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Cave bears from Grotta del Bandito (Piedmont-Northern Italy). The final scenario

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Abstract: In this work the teeth and the metapodia from Grotta del Bandito (Cuneo Province, Piedmont region, North Italy) were studied. From the morphometry studied with univariate and multivariate analysis of the teeth the most important observation is that no differences are noted between the different species of cave bears of Middle to Late Pleistocene in Europe and the denture (premolars and molars) of the Grotta del Bandito bears. Globally, the population of the Grotta del Bandito is homogenous. As already observed in other bears from the Italian caves the morphology of the $P^4/_4$ is simple and resembles in many cases that of *U. deningeri*. Also considering the analyses of the metapodia we arrive to the same conclusions already advanced for the teeth, notwithstanding the fact that in a cladogram which relates all the metapodia: the Grotta del Bandito bears are very close to the *U. s. eremus* from Ramesch, but very far from Conturines (*U. s. ladinicus*) and Gamssulzen (*U. ingressus*). The similarity in some cases to *U. s. eremus* or *U. s. ladinicus* seems consistent within the Italian scenario.

Kurzfassung: In dieser Arbeit werden die Zähne und die Metapodien aus der Grotta del Bandito (Cuneo, Region Piemont, Norditalien) untersucht. Aus der Morphometrie (univariate und multivariate Analyse) der Zähne ist die wichtigste Beobachtung, dass keine Unterschiede zwischen den verschiedenen Arten von Höhlenbären des mittleren bis späten Pleistozäns in Europa und dem Gebiss (Prämolaren und Molaren) der Bären von Grotta del Bandito festgestellt werden. Insgesamt ist die Population der Grotta del Bandito homogen. Wie bereits bei anderen Bären aus den italienischen Höhlen beobachtet, ist die Morphologie des $P^4/_4$ einfach und ähnelt in vielen Fällen der von *U. deningeri*. Auch bei der Analyse der Metapodien kommen wir zu den gleichen Schlussfolgerungen wie bei den Zähnen, auch wenn das Kladogramm alle Metapodien umfasst: Die Bären der Grotta del Bandito stehen den *U. s. eremus* aus Ramesch sehr nahe, sind aber sehr weit von Conturines (*U. s. ladinicus*) und Gamssulzen (*U. ingressus*) entfernt. Die Ähnlichkeit mit *U. s. eremus* oder *U. s. ladinicus* in einigen Fällen scheint mit dem italienischen Szenario übereinzustimmen.

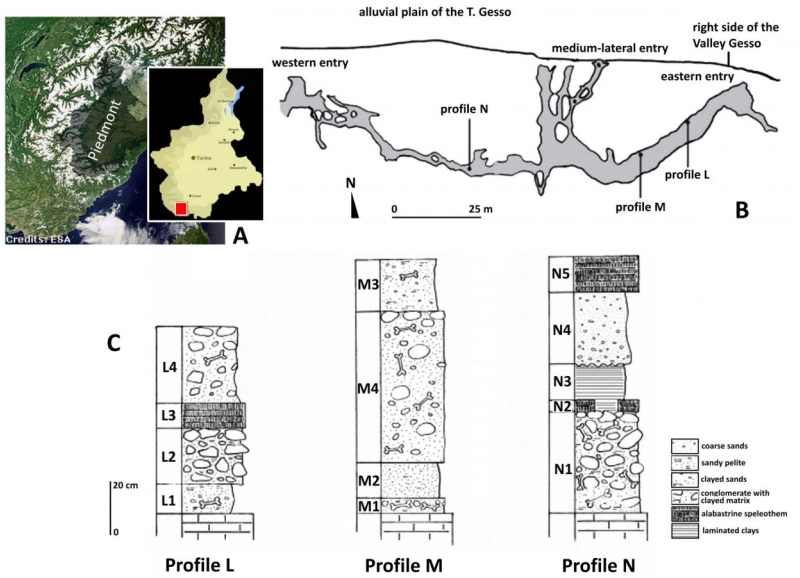


Fig. 1: Geographical position of the Grotta del Bandito (Cuneo Province, Piedmont, North Italy, from Santi & Rossi, 2020a, mod.). | **Abb. 1**: Geografische Lage der Grotta del Bandito (Provinz Cuneo, Piemont, Norditalien, aus Santi & Rossi, 2020a, mod.).

Introduction

The Grotta del Bandito (Cuneo Province, South Piedmont, North Italy) is a cave containing an abundant quantity of cave bear bones, that only recently has been studied in detail (Santi & Rossi, 2020 a). The geographical position of this cave is peculiar, being close to some caves in the Liguria region (the Basura cave is the better known one) in which remains of »modern« cave bears have been gathered; this is the only case in north Italy (Quiles, 2004). The presence of cave bears in north Italy is surely abundant from west to east, from both Liguria and Piedmont regions to Friuli Venezia Giulia region (i.e. Bona, 2004; Zunino & Pavia, 2005; Quiles, 2004; Santi et al., 2020 a, b; Indelicato et al., 2022; Kavcik-Graumann et al., 2022), but in Piedmont, few caves are known, excluding the Grotta el Bandito, the Sambughetto Valstrona and the caves excavated inside Mount Fenera (Vercelli Province) which have been studied. The importance of these Piedmont caves is also linked to the recent discovery of the probable *U. s. eremus* in the Mt. Fenera caves (Santi et al., 2022): is it possible that this taxon inhabited some parts of the region? The focus of this work is to introduce the results of the research on fossil bones coming from Grotta del Bandito focusing on the teeth and the metapodia and discussing the possibly reached evolutionary step.

The Grotta del Bandito: generalities

The Grotta del Bandito is located in the Cuneo Province (Piedmont) near the border with Liguria, and it has been recently studied by Zunino & Pavia (2005) who described its topographic configuration. Briefly, this cave opens inside the Valley of Gesso, its entrance is placed at 726 m. a.s.l. According to Zunino & Pavia (2005) the Grotta del Bandito is made of a 217 m long E-W corridor and two parts are filled with the same sediments: the »eastern branch« with sand-clay and pebbles and a second very similar to the first. Three profiles were also conducted and named L, M and N respectively (**Fig. 1**).

Material and methods

The fossil specimens consist of teeth and metapodia stored in the Museo Civico di Storia Naturale in Milan (Lombardy); using the morphometric parameters codified by Tsoukala & Grandal d'Anglade (1998), Rabeder (1999) and Withalm (2001), the bones have been measured. A morphodynamic analysis with the calculation of both Morphodynamic Index (IM) (Rabeder, 1999) and the Plumpness Index (IP) (Withalm, 2001) has been also proposed, and univariate and multivariate analyses have been conducted with PAST 3.02 software (Hammer et al., 2001). In particular the IW index (Roundness Index) was calculated for the incisors and molars, as follows:

IW = W / L x 100 (Baryshnikov & Puzachenko, 2020)

A Sex Dimorphism Analysis (SDA) has been elaborated mainly with canines and metapodia utilizing the Rabeder & Withalm (2014) and Baryshnikov & Puzachenko (2017) relationships; the indices considered are: the Sex Index (SI), Sex Ratio (SR) and Sex Dimorphism Index (SDI) for the canines (Rabeder & Withalm, 2014); the Sex Size Dimorphism (SSD) and Average Sex Size Dimorphism (ASSD) for the metapodia (Baryshnikov & Puzachenko, 2017). In **Tab. 1** the results of these analyses are shown. A multivariate analysis has been also attempted. Data for this kind of study were »transformed« into standardized values with the following formula:

$$y_{i,st} = \frac{(y_i - y_{min})}{(y_{max} - y_{min})}$$

(Baryshnikov & Puzachenko, 2017)

$y_{i,st}$ is the standardized value, y_i y_{min}, y_{max} the observed value, the minimum and maximum values.

Canines	Female	Male	n	Sex Index	Sex ratio	Sex dimorphism index		Sexing is
						Breadth	Breadth X Height crown	
upper	53	12	65	81.53	4.42	119.69	144.31	distinct
lower	34	3	37	91.89	11.33	122.04	128.30	distinct
Tot.	87	15	102	85.29	5.8	121.64	142.41	distinct

Metapodia	Female	Male	n	Sex Index	Sex dimorphism index		Sexing is
					Length	L x deb	
MC1	5	6	11	45.45	110.60	116.80	distinct
MC2	43	10	53	81.13	112.03	126.00	distinct
MC3	15	27	42	35.71	112.98	133.42	distinct
MC4	10	49	59	16.95	116.48	137.37	distinct
MC5	16	35	51	31.37	113.68	131.70	distinct
MT1	5	14	19	26.32	115.92	144.46	distinct
MT2	43	7	50	86	111.87	123.72	distinct
MT3	14	27	41	34.15	110.32	128.67	distinct
MT4	-	-	58	-	-	-	*indistinct*
MT5	12	28	40	30	113.26	121.35	distinct
SR m = 1.51	**163****	**203****	**424****	**43.01***	**113.02***	**129.28***	
ASSD = 6.96							

*Mean, **Total specimens, **SR = Sex Ratio, ASSD = Average Sexual Size Dimorphism**

$$\textbf{Sex-Index} = \frac{f}{(f+m)}\ x\ 100$$

$$\textbf{Sex-ratio} = \frac{f}{m}$$

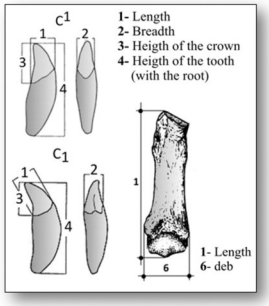
$$\textbf{Sex dimorphism Index} = \frac{xm}{xf}\ x\ 100$$

f = n. female; **m** = n. male; **xm/f** = mean of male and or female

$$\textbf{SSD} = \frac{(Mmale - Mfemale)}{(Mmale + Mfemale)}\ x\ 100$$

$$\textbf{ASSD} = \frac{1}{6}\sum_{i=1}^{6}\frac{(Mi,male - Mi,female)}{(Mi,male + Mi,female)}\ 100\%$$

"6" number of measurements, $\mathbf{M_{i,male}}$ and $\mathbf{M_{i,female}}$ are the means of measurements for males and females.



Tab. 1: Sexual distinction with canines and metapodia in the cave bears from Grotta del Bandito. | **Tab. 1**: Geschlechtsunterscheidung mit Eckzähnen und Metapodien bei den Höhlenbären aus Grotta del Bandito.

Sex dimorphism analyses

This study is elaborated on both the canines and metapodia (**Tab. 1**). Globally, the SD is distinct with the following values for the different relationships: sex index of 85.29, and a sex ratio of 5.8. Utilizing the »breadth« and the »breadth x height of crown« the Grotta del Bandito is dominated by females; with »length« and »width« different values have also been calculated: sex index 91.34, sex ratio 10.55 with the female part being rather similar to the previous ones. Inside the diagrams in Fig. 2 taken as examples, two clear clusters are identified for the females and males respectively; notwithstanding that there are the differences in »size« of these clusters, also considering the different parameters used and their relationships, canines are a good tool for sexual dimorphism analyses.

In **Tab. 1** are also shown the results of SD utilizing the metapodia; as for the canines the metapodia can also be considered very good fossils for this kind of analyses. From the table we can observe that only for mt4 the sexual dimorphism is indistinct. The mean of SR is 1.51 and the ASSD is 6.96. Curiously, males are in major quantity contrarily to the results of the canines. A comparison with European and Urals-Caucasian populations of cave bears (Baryshnikov & Puzachenko, 2017) shows that the ASSD for Bandito bears (7.52) is near that *U. s. eremus* (7.04), rather that *U. ingressus* (6.47) and *U. s. ladinicus* (5.51): from the lower to higher *ladinicus* → *ingressus* → *eremus* → Bandito bears; for these last we have the greatest sexual dimorphism among the alpine cave bears considered.

Data analysis

Morphometry of teeth

Incisors: Among the fossils studied, both the upper and lower I2, and upper and lower I3 were identified. The quantity is poor, and it is impossible to advance definitive conclusions. However, some considerations can be drawn. Studies about the incisors of cave bears in Italy are rather limited in number, only Santi & Rossi (2020 b) and Santi et al. (2022) studied this kind of teeth from Valsolda (Lombardy) and Mount Fenera (Borgosesia, Vercelli Province) respectively. A comparison between the incisors from Grotta del Bandito, Mt. Fenera and Valsolda is shown in **Fig. 3**. We can note that only for I2 and i2 the morphospaces of Valsolda and Fenera are separate, differently for the other cases. I3 is the most compact within the morphospace in which Mt. Fenera includes the other two, Grotta del Bandito and Valsolda, respectively. A morphological variability based on the measurements of the $I^2/_2$ and $I^3/_3$ of the different populations of cave bears from European and Ural-Caucasian sites is shown in **Fig. 4**. The position of the incisors from Grotta del Bandito is near to field of the group *spelaeus* (*eremus*, *ladinicus*, *spelaeus*). The *spelaeus* distribution is well separated from the *ingressus* one and from *deningeroides* specimens, and the others Ural-Caucasian distributions. Notwithstanding the position of the Grotta del Bandito near the *spelaeus* group we need other data to individuate the specific taxon/a.

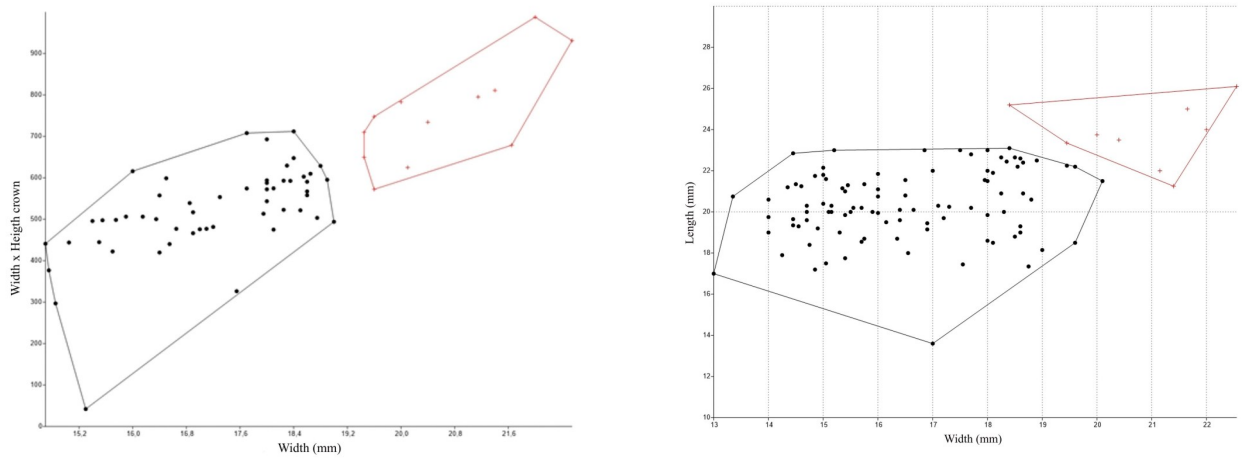


Fig. 2: Cluster of male and female individuals utilizing the Length-Width and Width-Heigth of cronwn relationships of the canines. Black points = females, red cross = males. | **Abb. 2**: Cluster von männlichen und weiblichen Individuen unter Verwendung des Verhältnisses Länge-Breite und Breite-Höhe der Eckzähne. Schwarze Punkte = Weibchen, rotes Kreuz = Männchen.

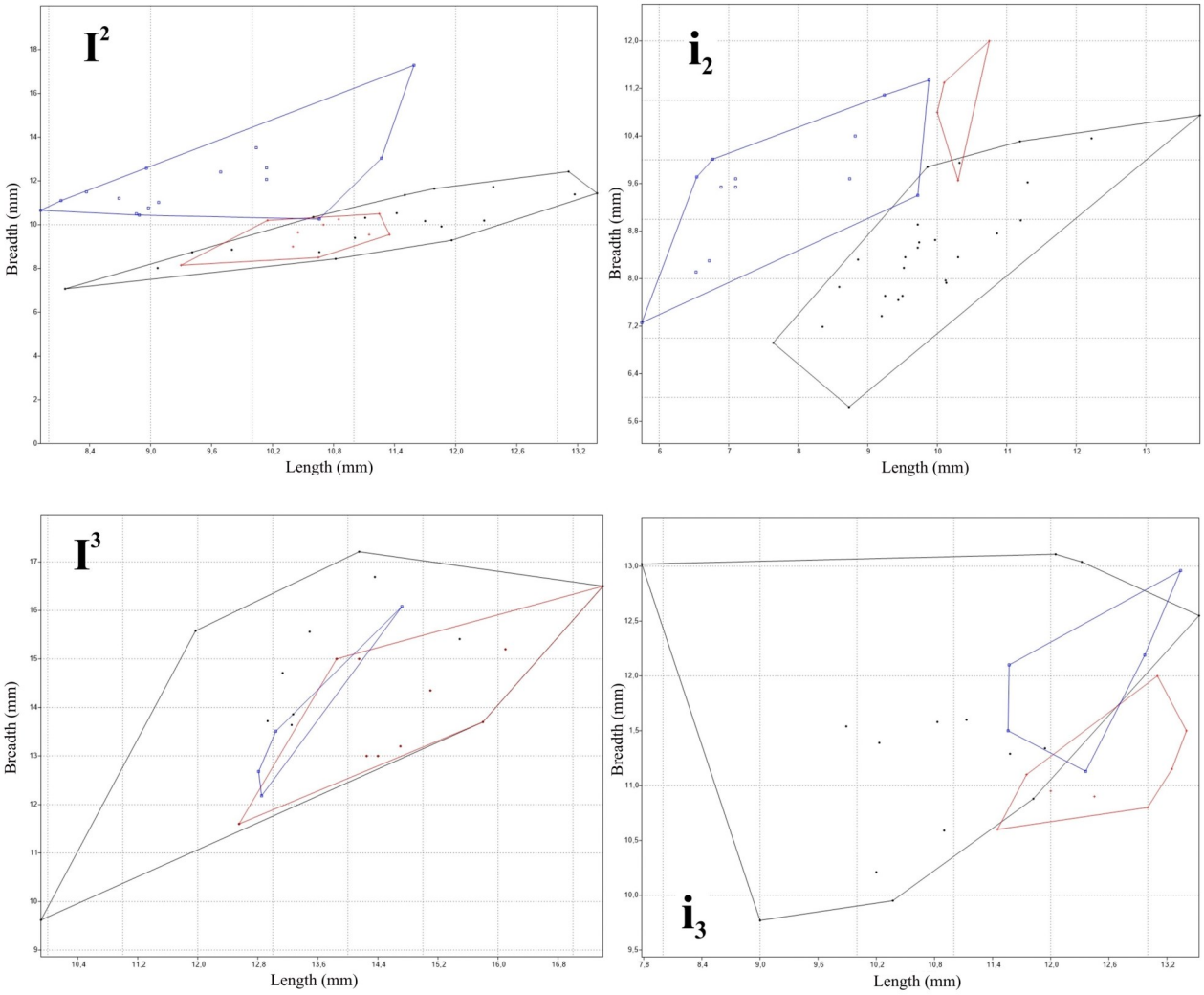
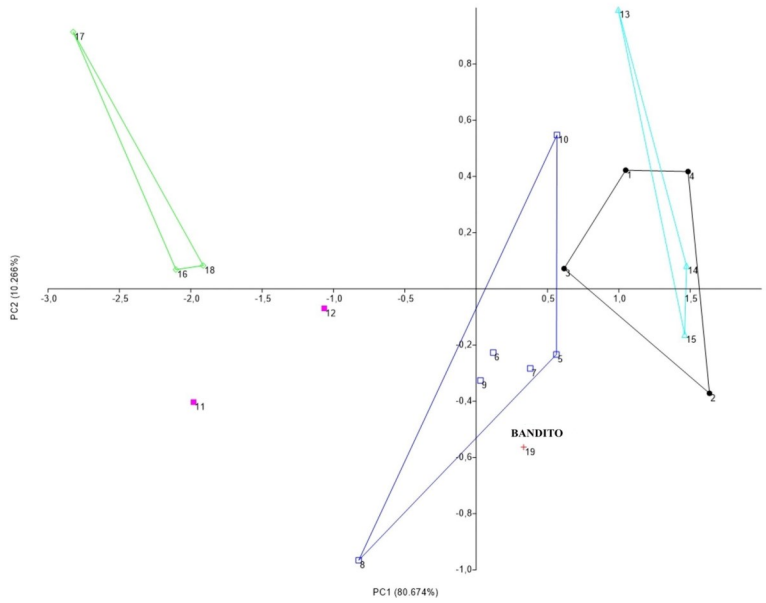


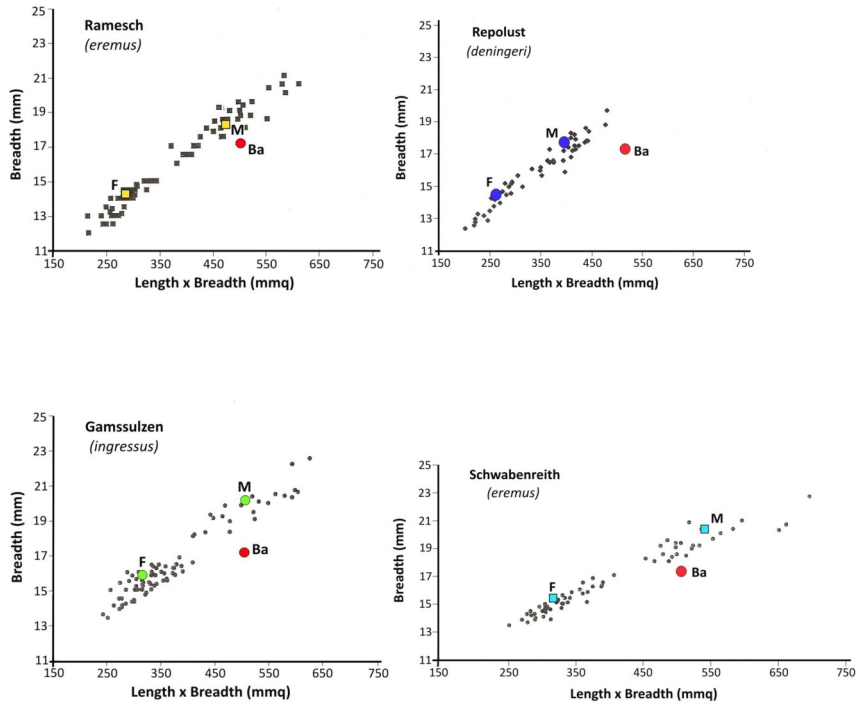
Fig. 3: Different clusters for the incisors from Grotta del Bandito (red rhombic), Valsolda (blue squares) and Mount Fenera (black points). | **Abb. 3**: Verschiedene Cluster für die Schneidezähne aus Grotta del Bandito (rote Rauten), Valsolda (blaue Quadrate) und Mount Fenera (schwarze Punkte).



Taxa	Locality
U. kanivetz ingressus Rabeder, Hofreiter & Withalm, 2004	Gamssulzenhöhle
U. k. ingressus	Steigelfadbalm
U. k. ingressus	Loutra Arideas bear cave
U. k. ingressus	Križna jama
U. spelaeus eremus Rabeder, Hofreiter & Withalm, 2004 + *U. k. ingressus*	Herdengelhöhle
U. s. eremus	Schlenkendurchgangshöhle
U. s. eremus	Schwabenreith-Höhle
U. s. ladinicus Rabeder, Hofreiter & Withalm, 2004	Conturineshöhle
U. s. ladinicus	Brieglersberghöhle
U. spelaeus ssp.	Eirós Cave
U. deningeroides Mottl, 1964	Dripstone cave of Flatz
U. deningeroides	Repolust
U. kanivetz kanivetz Vereshchagin, 1973	Zapovednaya Cave
U. k. kanivetz	Secrets Cave
U. k. kanivetz	Ignatievskaya Cave
U. kudarensis kudarensis Baryshnikov, 1985	Kudaro 1 & 3 (layers 3-4)
U. k. praekudarensis (Baryshnikov, 1998)	Kudaro 1 (layer 5)
U. kudarensis ssp.	Kudaro 3 (layers 5-8)

From **1** (*U. kanivetz ingressus*) to **18** (*U. kudarensis* ssp.).(Gimranov et al., 2021)

Fig. 4: PCA analysis with different taxa of cave bears from Grotta del Bandito and European and Ural-Caucasian caves. | **Abb. 4**: PCA-Analyse mit verschiedenen Taxa von Höhlenbären aus der Grotta del Bandito sowie aus europäischen und ural-kaukasischen Höhlen.



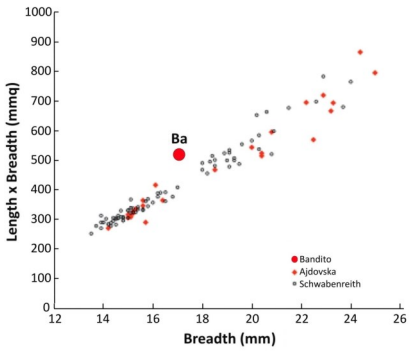


Fig. 5: Relationship between the »Length x Breadth« and »Breadth« in the canines from Grotta del Bandito and some European caves where different species of *Ursus* are found. F = female, M = males, Ba = Bandito (from Rabeder, 1999, mod.) and with Ajdovska (Slovenia), Schwabenreith (Austria) caves (from Rabeder, 2011, mod.). | **Abb. 5**: Verhältnis zwischen »Länge x Breite« und »Breite« bei den Eckzähnen aus der Grotta del Bandito und einigen europäischen Höhlen, in denen verschiedene *Ursus*-Arten vorkommen. F = Weibchen, M = Männchen, Ba = Bandito (Rabeder, 1999, mod.) und mit Ajdovska (Slowenien), Schwabenreith (Österreich) Höhlen (Rabeder, 2011, mod.).

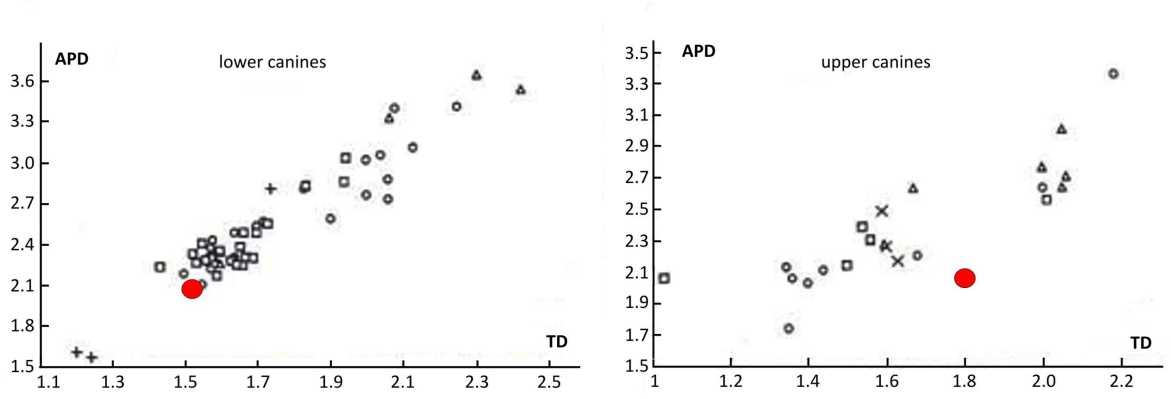


Fig. 6: Relationship between the »Transversal« and »Antero-posterior« diameter (TD-APD) in canines from Grotta del Bandito and Grotta Fontana Marella (from Perego et al., 2001, mod.). Symbols: circle = (FM1), square = (adults), triangle = (FM2), X = FM2 bis, red point = Bandito bear (from Perego et al., 2001 mod.). | **Abb. 6**: Verhältnis zwischen dem »transversalen« und dem »antero-posterioren« Durchmesser (TD-APD) bei Eckzähnen aus Grotta del Bandito und Grotta Fontana Marella (aus Perego et al., 2001, mod.). Kreis = (FM1), Quadrat = (Erwachsene), Dreieck = (FM2), X = FM2 bis, roter Punkt = Bandito-Bär (aus Perego et al., 2001 mod.).

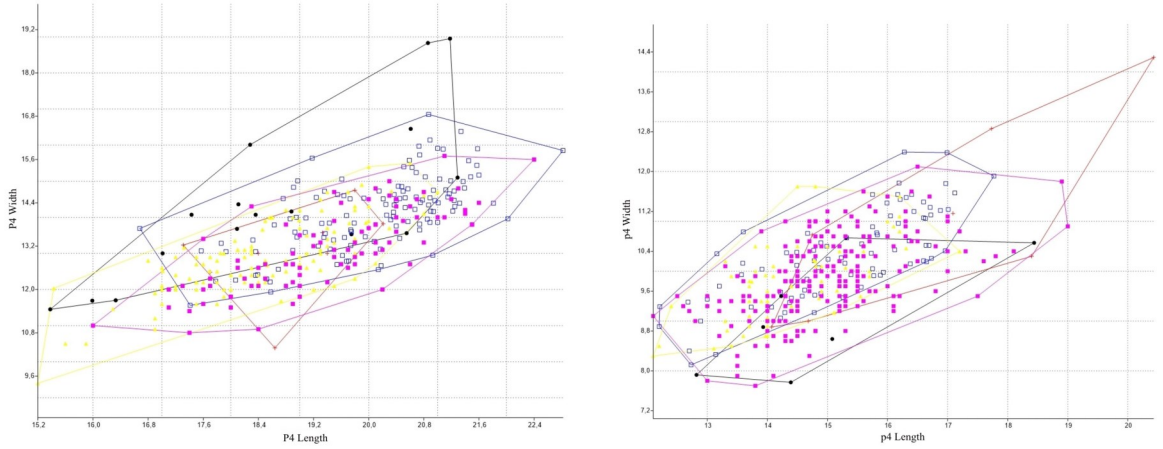


Fig. 7: Length-Width relationship in $P^4/_4$ from Grotta del Bandito (red cross), Mount Fenera (black points), Gamssulzen (blue squares), Conturines (yellow triangles) and Ramesch (pink squares) caves. | **Abb. 7**: Längen-Breiten-Verhältnis in $P^4/_4$ aus den Höhlen Grotta del Bandito (rotes Kreuz), Mount Fenera (schwarze Punkte), Gamssulzen (blaue Quadrate), Conturines (gelbe Dreiecke) und Ramesch (rosa Quadrate).

Canines: A comparison among some other different cave bears species shows that the morphometry of the canines from the Bandito cave is different from that of *deningeroides* (Repolust), *ingressus* (Gamssulzen) and *ladinicus* (Ajdovska), and it is closer to the cloud of *eremus* (Schwabenreith and Ramesch, **Fig. 5**). In **Fig. 6** a comparison with the canines from Fontana Marella cave (Varese, Lombardy), a site near the Piedmont region dated 28,810 ± 200 Ka (FM1) and 22,310 ± 200 Ka (FM2), is shown; the Bandito bears have teeth (upper and lower) with a small size placed just inside the dispersion cloud of the bears from the FM4 level (the older of the stratigraphic succession). Sizes of the canines are not a sufficient element in order to distinguish different species, and we have preferred to consider the Bandito bears as *Ursus* gr. *spelaeus* as well.

Fourth premolars $P^4/_4$: Several $P^4/_4$ were identified; in a preliminary short note Zunino & Pavia (2005) only superficially elaborated a small amount of them. **Fig. 7** shows the Length-Width relationships between the populations from Grotta del Bandito and others from Italian (Mount Fenera and Conturines area, the latter being the *locus-typus* of *U. s. ladinicus*) and European ones (Gamssulzen *locus-typus* of *U. ingressus* and Ramesch locus-typus of *U. s. eremus*). We can note that no separation in the fields of distribution exists, and that these are very concentrated. A confirmation can be shown in **Fig. 8** in which the medians of the Length and Width of the $P^4/_4$ are shown. Considering the IW ratio (Roundness Index) relating P4 the teeth from Grotta del Bandito have the lowest (69.18 ± 2.21) while the Fenera ones have the highest (77.22 ± 1.78); globally from the lower to higher we have: Bandito (61.18) → Ramesch (67.61) → Conturines (69.9) → Gamssulzen (70.49) → Fenera (77.22). On the contrary for p4 the specimens from Mt. Fenera have in mean the lowest value: 61.51 ± 2.13; from the lower to higher: Fenera (61.51) → Grotta del Bandito (65.85) → Ramesch (66.08) → Gamssulzen (67.88) → Conturines (68.07). Therefore, we must underline that the specimens from Mt. Fenera and Grotta del Bandito are lim-

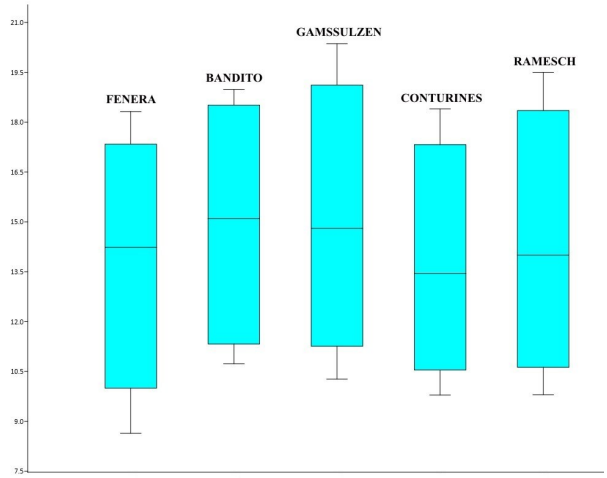


Fig. 8: Box plot of Length and Width medians of the $P^4/_4$ from Grotta del Bandito and of other Italian and European cave bears. | **Abb. 8**: Boxplot der Längen- und Breitenmediane des $P^4/_4$ aus der Grotta del Bandito und anderen italienischen und europäischen Höhlenbären.

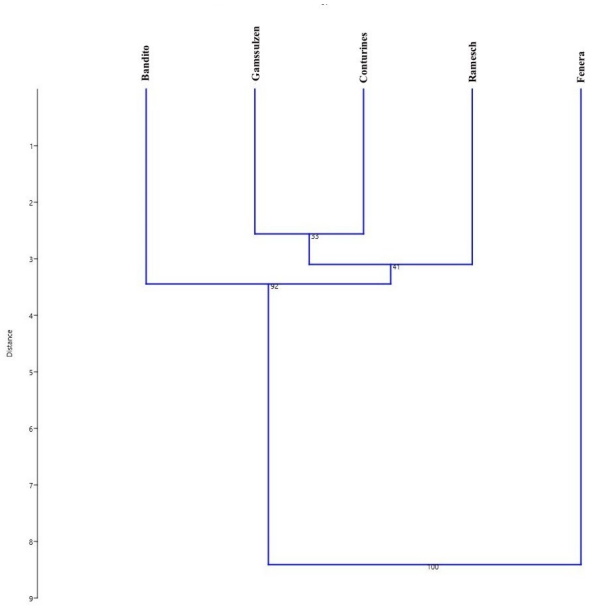


Fig. 9: UPGMA Euclidean cladogram (bootstrap 9999, cophen 0.9696) of the L,W and IW medians of $P^4/_4$ of Grotta del Bandito bears and other from Italian and European caves. | **Abb. 9**: Euklidisches UPGMA-Kladogramm (Bootstrap 9999, Cophen 0,9696) der L-, W- und IW-Mediane von $P^4/_4$ der Grotta del Bandito-Bären und anderer italienischer und europäischer Höhlen.

ited in number and these sequences can change in the future. An attempt of a cladogram based on the medians of some parameters and IW (cophen corr. 0.9696) is shown in **Fig. 9**. This diagram can be divided in two major blocks: the most internal one is composed of the taxa that formed the »*spelaeus* group« (*ingressus*-Gamssulzen, *s. ladinicus*-Conturines and *s. eremus*-Ramesch), where the extremities are occupied by the Bandito and Fenera fossils. This disposition for the Bandito and Fenera caves can have a twofold meaning: it can be a consequence of a limited number of specimens or the position of

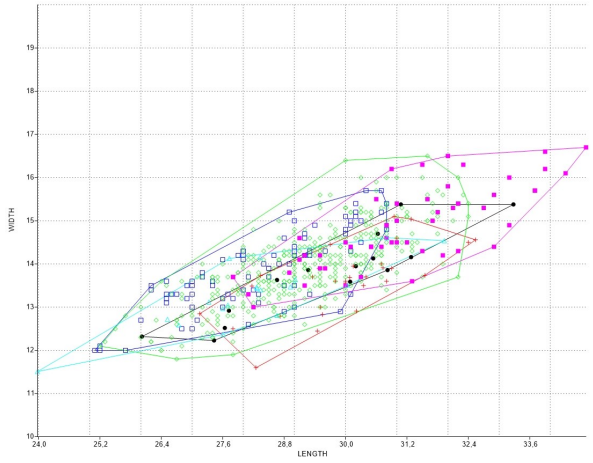


Fig. 10: Length-Width relationship in m1 from Grotta del Bandito (red cross), Mount Fenera (light blue triangles), Medvedja (lilac squares), Conturines (blue squares) and Ramesch (green rhombus), Valsolda (black points) caves. | **Abb. 10**: Längen-Breiten-Verhältnis in m1 aus den Höhlen Grotta del Bandito (rotes Kreuz), Monte Fenera (hellblaue Dreiecke), Medvedja (lilafarbene Quadrate), Conturines (blaue Quadrate) und Ramesch (grüne Raute), Valsolda (schwarze Punkte).

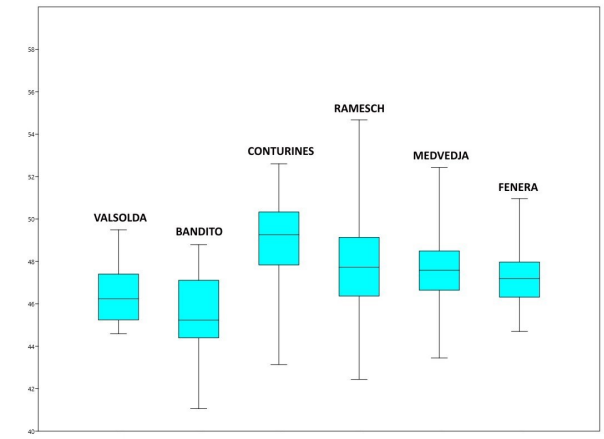


Fig. 11: Box plot of the IW in m1 from Grotta del Bandito and Italian and European cave bears. | **Abb. 11**: Boxplot der IW in m1 aus Grotta del Bandito und italienischen und europäischen Höhlenbären.

these caves are considered as »border caves« and »polluted« by bears of different taxa (Bandito by *ingressus*?, Fenera by *s. eremus*?). Future studies will enlighten this subject.

***m*$_1$**: Along with the $P^4/_4$ this kind of tooth is one the most important elements capable of explaining the evolutionary degree of cave bears. A comparison with Italian and European populations is proposed in **Fig. 10**. The IW index is shown in **Fig. 11**: only small differences among the blocks, are noted that can be probably linked to morphometric variability. This deduction explains the field distribution shown in **Fig. 10**. None of these fields is separate, and consequently it is impossible to separate the different taxa dimensionally. In **Fig. 12** different species of bears are reported together with those from the Middle and Late Pleistocene from Serbia. The Bandito bears have a size of m_1

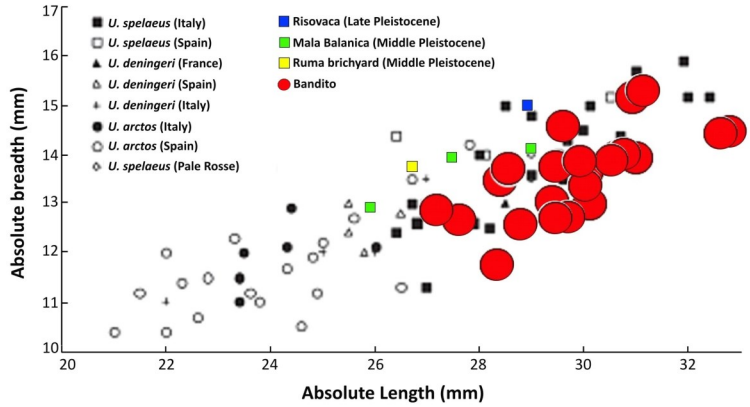


Fig. 12: Relationship between the »Length« and »Breadth« in M1 of different species of *Ursus* from Grotta del Bandito and caves from Italy (Pale Rosse, Trentino Alto Adige), France, Spain and Serbia (Risovaca, Mala Balanica, Ruma brichyard, from Rossi & Santi, 2012, mod.). | **Abb. 12**: Verhältnis zwischen »Länge« und »Breite« in M1 von verschiedenen *Ursus*-Arten aus der Grotta del Bandito und Höhlen in Italien (Pale Rosse, Trentino Alto Adige), Frankreich, Spanien und Serbien (Risovaca, Mala Balanica, Ruma brichyard, aus Rossi & Santi, 2012, mod.).

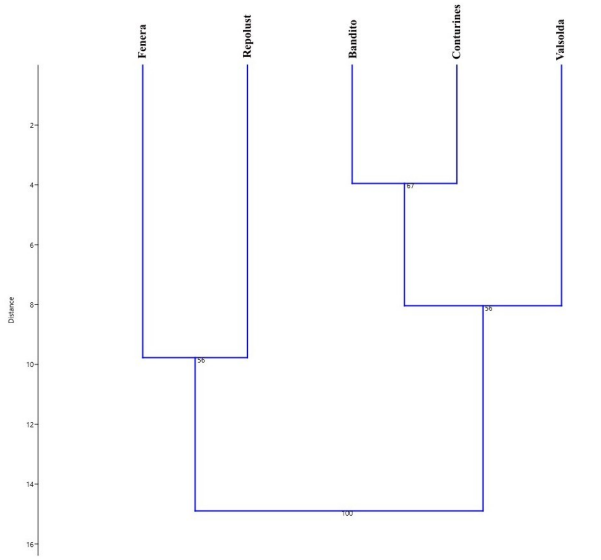


Fig. 13: UPGMA Euclidean cladogram (bootstrap 9999, cophen 0.689) of the L,W and IW medians of m1 of Grotta del Bandito bears and other from Italian and European caves. | **Abb. 13**: Euklidisches UPGMA-Kladogramm (Bootstrap 9999, Cophen 0,689) der L-, W- und IW-Mediane von m1 der Bären der Grotta del Bandito und anderer italienischer und europäischer Höhlen.

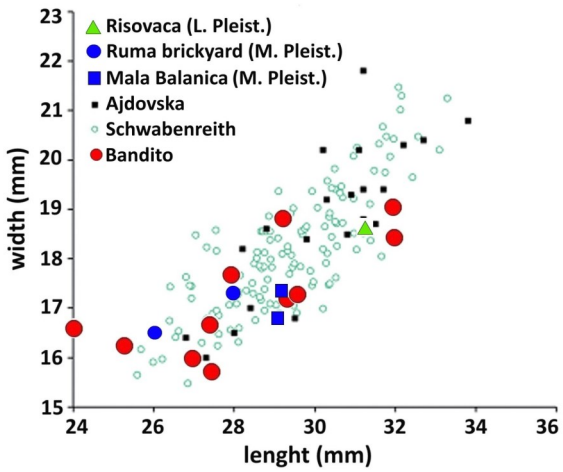


Fig. 14: Relationship between the morphometric parameters in M2 from Grotta del Bandito, Adjovska (Slovenia), Schwabenreith (Austria) and caves from Serbia (from Rabeder, 2011, mod.). | **Abb. 14**: Beziehung zwischen den morphometrischen Parametern in M2 aus Grotta del Bandito, Adjovska (Slowenien), Schwabenreith (Österreich) und Höhlen aus Serbien (aus Rabeder, 2011, mod.).

typical of *U. spelaeus* s. l. of the Middle-to Late Pleistocene. The observation that the size of cave bears in Italy were similar, at least to that of the populations of Late Pleistocene and partially to those of the Middle Pleistocene, is again confirmed. Probably in North Italy from west to east during the Late Pleistocene, populations of cave bears were very homogeneous in many of their features (size, complexity of teeth, etc.). Utilizing different parameters, Length, Width and some indices performed by Grandal d'Anglade & López-González (2004) a basic cladogram has been elaborated (**Fig. 13**). Two blocks are individuated: the first, composed by bears from Fenera and Repolust (*deningeroides*), a second with Bandito and Conturines. Valsolda is placed at the extremity and its link with the Bandito cave could be a confirmation that probably a single species of cave bear used to live in N. Italy: *Ursus spelaeus* or *Ursus* gr. *spelaeus* if better. On the contrary the Fenera-Repolust group could represent a »different« cave bear, the first for its nearness with some population in France in which *U. s. ladinicus* has been individuated, the second in which *U. deningeroides* was identified.

***m*$_2$**: Considering the size of m_2 the same observations deduced for the other teeth can be advanced, therefore this kind of tooth has a size similar to that of the *deningeri* ones as well, and no variation in size is observable within the different species of cave bears (*eremus*, *ladinicus*, in particular) and in general, of Middle-to-Late Pleistocene populations (**Fig. 14**) and only partially with the bears from Medvedja (*ingressus*, **Fig. 15**). A comparison of the IW between the Grotta del Bandito bears and other populations (**Fig. 16**) doesn't show substantially differences; m_2 for these populations shows more or less the same roundness value.

***m*$_3$**: Observing the diagram in **Fig. 17** which plots to the »length-width» relationship, the development of the field of the Grotta del

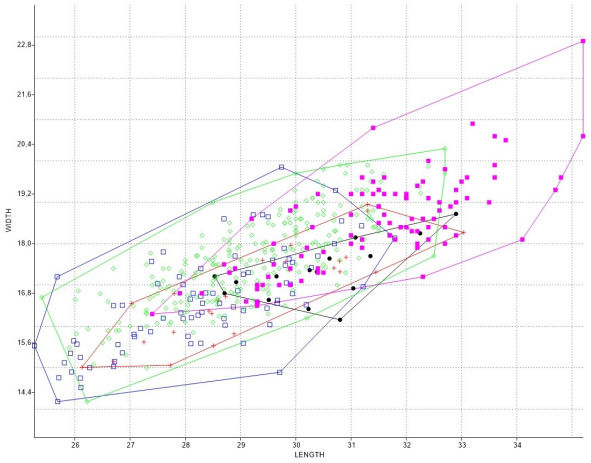


Fig. 15: Length-Width relationship in m2 from Grotta del Bandito (red cross), Mount Fenera (light blue triangles), Medvedja (lilac squares), Conturines (blue squares) and Ramesch (green rhombus), Valsolda (black points) caves. | **Abb. 15**: Längen-Breiten-Verhältnis in m2 in den Höhlen Grotta del Bandito (rotes Kreuz), Monte Fenera (hellblaue Dreiecke), Medvedja (lilafarbene Quadrate), Conturines (blaue Quadrate) und Ramesch (grüne Raute), Valsolda (schwarze Punkte).

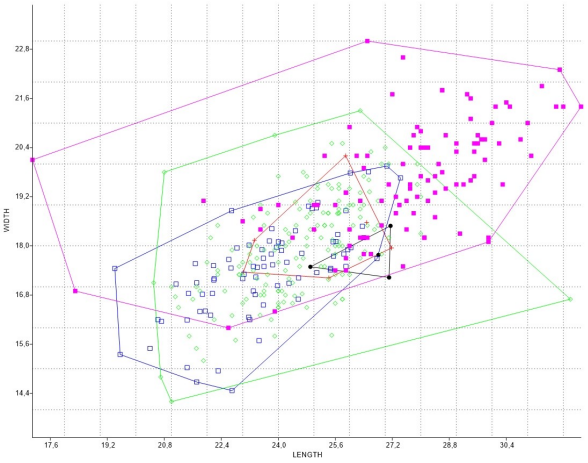


Fig. 17: Length-Width relationship in m3 from Grotta del Bandito (red cross), Mount Fenera (light blue triangles), Medvedja (lilac squares), Conturines (blue squares) and Ramesch (green rhombus), Valsolda (black points) caves. | **Abb. 17**: Verhältnis Länge-Breite in m3 aus den Höhlen Grotta del Bandito (rotes Kreuz), Monte Fenera (hellblaue Dreiecke), Medvedja (lila Quadrate), Conturines (blaue Quadrate) und Ramesch (grüne Raute), Valsolda (schwarze Punkte).

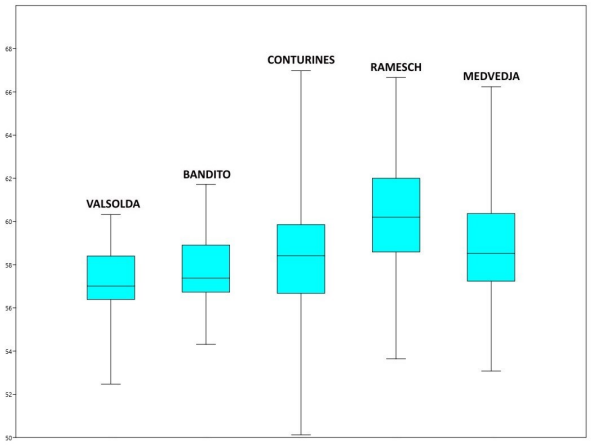


Fig. 16: Box plot of the IW in m2 from Grotta del Bandito and Italian and European cave bears. | **Abb. 16**: Boxplot des IW in m2 von Grotta del Bandito und italienischen und europäischen Höhlenbären.

Bandito is inside the others of Conturines, Ramesch and Medvedja, the latter with cave bears having the highest size. From the distribution of the IW index (**Fig. 18**) no significant difference can be individuated. Using some parameters and indices (Length, Width and IW) an example of cladogram is shown in **Fig. 19** in which two blocks have been individuated; the first with Medvedja (*ingressus*) and Valsolda bears and a second with Grotta del Bandito and Conturines (*U. s. ladinicus*) specimens. *Ursus s. eremus* from Ramesch is very separate. The relationship between Conturines and Bandito is a surprise because *U. s. ladinicus* was considered to be a high-altitude cave bear; despite not having the proof to indicate the presence of this taxon also inside the Bandito cave, the sizes in general are very similar. These considerations are valid also for the Medvedja (*ingressus*) and Valsolda link. With the Correspondence Analysis (CA) based on the medians of Length, Width and IW of the lower denture of the cave bears from different caves from Italy (Fenera, Bandito, Valsolda, Conturines) and Europe (Gamssulzen, Ramesch, Medvedja, **Fig. 20**), an extreme concentration of the points can be seen. All the cave bears have a great correspondence only for the molar parameters, were they are similar in their morphometry of the lower denture.

***M*^{1}**: Diagrams in **Figs. 21-22** plot the length and width of the M^1 from different cave bear populations and a distribution of IW index; the bears from Grotta del Bandito are generally similar in size to those from other localities. The differences can be linked to a rather low number of specimens and/or to population variability. This kind of tooth is also analysed in two diagrams (**Fig. 18**). The first is a comparison between the Bandito speleians and the bears with a small size comprising *U. deningeri*; the size of M^1 is similar to that of *U. deningeri*, and some specimens compared with the M^1 of *deningeri* have the same length, but are shorter in width. The second diagram is a correlation of M^1 compared with those of *U. s. eremus* and *U. s. ladinicus*. The points of the Bandito bears fit into the cloud of the *eremus-ladinicus* specimens, and consequently also for this kind of tooth no differences in size have been found among the fossils. An important consideration, when observing the first of these diagrams, can be advanced: the distribution of points could be an evolutionary path and, if this is true, the Bandito specimens should have the size of primitive cave bears, specifically *U. deningeri*. It is very difficult therefore that in the Grotta del Bandito *U. deningeri* could have been found. Speleians from Bandito do not differ in size with *ingressus* also, but fit within the cloud of the *spelaeus* from Cova Eiros (about 24 Ky) and Liñares (35 Ky) (Spain) very well (**Fig. 19**). From these diagrams the M^1 size is closer to that of the compared populations. An UPGMA relation

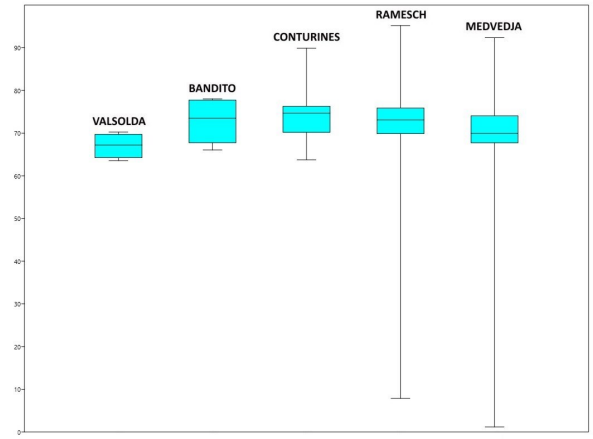


Fig. 18: Box plot of the IW in m3 from Grotta del Bandito and Italian and European cave bears. | **Abb. 18**: Boxplot des IW in m3 aus der Grotta del Bandito und italienischen und europäischen Höhlenbären.

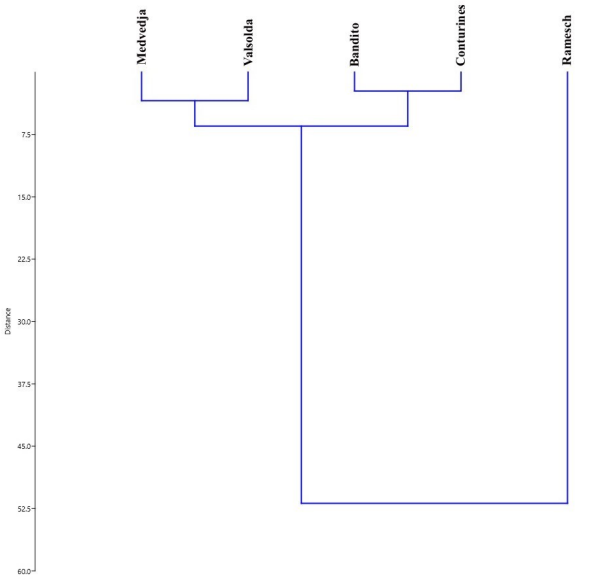


Fig. 19: UPGMA Euclidean cladogram (bootstrap 9999, cophen 0.9961) of the L,W and IW medians of m3 of Grotta del Bandito bears and other from Italian and European caves. | **Abb. 19**: Euklidisches UPGMA-Kladogramm (Bootstrap 9999, Cophen 0,9961) der L-, W- und IW-Mediane von m3 der Bären der Grotta del Bandito und anderer italienischer und europäischer Höhlen.

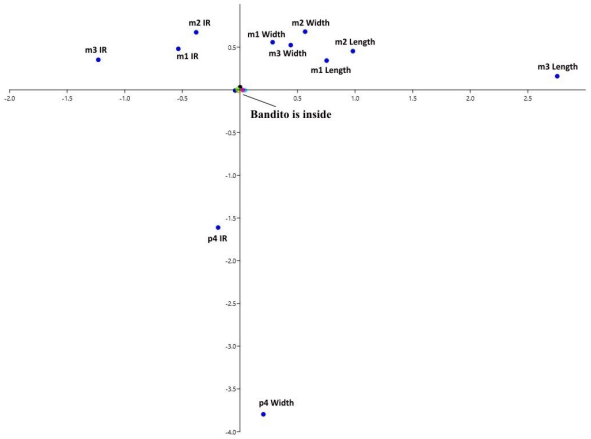


Fig. 20: Correspondence Analysis (CA) lower denture (p4-m3) based on L-W-IW medians of cave bears from Grotta del Bandito and Italian and European populations. Legend of colour points: black: Mt. Fenera, red: Grotta del Bandito, light blue: Valsolda, yellow: Gamssulzen. | **Abb. 20**: Korrespondenzanalyse (CA) unteres Gebiss (p4-m3) basierend auf L-W-IW-Medianen von Höhlenbären aus Grotta del Bandito und italienischen und europäischen Populationen. Legende der Farbpunkte: schwarz: Mt. Fenera, rot: Grotta del Bandito, hellblau: Valsolda, gelb: Gamssulzen.

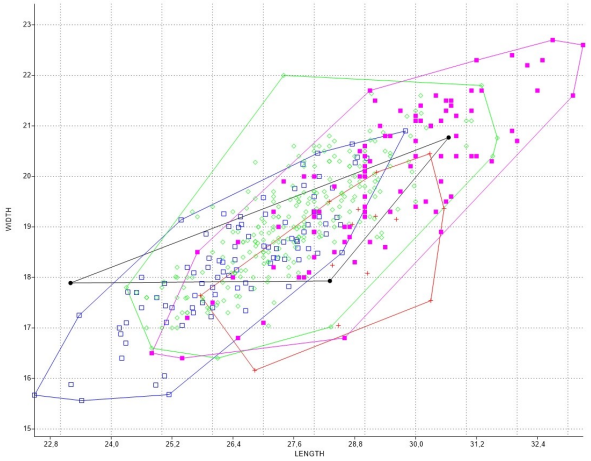


Fig. 21: Length-Width relationship in M1 from Grotta del Bandito (red cross), Mount Fenera (light blue triangles), Medvedja (lilac squares), Conturines (blue squares) and Ramesch (green rhombus), Valsolda (black points) caves. | **Abb. 21**: Längen-Breiten-Verhältnis in M1 aus den Höhlen Grotta del Bandito (rotes Kreuz), Monte Fenera (hellblaue Dreiecke), Medvedja (lilafarbene Quadrate), Conturines (blaue Quadrate) und Ramesch (grüne Raute), Valsolda (schwarze Punkte).

is shown in **Fig. 23** in which utilizing the medians of L, W and IW (cophen corr. 0.8515) a link of different populations is elaborated. The Grotta del Bandito bears are confined to an extremity, but mainly linked to the Medvedja *ingressus* bears; this suggests and could this be a confirmation that the Bandito cave was also inhabited by bears similar to *ingressus*?

***M*^{2}**: In **Figs. 24-25** a comparison between the Grotta del Bandito specimens and the M^2 from other localities is shown. As well as with M^1 and other kinds of teeth we note no differences in size, and the Grotta del Bandito specimens re-enter well within the distribution of the other caves. When compared with the bears of small size, the Bandito M^2 are concentrated within the cloud formed by different species comprising *U. deningeri* (**Fig. 26**); this distribution is clearly divided by the cloud generated by *U. etruscus* specimens. In the second diagram of **Fig. 21** the size of this kind of tooth, like the others analysed, is the same as that of the other species of cave bears (*eremus* and *ladinicus*) and consequently it is newly confirmed for these teeth also, that no dimensional differences between the species, can be noted. In other observations relative to other cave bear fossils we have supported the evidence that Italian bears have a medium size. An UPGMA cladogram (**Fig. 27**) shows a main link between the »*spelaeus* group« (Bandito, Conturines, Ramesch) with the Valsolda bears, and very separate from Medvedja (*ingressus*). This last taxon can be effectively separated from the *s. ladinicus*,

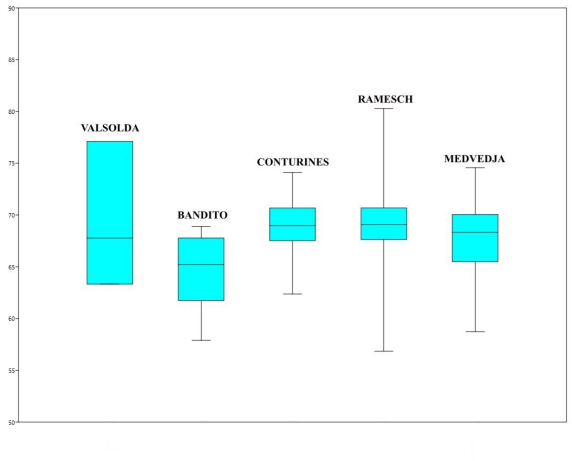


Fig. 22: Box plot of the IW in M1 from Grotta del Bandito and Italian and European cave bears. | **Abb. 22**: Boxplot des IW in M1 aus Grotta del Bandito und italienischen und europäischen Höhlenbären.

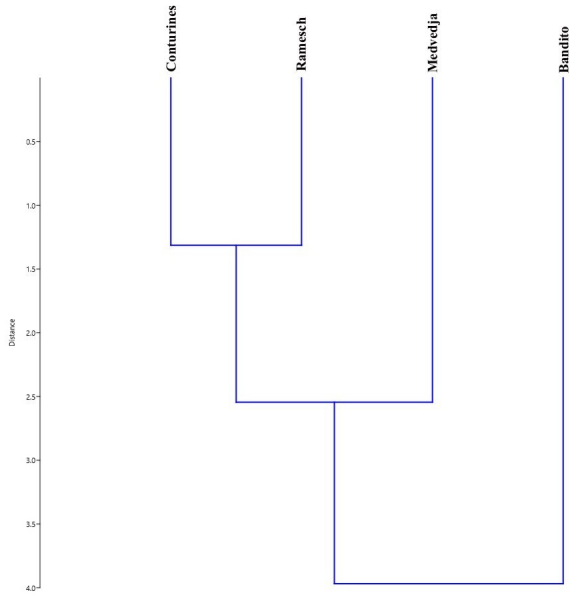


Fig. 23: UPGMA Euclidean cladogram (cophen 0.8515) of the L,W and IW medians of M1 of Grotta del Bandito bears and other from Italian and European caves. | **Abb. 23**: Euklidisches UPGMA-Kladogramm (cophen 0,8515) der L-, W- und IW-Mediane von M1 der Grotta del Bandito-Bären und anderer italienischer und europäischer Höhlen.

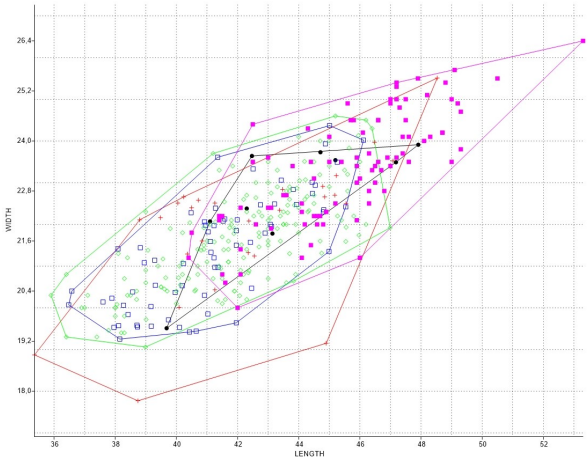


Fig. 24: Length-Width relationship in M2 from Grotta del Bandito (red cross), Medvedja (lilac squares), Conturines (blue squares),Valsolda (black points) and Ramesch (green rhombus) caves. | **Abb. 24**: Längen-Breiten-Verhältnis in M2 aus den Höhlen Grotta del Bandito (rotes Kreuz), Medvedja (lilafarbene Quadrate), Conturines (blaue Quadrate), Valsolda (schwarze Punkte) und Ramesch (grüne Raute).

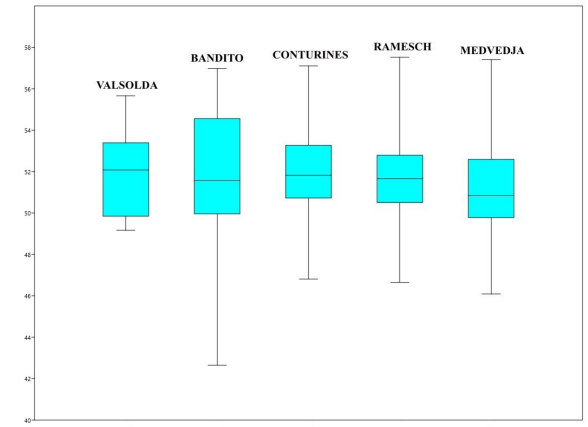


Fig. 25: Box plot of the IW in M2 from Grotta del Bandito and Italian and European cave bears. | **Abb. 25**: Boxplot des IW in M2 aus Grotta del Bandito und italienischen und europäischen Höhlenbären.

s. spelaeus and *s. eremus* taxa because it has been constantly repeated in the previous cladograms also for other kind of teeth.

Morphometry of the metapodia

Univariate analysis

In **Fig. 28** the development of the standardized values of the parameters and indices of the metapodia from Grotta del Bandito and others coming from Italian and European caves, is shown. In general, the Grotta del Bandito metapodia have a development similar to that of other compared populations (Gamssulzen, Buco dell'Orso, Conturines and Ramesch); only the Mt2 line is different compared to the others probably depending on morphometrical variability. We can say that these metapodia certainly belong to *Ursus spelaeus* but the species remains difficult to identify. This observation is also confirmed in **Fig. 29** in which the length of some metapodia (Mc 1, Mc 4, Mc 5, Mt 5) is placed in relation with the Plumpness Index; the dot belonging to the Grotta del Bandito falls within the range defined by *U. spelaeus*. As often observed for other populations of Italian cave bears, the size of the »speleians« is on average comparable with those of the populations from the Lower Pleistocene, or with *U. deningeri* Von Reichenau, 1904 (i.e. Santi & Rossi, 2014). From this point of view the sizes of the metapodia from the Grotta del Bandito are very similar to those of other populations of the Italian Alps but not with those from the Buco dell'Orso (Laglio, Como) or from Gamssulzen. In fact, contrarily to what we have seen for other Italian populations of cave bears, at the Buco

dell'Orso fossils were found that resemble in size those from Gamssulzen, the phalanges in particular (Rossi & Santi, 2018). Could this difference in size represent an attempt by species similar to *ingressus*, to enter this area of Lombardy? At the moment we do not have sufficient data to support this however intriguing hypothesis. In **Tab. 2** is the summary of means of IP index for the metapodia from Grotta del Bandito and the frequency of them; we can see also that the IP of all the metapodia from Grotta del Bandito are lower compared to the others from Italian and European bears.

Multivariate analysis

In **Figs. 30-31** a summary of the euclidean morphospaces (referred to the size) for the metacarpalia and metatarsalia from Grotta del Bandito compared with others from Italian and European cave bears is drafted. Metatarsalia morphospaces of the considered populations (Bandito, Buco dell'Orso, Gamssulzen, Conturines and Ramesch) are practically similar in their development and the small differences seen can be linked to size variability. On the contrary between the metacarpalia, morphospaces of mc1 have an »anomalous« distribution; the field of Conturines is clearly separate from the others. If this is correct can be Mc1 be considered a good tool to individuate different taxa? At the present we do not have main data to support this idea.

With the utilisation of the mean of medians of the parameters of all metapodia, the UPGMA dendrogram is visualized in **Fig. 32**, two blocks are individuated composed, the first by Buco dell'Orso, Ramesch and Grotta del Bandito and a second with Sambughetto and Gamssulzen. Conturines is placed at the border. Metapodia of Grotta del Bandito are well inserted within the general Italian *spelaeus* that are very similar to those from Ramesch; a surprise is the proximity of Sambughetto with Gamssulzen (*ingressus*). Sambughetto is located near the caves (Fontana Marella and Grotta Generosa) placed at the geographical border between Lombardy and Piedmont; the latter could have been inhabited by a bear similar to *U. ingressus*. This matter must be solved!

Morphodynamic of teeth

Incisors

Morphodynamic studies on the incisors are rare (Rabeder, 1999: Frischauf, 2014; Baryshnicov et al., 2018; Gimranov et al., 2021; Santi et al., 2022). Referring I2 from Grotta del Bandito, only the morphotype »p« (sensu Rabeder, 1999) was found, inherent the fossa lunaris-cingulum and the standardization of the index is rather low (58,91), but this value can be a possible consequence of a low number of specimens (n. 10). The same consideration can be advanced for I3 the low number of specimens (only 10) impedes any considerations on the evolutionary step; morphotype »0« (sensu Rabeder, 1999) for the kalyx distalis is very frequent. The i2 have a morphotype »s« (label of *spelaeus*), but the »surprises« are individuated in i3; in fact for sulcus mesialis the main frequency is »D« morphotype and the lower is »B/C«.

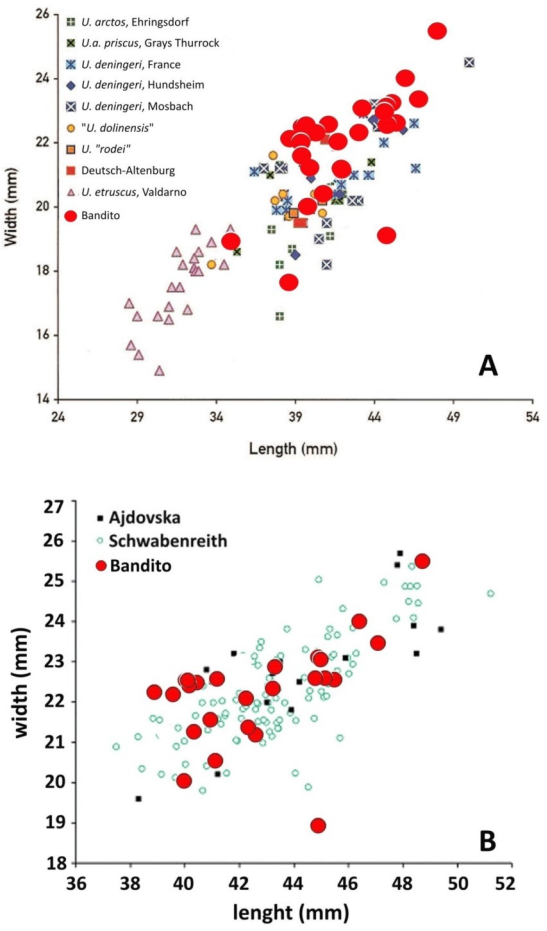


Fig. 26: A. Relationship between the »Length« and »Width« in M2 from Grotta del Bandito and small sized bears from European caves (from Rabeder et al., 2010, mod.). B. Relationship between the same parameters in M2 from Grotta del Bandito and Adjovska (Slovenia), Schwabenreith (Austria, from Rabeder, 2011, mod.). | **Abb. 26**: A. Verhältnis zwischen »Länge« und »Breite« bei M2 aus der Grotta del Bandito und kleinwüchsigen Bären aus europäischen Höhlen (aus Rabeder et al., 2010 mod.). B. Beziehung zwischen denselben Parametern in M2 aus Grotta del Bandito und Adjovska (Slowenien), Schwabenreith (Österreich, aus Rabeder, 2011, mod.).

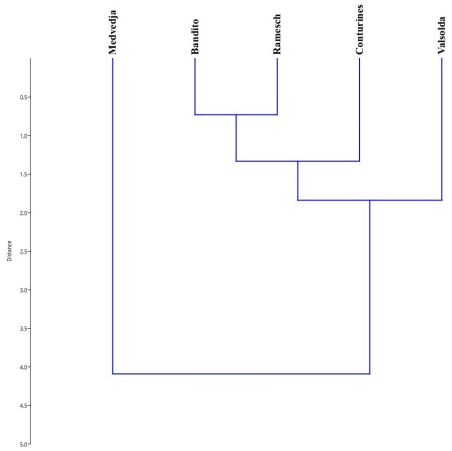


Fig. 27: UPGMA Euclidean cladogram (bootstrap 9999, cophen 0.9049) of the L,W and IW medians of m3 of Grotta del Bandito bears and other from Italian and European caves. | **Abb. 27**: Euklidisches UPGMA-Kladogramm (Bootstrap 9999, Cophen 0,9049) der L-, W- und IW-Mediane von m3 der Bären der Grotta del Bandito und anderer italienischer und europäischer Höhlen.

IP (means)	Gamssulzen	Bandito	B. Orso	Sambug.	Ram (upp.)	Ram (low.)	Contur.
mc1	30,19	29,83	30,02	29,55	29,8	29,8	31,07
mc2	34,2	31,1	32,3	33,93	32,3	32,6	32,62
mc3	33,11	29,1	31,09	32,12	30,7	31,3	30,29
mc4	33,6	30,02	31,49	32,58	30,6	31,8	32,31
mc5	35,46	32,31	33,35	34,14	33,2	33,6	34,04
mt1	32,04	28,5	31,23	31,4	30,7	31,4	33,44
mt2	31,82	28,96	30,21	31,79	30,4	30	31,1
mt3	30,33	26,89	28,38	28,69	27,5	28,4	28,8
mt4	28,97	25,18	27,48	27,92	27	27,7	27,18
mt5	28,71	26,35	25,99	28,55	26,9	26,6	27,39
means	31,84	28,82	30,15	31,07	29,91	30,32	30,83

Metacarpales					Metatarsales				
MC1	**N 10**	25-29	6	60 %	**MT1**	**N 19**	25-28	7	36.84
		30-33	4	40 %			28-30	9	47.37
							30-33	3	15.79
MC2	**N 54**	25-30	14	25.90 %					
		30-33	35	64.80 %	**MT2**	**N 50**	24-28	12	24 %
		33-35	5	9.25 %			28-30	26	52 %
							30-33	12	24 %
MC3	**N 43**	25-30	29	67.44 %					
		30-33	14	32.56 %	**MT3**	**N 41**	20-27	22	53,66 %
							27-32	19	46,34 %
MC4	**N 58**	25-30	27	46.55 %					
		30-33	29	50 %	**MT4**	**N 60**	21-25	17	28,33 %
		33-35	2	3.45 %			25-27	37	61,67 %
							27-29	6	10 %
MC5	**N 51**	28-31	12	23.53 %					
		31-34	29	56.86 %	**MT5**	**N 40**	22-26	18	45 %
		34-35	10	19.61 %			26-30	20	50 %
							30-32	2	5 %

Tab. 2: Summary of means of IP index for the metapodia from Grotta del Bandito and their frequency. | **Tab. 2**: Zusammenfassung der Mittelwerte des IP-Index für die Metapodien aus der Grotta del Bandito und ihre Häufigkeit.

Fourth premolars ($P^4/_4$)

Globally, the main frequency of the morphotypes is individuated in those lowest (16 C1 for p4 and 12 B and 9 A for P4) according with the main part of the Italian populations having simple premolars. In **Fig. 33** the position of the Grotta del Bandito premolars is between the MIS 5 (80-130 Ky) and MIS 4. Bears with younger chronological age have simplicity in the dentition (Santi & Rossi, 2020a).

Lower molars (m_1, m_2, m_3)

In m_1 the presence of one or more metastylid is well individuated, the main frequency of teeth is those with one metastylid, the same consideration is advanced for the enthypoconid (the simpler in the building). Analyses with the »Convergence Index« (sensu Grandal D'Anglade & López González, 2004, **Fig. 34**) carry these partially discordant observations: with the »Total Length-Talonid Breadth« relationship we have teeth that are closer to the »primitive« ones; on the contrary with the »Paraconid Convergence Index-Total Length« and »Trigonid Convergence Index-Total Length« relationships the teeth can be close to the »advanced« cave bears. This is a contradiction! Generally, in m_2, morphodynamic indices are medium-low and in particular this is clearer in the metalophids and in the trigonids where, in the latter, the simpler forms are lacking. Low index (practically only A) is individuated in the mesolophid as well as for the enthypoconid (A and D). Also, for this kind of tooth the nearness to »primitive« forms of cave bears is substantially confirmed. Considering the m_3 the low number of specimens prevents us from elaborating a detailed morphodynamic study.

Upper molars (M^1, M^2)

Morphodynamic indices for M^1 (for the paracone, metacone and proto?/metacone) and M^2 are low; we have a new confirmation that these kind of teeth are rather simple and probably these bears occupy and intermediate place in the evolutionary scale.

Discussion

Ursus gr. *spelaeus* colonized the Northern Italian regions, but in some areas different questions are still open. The composition and the »meaning« of the cave bear population from Grotta del Bandito is one of these problems for at least two reasons: 1. the

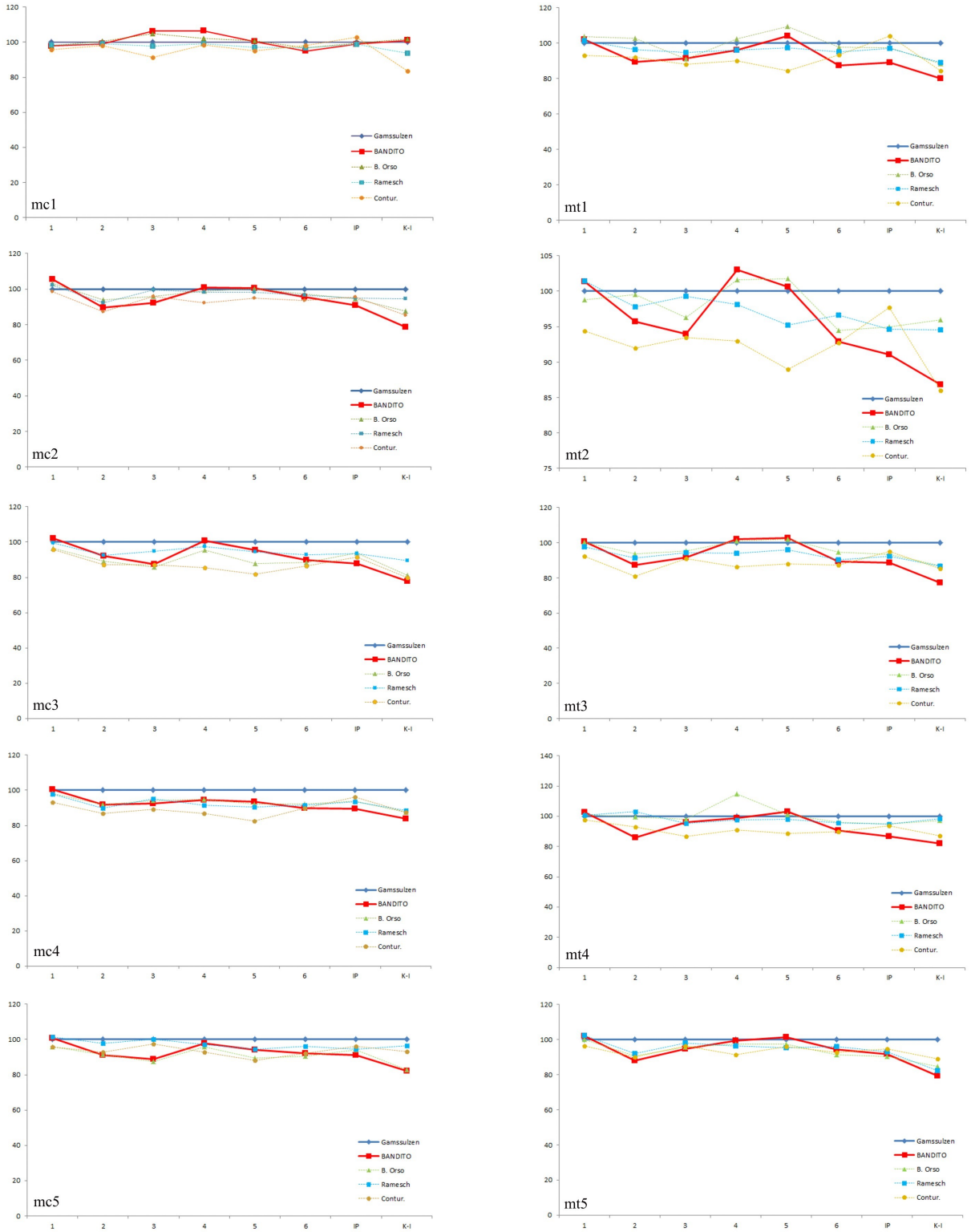


Fig. 28: The development of the standardized values of the parameters and indices of the metapodia from Grotta del Bandito and others coming from Italian and European caves. | **Abb. 28**: Die Entwicklung der standardisierten Werte der Parameter und Indizes der Metapodien aus der Grotta del Bandito und anderen Höhlen in Italien und Europa.

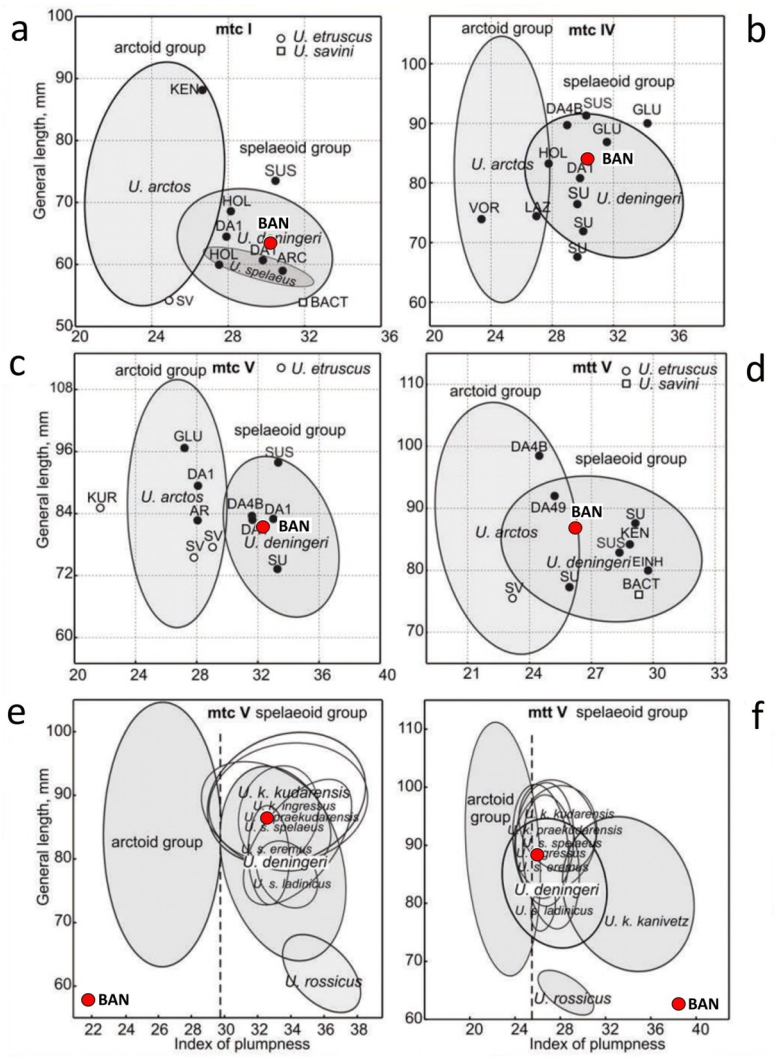


Fig. 29: Position of the bears from the Grotta del Bandito in the range of the different species of bears considering the General Length and Plumpness index relationship of the Mc1, Mc4, Mc5 and Mt5 (from BARYSHNIKOV & PUZACHENKO, 2017, mod.). | **Abb. 29**: Position der Bären aus der Grotta del Bandito im Verbreitungsgebiet der verschiedenen Bärenarten unter Berücksichtigung des Verhältnisses zwischen dem allgemeinen Längen- und Plumpheitsindex von Mc1, Mc4, Mc5 und Mt5 (aus BARYSHNIKOV & PUZACHENKO, 2017, mod.).

geographical position and 2. the eventuality of a soft presence of modern bears. The geographical position is an important element because this place is close to the caves in Liguria region in which cave bears with high IM of $P^4/_4$ have been found and the possibility of a migration way toward Grotta del Bandito (the individuation of high morphodynamic factors, sensu RABEDER, 1999; ZUNINO & PAVIA, 2005) can be a realistic idea.

It has been often noted that Italian cave bears sum up primitive and modern characters. For example the bears from Valsolda (Como Province, Lombardy) are in some components of the skeleton morphometrically similar to the *ingressus*, or in the Buco dell'Orso (Laglio, Como Province) the phalanges are in size similar to the *ingressus* ones.

From the morphometry of teeth from the Grotta del Bandito the most important observation to be made is that no differences between the different species of cave bears of Middle-to Late Pleistocene in Europe and the denture (premolars and molars) of the Bandito bears exists. Globally the population of the Bandito cave is homogenous, as well as already supported for other bears from the Italian caves and often, the overall morphology of the $P^4/_4$, is simple and in many cases, resembling *deningeri*. Also for the teeth from the Bandito cave the dualism between the simplicity of the tooth and the relative age of the bear (Late Pleistocene) is verified. In Italian caves this type of »relationship« seems to be constant.

After having considered the analyses on the metapodia we arrive to the same conclusions already drawn for the teeth, but observing the cladogram relating all the metapodia (**Fig. 32**) the Grotta del Bandito bear are very close to the *eremus* from Ramesch, but very far from Conturines (*ladinicus*) and Gamssulzen (*ingressus*). Can we think the »original« population of Bandito cave could have been similar in size to *U. s. eremus* and successively was mixed with »modern« bears from Liguria? The solution is not found yet. Considering the data currently known, a first theoretical picture on »age-evolutionary trend« for cave bears of NW Italy can be proposed (**Fig. 35**). 1 Step: starting about 100 Ky, namely medially the age of the Ciota Ciara (Mount Fenera), few waifs of populations of cave bears with a low IM in our case the Fate archaic and Mt. Fenera speleians, inhabited some limited areas of NW Italy, 2-3 Steps: successively a large colonization of the cave bears follows within N Italy, up to the eastern regions, namely an occupation of the Liguria, Piedmont

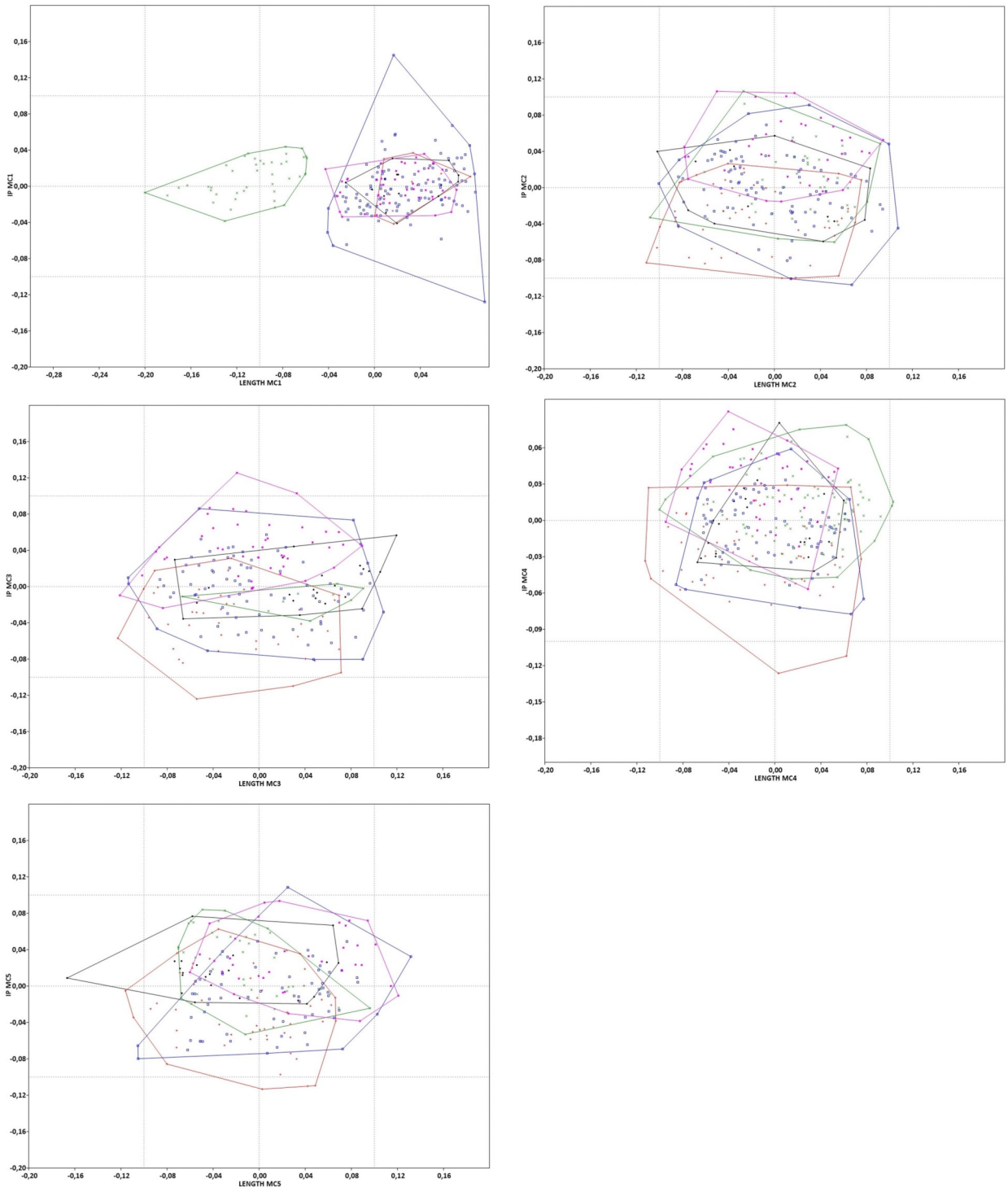


Fig. 30: Euclidean morphospaces of the metacarpalia from Grotta del Bandito (red cross) and other Italian and European cave bears. Symbols: Grotta del Bandito (red cross), Buco dell'Orso (black points), Ramesch (squares blues), Conturines (green cross), and Gamssulzen (lilac squares). | **Abb. 30**: Euklidische Morphospäen der Mittelhandknochen aus der Grotta del Bandito (rotes Kreuz) und anderen italienischen und europäischen Höhlenbären. Symbole: Grotta del Bandito (rotes Kreuz), Buco dell'Orso (schwarze Punkte), Ramesch (blaue Quadrate), Conturines (grünes Kreuz) und Gamssulzen (lilafarbene Quadrate).

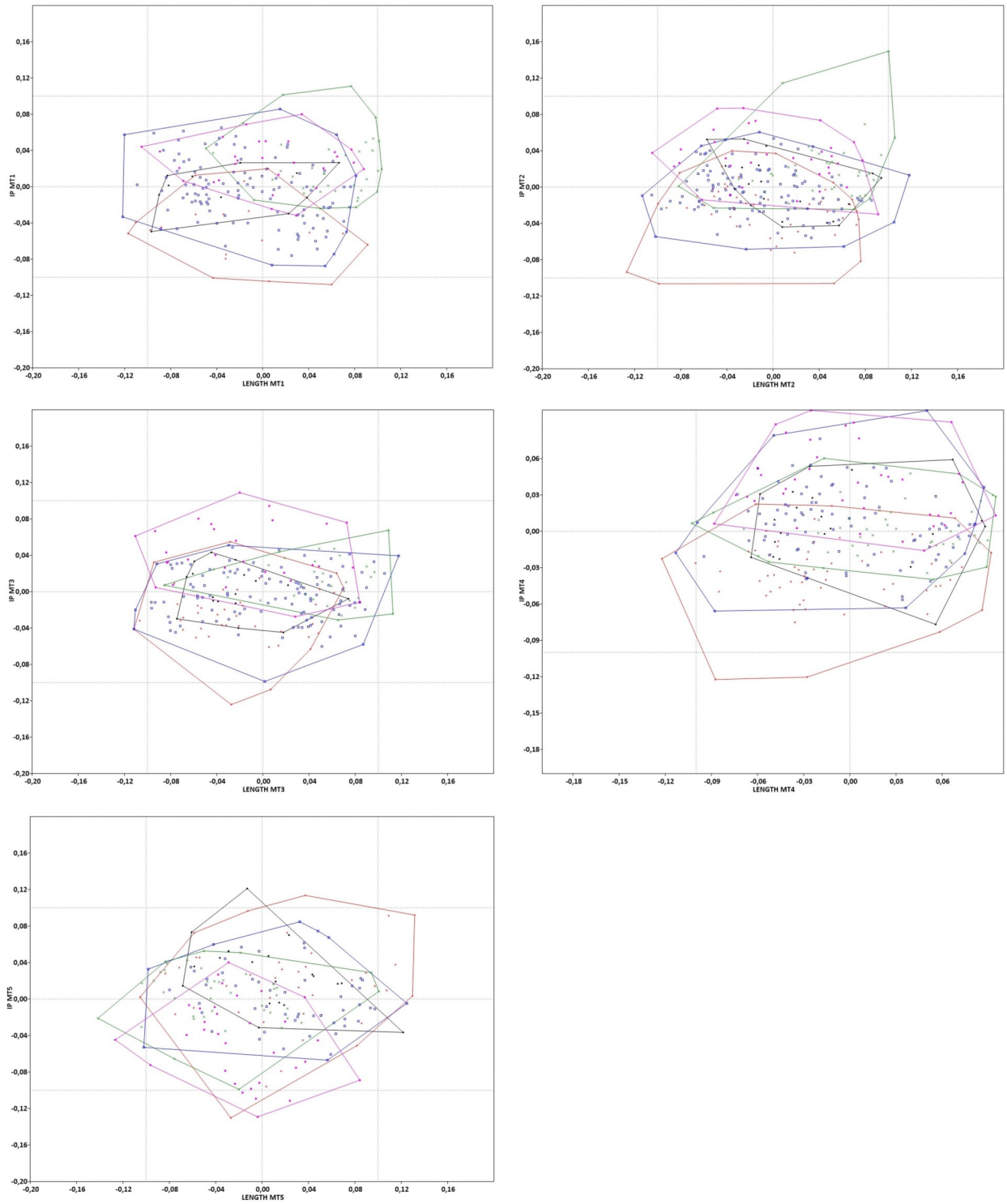


Fig. 31: Euclidean morphospaces of the metacarpalia from Grotta del Bandito (red cross) and other Italian and European cave bears. Symbols: Grotta del Bandito (red cross), Buco dell'Orso (black points), Ramesch (squares blues), Conturines (green cross), and Gamssulzen (lilac squares). | **Abb. 31**: Euklidische Morphospäen der Mittelhandknochen aus der Grotta del Bandito (rotes Kreuz) und anderen italienischen und europäischen Höhlenbären. Symbole: Grotta del Bandito (rotes Kreuz), Buco dell'Orso (schwarze Punkte), Ramesch (blaue Quadrate), Conturines (grünes Kreuz) und Gamssulzen (lilafarbene Quadrate).

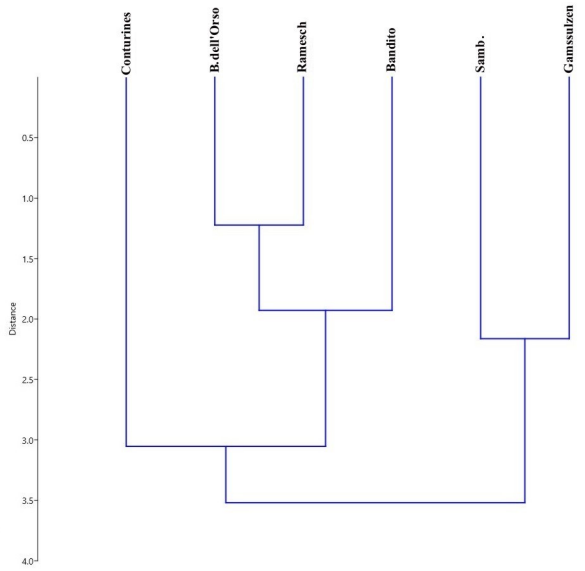


Fig. 32: UPGMA Euclidean cladogram (cophen 0.7) of the L,W and IW medians of the metapodia from the Grotta del Bandito and from Italian and European caves. | **Abb. 32**: Euklidisches UPGMA-Kladogramm (Kophen 0,7) der L-, W- und IW-Mediane der Metapodien aus der Grotta del Bandito sowie aus italienischen und europäischen Höhlen.

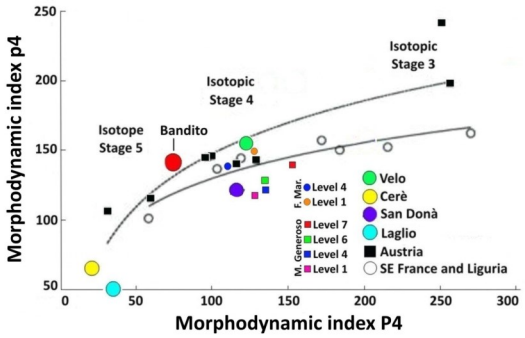


Fig. 33: Morphodynamic Index of $P^4/_4$ relationships for Italian and European cave bears (from Quiles, 2004, mod.). | **Abb. 33**: Morphodynamischer Index der $P^4/_4$-Verhältnisse für italienische und europäische Höhlenbären (Quiles, 2004, mod.).

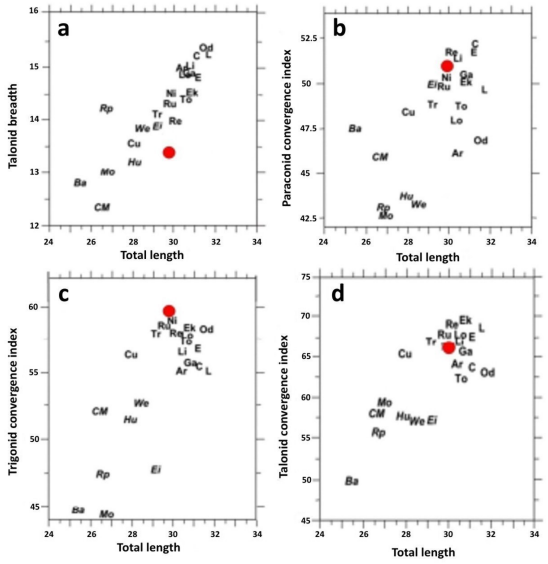


Fig. 34: Relationships between the Total Length and some indices in m1 from Grotta del Bandito and European cave bears (Grandal d'Anglade & López González, 2004, mod.). | **Abb. 34**: Beziehungen zwischen der Gesamtlänge und einigen Indizes in m1 aus Grotta del Bandito und europäischen Höhlenbären (Grandal d'Anglade & López González, 2004, mod.).

and Lombardy regions (»evolutionary homogeneity«) and at the same time, a »regionalism« (more or less strong) develops and at present only the cases of the Caverna Generosa (Mt. Generoso) and Fontana Marella are known (»inverse evolution«), 4 Step: from the west a probable passage (?) of more evolved (highest IM of Basura) populations that never has a complete colonization. Their presence is restricted to some limited areas.
In the easternmost part of Lombardy (Buco del Frate, Brescia province near to the border with Veneto), some possible passages of cave bear populations from East Italy (for example Veneto) could have occurred; at present we don't have proof of these »incursions«. The data referred to the eastern area of the N. Italy testify a mainly »complicated« interpretation probably linked to the easiness of movement of populations from N-E Europe belonging to different taxa, and the relationship between the different populations of the west and east Italy. The latter problem will be focused on in a following study.

Conclusions

In this study a final scenario on cave bear fossils (teeth and metapodia) from Grotta del Bandito (Cuneo Province, Piedmont, N. Italy) is presented. In general these bears fit within the range of the Italian speleians both in size and evolutionary step; they do not arrive to the maximum of the evolutionary stage like *U. ingressus*. The plumpness Index (IP) of whole metapodia is on average, lower of the taxa from the locus typus (*ingressus* from Gamssulzen, *s. eremus* from Ramesch and *s. ladinicus* from Conturines) and in general the Morphodynamic Index (IM) for the teeth are similar for the other Italian populations. On the contrary of other regions of North Italy, it seems that the western area of the Italy present the main problems about the characteristic of the populations; in particular the reason is not still clear of the coexistence of both high and lower IM for the $P^4/_4$. It is necessary to study the other kinds of teeth for an incisive answer. Or if *U. s. eremus* really inhabited the caves inside the Mount Fenera in Vercelli Province. With the present data we are unable to indicate one or more taxa present in the Grotta del Bandito and as well as the main part of the Italian populations, and a group *spelaeus* is the better attribution.

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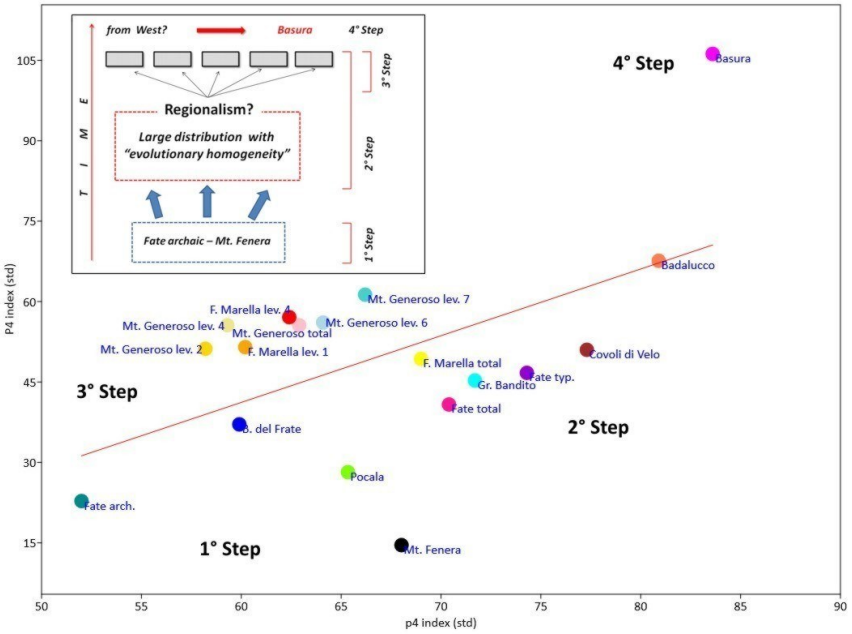

Fig. 35: A first theoretical picture on »age-evolutionary trend« for cave bears of the NW Italy. | **Abb. 35**: Ein erstes theoretisches Bild über den »Alters-Evolutions-Trend« für Höhlenbären in NW-Italien.

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Declaration of consent

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence this work. They are not conflicts of interest.

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