. 5. p4 V7004 labial view. 6. Cheek row V7093 occlusal view. 7. M2 V5084 occlusal view. 8. m3 S.N. occlusal view. 9. Mandible with m2-m3 V7093 internal view. 10. Mandible with cheek row p4-m1-m2 V7002 external view. 11. M1 S.N. occlusal view.

Rabeder, 1999) were also calculated and for the metapodia the Plumpness Index (IP) and the K-I (Gužvica and Radanović-Gužvica, 2000; Withalm, 2001) (Fig. 3). The morphodynamic analyses of the upper and lower teeth were elaborated by using the Rabeder's (1999) method; this method is based on the evolutionary trend particularly for the occlusal surface of the P4/p4. The steps that gradually must be followed are listed here (Robu et al., 2011).

Identification of the morphotypes and the morphodynamic factors positioning them within the morphodynamic schemes

Analysis of the frequencies of the morphotypes

Evaluation of the morphodynamic indices with this relation

$$(MphProduct/P4/p4amount) \times 100 \%$$

where *MphProduct* is the product of the frequencies x morphodynamic factors of the all morphotypes for P4 and or p4 and *P4/p4amount* is the global number of the upper and or lower fourth premolar.

Evaluation of the P4/p4 index

$$P4/p4 \text{ Index} = \text{geometric mean of } P4 \text{ and } p4 \text{ indices}$$

Standardization of the P4/p4 indices utilizing as landmark the population from Gamssulzen Cave (Austria), in which lived one of the most-younger populations of cave bears (*Ursus ingens*), with the equation:

$$(P4/p4 \text{ index Sambugetto/ } P4/p4 \text{ index Gamssulzen}) \times 100 \%$$

For the metapodia the Plumpness Index (IP) was calculated according to the following equation (Withalm, 2001):

$$(Distal epicondyleal width/Total Length) \times 100$$

And the K-I (Gužvica and Radanović-Gužvica, 2000) with

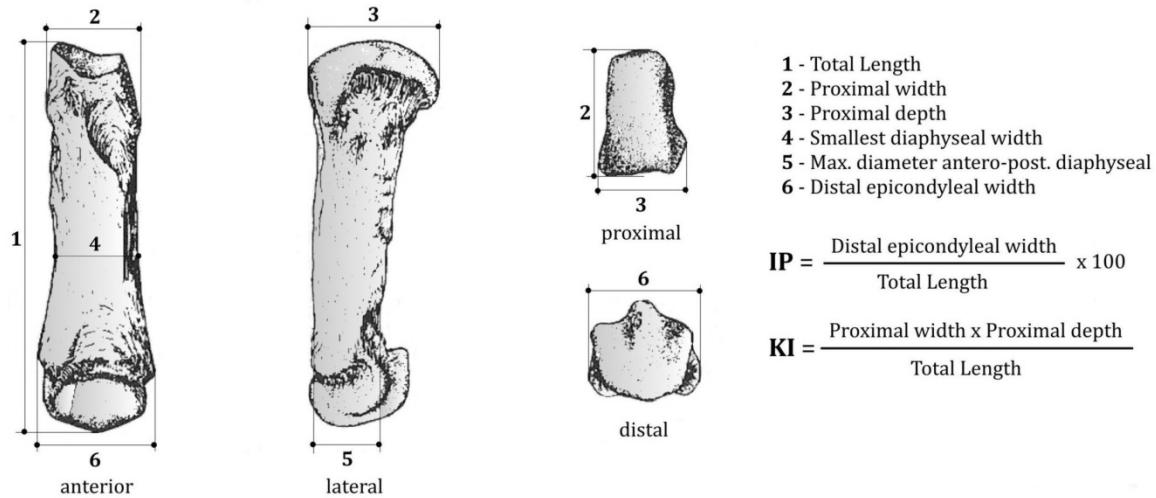
$$(Proximal width \times proximal depth)/Total Length$$


Figure 3. Parameters of the metapodia of the cave bear: Indices: IP = Plumpness Index and K-I.

For some of these analyses, moreover we have utilized Past 3.2 software (Hammer et al., 2001). A summary of the data is shown in Table 1.

1° MC	1	2	3	4	5	6	IP	K-I	1° MT	1	2	3	4	5	6	IP	K-I
Mean	62.67	24.97	20.27	13.27	10.74	18.62	29.55	8.08	Mean	57.11	24.03	24.73	12.50	12.15	17.94	31.4	10.41
St. dev.	5.62	2.56	2.97	1.48	1.13	1.91	1.34	1.24	St. dev.	4.24	2.45	2.29	1.44	1.07	1.73	1.56	1.26
Min.	54.16	21.33	16.01	10.57	8.89	15.78	27	5.81	Min.	50.98	19.39	21.14	10.61	10.67	15.57	29.24	8.00
Max.	74.9	29.84	27.26	15.91	12.69	22.07	32.21	10.47	Max.	68.37	29.87	28.55	16.71	14.5	21.58	34.27	12.17
St. error	1.20	0.55	0.63	0.33	0.25	0.43	0.30	0.26	St. error	1.06	0.61	0.57	0.40	0.27	0.43	0.39	0.31
2° MC	1	2	3	4	5	6	IP	K-I	2° MT	1	2	3	4	5	6	IP	K-I
Mean	75.39	19.10	26.54	18.07	13.14	25.60	33.93	6.75	Mean	70.88	17.25	25.64	16.18	12.03	22.70	31.79	6.28
St. dev.	5.98	1.84	3.11	1.84	1.40	2.41	1.91	0.97	St. dev.	6.8	2.92	2.58	2.45	1.61	3.07	2.75	1.23
Min.	66.02	16.47	16.33	14.64	10.5	21.79	31.1	4.09	Min.	58.69	12.7	20.68	12.05	9.38	16.11	24.33	4.37
Max.	85.66	22.76	31.42	21.59	15.86	29.41	42	8.39	Max.	90.83	22.9	31.45	21.39	15.18	28.39	37.86	8.94
St. error	1.04	0.32	0.54	0.32	0.24	2.41	0.34	0.97	St. error	1.06	0.46	0.40	0.38	0.25	0.49	0.44	0.19
3° MC	1	2	3	4	5	6	IP	K-I	3° MT	1	2	3	4	5	6	IP	K-I
Mean	80.80	20.72	29.33	17.63	13.88	26.05	32.12	7.53	Mean	77.02	18.81	29.53	16.04	13.15	22.11	28.69	7.24
St. dev.	4.95	1.89	2.09	1.34	0.88	2.02	2.11	0.85	St. dev.	4.35	2.40	2.42	1.68	3.01	2.96	3.38	1.19
Min.	69.49	17	25.14	14.82	12.21	22.23	27.48	5.94	Min.	69.17	14.00	24.77	12.00	9.89	10.93	14.7	5.29
Max.	89.24	24.59	33.16	20.23	15.68	29.71	35.57	9.40	Max.	85.56	24.06	34.8	19.41	27.58	25.88	33.26	10.17
St. error	0.84	0.32	0.36	0.23	0.15	0.36	0.37	0.14	St. error	0.76	0.42	0.42	1.68	0.52	0.51	0.59	0.21
4° MC	1	2	3	4	5	6	IP	K-I	4° MT	1	2	3	4	5	6	IP	K-I
Mean	81.24	22.40	31.14	18.38	15.66	26.76	32.58	8.63	Mean	84.09	21.46	30.00	16.52	14.28	23.55	27.92	7.67
St. dev.	5.73	2.00	2.76	1.67	1.87	2.50	2.10	1.23	St. dev.	6.58	2.61	2.56	1.40	1.81	1.78	1.44	1.11
Min.	69.5	18.87	25.85	13.63	13.27	22.45	26.25	6.17	Min.	69.94	18.11	25.56	13.62	11.31	20.09	25.28	6.35
Max.	91.91	26.35	35.74	20.92	21.29	31.56	36.11	12.01	Max.	99.16	29.52	34.66	20.43	17.65	27.13	30.94	11.76
St. error	1.06	0.37	0.51	0.31	0.35	0.48	0.40	0.23	St. error	1.20	0.48	0.47	0.26	0.33	0.33	0.27	0.2
5° MC	1	2	3	4	5	6	IP	K-I	5° MT	1	2	3	4	5	6	IP	K-I
Mean	81.69	30.27	33.28	19.08	16.71	28.04	34.14	12.37	Mean	87.72	28.34	30.24	14.27	15.88	25.04	28.55	9.82
St. dev.	5.32	2.89	3.31	1.35	1.32	2.01	1.99	1.85	St. dev.	4.77	3.21	3.11	1.44	2.03	2.16	1.30	1.75
Min.	74.59	26.84	27.83	17.16	14.2	23.84	30.01	10.17	Min.	81.13	23.21	26.33	11.41	12.54	22.40	26.56	7.72
Max.	91.73	36.47	39.15	21.55	18.82	31.84	37.93	15.59	Max.	96.28	34.04	37.13	16.58	19.6	30.24	31.41	14.17

<i>St. error</i>	1.29	0.70	0.80	0.33	0.32	0.50	0.50	0.45	<i>St. error</i>	1.12	0.76	0.73	0.34	0.48	0.52	0.31	0.41
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Table. 1. Mean, standard deviation, minimum and maximum values of the metapodia of the cave bears from Sambugetto Valstrona (Piedmont).

The lack of genetic and chronological studies prevents a more accurate individuation of the species of bears present in the Grotta delle Streghe; however the comparison among the populations that lived in nearby areas (Province of Varese in Lombardy), or in the region of Piedmont (Grotta del Bandito – Cuneo) allows to improve the knowledge of the distribution of the population of *Ursus* gr. *spelaeus* in Western Italy.

RESULTS

MORPHOMETRY

Teeth: The types are: I3, P4/p4, M1, M2, m2, m3. They are numerically few and for this reason, we can only put forward a few hypotheses about their morphometry and evolutionary step (morphodynamic indices). Regarding I3 (only 4 teeth were examined): the diagram in Fig. 4 is a synthetic picture of the morphometric trend of the Italian populations of *Ursus spelaeus*; it is rather difficult to clearly individuate the species they belong to. Observing this graphic we can exclude *Ursus deningeroides* and *Ursus s. ladinicus*, the latter being a typical species of high altitudes (Conturines, Tyrol, type-locality, about 2800 m a.s.l.), because their points are rather far from those of Grotta delle Streghe. Since the number of teeth analyzed is low these observations can only be useful for future discussions.

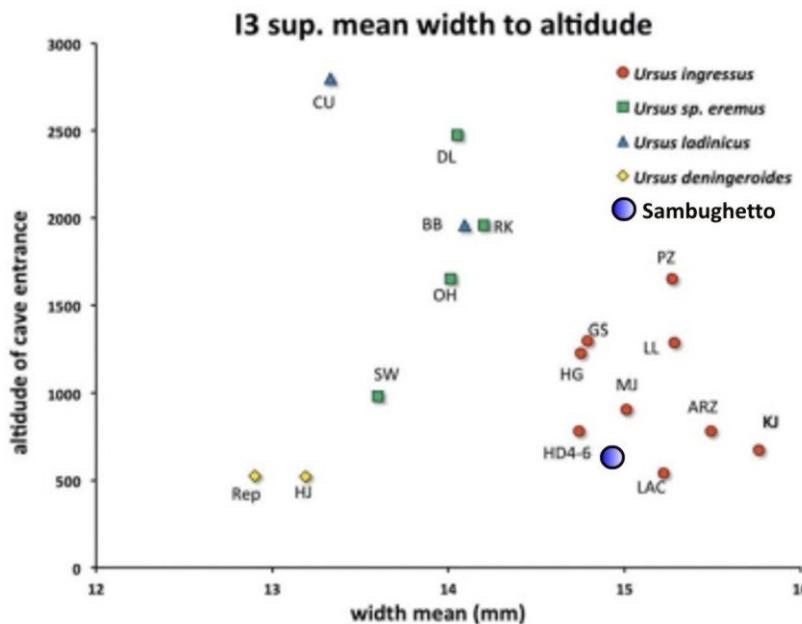


Figure 4. Relationship between the mean of the width of I3 and the altitude of entrance of more European cave having different species of cave bears and Grotta delle Streghe (Sambughetto Valstrona) (from Frischauf et al., 2017, modified).

We have studied three specimens, and in the diagram that correlates the length and width of the incisors from the Italian caves (Fig. 5), the I3 from Grotta delle Streghe falls within the range of the upper third incisors of the Valsolda, Buco dell’Orso (Como Province, Lombardy region) and Grotta del Bandito. This could be an indication of the “morphometric homogeneity” of the *Ursus spelaeus* populations that lived in the western-central area of the Italian Alps (Piedmont and W Lombardy). The morphometric study on the P4/p4 (only 2 specimens for P4 and 7 for p4) is necessarily limited because of the low number of teeth; Fig. 6 shows the measurements of the P4, which fall within the range of the Italian *spelaeus* s.s.; from a general point view and in this first analysis, the range in size is typical of “*spelaeus*” (Fig. 7).

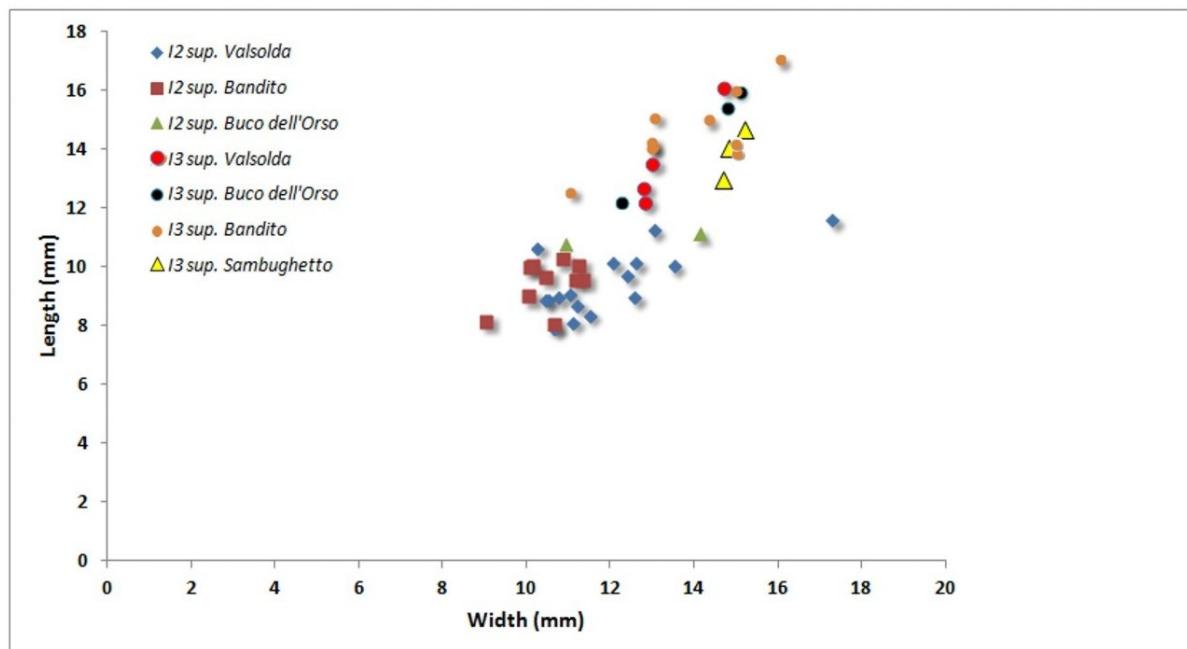


Figure 5. Relationship between the Width and Length of I2 and I3 from different caves in N. Italy.

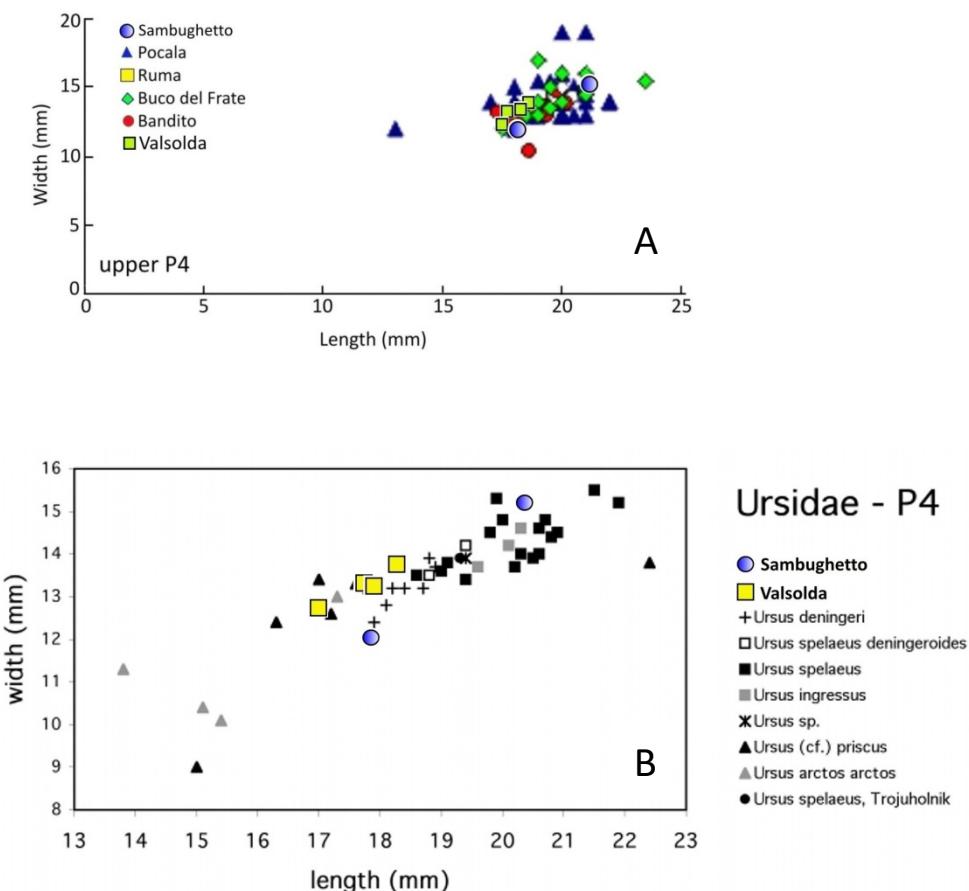


Figure 6. A) Relationship between the Length and Width in P4 from Italian caves. B) The same relationship in P4 of different species of cave bears (from Sabol, 2005, modified).

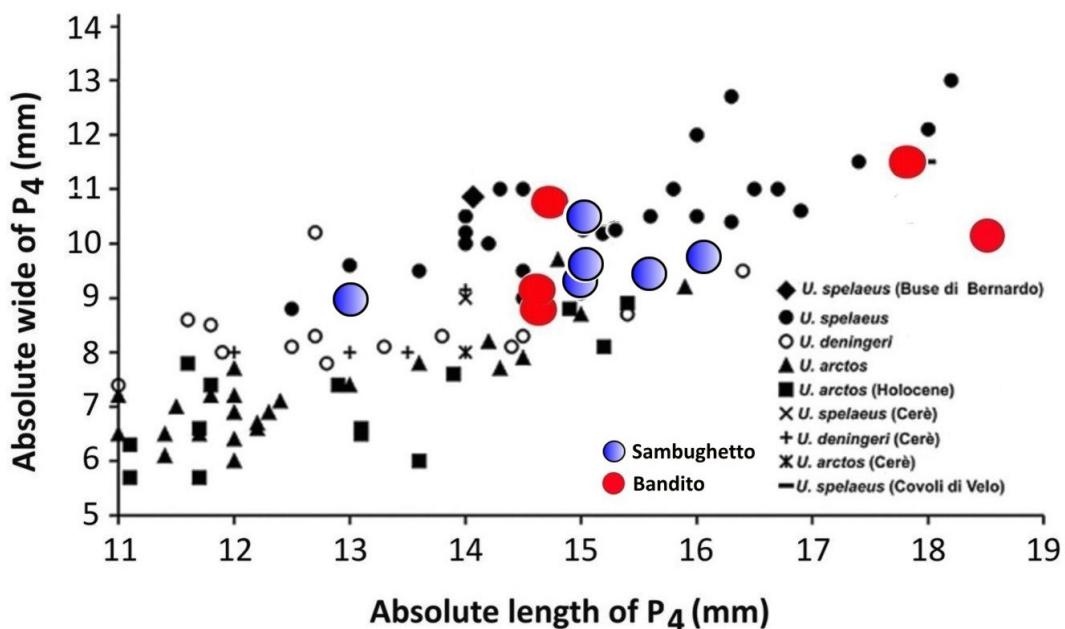


Figure 7. Relationship between the Length and Width in p4 of different species of bears from different caves in N. Italy (from Santi et al., 2011, modified).

The diagram of Fig. 8 shows a comparison between the Length and the Width of m2 for the Ramesch (*Ursus s. eremus*), Conturines (*Ursus s. ladinicus*), Grotta del Bandito (*Ursus gr. spelaeus*) and Grotta delle Streghe bears. We can distinguish two clear sectors; the Grotta del Bandito bears are well distinguished and show a “concentric” distribution. This diagram allows two different considerations: first, the remains from Grotta delle Streghe are very low in order to affirm with confidence that their distribution reported in this diagram is correct. A second consideration is that the comparison has been made with different species and bears of different sizes (*Ursus s. eremus* and *Ursus s. ladinicus*), and this indicate that the cave bears from Grotta del Bandito don't belong to *Ursus s. eremus* or *Ursus s. ladinicus* but rather to *Ursus gr. spelaeus* or even to *Ursus ingressus*.

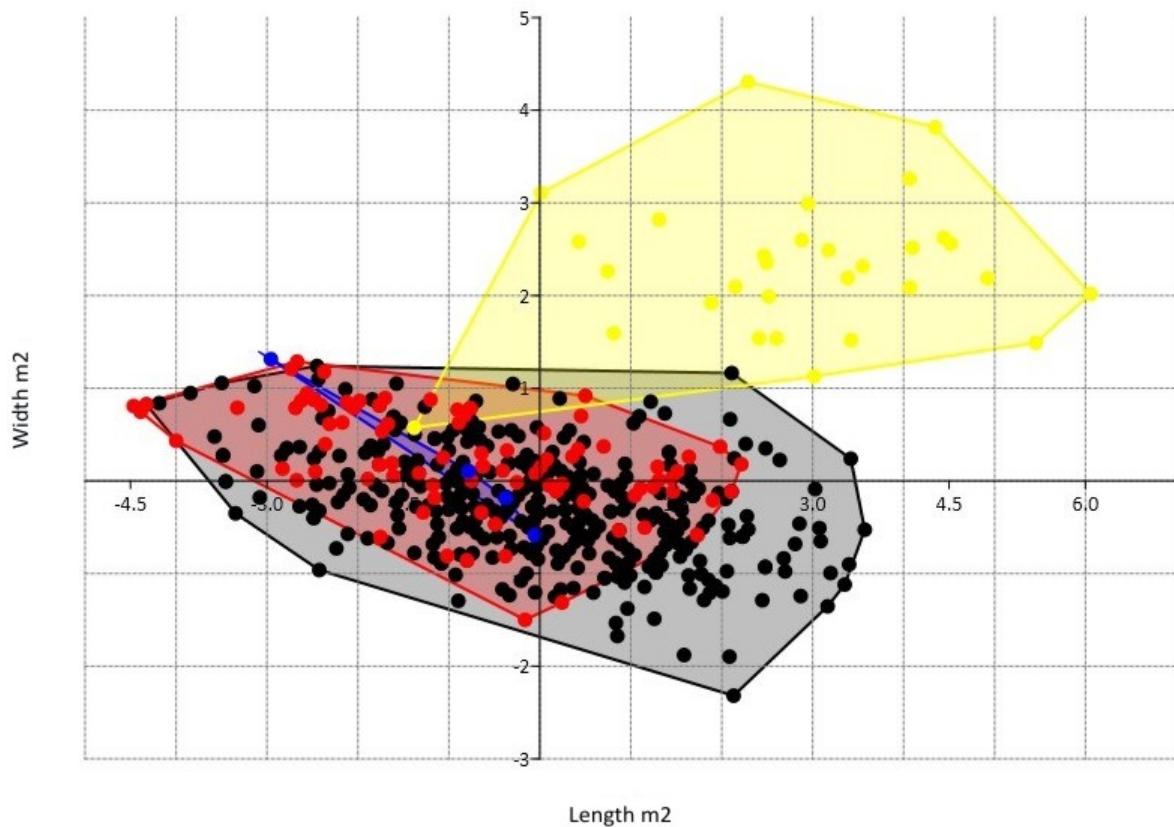


Figure 8. Relationship between the Length and Width in m² from Grotta delle Streghe (blue points), Ramesch (black points), Conturines (red points) and Grotta del Bandito (yellow points).

The analyses on m³ confirm that the bears from Grotta delle Streghe are similar to those from other Italian localities. With the present data we can hypothesize that on average, the Italian populations could have had a dimensional homogeneity independently of the area of provenance (Fig. 9). We also propose the diagram in Fig. 10 in which the Length and Width of m² of different species (*U. ingressus*, *U. deningeri*, *U. deningeroides*) is shown; also for this kind of tooth morphometry we are unable to distinguish one or more different species.

From this short morphometric analysis some brief conclusions can be advanced that can be useful for future discussions. The first is that it is difficult to clearly identify the species of cave bear from the remains from Grotta delle Streghe as they are too few, but we can establish these bears aren't *Ursus s. ladinicus* or *Ursus s. eremus* (bears with a small size). As well as with other Italian populations it is difficult to identify *Ursus ingressus* or *Ursus s. spelaeus*; for this we prefer to appoint them as generic *Ursus gr. spelaeus*.

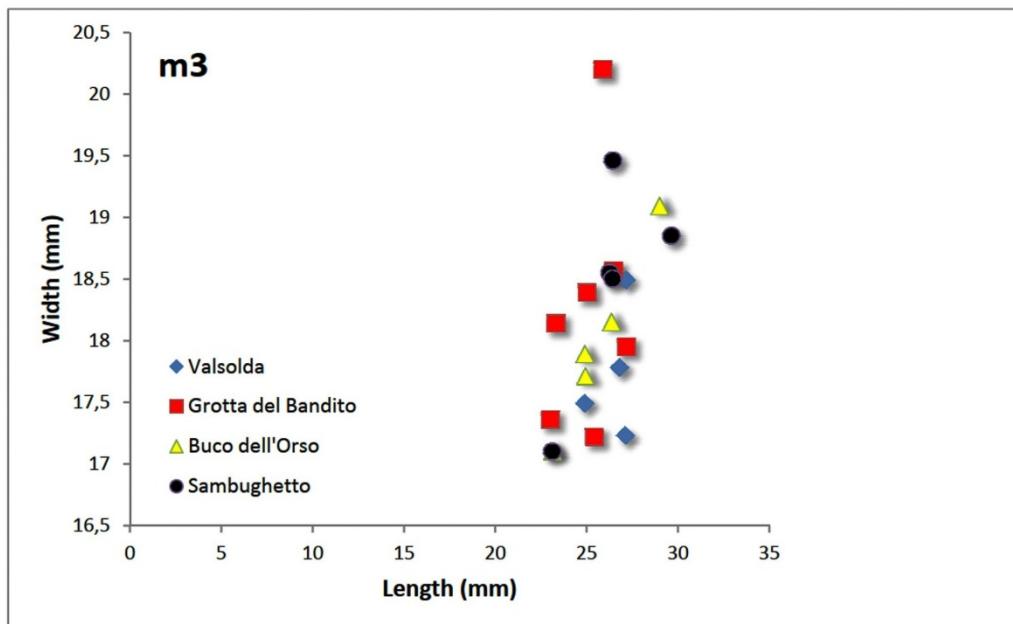


Figure 9. Relationship between the Length and Width in m3 of Italian cave bears.

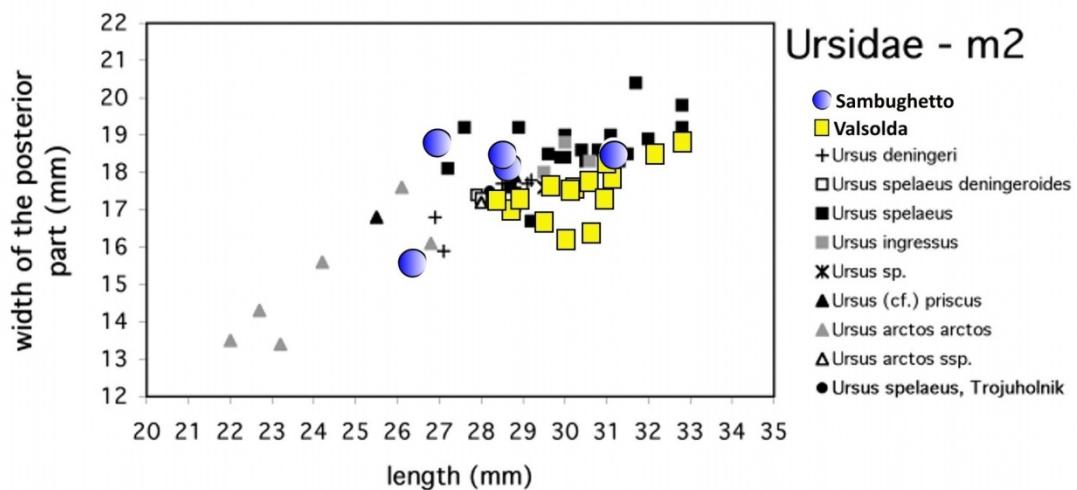


Figure 10. Relationship between the Length and the Width of the posterior part in m2 in different species of bears and the specimens from Grotta delle Streghe and Grotta del Bandito (from Sabol, 2005, modified).

Metapodia: The mean and the standardized mean of the morphometrical parameter and the indices (Plumpness index IP and K-I) are shown in Table 2. Table 3 shows a comparison between the Plumpness Index (IP) and K-I index values calculated for the most important

populations in Northern Italy and in the Gamssulzen Cave in Austria, where one of the youngest populations, *U. ingressus*, lived and is considered the landmark population. As for the teeth, the metapodia are the most important component of the skeleton with an evolutionary meaning. Also in this case, the overall study of the significant indices (IP and K-I) allows us to advance some considerations. A new confirmation that the Grotta delle Streghe population belongs to the *spelaeus* group can be deduced by observing Fig. 11; in this figure, a comparison between the metacarpi of different species of *Ursus* with those from the Grotta del Bandito and Grotta delle Streghe is shown. The points of Grotta delle Streghe and Grotta del Bandito fall within the field “gr. *spelaeus*” (Lower Pleistocene).

METAP.	n	1	2	3	4	5	6	IP	K-I
<i>Mc 1</i>	22	62.67	24.97	20.27	13.27	10.74	18.62	29.55	8.08
<i>Mc 2</i>	33	75.93	19.10	26.54	18.07	13.14	25.6	33.93	6.75
<i>Mc 3</i>	34	80.80	20.72	29.33	17.63	13.88	26.05	32.12	7.53
<i>Mc 4</i>	29	81.24	22.40	31.14	18.38	15.66	26.76	32.58	8.63
<i>Mc 5</i>	17	81.69	30.27	33.28	19.08	16.71	28.04	34.14	12.37
<i>Tot Mc</i>	135								
<i>Mt 1</i>	16	57.10	24.05	24.73	12.50	12.15	17.94	31.4	10.41
<i>Mt 2</i>	41	70.88	17.25	25.64	16.18	12.03	22.70	31.79	6.28
<i>Mt 3</i>	33	77.02	18.81	29.53	16.04	13.15	22.11	28.69	7.24
<i>Mt 4</i>	30	84.09	21.46	30	16.52	14.28	23.55	27.92	7.67
<i>Mt 5</i>	18	87.72	28.34	30.24	14.27	15.88	25.04	28.55	9.82
<i>Tot Mt</i>	138								

METAP.	n	1	2	3	4	5	6	IP	K-I
<i>Mc 1</i>	22	98.69	103.18	105.03	103.67	108.7	94.48	97.88	104.39
<i>Mc 2</i>	33	102.29	95.02	95.47	104.45	106.83	101.19	99.21	89.29
<i>Mc 3</i>	34	101.25	97.28	95.93	106.85	103.58	98.30	97	90.94
<i>Mc 4</i>	29	97.17	95.73	98.54	98.82	111.06	95.57	96.96	96.86
<i>Mc 5</i>	17	99.02	99.57	94.28	102.58	115.24	96.03	96.28	94.64
<i>Mt 1</i>	16	107.55	105.39	95.48	105.93	129.94	101.36	98	92.7
<i>Mt 2</i>	41	105.32	112.01	104.23	117.25	114.57	106.57	99.91	110.18
<i>Mt 3</i>	33	99.64	91.51	94.04	102.82	115.35	94.49	94.59	86.91
<i>Mt 4</i>	30	99.75	104.68	99.68	105.22	114.24	96.12	96.38	105.36
<i>Mt 5</i>	18	102.36	92.61	102.51	104.16	124.06	102.62	99.44	90.42

Table. 2. Mean and standardized mean of the morphometric values, IP and K-I of the metacarpalia and metatarsalia of the cave bears from Grotta delle Streghe.

SAMBUGHETTO	MC1	MC2	MC3	MC4	MC5	MT1	MT2	MT3	MT4	MT5
<i>IP</i>	29.55	33.93	32.12	32.58	34.14	31.4	31.79	28.69	27.92	28.55
<i>K-I</i>	8.08	6.75	7.53	8.63	12.37	10.41	6.28	7.24	7.67	9.82
GR. BANDITO	MC1	MC2	MC3	MC4	MC5	MT1	MT2	MT3	MT4	MT5
<i>IP</i>	28.97	31.23	29.54	30.31	32.68	29.20	29.18	27.26	26.51	27.09
<i>K-I</i>	7.55	6.84	7.25	8.03	11.54	10.18	5.26	6.65	7.69	8.78
BUCO DELL'ORSO	MC1	MC2	MC3	MC4	MC5	MT1	MT2	MT3	MT4	MT5
<i>IP</i>	30.02	32.30	31.09	31.49	33.35	31.23	30.21	28.28	27.48	25.99
<i>K-I</i>	7.89	6.62	6.70	7.80	10.83	9.95	5.47	7.23	7.08	9.18
SANDONA'DI L.	MC1	MC2	MC3	MC4	MC5	MT1	MT2	MT3	MT4	MT5
<i>IP</i>	29.26	33.43	31.95	32.25	33.93	32.27	31.46	29.33	28.21	27.89
<i>K-I</i>	8.47	6.81	7.02	8.27	10.96	10.12	5.52	6.68	6.41	8.71
COVOLI DI VELO	MC1	MC2	MC3	MC4	MC5	MT1	MT2	MT3	MT4	MT5
<i>IP</i>	30.23	33.46	30.67	32.19	33.78	31.79	31.19	29.64	28.86	37.87
<i>K-I</i>	8.93	6.47	6.85	7.71	10.85	9.55	5.25	7.09	7.77	9.93
CONTURINES	MC1	MC2	MC3	MC4	MC5	MT1	MT2	MT3	MT4	MT5
<i>IP</i>	31.07	32.62	30.29	32.31	34.04	33.44	31.10	28.78	27.18	27.39
<i>K-I</i>	6.85	6.43	6.6	7.39	12.26	9.72	5.17	6.47	6.04	9.71
GAMSSULZEN	MC1	MC2	MC3	MC4	MC5	MT1	MT2	MT3	MT4	MT5
<i>IP</i>	30.19	34.2	33.11	33.6	35.46	32.04	31.82	30.33	28.97	28.71
<i>K-I</i>	7.74	7.56	8.28	8.91	13.07	11.23	5.70	8.33	7.28	10.86

Table. 3. Comparison of the means of the IP and K-I of the metapodia of cave bears from the Italian caves and the Gamssulzen (Austria), the landmark population of *U. ingens*.

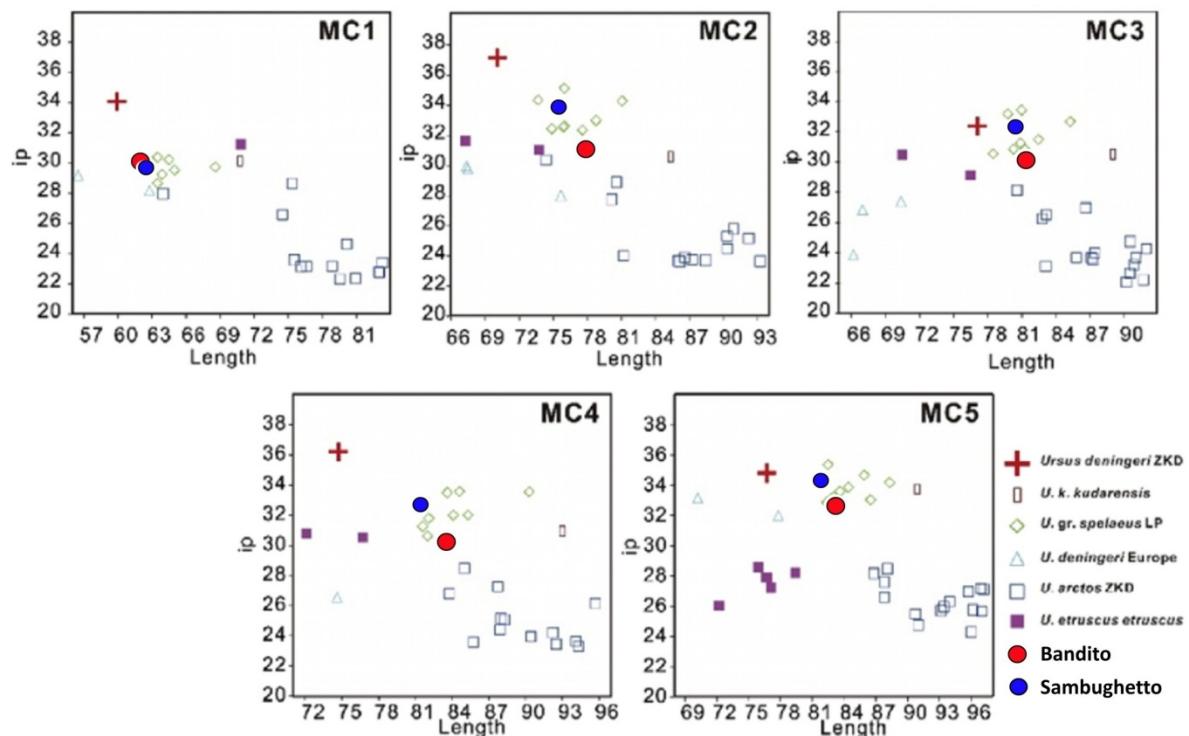


Figure 11. Relationship between the Length and the Plumpness Index (IP) in metacarpalia of different species of bears and the specimens from Grotta delle Streghe and Grotta del Bandito (from Jangzuo et al., 2018, modified).

In many studies it is underlined that the size of the Italian *spelaeus* is similar to that of *Ursus deningeri*, and only in some cases closer to that of the speleians (for example the Pocala bears, Friuli Venezia Giulia region, Rossi and Santi, 2015). In the frame of the Italian cave bears, the metapodia of the bears from Grotta delle Streghe aren't an exception as can be observed in the Fig. 12.

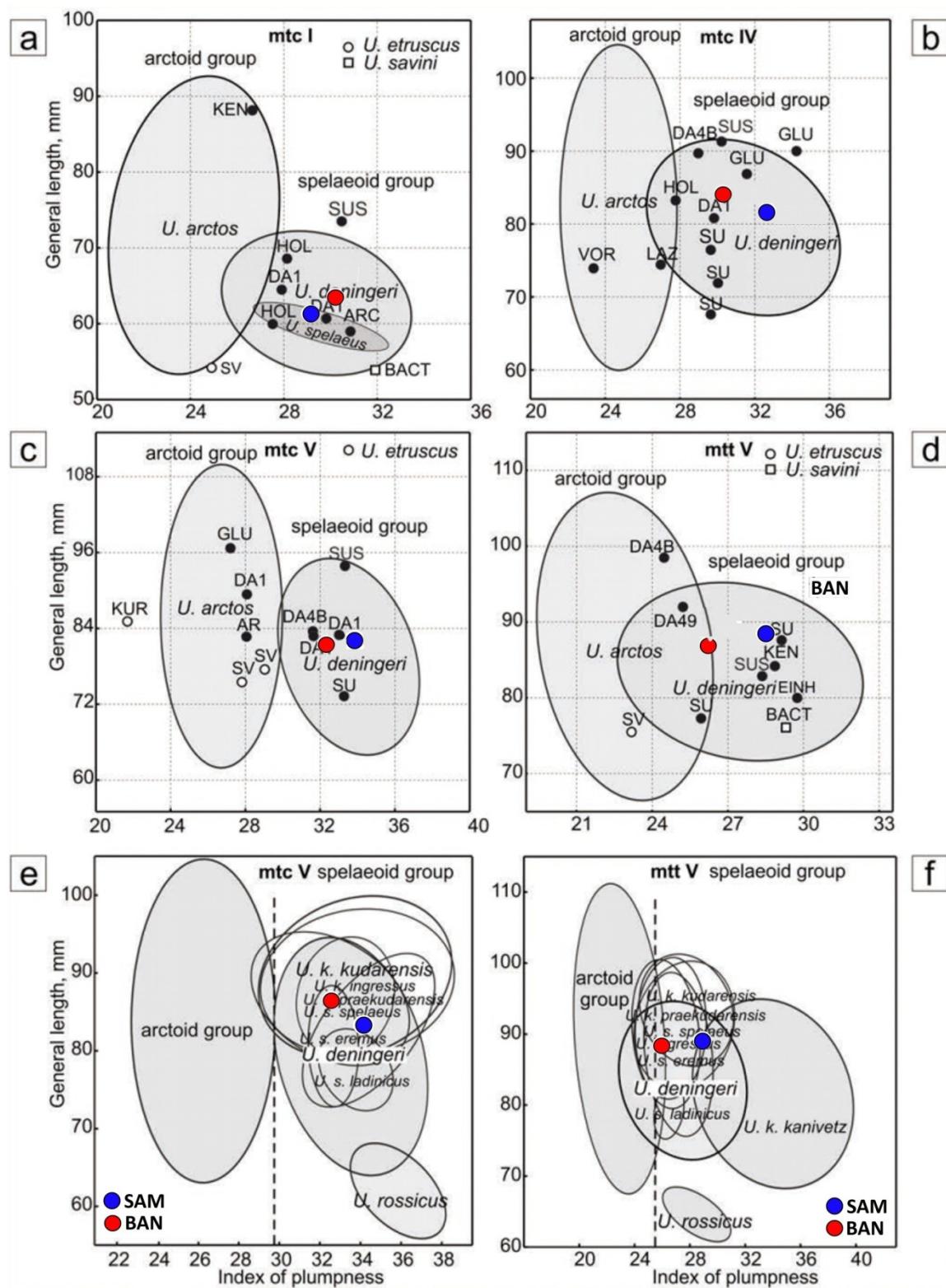


Figure 12. Position of the cave bears from Grotta delle Streghe and Grotta del Bandito in the range of the arctoid and speloid bears (from Baryshnikov and Puzachenko, 2017, modified).

Fig. 13A-B shows the multivariate analysis of the points of the relation between IP and K-I of the metapodia (metacarpalia and metatarsalia) of the populations of Grotta delle Streghe, Gamssulzen Cave, Grotta del Bandito, Buco dell'Orso (Como province, Lombardy), Conturines and Covoli di Velo. The presence of this latter cave (Covoli di Velo, Verona Province, Veneto region) in this diagram is justified by the recent publication of a chronological dating that showed that the bear population lived there $29,131 \pm 0,90$ years ago (Rossi et al., 2018). Between the populations of reference which are those from Conturines (*Ursus s. ladinicus*) with a clearly lower size, and that of *Ursus ingressus* (Gamssulzen, the type- locality and consequently the landmark population), the Italian bears are included within a single cloud of distribution. The Italian cave bears, at least those considered in this study are morphologically very similar, so that a “morphometric homogeneity” can be identified. If this picture is confirmed by future studies a problem of the Southalpine like an “island” within the areas of the European cave bears, could be discussed.

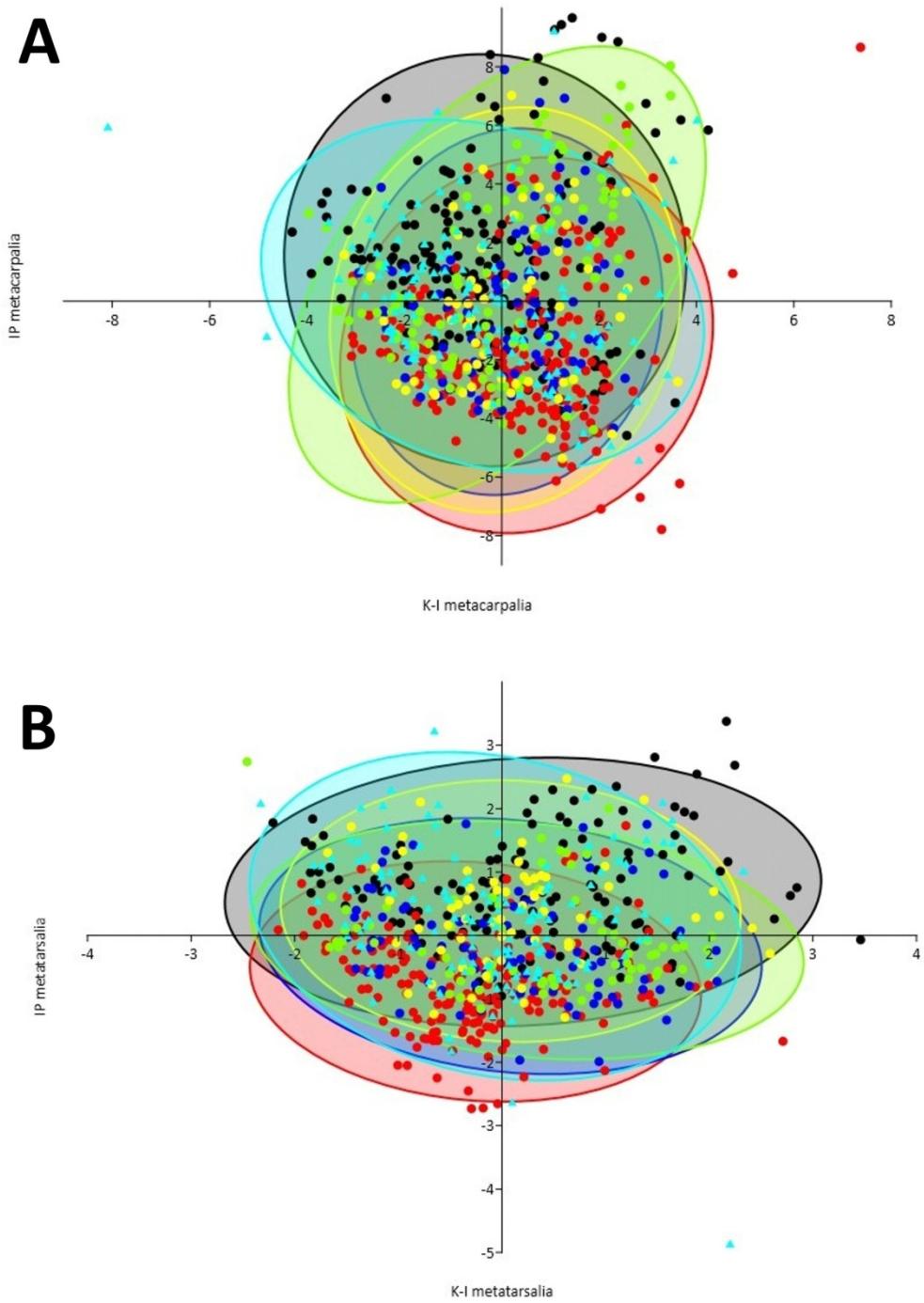


Figure 13. Relationship between the Plumpness Index (IP) and K-I in metacarpalia (A) and metatarsalia (B) from Gamssulzen (black points), Grotta del Bandito (red points), Buco dell'Orso (blue points), Conturines (green points), Covoli di Velo (yellow points) and Grotta delle Streghe (light-blue points).

MORPHODYNAMIC

The distribution (in percentage) of the morphotypes for the different kinds of teeth is summarized in Fig. 14. The data are only indicative, because of the low number of specimens. The mainly represented morphotypes are those belonging to a simple morphology of the masticatory surface (see Rabeder, 1999). In this first analysis the population of bears from Grotta delle Streghe is similar to those from other Italian localities (Stoppani et al., 2007; Rossi and Santi, 2013, 2015; Santi et al., 2011; Santi and Rossi, 2018, 2020) with the exception of the Basura bears (Liguria region) (Quiles, 2004), Monte Generoso (Lombardy) and Cerè (Veneto), the three extreme cases (Bona, 2004; Rossi and Santi, 2007, 2011). It appears that the morphodynamic doesn't have an absolute value for the evolutionary step evaluation, but has an indicative importance (Robu, 2016). With these first data, together with the other data for Italian localities, the “evolutionary homogeneity”, shown by the Italian populations can be confirmed again. However, these considerations are only preliminary and represent a basis for future discussions.

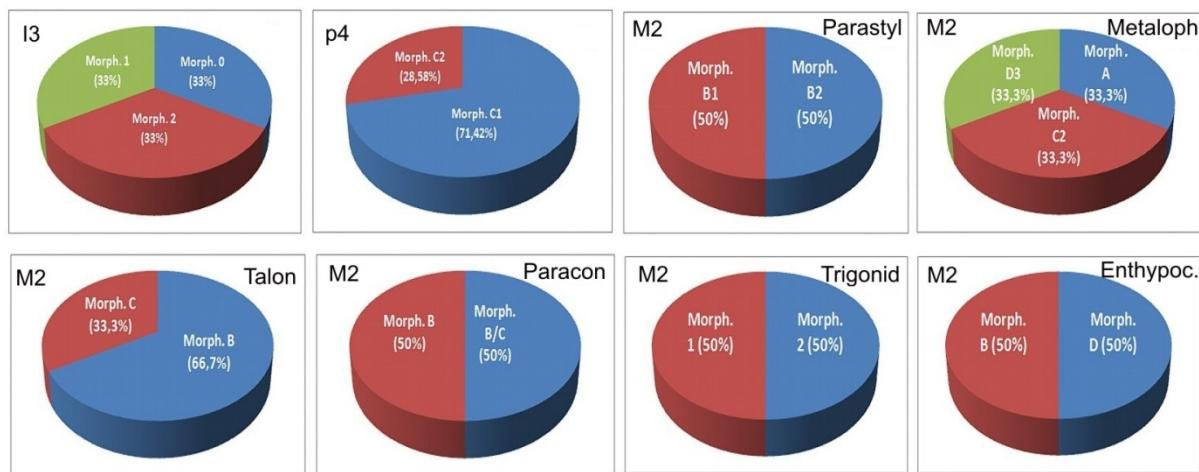


Figure 14. Percentage of the morphotypes in teeth from Grotta delle Streghe.

In the diagram of Fig. 15 the P4/p4 index std and K-I std are reported. The bears from Grotta delle Streghe fall within the range of distribution of *U. spelaeus* and hence within the evolutionary picture of the Italian bears.

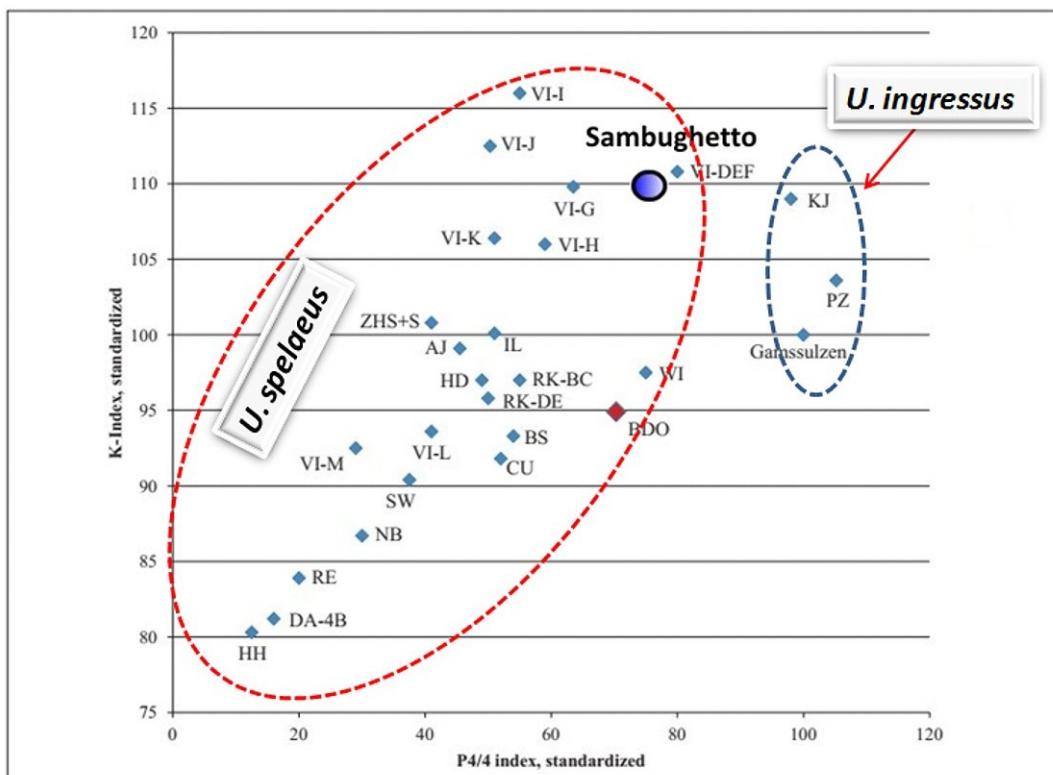


Figure 15. Relationship between the P4/p4 index (std) and K-I (std) in cave bears from European caves and the specimens from Grotta delle Streghe (from Argant et al., 2019, modified).

An attempt to correlate cave bears from some of the most important caves in Northern Italy is shown in Fig. 16. This dendrogram is based on the relationship between the length, distal epiphyseal width and the Plumpness Index (IP standardized) of the metacarpals. The closeness between the bears of the Sambughetto (Grotta delle Streghe) and those of Conturines is very interesting. We previously mentioned that bears from the Conturines belong to *Ursus s. ladinicus*, a taxon of high altitude (this cave is located at about 2800 m a.s.l.); but it is unusual to observe bears of high altitude and others of 700 m together. However, the proximity of these populations may not be so unlikely: in fact, near Grotta delle Streghe, is Mount Fenera where bear remains probably belonging to *U. s. ladinicus* have been found. In support of this hypothesis is the recent study by Argant et al. (2019) who have studied the fossils of bears from Azé (Saône-et-Loire, France) geographically near Mt. Fenera and Sambughetto, and have considered them as being *Ursus s. ladinicus*. So it can be assumed that the bears moved from

Monte Fenera to Sambughetto. If this is the case, the geographic distribution of *Ursus s. ladinicus* in North Italy should be redrawn.

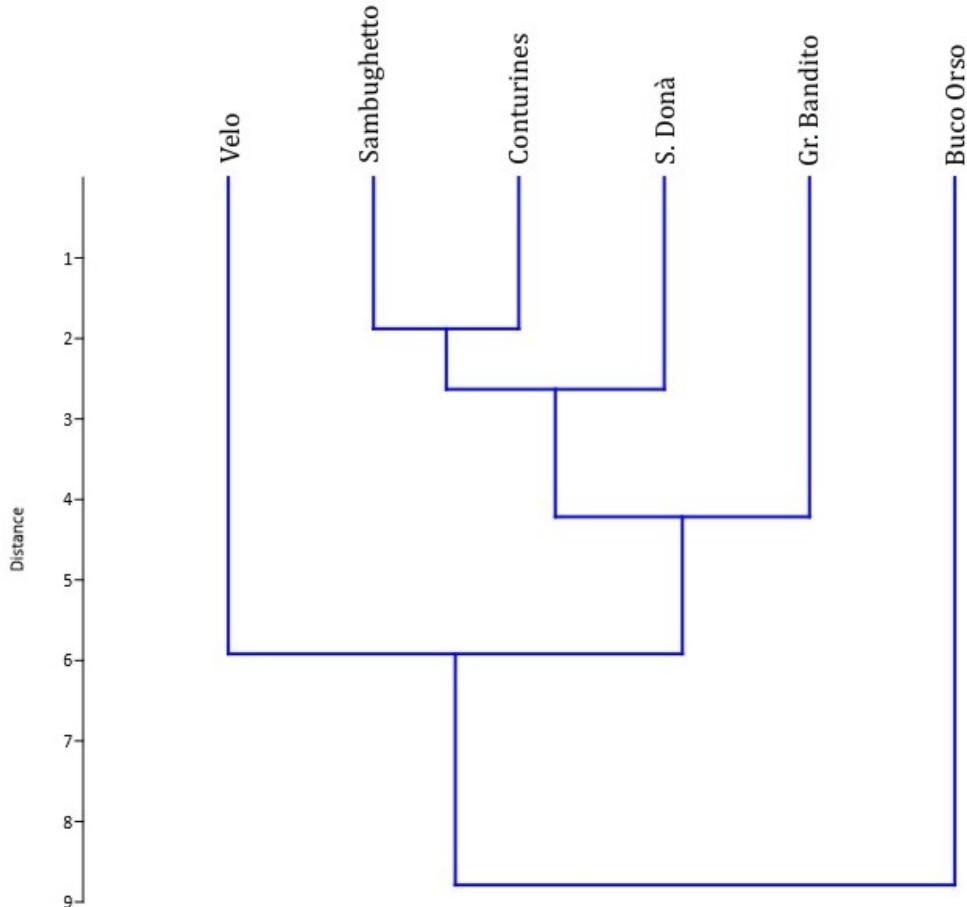


Figure 16. A phyletic relationship among the standardized means of Length, Distal epiphyseal Width and IP of the metacarpalia of the cave bears from the most important caves in North Italy.

CONCLUSIONS

The goal of this first paper, aimed at the study of the teeth and the metapodia of *Ursus spelaeus* from the Grotta delle Streghe (Sambughetto Valstrona, Piedmont, West Italy) was twofold: 1) to analyze the cave bear population of the Piedmont region which is still poorly known for its remains when compared with other Italian regions like Lombardy and Veneto

and consequently 2) to partially fill the gap with the nearby localities of Fontana Marella and Monte Generoso (Varese). The morphometric and morphodynamic study of the teeth and metapodia showed that the bears from Grotta delle Streghe fall very well within the range of the Italian *spelaeus*, in size and in evolutionary step, which is intermediate compared to the highest step of the cave bears evolution shown by *U. ingens*. With these partial data is therefore very difficult to identify the single species (*U. ingens*, *U. s. ladinicus*, *U. s. eremus*), but we can exclude *U. ladinicus* (being bears of high altitude), *U. deningeroides*, and *U. deningeri*, the latter being, in Northern Italy, an antique and rare species (with some remains are found only in Veneto region).

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