Bi-directional Neolithic blade technology in the northern Levant during the 7th–8th millennia CAL B.C.: New insights from Mamarrul Nasr 2, Syria

Ferran Borrell

The University of Manchester, Manchester, United Kingdom

This article focuses on the reconstruction of a particular opposed-platform knapping sequence from a Late/Final PPNB (7th–8th millennia CAL B.C.) flint workshop, at the site of Mamarrul Nasr 2 in the Douara Basin (central Syria), which is a variation on the usual reduction strategy associated with the bi-directional blade method. This strategy is characterized by a very specific and strict reduction sequence. The working surface is very narrow, and the direction of the debitage is slightly off-set, allowing the highest ratio of productivity of standardized targeted central blades. The analysis also points to the presence of competent knappers. The temporal and spatial distribution of the off-set bi-directional strategy in the central Syrian Desert indicates the existence of two technocomplexes in that region, indicating an important variability within bi-directional technologies and the presence of different lithic traditions. This suggests the existence of a diverse sociocultural background, probably the result of a cluster of minor cultural units. Furthermore, comparison with the lithic assemblages from middle Euphrates Valley, where the off-set bi-directional strategy has been identified during the Middle/Late PPNB, establishes a connection between the large, permanent settlements along the Euphrates Valley and the many campsites and workshops from the Douara and Palmyra basins. The existence of two lithic traditions in the central Syrian Desert re-opens the debate about the complexity, chronology, and origin of the Neolithic “conquest” of the semi-arid steppes of central Syria.

Keywords: Bi-directional blade technology, flint workshop, reduction strategy, lithic traditions, technocomplexes

Introduction

The prevalence of bi-directional blade technologies in Pre-Pottery Neolithic assemblages at a time of economic transformation that led to the emergence of village farming in the Near East is well known. This economic transformation also involved significant changes in lithic technology and studies examining bi-directional blade technology, along with the more notable Neolithic features (sedentism, domestication, means of subsistence, etc.), have contributed to the understanding of the first farming communities of the Near East.

The first definition of bi-directional blade technology was developed by J. Cauvin in the 1960s and subsequent studies focused on determining the temporal and spatial distribution of the bi-directional technology both in the Northern and Southern Levant (Bar-Yosef 1981; Todd 1966; Crowfoot-Payne 1983; Bader 1989; Cauvin and Cauvin 1993). Other studies, which have placed strong cultural emphasis on certain material aspects of the archaeological record and especially to bi-directional technology, have focused in identifying cultural regions like the “Levantine Province” (Kozłowski 1999), the “Euphratian” (Kozłowski and Aurenche 2005: 76), or “Moyen-Euphrate” (Cauvin and Cauvin 1993). In recent years, lithic studies have begun to take into account not only the tools and cores but also the debitage, thus permitting the reconstruction of the reduction sequence and the technological skills and behavioral patterns of its users (Calley 1986; Wilke and Quintero 1994; Quintero and Wilke 1995; Abbès 1998, 2003; Nishiaki 2000; Binder and Balkan-Atlı 2001). Many of these studies have emphasized the relationship of the bi-directional technology with broader changes in cultural and economic patterns, by identifying the development and decline of bi-directional technology as a response to changing socioeconomic conditions,
and to the existence of different degrees of specialized artisans or technical specialization (Quintero and Wilke 1995; Nishiaki 2000; Abbès 2003). These studies consider the evolutionary history of bi-directional technology within the broader context of changing economic and social conditions (Quintero and Wilke...
allowing a better understanding of the bi-directional technology in the Near East. They have contributed to the identification of an important degree of variability within the technology, the recognition of different lithic traditions in micro-regions that had previously been considered to be homogeneous cultural regions, and to the characterization of the social contexts in which it was practiced.

Investigations at Mamarrul Nasr 2

Our research in the central Syrian Desert (Douara/ Palmyra and El Kowm basins) contributes to the development of a picture of variability in the technologies and toolkits in Neolithic central Syria (Borrell et al. in press a, in press b) by reconstructing the reduction sequence from Mamarrul Nasr 2, a Late/ Final PPNB flint workshop in the Douara Basin (FIGS. 1, 2). This specific reduction sequence was first identified in the 1970s and 1980s (Suzuki and Akazawa 1971; Fujii 1986; Fujii et al. 1987) at the Neolithic sites found by the University of Tokyo in the Douara Basin and Palmyra region (Akazawa 1979a, 1979b). Later it was systematically described and termed the “naviform method of Douara type” at Douara Cave II (Nishiaki 1994, 2000: 84) and then re-defined as offset bi-directional strategy at Halula (middle Euphrates Valley) (Borrell 2006; Borrell in press a).

Previous studies on this particular bi-directional reduction sequence have dealt with a selection of surface material/collection (Suzuki and Akazawa 1971: 105), “…deposits hardly considered in situ…” with “…unsatisfactory stratigraphic contexts…” (Nishiaki 2000: 54) or material from “…exterior areas adjacent to the domestic buildings” (Borrell in press a: 214) which are not considered primary production contexts with material in situ. The lithic assemblage from Mamarrul Nasr 2 is the largest and the most systematically collected sample available from the Neolithic sites of the Douara and Palmyra basins. The context is a Neolithic flint workshop with in situ material and no traces of either earlier or later occupation, which allows reach a deeper understanding of the offset bi-directional strategy and associated technical behaviors.

The investigation of this particular sequence and its contextualization in the central Syrian Desert and the Northern Levant contributes to the identification of technological skills and behavioral patterns of its users and provides information on the socioeconomical context in which the specific lithic production took place. It highlights the role played by the variability of bi-directional technology as a means of providing evidence of the existence of diverse lithic traditions and technocomplexes in the central Syrian Desert, adding to the debate about the cultural diversity, chronology and origins of the first Neolithic settlement in central Syrian Desert.

Neolithic settlement in the central Syrian Desert

The vast semi-arid central Syrian steppe is a region where the Neolithization process is undocumented until a late stage of the Neolithic period. It is considered to have been sparsely inhabited from the end of the 9th millennium CAL B.C. until the very end of the 8th millennium CAL B.C. (Akazawa 1979a, 1979b; Cauvin 1981, 1987–1988; Stordeur 2000). After 7000 CAL B.C., archaeological evidence of occupation is abundant, especially in the El Kowm region. Archaeological work undertaken at three stratified sites (Qdeir 1, El Kowm 2, and Umm el Tlel) dated it to the first half of the 7th millennium CAL B.C. At the same time, Neolithic flint factory sites from the Douara and Palmyra basins were attributed to the first half of the 7th millennium. Notwithstanding, some researchers proposed that the Douara area could have been densely occupied during the PPNB (Akazawa 1979b: 216) and earlier occupation has also been considered (Fujii 1986; Fujii et al. 1987; Nishiaki 2000: 94). This model of Neolithization proposed in the 1980s and early 1990s (Cauvin 1981, 1982; Stordeur et al. 1982; Molist and Cauvin 1990; Stordeur 1993, 2000;
Cauvin and Cauvin (2000), concluded that the Pre-Pottery Neolithic of the Syrian steppe was a later occurrence which evolved separately from the neighboring regions; this model has been maintained without major changes until the present date.

The Neolithic complex of Mamarrul Nasr
Since 2006, four seasons of fieldwork including field survey, topographical studies, excavation, and a study season have been undertaken by the Universitat Autònoma of Barcelona, Paris X-Nanterre, and the DGAM of Syria in Douara Basin. We have identified a remarkable concentration of sites in the northern passage of Jebel Douara. The passage, called Mamarrul Nasr, is a strategic spot that affords good visibility of the steppe and visual control of the landscape (Fig. 3). Furthermore, it connects the Douara Basin and thesteppe flat lands between the Jebel Douara and the Palmyrides Mountains. The type of sites identified include eleven flint scatters with high concentrations of artifacts under rock shelters preliminarily interpreted as flint workshops, one lithic concentration in a middle-sized cave, one small concentration of lithics under a rock shelter, and one desert-kite (i.e. large kite-shaped stone structures generally interpreted as traps to hunt gazelle, though alternative interpretations also include their use as corral herds of semi-domesticated animals [Echallier and Braemer 1995]).

No other finds apart from chipped flint have been found on the surface of any of the sites at Mamarrul. An initial assessment of the lithics from all these sites shows a lack of variability within the assemblages. Raw materials seem to be the same at all sites and lithic technology is extraordinarily consistent, viz. opposed-platform blade cores that can be assigned to the Neolithic period. There is an apparent absence of both earlier and later occupation in any of the sites identified, although evidence of earlier periods is abundant in the Douara Basin itself (Akazawa 1979a). These facts imply that the sites are contemporary and suggest that Mamarrul Nasr is a Neolithic complex comprising a series of different types of interrelated activities (Borrell et al. in press b).

Mamarrul Nasr 2 is a flint workshop with a high concentration of lithics delimited by a dry stone wall under a small rock shelter (Fig. 2) 6 m long and 3.5 m deep. The material within this area is abundant and considered to be in situ. Outside this area the density of lithics is considerably less, and the material has been slightly moved from its original position. A test pit (2 x 1 m) was excavated under the shelter in 5 cm deep artificial spits and archaeological material collected in 50 cm squares. Archaeological deposits were found from the surface to the bedrock which was 40 cm below the surface. All the sediment was sieved and samples collected: 9767 flint artifacts, 1 medial fragment of an obsidian bladelet, 2 small bone fragments, and 4 spherical barite nodules were recovered (Fig. 4). At Mamarrul Nasr 2 the reduction of flint cores is exclusively oriented to bi-directional blade production from opposed-platform cores (30 opposed-platform blade cores and 3 indeterminate cores). Bladelets are interpreted not as deliberate production goal but as casual blanks obtained throughout the blade production sequence. Flakes are abundant and together with indeterminate fragments they seem to be by-products occasioned by blade production, though some flakes have been used to produce tools. The total number of flakes includes burin spalls, core tablets, proximal scar spalls, and D-shaped blades/flakes. Chipping debris less than 1 cm long is abundant. The presence of cortical flakes and

![Figure 4 A) Total number of flint artifacts from Mamarrul Nasr 2; B) Breakdown of the flakes.](image-url)
blades, many cores, technological blanks (crested blades, core trimming pieces, core tablets, core rejuvenation flakes, etc.), and large quantities of chipped debris suggests that virtually the complete reduction sequence is present at the site.

**Reconstructing the knapping sequence at Mamarrul Nasr 2**

The absence of earlier or later material, along with the use of the same raw material and the extremely homogeneous nature of the lithic technology, suggests that repeated knapping episodes were undertaken over quite a short time period. Cores, products, and by-products display common typological features suggesting that the general concept of core reduction was the same. The reconstruction of a knapping sequence is achieved through the study of the artifacts from a series of knapping episodes. This has permitted a better understanding of the method of knapping and enabling us to identify the specific technological behaviors and products of the knapping process. The reduction sequence described here includes the shaping out of opposed-platform cores, the production of blades, the maintenance and the abandonment of the core, and the production of retouched tools.

**Raw material choice**

The raw material is light beige to dark brown-black flint. It is fine grained and homogeneous, making it an excellent material for knapping. White to pale orange chalky cortex covers the nodules. This raw material is abundant in the Douara Basin itself (FIG. 1), where both nodules and discontinuous layers of flint lay within the Middle/Early Holocene formations. Eocene flint deposits occur in surface exposures as bedded and flat nodular forms. Flat nodules up to 40–50 cm long can easily be procured in the nearby outcrops. Thin sections from both geological samples and flint artifacts from Mamarrul Nasr 2 show no significant differences in their mineral and fossil content. The features identified indicate that flint artifacts from Mamarrul Nasr 2 and flint samples from the sources at Douara Basin derive from Eocene strata and belong to the Arak Flint Horizon (Borrell and Vicente in press), a raw material that was probably the main source of flint in the area around Palmyra and Douara (e.g., Krasheninnikov et al. 1996; Long and Julig 2007).

**Shaping the preform**

The first stage of knapping focused on shaping the tabular nodules into core preforms by the detachment of some flakes in a few knapping stages, during which most of the cortex was removed. Preliminary roughing out of the nodule was undertaken next to the outcrop itself, because there are few flakes in the assemblage that are entirely covered by cortex (no direct evidence was observed at the outcrops). The shaping of the core was not intensive and most of the cores display some cortical surfaces on their backs or lateral edges due to the tabular shape of the original nodules that allowed the required volume and morphology (crescent shaped with an asymmetric cross-section) to be reached without removing the entire cortical surface. The nodule was provided with a frontal ridge using bi-directional removals and the back of the core was shaped with a lateral-dorsal crested ridge, which was roughly prepared with a few uni-directional or bi-directional removals. Sometimes the back was shaped by two lateral dorsal ridges that did not meet leaving a cortical surface in between them (FIG. 5). These features distinguish most cores from Mamarrul Nasr 2 from those defined as naviform cores by J. Cauvin (1968: 226): “...il sont d’un type à deux plans de frappe qu’ont pour trait appelé naviforme, tellement le bord opposé à la surface d’éclatement ressemble, avec son arête et ses enlèvements bifaces à une carène de navire.”

The shaping of the preform produced a wide range of flakes. Specific production of flakes has not been documented at Mamarrul Nasr 2 and the flakes present have to be considered by-products. These flakes are different in size and morphology, according to their stage of shaping, though they were all removed after minimal preparation or without any preparation at all. They are short and usually have wide striking platforms knapped by direct percussion with a hard hammer. Although no hammerstones have been recovered during the excavation, some bi-directional cores found near the rock shelter show evidence of being reused as hammerstones. These were probably used during the roughing out of the nodule, while soft direct percussion might have been used during the reduction sequence.

Two opposed striking platforms were obtained by single blows that detached a substantial part of the dorsal ridges. The blow did not run perpendicular to the longitudinal axis of the preform but obliquely from the left side (FIG. 5). This means that the two platforms are parallel to each other but do not run perpendicular to the longitudinal axis of the core, showing a remarkable slant from the left to the right side. In other words, the platforms are opposed, rotated may be 15–20° from one another, slightly offset from the axis of the core—a feature that is maintained throughout the whole reduction sequence. Dorsal crested blades (FIG. 6.3) are slightly curved and rarely show the characteristic S-shaped profile common in the other products including frontal crested blades, lateral blades, and central blades. At this stage the preforms measured up to 20–25 cm in length and their width, calculated by measuring the abandoned cores, the opening-platform crested blades, and the frontal crested blades, was standard, ranging from 4 to 6 cm.
Blade production and maintenance

The first item to be detached from the narrow working surface was a frontal crested blade (FIG. 7). The impact point of the blade was located on the right edge of the platform, almost at the side of the core. The direction of flaking was slightly off-set and went from the right side of the striking platform to the opposite side of the distal end of the core. This blade, which could be up to...
22 cm long, did not often extend along the whole length of the removal surface because of the large size of the core, so a second crested blade was detached from the opposed platform also from its right edge. Consequently frontal crested blades often display a twisted longitudinal profile. The profile of the right edge displays an S-shaped delineation especially noticeable on the proximal part (FIGS. 6.1, 6.2, 7).

Continuous blade production was oriented to the production of a series of large pointed central blades.
which followed the slightly off-set direction (FIGS. 5H, 8). The standardization of these blade blanks, each with exactly the same features and morphology, was achieved through rigid and systematic control of the volume available for exploitation.

Many of the central blades (CB) have a burin-like scar which removes the impact point and butt, though it is still possible to observe that the impact point was located on the right side of the proximal end, indicating that the core was struck on the side of the striking platform so that the blade ran obliquely to the longitudinal axis of the core (FIG. 8). The central blades have an asymmetric trapezoidal cross-section. The right side of the trapeze is almost always the shortest. The left side of the trapeze is wider. Furthermore, there is a repetitive pattern in the distribution and direction of the dorsal scars. There are often two opposed short removals on the right side and only one large one coming from the opposite direction on the left side. This is the negative removal of the previously detached central blade, while the negative removals on the right side are the scars left by a left lateral blade and a right lateral bladeflake. In the middle of the dorsal face there is almost always a negative removal of the previous central blade detached from the same platform. This is because the arrises left on the working surface by the previous central blade (detached from the opposing platform)
were used to guide the direction of the next central blade. Some of the central blades have their distal ends slightly curved to the left, though this feature seems to have been partly corrected by detaching a D-shaped blade, the negative of which can sometimes be identified at the distal end of the blade. The length of the central blades ranges from about 20 cm (estimated) to 7.3–9 cm (the last complete central blade negative removal measured on abandoned cores); they become much shorter and narrower as production proceeded,

Figure 10 1–3) Right lateral flakes/blades; 4–5) Upsilon blades; 6–11) D-shaped blades; 12–16) Proximal scar spalls.
but they display the same features. Central blades were detached after careful preparation of the platform edge, which can be observed on the right edge of the butt, although this part was often removed by a burin-like blow that also removed the impact point and part of the flat or linear butt.

As well as the targeted central blades, other blades were detached from the main working surface even
though the reduction sequence was very strict. These blades were not pointed and they rarely display any of the characteristic features described above. This category we have termed non-lateral (NL) blades. It includes a heterogeneous group of blades which are neither lateral blades, nor the targeted pointed central blades but which nevertheless occur as part of the reduction sequence. They might be multi-purpose blades struck to renew/modify the main working surface, correct the orientation of the knapping sequence, or may simply be misaligned removals that did not meet the intended product.

Preparation for the removal of the central blades was not done by the removal of two lateral blades from the opposed platform and two flake/blade removals from the same platform. Rather, the negative removal of the previous central blade, knapped from the opposed platform, was used to guide the next central blade as if it was a right lateral blade. In this way, the last central blade partially overlaps the previous one. Throughout the reduction sequence, left lateral blades (LLB) were used to maintain the working surface as well, one for each central blade detached. The maintenance of the sides of the cores was done by the removal of left lateral blades and of right lateral flakes and blades (RLF/B) (FIG. 5); the latter barely affecting the working surface and mostly used to maintain the back and the sides of the core, together with flakes detached from the dorsal ridge(s).

Left lateral blades are abundant and have a series of characteristic features (FIGS. 5B, 5F, 9) such as remains of cortex on the left side of the blade. The proximal end is triangular-shaped, and the angle described by the butt and the right edge indicates the angle between the working surface and the striking platform of the core, which is around 55–60°. Left lateral blades are thick robust blades with trapezoidal cross-sections and large, flat uni-faceted butts. They often show negative removals on the left edge coming from the back of the core. Butts are trapezoidal, irregular, and, since they appear similar to burins, have been termed Imitating Dihedral Burin (IDB) butts (Suzuki and Akazawa 1971; Nishiaki 2000). The removal of these blades involved careful preparation including the abrasion of the platform edge and the removal of other tiny flakes. As with central blades, the percussion point is located towards the right end of the butt and percussion direction is slightly off-set from the longitudinal axis of the blades.

Right lateral blades are scarce (FIGS. 5A, 5G, 10.1–3), and display the same features as left lateral blades but the opposite way round. The cortex is always located along the right edge. Butts are robust, flat, and uni-faceted. The percussion point is rarely located at the right end of the butt, usually more towards the middle, although the knapping direction is completely off-set from the longitudinal axis of the blade. Detailed study of the flakes allows the identification of some with similar features (FIGS. 5G, 10.3). This indicates that the right proximal side of the core was maintained through the removal of a few short blades and some flakes detached from the right side of the striking platform. The purpose of these flakes was to maintain the shape of the core and to keep the working surface narrow. The right side of the working surface was maintained by the removal of the previous central blade, whose proximal side was part of the side of the core itself.

After the removal of the central blade, a very characteristic flake/blade, termed a D-shaped blade by Y. Nishiaki (2000), was often detached from the same platform (FIGS. 5E, 10.6–11). D-shaped flakes played an important role in maintaining the working surface by flattening the proximal left part of the removal of the last central blade. The surface was modified in order to prepare the shape of the distal end of the next central blade which was detached from the opposite striking platform. By doing this, the direction of knapping was maintained and was slightly off-set and the next central blade detached from the opposite platform would not have the distal end curved to the left. D-shaped blades have a punctiform butt and an asymmetric outline with a longitudinal dorsal ridge, parallel to the left edge. They often display previous small removals on the proximal end and their size is 1–3 cm in length. Their cross-section is always that of a flat scalene triangle, and their longitudinal profile is often “humped” near the proximal end and very thin or/and broken at the distal end. The direction of the
left dorsal removal is either the same as the D-shaped blade or from the opposite direction, depending on whether it is the negative removal from the left dorsal blade or the distal end of the previous central blade.

Within this reduction sequence upsilon blades/flakes are scarce and small, and many of them show an asymmetric Y-shaped dorsal ridge pattern (FIGS. SC, 10.4, 10.5). This is mostly a result of the fact that central blades extended from the proximal end right to the distal end of the core, so that there was no need to modify the shape of the core. Furthermore, because the distal end of the central removal was close to the side of the core, it could be modified by the next left lateral blade.

Blade production was thus in this sequence: one central blade, one D-shaped flake (from the same
platform), one right lateral blade/flake from the right side of the core (from the same platform), and one left lateral blade (from the opposed platform), together with some minor removals to maintain the striking platform, the working surface and the sides of the core (FIG. 5).

The angle between the platforms and the working face was acute, around 50–60° (FIGS. 5D, 11). Detachment of left lateral and especially central blades was preceded by intensive preparation in the form of abrasion and micro-chipping. This can be observed on both the blanks and the cores, especially on the right side of the overhang. The striking platform was renewed after the first series of blade removals. This was accomplished by removing thin and elongated flakes/core tablets. The proximal part is triangular-shaped and often displays cortex and an asymmetrical cross-section, though most of them have a trapezoidal cross-section. Those with asymmetric cross-sections display “core tablet scars” only on one lateral edge while the other display a cutting edge. This is because the platforms were slightly rotated and did not run perpendicular to the longitudinal axis of the core but slightly deviate. The retention of this slant from the left to the right side resulted in a high proportion of core tablets with asymmetrical cross-sections.

The back of the core was also renewed at the same time as the striking platform. Following the first series of blades and the core tablet removal, the back and side of the core were re-shaped. Most of these shaping flakes were struck from one side of the back of the core and so were reminiscent of the lateral-dorsal crested ridge and the striking surface too (FIG. 11).

Core abandonment
Cores were abandoned when they became shorter than about 7–10 cm (FIGS. 5D, 11) although they could have produced further short blades. The abundance of high quality flint in the surrounding area permitted the early abandonment of small to middle-sized cores.

Most of the abandoned cores display cortical surfaces on their backs or lateral edges. At this final stage, the striking platforms at the back of the core often overlapped, whether crested or cortical, and cannot be distinguished. The only evidence of the reuse of the cores after they were discarded is a core found on surface at Mamarrul Nasr 2 which was used as a hammerstone. Two others (FIG. 11) have evidence of having been used for abrading, perhaps to reduce the overhang of another core. The presence of four barite nodules at the site is difficult to interpret. They could have been related to the abrasion of the overhang of the cores as well, though none of the nodules shows marks of having been used in such a way nor for any other task.

It is striking how similar the abandoned cores are in size, morphology, and other features. The opposed
platforms are parallel to each other but they are not perpendicular to the longitudinal axis of the core. The arrises on the working surface run obliquely to the longitudinal axis of the core, are rotated 15–20° from one another, and are slightly offset from each other along the axis of the core. The working surface of the core is narrow and the negative removals of two opposed central blades, one partially overlapping the other, can be identified together with the negative removals of two left lateral blades, two right lateral flakes/blades, and even sometimes the negative removal of one or two D-shaped blade/flakes. Preparation of the striking platform included a series of small removals and sometimes abrasion and micro-chipping of the overhang, which is obvious at the right edges of both the striking platforms.

**Tool production/blank modification**

Retouched tools were also produced at the site in small numbers (FIGS. 12, 13). Only 99 pieces display clear intentional retouch and less than half fall into conventional typological categories: burins (27), notches (11), denticulates (4), a small number of scrapers (3), side-scrapers (2), truncations (1), and projectile points (3) (Byblos type). Byblos points are made on central blades whereas most of other tools were made on other blades obtained through the reduction. All projectile points are broken. Complete central blades are also rare. The original size of the cores is estimated to have been around 20 cm in length, while central blades recovered at the site never exceed 12 cm in length. It is thought that large complete central blades, whether transformed into tools or not, were taken away from the workshop.

Apart from the presence of conventional tools and the retouched pieces mentioned above, the knapping sequence included the modification of a great number of blades in a very specific way. A large number of blades (FIG. 14B) have a proximal burin-like negative scar on the ventral face of the right edge (FIGS. 6, 7, 8, 9). This proximal scar resembles a burin facet, and is the result of an intentional action, not a knapping accident, though it evokes the accidental splitting determined in replicative experiments using soft stone percussion (Pelegrin 2000: 79, fig. 3f). The proximal scar has also been defined as “a burin blow” (Cauvin 1972), “PPNB proximal scar” (Verhoeven 1994; Nishiaki 2000), “burin-like scar” (Nishiaki 2007), and “proximal scar” (Borrell in press a). The proximal scar rarely affects the left edge. Sometimes the facet is obtained not by a single blow but by a series of blows or through inverse retouch. This technical procedure was applied systematically to the blades and was carried out in the site. High numbers of proximal scar spalls have been found (FIG. 10.12–16).

Previous studies have identified this modification on a wide range of retouched tools (Byblos points, glossed tools, borers, burins, non-retouched blades, etc.) at other sites including Halula (Borrell and Molist 2007) and Douara Cave II (Nishiaki 2000). Some suggest that the purpose of the proximal scar is to eliminate the S-shaped profile on the proximal part of the right edge, in order to facilitate the hafting of the tool by tightening and straightening the proximal end of the blade (e.g. Nishiaki 2000, 2007; Borrell 2006, in press a; Borrell and Molist 2007). Furthermore, it has been possible to establish a statistical correlation between the S-shaped profile and the presence of the proximal scar (Borrell 2006; Borrell and Molist 2007), which is remarkably high among the central blades.

Many blades from Mammarr Nasr 2 display a twisted profile to the right. Though it is difficult to quantify because of the high number of unidentifiable blade fragments (FIG. 14B), it can be stated that almost 60% of the blades produced at Mammarr Nasr 2 had a longitudinal section which is twisted towards the right. This trait correlates with the proximal left scar, which...
removes the bulb and the butt and corrects the S-shaped profile of the right edge. Both features have been identified on all blades (crested blades, upsilon, lateral, etc); most of them without retouch, and even on a few flakes. It is obvious that many of these blanks were not intended to be hafted and some of them could hardly have even been used. Further use-wear analysis of a substantial sample of pieces from different sites could help in developing an interpretation of such a characteristic feature.

Knappers, knapping expertise, and transmission of knowledge

Examination of the reduction sequence reveals that blade production was highly patterned and embedded in specific technical behaviors, and was developed within a shared technological knapping concept. Standardization of the knapping process and the blanks as well as the productivity allow us to infer a high level of knapping skills and recognize what has frequently been designated a “competent knapper” (Bodu *et al.* 1990; Pelegrin 1990; Pigeot 1990; Karlin *et al.* 1992) at Mamarrul Nasr 2. The fact that there is evidence only of highly competent knapping could indicate that the group of knappers was homogeneous in terms of skill level and age. Since apprenticeship is commonly associated with adolescence (Pigeot 1990; Pelegrin 1990; Roux 1990), the presence of a single level of expertise suggests that the knappers from Mamarrul Nasr were a group of adults. These knappers made temporary encampments in Mamarrul Nasr, a strategic spot in the passage to the Douara Basin close to the flint outcrops, and undertook intensive production of lithic tools. We do not know if they were organized as a group or acted individually but the same level of knapping was achieved by all the knappers and it has to be assumed that this is due to the absence of restrictions of knowledge related to flint knapping, at least between some groups. Similar episodes of intensive knapping were undertaken at many locations in the Douara and Palmyra basins, thus providing evidence of the wider transmission of a specific strategy within bi-directional technology.

At this point, however, it cannot be determined if blade production at Mamarrul Nasr 2 is a specialized production process. To approach such a question, it is necessary to try to understand its social value, the socioeconomical context of the settlement (Baird 2001), without over-valuing, a *priori*, the role played by technical complexity. In other regions, for example at some permanent sites of the Southern Levant, it has been stated that bi-directional technology was restricted to a small group of part-time specialists producing materials for exchange with other members of the social group (Quintero and Wilke 1995). This interpretation cannot be directly exported to other regions, particularly those with different socio-economical contexts such as those identified in the Douara and Palmyra basins. As little is known about the socioeconomical context in which the blade production at Mamarrul Nasr 2 and at the other workshops and campsites took place, we prefer to consider Mamarrul Nasr a specific context of intensive and repeated lithic production rather than a specialized production center.

**Evaluation of the off-set bi-directional strategy**

The off-set bi-directional strategy at Mamarrul Nasr 2 is characterized by a specific reduction sequence involving a narrow working surface, and by the fact that the direction of the debitage is slightly off-set, allowing the highest ratio of productivity of standardized central blades. The reduction sequence can thus be considered to be a subsidiary reduction strategy within the bi-directional blade method.

Standardized central blades were the desired blanks of the reduction sequence. At Mamarrul Nasr 2 although most are broken, the largest complete central blade is only 12.1 cm long, and most range from between 7.4 and 9.2 mm. The estimated sizes of the first central blades obtained were around 15–20 cm suggesting that the largest blades (12–20 cm) were taken away from the site. It is difficult to know how many blades were produced and exported or to make a techno-economical evaluation of the productivity of the off-set bi-directional strategy. Despite these difficulties, our study of the specific reduction sequence, the recognition of the different blade/flake types produced, and the identification of the characteristic features of every blank, make possible the reconstruction of an ideal reduction sequence and enable a calculation about its productivity.

The observation of the techno-economical representation seems at first sight balanced and reasonable. Around 30 cores fit with 120 crested blades (ideally four per core: two frontal to open the working surface and two dorsal to open the striking platforms) and with 82 core tablets (almost three rejuvenation tablets per core plus the two opening tablets that have been counted as dorsal crested blades). Comparison of frequencies of central, non-lateral, left lateral, right lateral, and indeterminate blades shows an important variation in the percentages (FIG. 14A). Indeterminate blades appear to predominate because most of them are medial or distal fragments of blades. Non-lateral blades are abundant though they give little information about the productivity of the off-set bi-directional strategy, as they are a heterogeneous group of multi-purposed blades which are neither lateral blades, nor the targeted pointed central blades but which occur as part of the reduction sequence. On the other hand,
the number and frequency of central blades and left and right lateral blades plays a key role in reconstructing the ideal reduction sequence and in the evaluation of the productivity of the cores. Left lateral blades were used to modify and prepare the working surface, but right lateral blades/flakes are very scarce. The difference in frequency of left and right lateral blades indicates an asymmetry in production due to the fact that left lateral and right lateral flake/blades have had different purposes and the right laterals were only used to modify and maintain the side of the core. Finally, because the central blades were the designated blanks, the negative blade removals on the cores and on the dorsal surface of these blanks help to explain the knapping sequence and reconstruct an idealized sequence (FIG. 15). This scheme indicates that there should be an agreement between the number of left lateral blades and central blades. This ratio (1 : 1) is evidence of the highest productivity obtained through the off-set bi-directional strategy. At Mamarrul Nasr 2, however, there is a clear difference between the number of central blades (194) and left lateral blades (401), which supports the idea that the largest and optimum central blades were taken off-site. A simple comparison (401 left lateral blades and only 194 central blades) is enough to conclude that at least around 200 central blades are missing, maybe more if we consider that a few lateral left blades, and some non-lateral blades might have been considered useful and taken away too.

By doing the same calculation using the total number of proximal scar spalls, the total number of blanks with proximal scars found at the site, the frequency of presence of the proximal scar on each type of blade points to the same conclusions. The 370 proximal scar spalls have been found but only 218 blades display the proximal scar (FIG. 14). Thus, about 170 blades with proximal scars are missing. Central blades are half of the blades with proximal scars but only around 55% (108 of 194) of the central blades display the proximal scar. Non-lateral blades are even more frequent than central blades, but only about 25% have a proximal scar, suggesting that proximal scars were mostly made on the targeted, twisted central blades, and on a few non-lateral blades, some of which could also have been used and taken away, but scarcely at all on other blanks that were considered by-products. According to this interpretation and the rates obtained, and considering that central blades were the main blanks that were brought away, it is possible to calculate that around 200 (110 with proximal scar) central blades are missing as well as about 50 (12 with proximal scar) non-lateral blades. Through this hypothesis the total number of blades with proximal scar would increase (218 + 110 + 12 = 340), fitting well with the total number of proximal scar spalls (370). At the same time, the estimated number of central blades produced would be around 400 too, fitting with the first calculation based only on the total number of left lateral blades abandoned at the site. At this point, although slight differences in percentages could be proposed, it seems reasonable to suggest that at least somewhere in the region of 400 central blades and 250 non-lateral blades were produced from 30 cores (13–14 central blades plus 8 non-central blades per core). Around half of the central blades were taken off-site together with some non-lateral blades and a small number of other blanks.

The off-set bi-directional strategy permitted knappers to reach a high productivity rate of standardized large pointed central blades. They were able to maintain strict control of the blades that they produced. We do not know which type of finished tools required such standard blanks, but they may have mostly been used to produce projectile points. Knappers at Mamarrul Nasr also produced a few other retouched tools on other blades and by-products, like denticulates and burins that were soon abandoned (27 burins fits 24 burin spalls). Other blanks like crested blades or flakes were roughly retouched and used (macro use-wear traces are evident in some artifacts). After that, the knapper/s left taking 200 central blades with them, some of which may already be transformed in tools.

Bi-directional technology in the central Syrian Desert: New insights

It has been possible to identify diagnostic traits of the reduction sequence, termed off-set bi-directional strategy, at all the sites located in Mamarrul Nasr. Comparative analyses of the lithic assemblages indicate that the opposed-platform bi-directional blade technology documented at Mamarrul Nasr and those found by the University of Tokyo in the Douara Basin and Palmyra region constitute a specific technocomplex (Borrell et al. in press b).

Further comparison of the lithic assemblages from Mamarrul Nasr and the well dated Neolithic sites from El Kowm (Umm el Tlel, Qdeir 1, and El Kowm 2) shows significant differences, especially with Umm el Tlel (Borrell et al. in press a, in press b). Lithic production in both regions was oriented toward bi-directional blade production from opposed-platform cores, but data from the El Kowm region was not conclusive enough to suggest the existence of the off-set bi-directional strategy reduction sequence in that region. Our examination of the reduction sequence reveals different knapping concepts and technical behaviors, as it has been possible to observe through the comparison of the length/width indexes of the bi-directional cores from Mamarrul Nasr 2 and Umm el Tlel (FIG. 16A–B). In conclusion, at this stage it seems reasonable to suggest that two different lithic technocomplexes co-existed in the central Syrian Desert.
Desert region at the end of the 8th millennium \( \text{CAL} \) B.C and the beginning of 7th millennium \( \text{CAL} \) B.C (Late/Final PPNB).

The chronology of the technocomplex identified in El Kowm region can be established to the first half of the 7th millennium \( \text{CAL} \) B.C. and the earliest radiocarbon date from El Kowm 2 is \( 8030 \pm 80 \text{ B.P.} \) (7100–6620 \( \text{CAL} \) B.C.) (Stordeur 2000: 305). Persistence of bi-directional technology in El Kowm during the Final PPNB (first half of the 7th millennium \( \text{CAL} \) B.C.) is one of the sets of evidence that has led to belief that the central Syrian Desert was an oasis or island, as some researchers have called it (Stordeur 2000), that followed a distinct path of development separate from the mainstream of the core regions of the Northern and Southern Levant where bi-directional technology was abandoned for different reasons (Quintero and Wilke 1995; Nishiaki 2000, 2007; Abbès 2003; Borrell 2007, in press b).

Fine-tuning the dating the Neolithic technocomplex identified in the Douara and Palmyra basins, which means dating the off-set bi-directional strategy in this region, can only be done through typological and technological comparison of the lithics with those from other dated sites. The obvious similarity between the Douara and the Abu Hureyra D (Middle PPNB) technologies was already documented in the 1990s (Nishiaki 2000). The earliest evidence of the use of the off-set bi-directional strategy at a stratified and well dated site with a detailed lithic analysis in the Northern Levant has been documented at Tell Halula, dating to the end of the Middle PPNB (Borrell in press a). It expanded rapidly from 7700 \( \text{CAL} \) B.C. onwards to the lower part of the middle Euphrates Valley and probably to the Balikh Valley, while blanks with similar and diagnostic traits can be found over a wide area (Nishiaki 2000; Borrell 2006, in press a). The off-set bi-directional strategy was abandoned in the Euphrates Valley at the very end of the Late PPNB, in much the same way that the bi-directional technology of the Northern Levant was abandoned. This could suggest an early date (end of Middle PPNB and beginning of the Late PPNB) for the Mamarrul Nasr Neolithic complex but there is no other evidence to support the existence of substantial settlement of this region at this time. A later chronology, therefore, seems more plausible in accordance with the well dated Neolithic sites from El Kowm (Final PPNB–PN). Even though this seems probable, it is not yet known why and how the off-set bi-directional strategy could be so widely represented in the Douara region when it had already been abandoned in the core region of the Euphrates Valley. Furthermore, if we assume that the technocomplexes coexisted, it is difficult to explain why the off-set bi-directional strategy, which seems to originate in the Euphrates, has not been identified at El Kowm, between the Douara and the Euphrates Valley, while it is present in the Douara and Palmyra basins.

Conclusions

The central Syrian Desert is an under-studied region in comparison with neighboring regions. Our project aimed to fill this gap and focused on gaining new insights into the Neolithic period of this semi-desert region with a particular development differing from the mainstream processes of Neolithization observed in neighboring regions. During the Pre-Pottery to Pottery Neolithic transition most parts of northern Syria such as the Balikh, Euphrates, and Khabour valleys witnessed a series of important socioeconomic changes, the causes, consequences, and rhythms of which are still debated. Out of the main stream, the central Syrian Desert remained a sort of island based on conservatism in technology (e.g. Nishiaki 2000: 95) and characterized, for example, by the extensive use of bi-directional technology and the absence of pottery. The meaning of this technological conservatism cannot yet be explained, but there is no doubt that detailed analyses of the lithic assemblages are useful for understanding the socioeconomic implications of bi-directional technology.

The reconstruction of the reduction sequence from Mamarrul Nasr 2 reveals a restricted but systematic range of technical behaviors and operational sequences within a shared technological knapping concept that implies a high level of knapping expertise. It is a different reduction strategy within the bi-directional blade method characterized by its high ratio of productivity of very standardized central blades. The analysis also contributes to a better understanding of the socioeconomic organization of the groups who undertook blade production at the site and identifies the presence of competent knappers, though it is not yet possible to state whether flint workshops and other flint concentrations provide evidence of nomadic or semi-nomadic communities that lived permanently in the region, or if these groups of competent knappers could come from more established communities far from Douara Basin. Present data point to the existence of highly-mobile groups who ventured repeatedly deep into the steppes to undertake flint knapping to produce blades and tools, probably tanged points, which were taken away from the production sites. The absence of permanent settlements in the region, the strategic position of the passage, the identification of a desert-kite next to the sites, the presence of a group of competent knappers, and the existence of only one reduction strategy to obtain central blades allows us to state that the massive exploitation of mineral resources at Mamarrul Nasr was a seasonal/temporary task and that the location and amazing concentration of flint workshops at that strategic spot was probably related
to the exploitation of steppic animal resources. The sites should be understood as short-time shelters where the production of large, robust and straight blades ideal for transforming into projectiles would be the main activity. These projectiles were produced in strategic spots and taken to be used during short periods of intense hunting in the steppes involving the construction and use of desert kites, whether these structures were intended for hunting, capturing, trapping, or enclosing wild or semi-domesticated animals.

The temporal and spatial distribution of the off-set bi-directional strategy in the central Syrian Desert has revealed the existence of two technocomplexes in that region, indicating an important variability in the bi-directional method and pointing to the existence of different lithic traditions, indicating the existence of a richer sociocultural background, probably the result of the clustering of minor cultural units. Further comparison with the lithic assemblages from middle Euphrates Valley (Halula, Bouqras, and Abu Hureyra), where the off-set bi-directional strategy has been identified during the Middle/Late PPNB, permits us to establish a connection between the large and permanent settlements along the Euphrates Valley and the abundant campsites and workshops from the Douara and Palmyra basins, suggesting a possible origin for the them. The fine tuning of the chronology of the Mammarr Nasr Neolithic complex is a key element that will allow to determine whether the Neolithic settlement of central Syrian Desert is contemporary with the existence of the major Middle/Late PPNB sites along the middle Euphrates Valley and before the foundation of the Final PPNB sites from El Kowm or if, as actually proposed, the “conquest” of the semiarid steppes of central Syria started at the beginning of the 7th millennium CAL B.C., meaning that both technocomplexes identified at the central Syrian Desert coexisted.

In conclusion, we have outlined a growing picture of variability in the technologies, toolkits, and social contexts in Neolithic central Syria that allows us to reopen the debate about the complexity of the Neolithization process in that region, its chronology, and the origin of the Neolithic communities that adapted to a challenging environment. Our results point to the significance of this region for fully understanding the Neolithization of the Northern Levant, and providing valuable data for better understanding the socioeconomical transformations that occurred “out there,” far from the oasis.

Acknowledgments
I would like to express my gratitude to M. Molist, E. Boëda, Al-Shakel, and O. Vicente for their kind and helpful support concerning this study. I am also grateful to the General Direction of Antiquities and Museums of Syria, the French Ministère des Affaires Etrangères, the Spanish Ministerio de Ciencia y Tecnología (HUM2007-66237), the Spanish Ministerio de Ciencia e Innovación (MICINN/Fulbright 2008-0125), and the Generalitat de Catalunya (SGR-2009-00607). I am also thankful to Y. Nishiaki, T. Akazawa, and S. Fuji. Without their pioneering work in Palmyra and Douara basins this paper wouldn’t have been possible. Finally, I gratefully acknowledge the comments, criticisms and corrections made by Elizabeth Healey, Jacques Pelegrín, and the anonymous peer reviewers.

Ferran Borrell (Ph.D. 2006, Universitat Autònoma de Barcelona) is a post-doctoral fellow at the School of Arts, Histories and Cultures of The University of Manchester. His research focuses on the study of the Neolithic period in the Mediterranean basin and the Near East. He is involved in different projects in Syria, Turkey, Western Sahara, and northeastern Spain. His main research subjects are lithic production, raw materials characterization and exchange networks. Other research interests include identification of craft specialization, prehistoric mining, and social complexity of the first farmer communities.

References