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Badegoulian eyed needles: New data on morphometric and technology from the rockshelters of Fritsch and Cuzoul de Vers, a synthesis

Aiguilles à chas badegouliennes : nouvelles données morphométriques et technologiques des abri-sous-roche de Fritsch et du Cuzoul de Vers, une synthèse

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Abstract: The precise timing of the appearance of eyed needles in Southwest Europe (Solutrean or later periods) is still debated. The problem is made more complex because the distribution and representativeness of eyed needles vary, depending not only on the more or less intensive production of these objects, but also on preservation hazards and the excavation methodology employed. This paper presents the study of eyed needles and their by-products recovered from two archaeological sites in France, Cuzoul de Vers and Abri Fritsch. The studied assemblages come from layers attributed to the Solutrean to Badegoulian transition and the Ancient and Recent Badegoulian. Here, we document: (1) the different operational schemes employed, how the raw material is acquired and what techniques and procedures are used in its transformation into a needle; (2) the variability of morphology and metrics approached through a compared statistical analysis in each site; and (3) the reality of the existence of needles during the Solutrean period. We then assess the technological development of eyed needles and their implications in the daily lives of the Badegoulian human groups.
Keywords: Eyed Needle, Badegoulian, Cuzoul de Vers, Abri Fritsch, Last Glacial Maximum, Upper Palaeolithic, sewing, clothing.

Résumé : La date précise d'apparition des aiguilles à chas au cours du Paléolithique récent ainsi que l'origine géographique de ces objets et leur diffusion – qu'elle émane d'un foyer unique ou de foyers multiples issus de convergences culturelles indépendantes – sont encore aujourd'hui sujettes à débat. Dans ce contexte, comprendre l'émergence des premières aiguilles à chas en Europe du Sud-Ouest constitue un enjeu central.

Nous proposons ici une synthèse de l'étude des aiguilles à chas et des restes liés à leur fabrication issus de deux sites majeurs en France : le Cuzoul de Vers, fouillé de 1982 à 1986, et l'abri Fritsch, fouillé de 1960 à 1978. Les ensembles analysés proviennent de niveaux attribués au Solutréen, au Badegoulien ancien et au Badegoulien récent. Ces deux sites offrent un corpus exceptionnel tant par le nombre d'aiguilles à chas retrouvées (338 pièces au total) que par la quantité de restes de fabrication, permettant ainsi une reconstitution détaillée des différentes étapes de leur production.

L'analyse technologique permet d'identifier les techniques et procédés mis en œuvre pour l'élaboration de ces aiguilles, ce qui nous conduit à proposer des schémas opératoires de transformation de la matière première. Cette dernière est vraisemblablement sélectionnée parmi les éclats osseux issus de la boucherie, choisissant des pièces dont le tissu compact est épais en moyenne de 4,1 mm (Cuzoul de Vers) ou 6,4 mm (Fritsch). Ces éclats sont ensuite façonnés par raclage, puis l'ébauche d'aiguille est détachée par raclage en diabolo. La partie proximale est en général raclée jusqu'à être plus mince que le fût de l'aiguille, et la perforation est réalisée par rotation bifaciale. Au Cuzoul de Vers, dans les niveaux du Badegoulien récent, quatre pièces en os témoignent d'extractions par double

rainurage longitudinal. Ce procédé n'étant pas attesté par ailleurs dans l'industrie osseuse du Badegoulien, des dates directes sur ces objets seraient nécessaires pour vérifier s'ils sont intrusifs.
En complément de cette approche technologique, nous présentons une analyse morphologique et métrique des aiguilles, réalisée en ayant recours à une analyse statistique avancée via le langage « R ». De légères différences sont perceptibles entre les deux sites (le calibre des aiguilles du Cuzoul de Vers est en moyenne légèrement plus réduit et plus homogène), mais pas entre Badegoulien ancien et Badegoulien récent. Surtout, ces analyses montrent qu'une grande variabilité morphologique, et surtout métrique, est déjà observable dès le Badegoulien ancien. Or, cette variabilité métrique était jusqu'ici attribuée au Magdalénien, où les procédés de fabrication des aiguilles sont très différents. Le degré de variabilité morphométrique n'est donc pas lié à la nature de ces procédés.
En nous appuyant sur l'ensemble de ces données, nous discutons de la réalité de la présence d'aiguilles à chas dès le Solutréen dans les deux sites étudiés. Les niveaux du Solutréen et de la transition Solutréen-Badegoulien ne livrent que de très rares aiguilles et aucun vestige de leur fabrication, ce qui ne permet pas de confirmer la présence de cet objet à cette époque et suggère plutôt que les quelques objets retrouvés dans ces niveaux sont intrusifs. *A contrario*, dès le Badegoulien ancien, les aiguilles apparaissent comme un composant bien établi de l'outillage, dont l'utilisation continue sans interruption dans les siècles suivants. Ceci montre le succès de cette innovation, son importance durable dans l'histoire des technologies préhistoriques et ses répercussions sur le mode de vie des populations.
Mots-clés : aiguille à chas, Badegoulien, Cuzoul de Vers, abri Fritsch, Dernier Maximum glaciaire, Paléolithique récent, couture, vêtement.

INTRODUCTION

The emergence of sewing technologies during the Palaeolithic represents a highly significant aspect of understanding various dimensions of the lives of Palaeolithic human groups. Sewing technologies marked substantial social, cultural, and technological advancements with considerable implications for their daily life. From a technological perspective, it led to the creation of a new set of tools made of stone, bone, antler, ivory, and probably wood, used in various stages of the preparation and transformation of materials involved in sewing, such as processing hides, tendons, and plant fibres, and sewing itself. Additionally, new methods for crafting and utilising these tools emerged, driven by evolving needs. This development introduced an entirely new domain of labour focused on the production of various garments and protections, footwear, backpacks and containers, tents and covers, and a wide range of other perishable items (e.g. Owen, 1993 et 1999; Soffer, 2004; Gilligan, 2010; Gilligan et al., 2024).

The eyed needle is a technological innovation that marked the beginning of intricate sewing in the Palaeolithic. It has been suggested that its emergence may be linked to the need for finer sewing, facilitating the passage of the thread through a hole, or achieving more efficient sewing by piercing and threading in a single step (Gilligan et al., 2024). Nevertheless, the presence of awls in the archaeological record remains abundant, and traceological evidence indicates that they were used as hide perforators (Caurette, 2024).

The origin of the eyed needle has been the subject of considerable debate, and multiple centres of origin have been proposed (d'Errico et al., 2018; see also endnote 1). A review of the evidence shows that the earliest eyed needles were found at Denisova and Mezmaiskaya between 40 and 35 ka cal. BP associated with the advent of the Anatomically Modern Human (AMH; Golovanova et al., 2010; Derevianko et al., 2016; Baumann et al., 2018; Shunkov et al., 2020; Fedorchenko and Belousova, 2021). Between 35 and 25 ka cal. BP, eyed needles are widely spread in Russia, China and the Caucasus (e.g. Hoffecker, 2005; Golovanova et al., 2010; Goutas, 2013; Song et al., 2016; Kandel et al., 2017; Kuzmin et al., 2017; Li et al., 2018; Wang et al., 2020; Fedorchenko and Belousova, 2021; Tejero et al., 2021; Pitulko and Pavlova, 2022). It is between 25 and 20 ka cal. BP that eyed needles arrive in Europe, but apparently, not before 23.5 ka cal. BP (Anghelinu et al., 2017; Demidenko, 2020; Ahmetgaleeva and Burova, 2021; Kulakovska et al., 2021; Pfeifer, 2024; Pfeifer et al., 2024), coinciding with the emergence of the Badegoulian culture in West Europe (Ducasse et al., 2014).

In this context, this study focuses on the eyed needles from two key sites in France, Cuzoul de Vers and Abri Fritsch, during the Ancient and Recent Badegoulian (23.5-21.5 ka cal. BP). The aim is to characterise the assemblages technologically and morphometrically to highlight: (1) the operational schemas that were developed; (2) the morphometric variability in the Badegoulian as opposed to what has been established so far; and (3) the probability of the existence of Solutrean eyed needles in both sites.

1. THE ARCHAEOLOGICAL SITES

Abri Fritsch is a rock shelter located in the Indre region of France. It was excavated by J. Allain and R. Fritsch between 1960 and 1978, describing a 3-metre-deep stratigraphy, which included Solutrean (layers 10-8d), Ancient (layers 6-5d) and Recent Badegoulian (layers 5a-3a) levels, along with a few remains possibly contemporaneous with the Magdalenian in the upper layers[2] as well as transitional layers between the Solutrean and the Badegoulian (layers 8b-7a: Aubry et al., 2007, pp. 702–704; fig. 1b). Furthermore, Fritsch is one of the sites where the Badegoulian was first characterised (Allain and Fritsch, 1967; Allain et al., 1974; Trotignon et al., 1984; Allain, 1989; Rigaud, 2004).

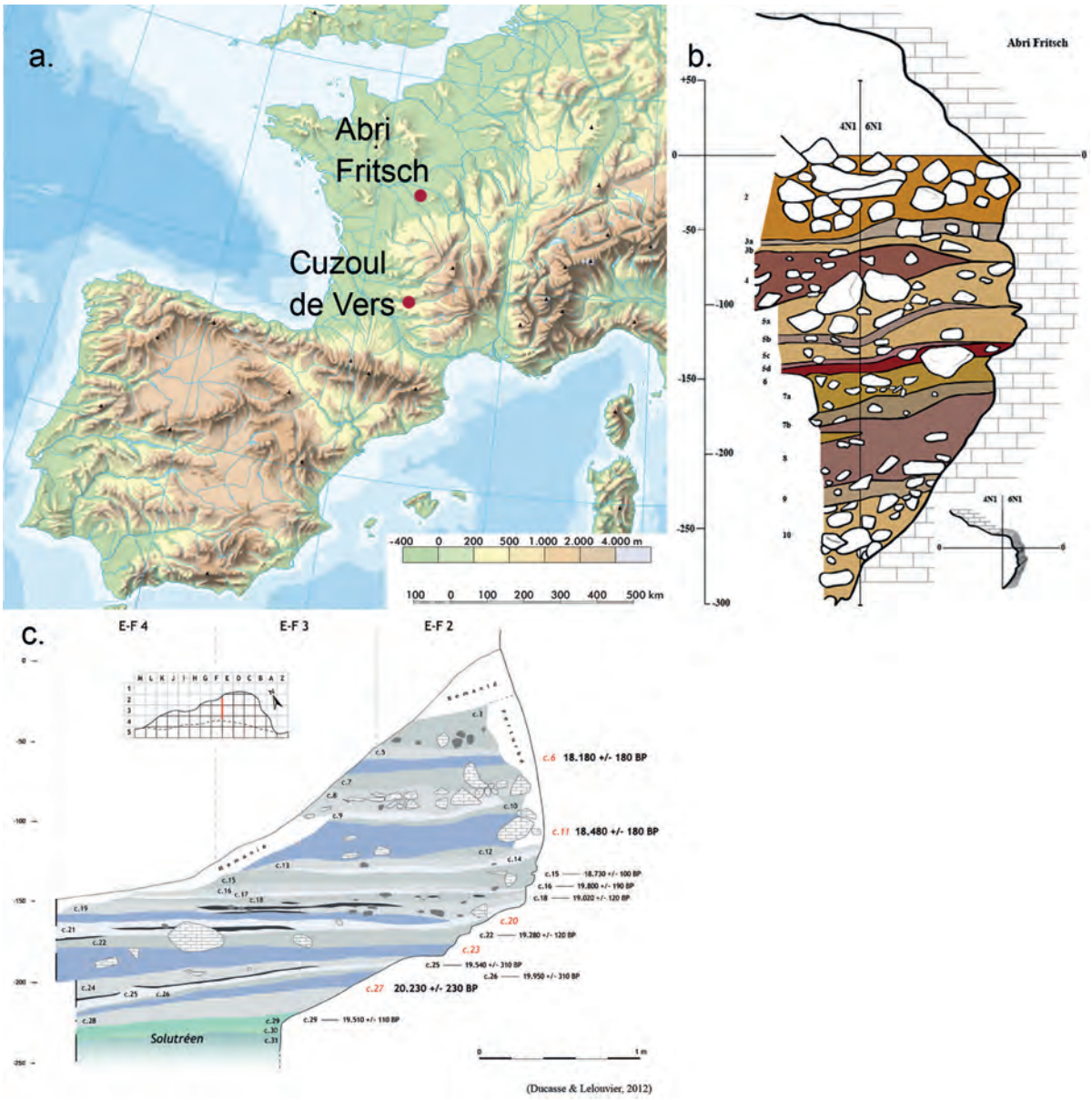

Fig. 1 – a) Geographic location of Abri Fritsch and Cuzoul de Vers; b) stratigraphy from Abri Fritsch (modified from Allain, 1967); c) stratigraphy from Cuzoul de Vers (Ducasse and Lelouvier, 2012).

***Fig. 1** – a) Localisation géographique de l'abri Fritsch et du Cuzoul de Vers; b) stratigraphie de l'abri Fritsch (d'après Allain, 1967); c) stratigraphie du Cuzoul de Vers (Ducasse et Lelouvier, 2012).*

Cuzoul de Vers is a rock shelter in the Quercy region of France. J. Clottes and J.-P. Giraud excavated it between 1982 and 1986 (Clottes et al., 2012). The stratigraphy consists of 31 layers, of which 1 to 21 correspond to the Recent Badegoulian, 22 to 27 to the Ancient Badegoulian, and 29 to 31 to the Upper Solutrean (Ducasse et al., 2014; fig. 1c). The revision of the radiometric data places the chronology of the occupation between 23.5 and 22.3 ka cal. BP (Ducasse et al., 2014), with the Ancient Badegoulian between 23.5 and 23 ka cal. BP and the Recent Badegoulian between 23 and 22.3 ka cal. BP (Ducasse et al., 2014 and 2021).

Abri Fritsch and Cuzoul de Vers are among the rare sites where the stratigraphy shows the Solutrean to Badegoulian transition. These sites provide a unique opportunity to evaluate the manufacture of eyed needles at the onset of their appearance in Southwest Europe.

2. MATERIALS AND METHODS

A total of 338 pieces, including eyed needles and their by-products from Abri Fritsch and Cuzoul de Vers (CdV; table 1), were analysed. The assemblage of bone industry from CdV was previously studied by Y. Le Guillou (2012), and the present study focuses specifically on the needles. The assemblage from Abri Fritsch was preliminarily examined by R. Malgarini (2022) and M. Borao and J.-M. Pétillon (2024). Both assemblages

	Number of needles	Use Waste product	Preforms	Blanks	Shaping Waste Product	Worked Shaping Waste Product	Waste products	Blanks GST	Waste products GST	Total
Cuzoul de Vers										
Recent Badegoulian	113	-	12	12	4	18	1	2	2	164
Ancient Badegoulian	65	2	4	5	-	3	-	-	-	80
Transition layers	1	-	-	-	-	-	-	-	-	1
Solutrean	3	-	1	1	-	-	-	-	-	5
Total	**183**	**2**	**17**	**18**	**4**	**21**	**1**	**2**	**2**	**250**
Abri Fritsch										
Recent Badegoulian	43	-	16	-	-	-	-	-	-	59
Ancient Badegoulian	11	-	3	1	-	2	-	-	-	17
Transition layers	2	-	-	-	2	-	1	-	-	5
Solutrean	-	-	-	-	-	-	-	-	-	-
Total	**56**	**-**	**19**	**1**	**2**	**2**	**1**	**-**	**-**	**81**

Table 1 – Eyed needles and by-products from Abri Frisch and Cuzoul de Vers.
***Tabl. 1** – Aiguilles à chas et restes de fabrication issus de l'abri Fritsch et du Cuzoul de Vers.*

are well preserved, making a technological study feasible. Some pieces show slight material loss or evidence of various alteration factors, such as concretions, tooth marks, roots or fire, but though these are present in low proportions. Post-depositional fractures, however, are very frequent (64,7% at CdV, 45,8% at Fritsch).

The needles have been studied following D. Stordeur-Yedid's (1979) classification. Measurements were taken for the total length of the piece, the width and thickness at the distal, medial, and proximal parts, the diameter of the perforation, the perforation arc, the distance from the perforation to the lateral edge, and from the perforation to the base were measured (fig. 2). For the technological analysis, we followed the methodology of A. Averbouh (2001) and M. Christensen and N. Goutas (2018). An initial exploratory analysis was conducted on the variables MaxWidth, and MaxThickness. Subsequently, Principal Component Analysis (PCA) was performed using the "FactoMineR" library in RStudio (R Core Team 2021) to examine group distributions in the Euclidean space. PCA biplots, categorised by archaeological site and cultural attribution, were used to visualise the relationships between groups and to assess intra- and intergroup variability.

3. RESULTS

The analysis of the various product categories (blanks, preforms, waste products, and objects) has enabled us to characterise the Operational Schemes involved in the manufacture of eyed needles during the Badegoulian at Abri Fritsch and Cuzoul the Vers.

3.1. Raw material acquisition

Taxonomic identifications could not be made due to the characteristics of the pieces, which consist of small, heavily modified diaphyseal bone flakes. As a result, we can only hypothesise that the raw material acquisition was likely linked to butchery practices, with the selection favouring compact bone flakes measuring 1.2-7 mm in thickness (4.1 mm mean) at CdV, and 5.8-7 mm (6.4 mm mean) at Abri Fritsch.

During the Badegoulian at Abri Fritsch, the reindeer (*Rangifer tarandus*) and horse (*Equus ferus*) were the primary prey species (Poulain, 1984; Bignon-Lau et al., 2021). In contrast, at Cuzoul de Vers, reindeer was the most frequently hunted taxon, followed by *Rupicapra rupicapra* and *Capra ibex* (Castel, 2012).

3.2. Blank production and transformation

At both Cuzoul de Vers and Abri Fritsch, we identified a consistent operational scheme by fracturing sensu lato (Bignon-Lau et al., 2018). This scheme involves selecting bone flakes derived from butchering waste based on specific morphometric criteria. However, the discovery of a single block at Abri Fritsch (fig. 3, no. 1), potentially associated with eyed needle production, may challenge this interpretation. This piece consists of a bone segment sectioned by direct cutting percussion, or chopping,

Fig. 2 – Nomenclature used for the description of needle parts and sections. Arrows indicate where the measurements are taken. Eyed needles from Abri Fritsch and Cuzoul de Vers: (1 to 8) Ancient Badegoulian from Cuzoul de Vers; (9) Solutrean from Cuzoul de Vers; (10 to 18) Recent Badegoulian from Cuzoul del Vers; (19 to 23) Ancient Badegoulian from Abri Fritsch; (24) layer 8b from Fritsch; (25 to 27) Recent Badegoulian from Fritsch.

***Fig. 2** – Nomenclature utilisée pour la description des parties et des sections des aiguilles. Les flèches indiquent les points de mesure. Aiguilles à chas provenant de l'abri Fritsch et du Cuzoul de Vers : (1 à 8) Badegoulien ancien du Cuzoul de Vers ; (9) Solutréen du Cuzoul de Vers ; (10 à 18) Badegoulien récent du Cuzoul de Vers ; (19 à 23) Badegoulien ancien de l'abri Fritsch ; (24) couche 8b de l'abri Fritsch ; (25 à 27) Badegoulien récent de l'abri Fritsch.*

to remove the epiphysis and exhibits fracture planes on one face. It is therefore plausible that the block was pre-formed before debitage using direct percussion. The selected flakes, chosen for their morphometric properties, were then used as blanks, suggesting that the operational scheme is by fracturing, as some degree of planning in the debitage process is evident.

The blanks (N = 19) exhibit fresh fracture planes along their edges and have been partially worked by scraping; otherwise, they could not have been distinguished from butchering debris (fig. 3, nos. 2-7). As a result, our analysis focuses on pieces displaying clear evidence of inclusion within the blank reduction sequence, such as waste products produced by *raclage en diabolo*, a technique used to define the needle's length. This technique is attested at both sites and appears to have been applied both prior to and following the shaping phase. Accordingly, six waste fragments without scraping marks (fig. 3, no. 21) and 23 fragments detached during shaping (fig. 3, nos. 16-20) were identified.

Once the blank was obtained, it was shaped by scraping to regularise both the fracture planes and the surfaces. Most of the preforms exhibit flattening at the drilled end, indicating intensified scraping in the proximal part, as shown by the 19 identified preforms (fig. 3, nos. 8-13). The perforation was executed bifacially and using alternative rotational technique.

At Cuzoul de Vers, during the Recent Badegoulian, the Groove and Splinter Technique (GST), associated with eyed needle manufacture, has been identified on four pieces: two blanks and two waste products. One waste product from layer 12 (fig. 3, no. 23) is a debited block by bifacial grooving, with all the surfaces scraped except the epiphysis. The fragment was then detached via *raclage en diabolo*. The second waste product (layer 6c) is a flake featuring two extractions made using double convergent grooving (fig. 3, no. 22). One blank from layer 12 has been scraped on both faces and bears a longitudinal groove on the ventral face (fig. 3, no. 25). The final piece (from layer 1) is a partially scraped blank with modification concentrated on the dorsal face (mainly in the proximal part) and on the left margin. It exhibits parallel grooves on both lateral edges (fig. 3, no. 24). These pieces reflect an operational scheme by extraction.

3.3. Morphometric Characteristics of Eyed Needles

The needles from the Ancient Badegoulian levels at Abri Fritsch (fig. 2, nos. 19-23) range in length from 47.73 to 78.1 mm (mean = 62.7; SD = 21.8), in width from 2.2 to 5.4 mm (mean = 3.0; SD = 0.6), and in thickness from 1.8 to 3.6 mm (mean = 2.7; SD = 1.0). The most common cross-section is circular (n = 8), followed by flattened (n = 2) and oval (n = 1). For the Recent Badegoulian levels (fig. 2, nos. 25-27), only one complete needle was recovered (58.6 mm in length), although fragments exceeding this length were also identified, for example, a mesial fragment measuring 63.2 mm. Width ranges from 2.2 to 4.6 mm (mean = 3.3; SD = 0.6), and thickness ranges from 1.6 to 3.9 mm (mean = 2.7; SD = 0.6). The cross-sections include circular (n = 23), oval (n = 15), subquadrangular (n = 2) and plano-convex (n = 2).

At Cuzoul de Vers, needles from the Ancient Badegoulian (fig. 2, nos. 1-9) range in length from 19.0 to 87.2 mm (mean = 48.4; SD = 29.3), in width from 1.5 and 5.0 mm (mean = 2.7; SD = 0.7), and in thickness from 1.1 to 3.5 mm (mean = 2.3; SD = 0.6). The cross-sections include circular (n: 35), oval (n: 25), flattened (n: 7) and subquadrangular (N = 1). In the Recent Badegoulian levels at the same site (fig. 2, nos 10-18), needles lengths vary from 43.0 to 50.0 mm (mean = 47.2; SD = 3.7), widths from 1.5 to 4.3 mm (mean = 2.6; SD = 0.6), and thicknesses from 0.8 to 3.4 mm (mean = 2.1; SD = 0.5). The most frequent cross-sections are oval (N = 59), followed by circular (N = 44), flattened (N = 7), polygonal (N = 2) and triangular (N = 1).

3.4. Statistical results on morphometric variability

The first principal component (Dim1) is strongly dominant, accounting for 87.91% of the total variance, while the second component (Dim2) explains the remaining 12.1% (fig. 4). When examined by site (fig. 4A), the CdV assemblage tends to cluster toward the central-left region of the plot, whereas the Abri Fritsch group occupies a broader range, predominantly on the right side.

Since the two input variables are Maximum Width and Maximum Thickness, specimens plotted on the positive side of Dim1 correspond to needles with larger values in these dimensions. Accordingly, the Fritsch group includes needles with somewhat greater maximum measurements, although it also exhibits internal variability, as indicated by the dispersion of triangle markers. In contrast, the CdV group forms a more compact cluster, suggesting a slightly smaller and more homogeneous distribution of width and thickness values.

Specimens positioned to the right of the graph exhibit higher maximum dimensions, while those to the left tend to display lower values. More specifically, the upper-right quadrant, dominated by the Fritsch group, corresponds to bone needles with larger overall dimensions and moderate internal dispersion. The upper-left quadrant, containing primarily CdV specimens, reflects needles with smaller dimensions but greater internal variability. The lower-left quadrant, which also consists mainly of CdV needles, represents the smallest specimens in absolute terms.

When the sample was displayed according to Cultural Attribution (fig. 4B), there is a complete overlap between Ancient and Recent Badegoulian groups. Although no distinct separation is observed, there is a slight tendency for the Recent Badegoulian specimens to plot toward the right side of the graph, suggesting a subtle shift toward greater maximum measurements.

Fig. 3 – Blanks, preforms and waste products from Fritsch and Cuzoul de Vers.
***Fig. 3** – Supports, ébauches et déchets de production provenant de l'abri Fritsch et du Cuzoul de Vers.*

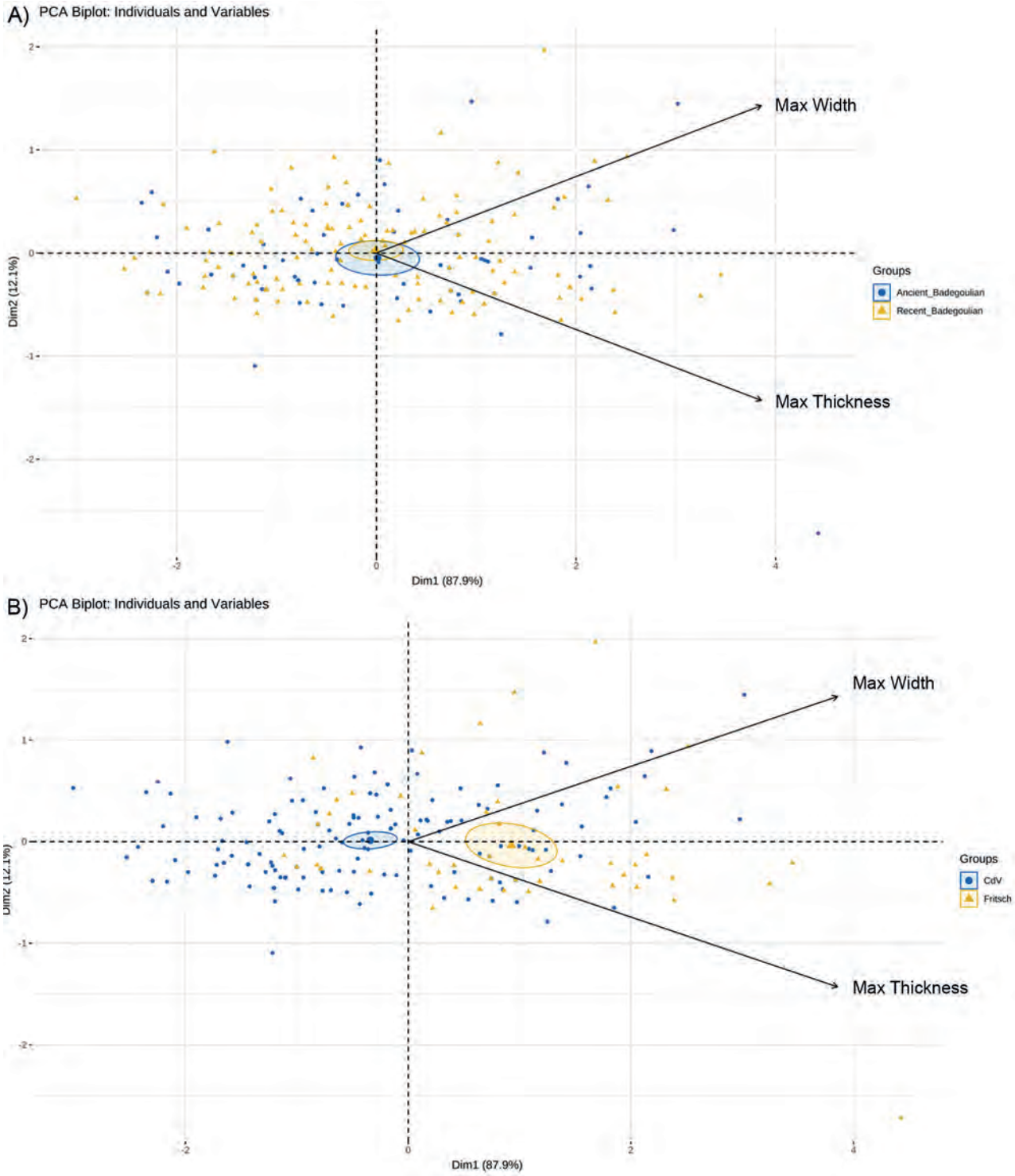

Fig. 4 – Principal Component Analysis (PCA) of bone needles based on Maximum Width and Maximum Thickness, displayed by archaeological site (A) and cultural adscription (B). PC1 explains 87.9% of the total variance, while PC2 accounts for 12.1%.

***Fig. 4** – Analyse en composantes principales (ACP) des aiguilles en os, basée sur la largeur maximale et l'épaisseur maximale, représentée par site archéologique (A) et par appartenance culturelle (B). La première composante (PC1) explique 87,9 % de la variance totale, tandis que la deuxième composante (PC2) en représente 12,1 %.*

DISCUSSION AND CONCLUSIONS

The extreme climatic conditions of the Last Glacial Maximum (LGM) profoundly affected glacial expansion, sea levels decline, winter temperatures, and most critically, the subsistence strategies of human populations. One of the most significant adaptative responses appears to be the invention of eyed needles, which enabled the production of finely stitched, multilayered garments essential for survival in harsh environments (d'Errico et al., 2018; Gilligan et al., 2024). Establishing the chronology of this technological innovation is therefore of considerable importance.

In this regard, three eyed needles have been recovered from Solutrean layers at CdV (two in layer 29 and one in layer 30), and additional examples were found in the Solutrean-Badegoulian transitional layers at both sites (one in layer 28 at CdV and two in layer 8b at Abri Fritsch). These transitional assemblages contain technological features characteristic of both technocomplexes. However, none of these layers yielded manufacturing by-products associated with needle production. The absence of production debris has been interpreted as evidence of possible stratigraphic intrusion of the needles in these earlier contexts.

Thus, the in situ evidence of needle production at Abri Fritsch and CdV strongly supports attributing the origin of the eyed needles in southwestern Europe to the Ancient Badegoulian, rather than to the Solutrean. Other sites, such as Abri des Harpons, yielded several needles in layer D; however, this layer has been demonstrated to contain a palimpsest of materials from multiple cultural periods, not solely Solutrean (San Juan-Foucher, 2005; Ducasse et al., 2017).

The high frequency of needles at CdV is consistent with ethnographic insights. As Spiess (1979) notes, the optimal period for procuring hides suitable for garment production is between late summer and early autumn. Faunal seasonality studies at CdV confirm that animals were hunted during this time frame (Castel, 2012). Comparative data from other Badegoulian sites with differing seasonal occupation would be valuable for evaluating whether the frequency of needles varies with seasonality. However, to our knowledge, such comparative datasets are currently unavailable. Regardless of occupation timing, the needle emerged as an essential component of the Badegoulian toolkit.

Strikingly, the number of needles doubles from the Ancient to the Recent Badegoulian. Whether this increase reflects more intensive use, extended occupation, or merely larger excavated surfaces remains uncertain. Nonetheless, it is evident that even during the Ancient Badegoulian, eyed needles were not isolated innovations but part of a fully developed bone industry, one that continued unbroken into the subsequent centuries, highlighting the enduring success of this invention.

Morphometric variability among eyed needles has also been a subject of recent debate. Traditionally, such variability has been linked to the Magdalenian, where it is attributed to the use of standardised manufacturing protocols. However, our results show that considerable morphometric diversity was already present at the onset of needle production. The PCA reveals a broad size range, with slightly larger specimens at Fritsch, and the greatest variability occurring during the Ancient Badegoulian. This evidence suggests that variability is not the result of technological constraints.

The Operational Scheme by fracturing identified at both sites, characterised by the use of direct percussion, followed by shaping via scraping, shows that dimensional standardisation occurred primarily during the shaping phase, not during blank production. This contrasts with the Magdalenian, where standardised matrices were used to extract precisely calibrated blanks (e.g. Lázničková-Galetová, 2010; Bignon-Lau and Lázničková-Galetová, 2016), and yet morphometric variability still exists in the final products. This indicates that manufacturing techniques alone cannot account for dimensional diversity. Alternative explanations must therefore be considered. While equifinality cannot be dismissed, functional differentiation among needles, potentially linked to different types of garments, stitching techniques, or raw materials, may be a more fruitful avenue for further investigation.

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NOTES

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2. R. Malgarini – L'industrie osseuse de l'abri Fritsch (couche C1 à C5c): état de la série, inventaire et premières données typo-technologiques, in L. Mevel, S. Griselin (eds.), *Du dernier maximum glaciaire à l'optimum climatique dans le Bassin parisien et ses marges Habitats, sociétés et environnements*, rapport de projet collectif de recherche, 2022, pp. 77–93.

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