

## Settlement Dynamics and Cultural Interactions in Upper Pleistocene Libya: A Historical and Eco-Evolutionary Perspective

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ديناميات الاستيطان والتفاعلات الثقافية في ليبيا خلال البليستوسين الأعلى: منظور تاريخي وإيكولوجي-تطوري

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Received: January 09, 2026

Accepted: February 14, 2026

Published: February 21, 2026

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### Abstract:

Although extensive research has been conducted on Pleistocene cultures in Libya, our understanding of human settlement dynamics and patterns of cultural exchange during the Upper Pleistocene remains limited and fragmented. To the best of the author's knowledge, most previous studies have focused primarily on classifying lithic assemblages within stratigraphic and typological frameworks and analyzing habitation sites, often neglecting an integrated approach that connects spatial, temporal, and cultural dimensions. Paleoenvironmental evidence indicates successive phases of aridity and humidity; however, the impact of these environmental changes on human mobility, settlement distribution, and cultural exchange remains insufficiently explored. This study seeks to address these gaps by adopting a dual historical and eco-evolutionary perspective, emphasizing the dynamic interplay between environmental change, human settlement, and cultural interaction. The analysis is further expanded to incorporate the "Green Corridors" hypothesis and genetic evidence, while employing an eco-cultural methodological framework to examine human mobility across diverse ecological settings and its relation to ecological and technological mechanisms underlying cultural and economic transformations. The results reveal morphological and typological similarities between Pre-Aurignacian and Dabban tools at Haa Fteah Cave in Libya and those from Mount Carmel in Palestine and Ksar Akil in Lebanon. Moreover, environmental equivalencies were observed among human groups in the Tadrart Acacus, Hoggar, and Air-Ténéré regions. The study also demonstrates that changes in human settlement patterns were influenced not only by environmental fluctuations but even more strongly by transformations in the structural and functional characteristics of human groups. Overall, the stratigraphic sequences and artifacts from Jabal al-Akhdar, Tadrart Acacus, and Jebel Gharbi provide a unique window into a network of cultural interactions spanning the coastal zones, the Sahara, and the Levant, likely involving the exchange of technological elements, ideas, and adaptive behaviors. Collectively, these findings position Libya as a central hub for understanding the dispersal of modern humans in the region, whether through early migrations out of Africa or reverse movements from the Levant.

**Keywords:** Upper Pleistocene, Eco-cultural, Pre-Aurignacian, Libya, Aterian, Cultural Interactions.

## المخلص:

على الرغم من كثرة البحوث حول ثقافات البليستوسين في ليبيا، إلا أن فهمنا لأنماط الاستيطان البشري والتبادل الثقافي خلال البليستوسين الأعلى لا يزال محدودًا ومجزأ؛ إذ ركزت الأبحاث السابقة—على حد علم المؤلف—غالبًا على تصنيف الصناعات الحجرية ضمن أطرها الاستراتيجية والتكنولوجية وتحليل المواقع السكنية، متجاهلةً الربط بين الأبعاد المكانية والزمانية والثقافية. كما يشير السجل البيئي القديم إلى تعاقب فترات من الجفاف والرطوبة، غير أن تأثير هذه التغيرات في حركة الإنسان، وتوزيع المستوطنات، والتبادل الثقافي، لم يُدرس بشكلٍ كافٍ. وعليه، تهدف هذه الدراسة إلى معالجة هذه الفجوات من خلال طرح منظور مزدوج، تاريخي وإيكولوجي-تطوري، مع التركيز على الترابط بين البيئة والاستيطان والتفاعل الثقافي. كما تسعى إلى توسيع مجال التحليل ليشمل فرضية "الممرات الخضراء" والأدلة الجينية، وتقرح اعتماد المنهج الإيكولوجي-الثقافي لفهم التنقل البشري بين البيئات الفيزيولوجية المختلفة، وربط ذلك بالميكانيزمات الإيكولوجية والتقنية للتحويل الثقافي/الاقتصادي. تشير النتائج إلى وجود تشابه في مورفولوجية وتيبولوجية الأدوات ما قبل الأوريجانسية والضبعانية في كهف هوى أفتيح في ليبيا، مع الأدوات المكتشفة في كهوف جبال الكرم في فلسطين، وقصر عقيل في لبنان. كما تم الكشف عن وجود متكافئات بيئية بين المجموعات البشرية في تادرارات الأكاكوس، والهوجار، والإير-تنيري. إضافةً إلى ذلك، أظهرت الدراسة أن التغير في نمط الاستيطان البشري كان مرتبطًا بالتغيرات في البيئة الطبيعية، وبدرجة أكبر بالتغير في المظاهر البنيوية والوظيفية. وعلى العموم، تفتح التواترات الاستراتيجية والمواد الصنعية القادمة من الجبل الأخضر، وجبال تادرارات أكاكوس، والجبل الغربي، نافذةً لرصد وتتبع شبكة من التفاعل الثقافي بين الساحل والصحراء والمشرق، شملت—على الأرجح—تبادل عناصر تقنية، وربما أفكارًا وسلوكيات تكيفية. وبناءً على ذلك، تجعل هذه المعطيات من ليبيا مركزًا محوريًا ورئيسًا لدراسة حركة انتشار الإنسان الحديث في المنطقة، سواء أكان ذلك خروجًا مبكرًا من أفريقيا، أم هجرةً معاكسةً من المشرق.

**الكلمات المفتاحية:** البليستوسين الأعلى، إيكولوجي-ثقافي، ما قبل الأوريجانسية، ليبيا، العاترية، التفاعلات الثقافية.

## Introduction:

Despite the numerous studies addressing Pleistocene cultures in Libya, our understanding of human settlement dynamics and patterns of cultural exchange during the Upper Pleistocene remains limited and fragmented. Most previous research—within the scope of the present author's knowledge—has focused primarily on the classification of lithic assemblages within stratigraphic and typological frameworks, as well as on the description and analysis of habitation sites, while largely overlooking an integrative perspective that connects spatial, temporal, and cultural dimensions. Nevertheless, some scholars have attempted to examine the cultural content of prehistory through alternative approaches. Among the most notable is the work of Graeme Barker, who approached Libyan prehistory and early history within a broader pan-African context (Barker, 1989, pp. 31–43).

Moreover, paleoenvironmental reconstructions indicate that North Africa experienced successive—and at times overlapping, phases of aridity and humidity. Yet, the impact of these environmental shifts on human mobility, settlement distribution, and cultural exchange has not been systematically or adequately assessed. Accordingly, this study seeks to address this gap by adopting a dual historical and evolutionary-temporal perspective, highlighting the interconnections between environmental change, human settlement, and cultural interaction in Libya during this period.

In general, this topic is characterized by several major challenges and persistent knowledge gaps, which may be summarized as follows: (1) **The Eco-Phenological Gap:** Although the impact of climatic fluctuations on the distribution of natural resources is well established, the relationship between these environmental changes and human adaptive behavior remains insufficiently supported by empirical evidence. This limitation renders our understanding of hunter-gatherer responses incomplete and, at times, fragmented. (2) **The "Dead-End" Paradigm:** Paleoanthropological literature has often suggested that North Africa represented an evolutionary cul-de-sac, thereby excluding it from discussions of the emergence and development of modern humans. However, the mandibles recovered from Haula Fteah Cave provide significant evidence supporting the dispersal of modern humans, comparable to finds from Jebel Irhoud and Taforalt in Morocco. These discoveries reinforce the view that North Africa functioned as a center of cultural development and human migration. (3) **Techno-Spatial Disparity:** The technological similarities between the Pre-Aurignacian and Dabban industries in the Jabal al-Akhdar and their counterparts at Mount Carmel in Palestine and Ksar Akil in Lebanon suggest the existence of interaction networks. However, this raises key questions regarding the nature of such connections: were they the result of direct human migrations (demic diffusion), or merely forms of transient cultural exchange? Additionally, the extent to which these influences spread into western Libya and the Saharan interior remains unclear.

This study also seeks to address a broader question concerning the mechanisms underlying changes in human settlement patterns. While many researchers emphasize environmental change as the primary driver of such transformations—often framed within the principle of environmental

determinism and expressed through the simplified equation (**water + food = human settlement**)—this reductionist perspective has significantly influenced general interpretations of settlement sites, lithic industries, and subsistence strategies, not only in Libya but across the Old World. This issue clearly requires stronger empirical support and more in-depth investigation through interdisciplinary approaches grounded in the integration of multiple fields within a historical eco-evolutionary perspective. Accordingly, this study expands its scope to include the “Green Corridors” hypothesis and genetic evidence, while also examining patterns of cultural interaction within Libya—between the coastal zones, the Sahara, and the Mediterranean world—raising the question of whether Libya functioned as a hub of interaction or remained relatively isolated.

Given that technical terminology in Mediterranean and North African archaeological and historical studies serves a specific analytical function in identifying cultural horizons (di Lernia and Garcea, 1997, pp. 11–21), this paper proposes the use of the “eco-cultural” concept in analyzing Upper Pleistocene settlement patterns in Libya and tracing their transformations and cultural interactions.

As will be elaborated in this paper, the eco-cultural approach considers both natural and cultural environments as key, interdependent factors shaping human mobility and societal development across different chronological phases, encompassing economic and technological dimensions. While the application of modern concepts such as “eco-cultural” to prehistoric data may be viewed as potentially problematic, it is argued here that it offers significant methodological advantages. Indeed, the adoption of new analytical frameworks in archaeological and historical research has become both necessary and urgent—an epistemological imperative—not only to move beyond outdated terminological debates and their associated ambiguities, but also to establish a solid foundation for reconstructing the chronological, cultural, and technological record of prehistory in Libya, North Africa, the Mediterranean basin, and Africa as a whole within a critical and comprehensive framework.

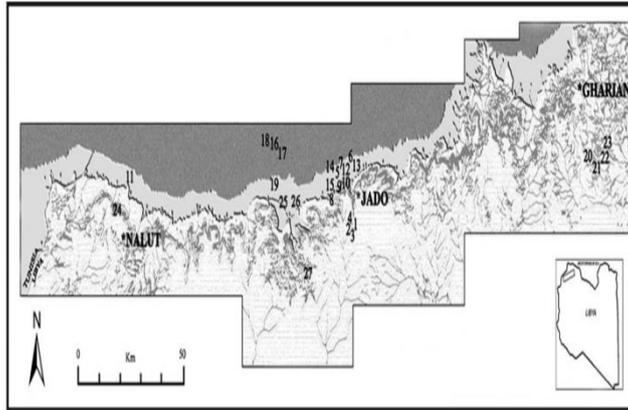
For instance, the emergence and development of Acheulean, Levallois–Mousterian, and Aterian traditions were shaped by both geographical and cultural processes, and their nomenclature itself derives from diverse spatial and regional contexts. In general, archaeological and historical studies point to evidence of cultural exchange, reflected in both similarities and regional differences between Upper Pleistocene settlement sites in Libya and those in the Nile Valley, North Africa, and Southwest Asia. These patterns are evident in lithic morphology and typology, adaptive behavior, economic strategies, and chronological sequences, among other aspects—issues that this study seeks to highlight.

Furthermore, the term “Libya” in prehistory and early history carried complex historical, linguistic, and geographical meanings, encompassing diverse cultural identities and spatial-temporal dimensions. Without delving into the various historical terminologies used by ancient writers, it suffices to refer to the concept of the “Libyan Sahara” as a terminological framework describing a vast geographical unit that includes parts of Libya, Egypt, and western Sudan (or Nubia). Scientifically, this term remains one of the most appropriate for characterizing the region as a broad and complex environmental system (Heiko and Karin, 2019, pp. 195–216). On the other hand, Libya constituted a dynamic cultural and ecological space repeatedly inhabited—over extended periods—by successive groups of hunter-gatherers equipped with diverse lithic technologies and practicing subsistence strategies based on locally available environmental resources. It is essential to emphasize the environmental changes that affected Libya in particular and North Africa in general during the Upper Pleistocene and Early Holocene, which played a crucial role in large-scale population movements across the continent, influencing—directly or indirectly—the distribution of populations and languages up to the present day.

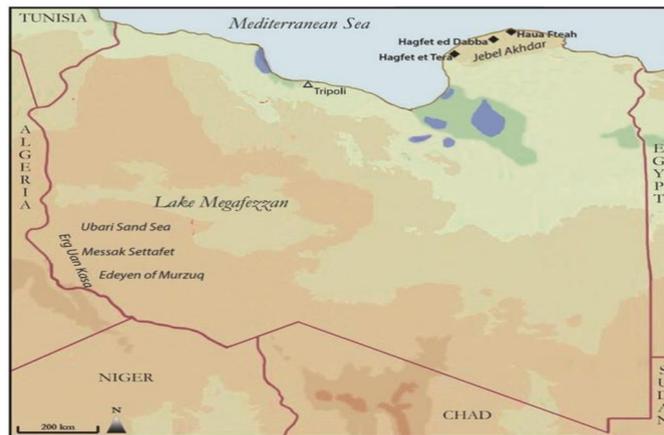
Finally, Upper Pleistocene settlement sites in Libya hold exceptional importance for archaeological, historical, paleoanthropological, and geological studies of North Africa. At Haua Fteah, deep stratigraphic soundings have revealed a highly detailed archaeological sequence and one of the most complete successions of Upper Pleistocene industries known in North Africa and the Mediterranean basin. Meanwhile, Uan Afuda Cave in the Acacus Mountains, with its well-defined and successive developmental sequences, represents an ideal model for understanding the emergence of cultural complexity among human groups in the Central Saharan highlands.

### **The Eco-cultural methodology:**

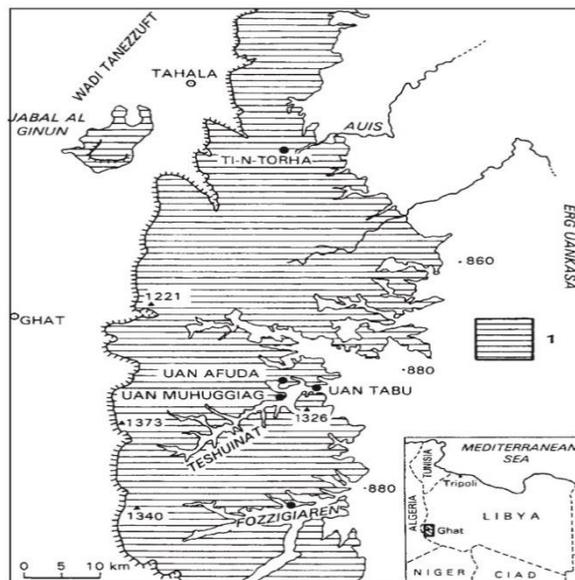
An examination of the geo-historical map of prehistoric Libya reveals that human settlement patterns emerged and flourished across three primary ecological zones: the coastal belt, the mountainous highlands and valleys, and the modern-day Saharan interior. In the north, two pivotal regions dominate the landscape: Tripolitania to the west (Garcea, 2012, 131–132) and Cyrenaica to the east (Farr et al., 2014, 163–173). Both regions are defined by prominent topographic features: Jebel Gharbi in the west (Figure 1) and Jebel al-Akhdar in the east (Figure 2). Furthermore, the scope of human habitation extended deep into the southern territory of Fezzan, with a significant concentration in the Tadrart Acacus massif and its surrounding basins (Figure 3) (Lahr et al., 2008, 263–294).



**Figure (1):** map showing the distribution of archaeological sites in the Jebel Gharbi (Northwest Libya): Early MSA site: 11 Wadi Nalut, SJ-00-60. 2 Ras el Wadi, SJ-98-27; 3 Ras el Wadi, SJ-98-27A; 4 Ras el Wadi, SJ-98-28; 5 Shakshuk West, SJ-00-55/Test 2; 6 Shakshuk East, SJ-00-55 East; 7 Shakshuk West, SJ-00-56/Ext. 2; 8 Mahatta Frid, SJ-00-57; 9 Shakshuk West, SJ-00-58; 10 Shakshuk West, SJ-00-58A; 13 Aïn Soda, SJ-02-67; 14 Wadi Sel, SJ-02-68; 15 3 km W Shakshuk, SJ-0269 16 'Wadi Ali, SJ-02-70; 17 Wadi Ali, SJ-03-71; 18 Wadi Ali, SJ-03-77 19 'East Badarna, SJ-03-78; 20 Wadi Ghan, SG-99-40; 21 Wadi Ghan, SG-99-41; 22 Wadi Ghan, SG-99-46; 23 Wadi Ghan, SG-00-61; 24 Nalut, SJ-06-89; 25 Josh, SJ-06-88; 26 Josh, SJ-06-87; 27 Josh, SJ-06-86 .LSA site: 12 Shakshuk East, SJ-02-66. (Garcea, 2012, 129).



**Figure (2):** Human settlement sites in Jebel al-Akhdar, Cyrenaica. (After Garcea, 2023, 676).



**Figure (3):** Human settlements in the Tadrart Acacus Mountains. (After di Lernia, 1999a, 3)

Within these three ecological zones, hunter-gatherers and fishers lived in small, dispersed groups whose rudimentary cultures were profoundly shaped by their natural surroundings, yet characterized by constant interaction with neighboring communities. At this juncture, it is essential to reiterate a fundamental axiom: the culture of any human group cannot be adequately analyzed in isolation from its environmental context. During the Paleolithic era, humans were entirely dependent on the natural world, roaming the landscape over vast periods in pursuit of game and wild flora. Consequently, the natural environment remains a cornerstone of cultural studies, particularly as eco-cultural researchers assert that humans are essentially products of their environment, a force that continuously modulates every stage of the human life cycle (Sutton and Anderson, 2010, 91–97).

When addressing environmental themes, several pivotal questions arise: Did prehistoric hunter-gatherers perceive their surroundings as a singular, monolithic entity, or as a multifaceted construct composed of numerous discrete elements? The material record suggests a nuanced perspective: these groups likely viewed the environment as both a cohesive and a fragmented entity, a duality synthesized through complex cognitive processes and articulated through symbolism.

Perhaps the most compelling artifacts testifying to this behavioral complexity are the specialized bone tools crafted by the Aterian hunter-gatherers of Libya and North Africa approximately 90,000 years ago (Bouzouggar et al., 2018, 2). These implements, measuring roughly 122 mm in length, were fashioned from the ribs of large mammals (likely of the *Bovidae* family) through meticulous carving, scraping, and polishing—suggesting their specialized use as knives for processing fish.

Another striking example of this behavioral sophistication is found within the stratigraphic sequence of Haua Fteah cave (Prendergast et al., 2016a, 80–93), specifically in the abundance of mollusks and shellfish recovered from the Dabban industry layers. Beyond serving as a nutrient-rich food source, these marine organisms were likely utilized for non-dietary purposes; their shells were repurposed to manufacture ornaments. This practice mirrors the symbolic behavior observed at Blombos Cave in South Africa and serves as a key proxy for Modern Human Behavior, which first emerged approximately 200,000 years ago (d’Errico et al., 2005; Wong, 2006, 76).

Culture, much like the environment, is subject to a wide array of definitions, interpretations, and conceptual frameworks among specialists. These discrepancies are often subtle, frequently obscured by differing theoretical stances and specialized technical nomenclature. From this perspective, culture serves as the primary lens through which humanity perceives and navigates the external world; it is the fundamental strategy for human adaptation to environmental fluctuations. Specifically, "culture" in this context refers to the ancestral groups inhabiting the Libyan region, living in a state of perpetual interaction with their natural surroundings. The environment does not merely influence human life; it plays a decisive role in the distribution of critical resources, including flora, fauna, and raw materials. Consequently, even the selection of settlement sites—along with their constituent materials—and demographic distributions are largely dictated by environmental parameters.

Furthermore, human groups—the architects of culture—exist in a state of continuous mutual interaction. The behavioral patterns emerging from these social dynamics can be discerned through hunting strategies, as well as through the sedimentation processes and post-depositional dynamics that shape the archaeological record (Rosenstock, 2018, 252-253). Ultimately, artifacts and archaeozoological remains provide indispensable data, offering profound insights into group behavior and their intricate, symbiotic relationship with the surrounding ecosystem.

The classification of Late Pleistocene cultures in Libya and other Old World regions—traditionally based on morphological and functional diversity—often masks a profound methodological and terminological ambiguity. Historically, researchers have categorized prehistoric cultures through variations in lithic assemblages, assigning them distinct names that eventually evolved into proxies for cultural identities and, more significantly, evolutionary sequences. However, as new discoveries emerge, this taxonomic process has become increasingly convoluted. Scholars now face a formidable challenge: mapping cultural and behavioral shifts across space and time is exceptionally complex, as traditional hypotheses regarding cultural change are being directly challenged by modern interpretations rooted in multidisciplinary frameworks. This analytical trend brings us to the work of Gonen Sharon, whose study of human behavior, cognitive capacities, and adaptation to diverse ecosystems is predicated on the principle of convergent cultural evolution. Sharon utilizes the Acheulean hand-axe—which appeared in geographically disparate locations—as an archetypal model for cultural change; these tools exhibit striking similarities in both form and intended function. Drawing upon the lexicon of evolutionary anthropology, Sharon argues that the invention of the Acheulean handaxe is analogous to the origins of writing, agriculture, or the wheel: it emerged within a specific socio-environmental context before dispersing globally through the transmission of information or demic diffusion (Sharon, 2019, 237–247).

For these reasons, the eco-cultural framework stands as the most comprehensive paradigm for examining the adaptive behavioral shifts of Paleolithic hunter-gatherer groups. This lens allows for a meticulous tracing of settlement formation—a process inherently tied to paleoenvironmental fluctuations—and the analysis of their sedimentary records. Central to this approach is the recognition of how resource variability dictates the expansion, diversification, or contraction of subsistence systems. Such dynamics are invariably intertwined with adaptive modifications in site selection, group size, and the morphological and functional attributes of lithic industries. I have frequently reflected on the evolving paradigms of the "natural environment," seeking to identify the primary mechanism driving shifts in settlement patterns and subsistence strategies among the region's Pleistocene inhabitants. Invariably, the "prime suspect" in this cultural metamorphosis is paleoclimate.

Broadly, paleoclimatic data is invoked to interpret human habitation, track its transformations, and delineate migrations triggered by environmental pressures. The reconstruction of paleoclimates has become a vital endeavor, offering immense scientific value to the advancement of prehistoric studies and the broader cultural horizons of the Old World. Consequently, since the 1990s, paleoclimatology has assumed a pivotal role in prehistoric research. Integrated data regarding faunal, floral, and physical environments now provide the systematic and technical foundation for modern prehistoric perspectives—perspectives that strive to evaluate ecological, biological, and technological datasets in a unified manner (deMenocal, 2011, 540). During the Late Pleistocene, Libya experienced profound environmental upheavals, the magnitude and impact of which were as significant as those felt across North Africa, Southwest Asia, and Europe (Barnosky et al., 2004, 71–72; Surovell and Waguespack, 2005, 6231–6236).

#### **Environmental Context: Fluctuations Between Humid and Arid Phases:**

We now turn to the findings of recent field studies to evaluate how they have refined or expanded our understanding of the prehistoric environment, climate, and human presence in Libya and its adjacent regions. Comprehensive geological, morphological, pedological, palynological, and micromorphological surveys—primarily conducted from the 1960s through the 1980s—focused on Late Pleistocene and Early Holocene data. These investigations yielded robust radiocarbon and stratigraphic sequences that illuminate the natural conditions of the era and their profound influence on human habitation and subsistence strategies. The resulting evidence is remarkably diverse, featuring well-preserved paleoenvironmental records protected from microbial degradation and erosion; these include sedimentary successions, pollen spectra, malacological remains (mollusks), and various botanical and faunal assemblages. This research has been particularly concentrated within the Libyan Desert, the Nile Valley, the Lake Chad Basin, and across the Saharan interior to the Atlantic coast (Cancellieri et al., 2016, 125–126).

These findings indicate that the hydrological status of the Pleistocene—specifically the interplay of thermal and aquatic conditions—fostered open microclimates characterized by high humidity and intensified precipitation. This favorable environment led to a concentration of floral and faunal biomass, establishing ideal "occupation levels" for human groups. Consequently, these archaeological sites are marked by dense accumulations of organic debris alongside sophisticated lithic assemblages.

In a more rigorous scientific sense, the reconstruction of North African paleoenvironments is anchored in fundamental climatic sequences, most notably the Chad–Tibesti system (Adaba, 2026; Hering et al., 2025; Hoelzmann et al., 2025). It is geologically established that during the Last Glacial Period, the Lake Chad Basin expanded into a massive inland sea comparable in scale to the Caspian Sea (Yacoub, et al, 2023; Quade et al, 2018; Cancellieri et al., 2016, 125–126). This "Mega-Lake" irrigated a vast territory, stretching from the Central Saharan massifs to the adjacent savannas and tropical forests. The cyclical expansion and contraction of this system significantly shaped the paleomorphology of the Tibesti, Hoggar, and Acacus ranges. Within this framework, ( Barich, 1984; Adaba, 2026; Adaba, 2022) posit a direct correlation between the climatic oscillations of the Chad–Tibesti system and the socio-cultural developments at Ti-n-Torha, as evidenced by the high-resolution paleomorphological data found in faunal and botanical macrofossils.

Over the past two decades, paleoenvironmental research methodologies have advanced significantly. The diversification of analytical techniques and the evolution of high-resolution technologies have illuminated previously obscure facets of ancient ecosystems, climatic oscillations, and their profound impact on human trajectory. It is now increasingly evident that the Late Quaternary in North Africa was defined by critical climatic phenomena, where intermittent humid phases alternated with prolonged arid intervals—a dynamic that fundamentally steered the evolution of prehistoric societies (Armstrong et al., 2023).

While the drivers of these fluctuations remain a subject of debate due to their complexity, a broad consensus has emerged: the heightened humidity and precipitation during the Terminal Pleistocene were primarily triggered by a northward migration of the Monsoon belt (Skonieczny et al.,

2019, 1–8). A seminal consequence of this atmospheric shift was the onset of the African Humid Period (AHP). Beginning approximately 20,000 years ago, this era transformed the Libyan Desert into a lush, open ecological system teeming with floral and faunal resources. This transition effectively reclassified the region from a "marginal environment" into a highly favorable habitat for sustainable human settlement (Hao et al., 2026; Nutz et al., 2024; Dallmeyer et al., 2020, 117–140; Sha et al., 2019, 14093–14102).

Pollen spectra distributions and geological proxies—most notably speleothems enriched with oxygen isotopes—reveal that the past 140,000 years were marked by significant fluctuations in temperature and moisture, triggering a notable northward and westward migration of vegetative cover. These environmental shifts profoundly influenced the trajectory of human societies across Libya, North Africa, and the Sahara, as well as the Arabian Peninsula and the Levant (Kutzbach et al., 2020, 2255–2264; Hartman et al., 2010, 106).

In light of these data, the eco-cultural approach provides a robust framework for comprehending prehistoric societies and their environmental interdependencies. It offers critical insights into the transformation of human behavior and customs, suggesting that the interaction between humanity and the environment is the catalyst for the emergence of the Cultural Area. In this view, the environment is not merely a passive vessel for human activity; rather, humanity and the environment constitute a unified, dynamic eco-cultural entity.

From this perspective, I propose the following hypothesis: Late Pleistocene hunter-gatherers in Libya successfully adapted to volatile environmental conditions by leveraging the cumulative culture acquired through high mobility and continuous interaction with their biosphere. This sophisticated indigenous knowledge of the natural world functioned as a "cognitive reservoir," empowering groups to navigate climatic flux and economic instability while forging innovative cultural solutions to resource unpredictability.

Consequently, cumulative culture has emerged as a cornerstone in the study of human cultural complexity. This concept refers to the accretion of continuous evolutionary modifications within Late Pleistocene assemblages and subsistence economies. As Haidle (Haidle, 2019, 128–130) asserts, cumulative culture is a fundamental process acquired by human groups through interactive social learning, which facilitates the transmission and refinement of complex skills and technologies across generations.

In this framework, human culture is conceptualized not as a static body, but as a dynamic and kinetic entity—one that is preserved and transmitted through social learning, practice, and adaptation, while undergoing continuous modification across chronological stages and generations. As Haidle (Haidle, 2019, 132) observes, cumulative culture was never a singular, episodic event occurring within a brief interval; rather, it was the result of multifaceted, overlapping, and incremental processes spanning millennia.

Regardless of these complexities, the eco-cultural mechanisms most influential in the lives of Paleolithic hunter-gatherers can be traced and measured through three primary pillars: environmental determinism, the Green Corridors hypothesis, and genetic/hereditary factors. From the perspective of environmental determinism, our understanding of the symbiotic relationship between natural environmental shifts and their impact on Late Pleistocene hunter-gatherers has been significantly bolstered by recent scholarship. These studies indicate that Libya underwent humid phases punctuated by arid and semi-arid intervals, which fundamentally dictated human settlement patterns. For instance, extreme aridity in the Tadrart Acacus region (southwestern Libya)—linked to the expansion of desert systems approximately 69,000 years ago—led to the desiccation of paleolakes within and around the mountain massifs. This period was characterized by increased calcium carbonate deposition and the accelerated erosion of weathered slopes.

Consequently, these rigorous environmental pressures compelled human groups to migrate out of the Saharan interior, predominantly dispersing toward the north (di Lernia, 1999c, 223–224). Notably, this aridification led to the "eclipse" or decline of Aterian industries in the desert; meanwhile, the Jebel al-Akhdar witnessed the flourishing of the Dabban industry at Haua Fteah cave, coinciding with cooler climatic conditions (Prendergast et al., 2016a, 94–95).

Within this ecologically-driven framework, the Aterian occupation—as well as the preceding Acheulean and Mousterian phases—in the Saharan region has been closely linked to the humid fluctuations of the Late Pleistocene. This correlation is predicated on the principle of geographical determinism, which posits that the emergence of humid conditions was a fundamental prerequisite for human habitation (di Lernia, 1999c, 226). This conceptual model has profoundly shaped general interpretations of settlement sites, lithic industries, and their relationship to modern human dispersals, not only within the Acacus region but also across the Central Saharan massifs, the Nile Valley, and Mediterranean African sites (Foley and Lahr, 2015, 4). Furthermore, Middle Paleolithic settlement

patterns in the Jebel Gharbi —specifically at Shakshuk, Wadi Ghan, and Wadi Ain Zargha — demonstrate a clear distribution along freshwater springs formed by Quaternary tectonic activity. These springs served as perennial attraction points for Aterian hunter-gatherers, who established both sedentary and mobile camps there between 80,000 and 40,000 years ago (Garcea & Giraudi, 2006, 412–419).

Evidence suggests a discernible migration of hunter-gatherer groups from neighboring regions in North Africa and the Central and Western Sahara toward these water sources. These sites seemingly evolved into resource-rich refugia, providing a critical sanctuary for populations, particularly during peak arid intervals (Garcea & Giraudi, 2006, 419–420).

From a different vantage point, environmental determinism should not be interpreted as a fatalistic process. Rather, it functions as a statistical proxy—expressed in varying degrees—that describes the extent of environmental influence on human life and decision-making, without ever becoming the absolute sovereign over individual agency or behavior. Admittedly, the prolonged stratigraphic hiatus between the Late Pleistocene occupation (dominated by hunter-gatherers utilizing Aterian technologies) and the Early Holocene/Acacus phase (distinguished by Epipaleolithic traditions) serves as a stark indicator of the hyper-arid conditions that prevailed during the Terminal Pleistocene. These climatic extremes likely precluded continuous human habitation in the region, suggesting a significant rupture in hominin lineage continuity (di Lernia, 1999c, 226). To date, we cannot definitively correlate Aterian industries with specific human taxa, and we remain largely ignorant of the mechanisms through which diverse human groups partitioned this landscape over millennia. Such coexistence—regardless of its form—remains an archaeological enigma.

We must concede that establishing a definitive link between Pleistocene lithic industries and specific human species in this region requires evidence far beyond what stone tools alone can provide. Consequently, a substantial research gap persists, primarily due to the region's harsh climate, which severely compromises the preservation of ancient DNA (aDNA) (Vai et al., 2019). However, research into the ancestral origins of Pleistocene and Holocene populations in Libya is poised for an upward trajectory. This optimism is driven by the rapid evolution of paleogenomic techniques, which have become exponentially more precise. Modern advancements in high-throughput sequencing, computational algorithms, and specialized extraction protocols now enable the isolation of minute, target-specific human DNA fragments from the vast background of non-human genetic material found in degraded ancient samples (Harney et al., 2021; Reich, 2018; Haber et al., 2016).

Consequently, the long-standing hiatus in the prehistoric record is beginning to close. A landmark study by Nada Salem and her team (Salem et al, 2025) successfully analyzed ancient genomic data from Pastoral Neolithic females discovered at the Takarkori rock shelter in the Tadrart Acacus mountains, dating to approximately 7,000 years ago. Their findings reveal that these genetic lineages descend from a previously unidentified North African ancestral population. This group branched off from Sub-Saharan lineages concurrently with the initial dispersal of modern humans out of Africa, remaining genetically isolated for much of its history. Furthermore, the research establishes a significant genetic link between the inhabitants of Takarkori and the hunter-gatherers who occupied Tatoralt Cave in Morocco 15,000 years ago. Crucially, the study concludes that the transition to pastoralism within these populations was driven by cultural diffusion and social exchange rather than large-scale demic migration. This suggests that technological and subsistence shifts were mediated by the transmission of ideas and cumulative knowledge across existing social networks, rather than the displacement of local populations (Salem et al, 2025).

Accordingly, if we attribute an absolute sovereignty to environmental interventions—as observed in specific regions of Libya—by assuming they imposed insurmountable constraints on human habitation, we risk adopting misleading or reductive interpretations of prehistoric settlement behavior, particularly within arid and semi-arid zones. However, accumulated geomorphological evidence affirms that human occupation persisted in various sectors of the Saharan region, even during the severe arid intervals that punctuated the Late Pleistocene (di Lernia, 1999b, 63).

This resilience was primarily sustained by the availability of relict groundwater resources, which had accumulated during previous humid phases and remained stored within the landscape over vast timescales. These reservoirs were instrumental in maintaining localized vegetative cover, creating "ecological islands" or refugia. Consequently, hunter-gatherer groups demonstrated a profound capacity for adapting to these shifting environmental conditions. This adaptation was intrinsically coupled with the innovation of novel lithic technologies, specifically engineered to exploit the niche resources available in these persistent habitats (van de Loosdrecht et al., 2018, 548–552; Scerri, 2017, 99–137). The high density of lithic assemblages and dispersed settlement sites across Libya and broader North Africa presents a stark contrast to the hyper-aridity that characterizes the region today. Consequently, we must conceptualize the climatic and anthropogenic events of the Pleistocene as a

series of fluctuating frequencies—alternating humid and arid phases that profoundly reshaped communal life. This necessitates that the study of paleoecology and human history in North Africa remain intrinsically and inextricably linked.

Regarding the Green Corridors hypothesis, geological and geomorphological evidence suggests that increased humidity during the Pleistocene facilitated the opening of verdant pathways across Northern and Western Africa. During this era, the Libyan Desert was transformed into dynamic hydrological systems characterized by savannas and lush grasslands. Within a prolonged humid interval—spanning approximately 130,000 to 75,000 years ago—the emergence of paleolakes and ephemeral river networks provided viable habitats for hunter-gatherers and semi-aquatic foragers (van de Loosdrecht et al., 2018). These populations exhibited adaptive settlement strategies, as evidenced by their specialized lithic toolkits and distinct archaeological footprints. Their mobility patterns ranged from ephemeral campsites to sophisticated logistical movements between wadis, massifs, ergs (dune seas), and lacustrine basins. Furthermore, their economies were predicated on complex extractive strategies aimed at a broad spectrum of floral and faunal resources, reflecting a high degree of ecological resilience (di Lernia, 1999c).

In other contexts, hunter-gatherer groups equipped with Pre-Aurignacian and Levallois-Mousterian technologies have been documented in Cyrenaica (Barton et al., 2018, 99–100), while Aterian technologies dominated the Jebel Gharbi of Tripolitania (Garcea & Giraudi, 2006, 420). These populations maintained diversified extractive economies characterized by semi-sedentary spatial organization within mountainous environments. Their subsistence patterns revealed high selectivity for specific wild flora and fauna, alongside a burgeoning reliance on marine resources, particularly mollusks and crustaceans (Prendergast et al., 2016b, 81–82). From a hydrological perspective, these "green corridors" functioned as primary conduits for seasonal migration and communication among groups from disparate environments and technological traditions. Ultimately, they served as pivotal evolutionary hubs for the exchange of behaviors, information, and genetic material.

Broadly speaking, while environmental determinism and the "green corridors" hypothesis play significant roles in shaping human settlement patterns, another equally vital factor governs behavioral variance and cognitive capacities: genetics. From this perspective, many biologists and geneticists argue that the human being is the product of a fundamental interaction between the natural environment and heredity. The environment influences every stage of an organism's lifecycle, affecting not only biological and organic development but also behavioral manifestations (Tattersall, 2006, 66–67).

Accordingly, researchers in heredity and paleogenomics posit that geographical environments contribute significantly to the evolution of genetic systems. A research team led by Lancani and Sforza analyzed the ancient DNA (aDNA) of various ancestral populations, concluding that genetic differentiation between groups is largely attributable to geographical distance. Geographical separation serves as a primary mechanism for generating genetic divergence (Sanchez-Mazas, 2001, 86). Modern human populations differentiated gradually during their migrations, originating from a single ancestral lineage in Africa (Hammer, 2013, 70). Thus, global genetic variation is intrinsically linked to geographical spacing; populations in close proximity tend to exhibit fewer genetic disparities.

Regardless of these complexities, shifts occurring within ecological equivalents (Doncaster, 2009, 60–74) cannot be dismissed as random developments or merely the byproduct of accumulated mutations—particularly in large populations. Such transitions cannot be measured by environmental variables alone; they must be contextualized within demographic and technological frameworks. Human cognition and technology serve as potent instruments for mediating environmental change. The transition of a society through successive stages contributes to the formation of a climax community, characterized by an integrated state of equilibrium and adaptation within its ecological niche (Doncaster, 2009, 87–88).

From an eco-cultural standpoint, the concept of adaptation—in its diverse forms and objectives—remains a highly elastic term. It can be viewed as an element of a deterministic, gradual process of behavioral and cultural refinement. Conversely, it functions as a biological/genetic filter that reinforces or eliminates variations and potentials as they emerge, whether favorable or unfavorable. Ultimately, the process of adapting to environmental shifts hinges on the specific natural conditions experienced by prehistoric hunter-gatherers. Crucially, we must recognize that adaptation is neither inherently nor inevitably directed; it is a dynamic process that reflects itself with agility and speed in response to the volatile nature of the environment.

For instance, by moving beyond interpretations rooted solely in anthropology and physical biology—which often simplify genetic diversity as a mere byproduct of population expansion—we find that genetic variation in contemporary Africa is intrinsically coupled with linguistic diversity. The continent is characterized by four major linguistic phyla: Niger-Congo (including the Bantu languages), Afro-Asiatic, Nilo-Saharan, and Khoisan. Genomic studies have demonstrated that an Afro-Asiatic-speaking

group, for example, shares a closer genetic affinity with another group of the same linguistic lineage, even when separated by hundreds of kilometers. Conversely, Bantu-speaking populations often exhibit no significant genetic relationship with neighboring Afro-Asiatic groups despite their geographical proximity. Thus, genetic differentiation among these populations is effectively a reflection of the historical dispersal of distinct linguistic lineages (Fan et al., 2019, 1–6). From the preceding discussion, it can be concluded that Late Pleistocene hunter-gatherer groups across the Old World shared—to varying degrees—similar patterns of susceptibility to climatic shifts, which appear to have followed consistent global trajectories. This commonality extends to the mechanisms of environmental determinism, the strategic utilization of "green corridors," and the underlying influence of genetic factors. These points of convergence further encompass the occupation of caves and rock shelters, subsistence strategies centered on specialized foraging, and the sophisticated fabrication of stone, bone, and wood implements. Collectively, these elements constitute the stratigraphic and sedimentary records that define Pleistocene habitation sites.

#### **Human Settlement Sites during the Upper Pleistocene:**

In the immediate aftermath of World War II, field explorations began to uncover the ecological and cultural landscapes inhabited by Pleistocene groups characterized by extractive economies. Over millennia, these populations transitioned into more sedentary settlement systems, defined by dynamic, diversified subsistence bases and functionally interdependent social units. Initially, academic inquiry interpreted the stratigraphic, technological, and fossil records of the Late Pleistocene in Libya and broader North Africa through a Mediterranean-centric lens. This phase relied heavily on technical terminology exported from European and Middle Eastern contexts to define the cultural, technological, and radiometric processes of the Libyan Pleistocene.

However, as it became clear that North African hunter-gatherers and fishers followed distinct trajectories in their economic transitions, these shifts were reassessed as independent cultural processes. Consequently, researchers began situated Pleistocene and Holocene contexts within a dedicated African continental framework. This epistemological shift gave rise to African-centric paradigms for interpreting artifacts, spatial organization, and behavioral patterns (Barich, 2019, 25–27). A prime example of this transition is the emergence of "Pre-pastoral archaeology"—a term that serves as both a technical and theoretical tool for interpreting the subsistence strategies, mobility, and settlement patterns of hunter-gatherers in the Tadrart Acacus of southwestern Libya and the Middle Nile Valley in Sudan (di Lernia, 1999a, 1–8).

A pivotal procedural advancement in this field has been the reassessment of spatial dimensions. Research has moved beyond the traditional "single-site" unit toward expansive regional frameworks, correlating sites of equivalent chronological and cultural depth. For instance, the Pre-Aurignacian stratigraphy of Haua Fteah in Libya has been historically linked to Levantine sites such as Mount Carmel in Palestine (Skhul and Qafzeh) and Shanidar Cave in Iraq (Reynolds, 2018, 14–15). Conversely, the Aterian technologies of the Acacus (e.g., Uan Afuda and Uan Tabu) are now viewed as analogous to Saharan complexes in the Hoggar (Algeria) and the Aïr-Ténéré (Niger) (Foley et al., 2013, 153–170).

Ultimately, the archaeological and fossil records of Libya should not be viewed as static or isolated units; they are integral components of a continuous evolutionary trajectory in which cultural content evolves and merges. This represents an escalating process of behavioral adaptation in response to environmental fluctuations. This leads us to a fundamental inquiry: Did Late Pleistocene cultures embody a singular, shared identity, or were they a mosaic of distinct regional variations?

In my view, I argue that Pleistocene human cultures did not necessarily form distinct or divergent identities. In many instances, these groups should be conceptualized as ecological equivalents operating within a cohesive ecological system, sharing a common cultural repertoire and relying on similar extractive subsistence strategies. A fundamental distinction lies not in their cultural essence, but in the diverse ecosystems they inhabited—ranging from coastal fringes to Saharan interiors—which were geographically dispersed yet functionally linked, and varied significantly in their morphological and physiological demands. In fact, archaeological and historical scholarship converges on the interpretation of Late Pleistocene and Early-to-Middle Holocene habitation sites in Libya as manifestations of human behavioral adaptation. These sites reflect a complex interplay of cultural frequencies and environmental transformations, anchored within a rigorous chronological framework. Modern excavations have demonstrated that Libya and the broader Sahara have been central to human habitation since the very dawn of the genus *Homo* on the African continent. Significant findings include Acheulean hand-axes and, in certain contexts, surface assemblages resembling Oldowan technologies. These have been identified at pivotal Libyan sites such as Bir al-Dufani (east of Tripoli within the Wadi al-Mardum catchment), Wadi al-Ajal in Fezzan, and Taucheira in Cyrenaica (Alimen, 1955, 73).

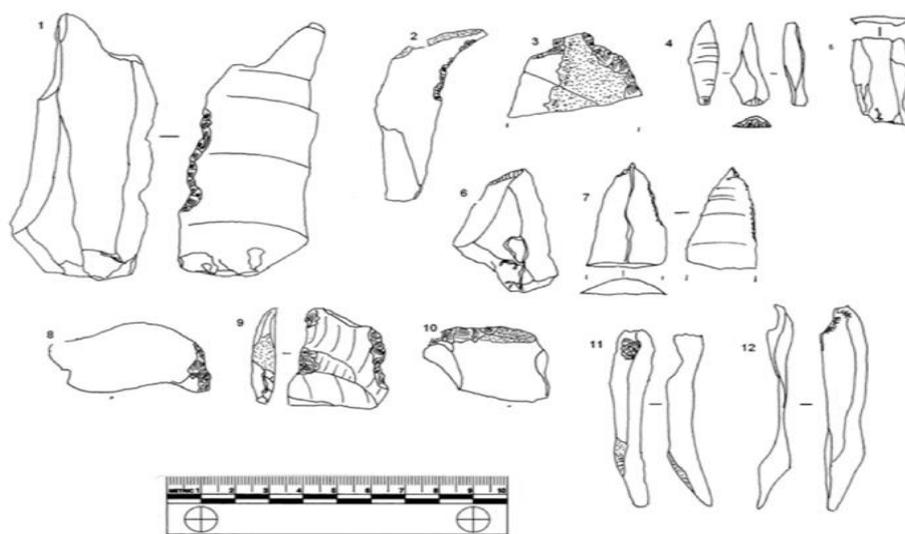
Settlement patterns at these sites appear intrinsically linked to a diversified economy of big-game hunting, fishing, and the intensive gathering of wild flora. Furthermore, a striking morphological and typological correspondence exists between the lithic assemblages discovered in Libya and those documented at major North African sites, including Arbaoua, Sidi Abderrahmane, and Ain Hanech in Morocco, as well as the Tighennif (Ternifine) site in Algeria (Alimen, 1955, 74, Geraads, 2022). This evidence underscores a trans-Saharan technological unity that transcends modern borders.

Furthermore, fossil discoveries at the Dur At-Talah site in central Libya in recent years have the potential to push the documented presence of hominoids in the region back to a much earlier epoch than previously established. Scientists have unearthed a scattered collection of fossils belonging to primates with an estimated adult body mass ranging from 120g to 470g (Jaeger et al., 2010, 1095-1099). Despite the ambiguity surrounding these finds—notably their departure from known evolutionary lineages and the uncertainties regarding their dating and stratigraphic context—they open promising new horizons for the study of Libya’s biological and paleoanthropological history.

Amidst the vast array of data, chronological variations, and the complex horizontal and vertical distributions within the Libyan fossil record, two pivotal studies stand out for their role in grounding the study of prehistoric Libya. The first is McBurney’s seminal work on the stratigraphy of Haua Fteah. McBurney began by tracing the chronological and stratigraphic sequences of Paleolithic sites along Cyrenaica’s eastern coast, conducting preliminary test excavations at Hagfet ed-Dabba in the Jebel Akhdar. Subsequently, between 1951 and 1955, his extensive excavations at Haua Fteah revealed a meticulous record of human occupation and sedimentary strata spanning from the Middle Paleolithic and Mesolithic through to the Neolithic (McBurney, 1953, 72-73). The Haua Fteah record provides an exhaustive description of geological and archaeological layers, encompassing organic floral and faunal remains, mollusks, and distinct stone tool assemblages (McBurney, 1953, 74).

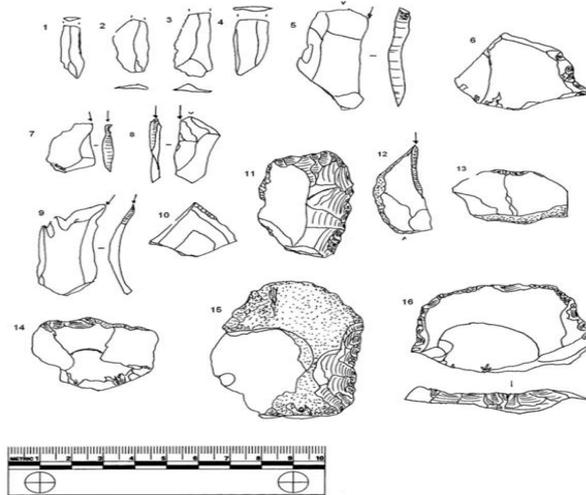
Most significantly, McBurney’s excavations unearthed two left mandibular fragments, including preserved posterior molars, belonging to two distinct individuals who inhabited the cave approximately 80,000 years ago. This discovery represented a paradigm shift in Libyan paleoanthropological research, positioning Haua Fteah as a focal point in the global discourse concerning the origins, expansion, and dispersal of anatomically modern humans across the Old World (McBurney, 1953, 76-78).

Within the deepest stratigraphic horizons reached by McBurney, a Pleistocene lithic industry known as the Libyan Pre-Aurignacian was identified. Radiocarbon-14 dating placed this industry between 80,000- and 65,000-years BP (Figure 4). It is characterized by the systematic production of parallel-sided blades struck from prismatic cores (McBurney, 1953, 75). Archaeological and historical analyses suggest that the practitioners of this industry were highly proficient hunter-gatherers who specialized in the exploitation of Barbary sheep, gazelles, and zebras. Furthermore, marine mollusks constitute the most prevalent faunal remains within the Haua Fteah stratigraphic record for this period, indicating their significant integration into the dietary patterns of the cave’s inhabitants (Hiscock, 2014).



**Figure (4):** Pre-Aurignacian lithic artifacts from Haua Fteah Cave. (1) inversely retouched blade; (2) retouched blade; (3) 8–10 sidescrapers; (4) proximally retouched bladelet; (5) blade fragment; (6) endscraper; (7) marginally retouched point; 11–12 burin spalls. (After Garcea 2023, 678).

Subsequently, the Levalloiso-Mousterian industry emerged during the Pleistocene, spanning from 65,000 to 40,000 years BP (McBurney, 1953, 75). This tradition persisted for over twenty millennia (Figure 5) before eventually disappearing and being succeeded by the more sophisticated Dabban industry—named after the Hagfet ed-Dabba type-site in the Jebel Akhdar—which flourished between approximately 40,000- and 15,000-years BP (McBurney, 1953, 78). The Dabban toolkit was distinguished by its specialized pointed blades, scrapers, and chisel-like implements known as 'burins'. Around 14,000 years BP, the Dabban industry gave way to the Eastern Oranian complex, a tradition characterized by a proliferation of microlithic backed blades and various cutting tools (McBurney, 1953, 80).



**Figure (5):** Levalloiso-Mousterian stone tools unearthed in the Haua Fteah cave: (1–4) bladelet fragments; (5, 7–9, 12) burins; (6, 16) retouched Levallois flakes; (10) retouched Levallois point; (11, 15) sidescrapers; (14–13) endscrapers. (After Garcea 2023, 684)

It should be noted that Radiocarbon (C14) dating was in its infancy during McBurney's original fieldwork; consequently, the initial laboratory results lacked precision and necessitated subsequent calibration. Over the past three decades, however, a technological revolution has transformed dating methodologies, most notably with the advent of Optically Stimulated Luminescence (OSL) (see Roberts and Lian, 2015, 438-439). Ongoing geoarchaeological and geomorphological investigations at Haua Fteah—which seek to expand our comprehension of human occupational sequences and reconstruct paleoenvironmental dynamics alongside functional lithic analysis—have enabled researchers to meticulously refine the site's absolute chronology (Table 1). By analyzing quartz and feldspar grains from the cave's sedimentary strata, which function as light-sensitive electron traps, scientists have successfully recalibrated these temporal records (Jacobs et al., 2017).

**(Table 1):** Chronological/Cultural sequence of human occupation at Haua Fteah cave, based on McBurney's Radiocarbon (C-14) readings alongside the new dates obtained through high-resolution Optically Stimulated Luminescence (OSL) dating.

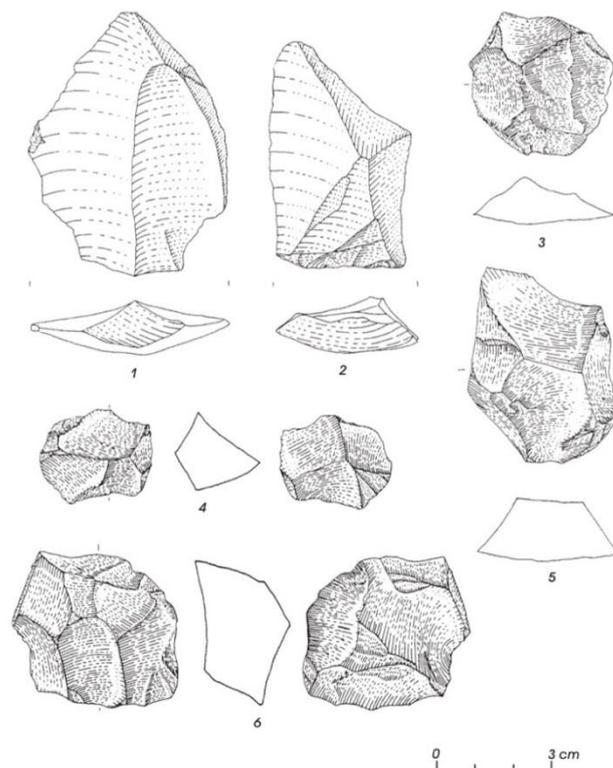
| Industrial/Cultural Phase | Radiocarbon (C-14) dates according to McBurney (1967) | Dates according to Optically Stimulated Luminescence (OSL) technique |
|---------------------------|---|--|
| Pre-Aurignacian           | 80,000–65,000 years ago                               | 101,6–67,7 thousand years ago  |
| Levalloiso-Mousterian     | 65,000–40,000 years ago                               | 73,3–43,5 thousand years ago   |
| the Dabban                | 40,000–15,000 years ago                               | 43,5–17,1 thousand years ago   |
| Oranian                   | 15,000–10,000 years ago                               | 17,2–12,5 thousand years ago   |
| Libyco-Capsian            | 10,000–7,000 years ago                                | 12,7–7,9 thousand years ago  |
| Neolithic                 | 7,000–4,500 years ago                                 | 9,3–5,4 thousand years ago   |

The second pivotal study was conducted by Fabrizio Mori on the rock art of the Tadrart Acacus. Mori systematically documented and categorized the rock art complex, offering comprehensive interpretations of its artistic, economic, and social dimensions. By analyzing stylistic divergences and technical execution, he successfully devised a chronological framework for rock art themes. Crucially, Mori identified a profound correlation between these artistic expressions and long-term anthropogenic deposits (Mori, 1998, 31-38), a framework that subsequently served as the definitive benchmark for regional chronological stages (Mori, 1998, 43-51).

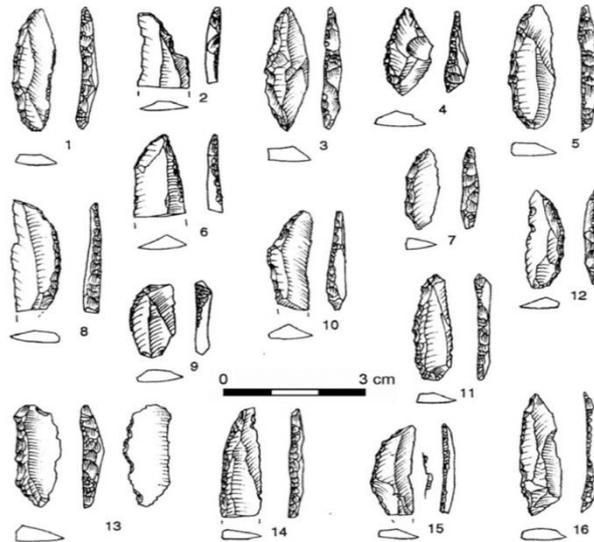
Mori's pioneering efforts laid the groundwork for subsequent archaeological investigations. Specifically, the joint Libyan-Italian Mission (Sapienza) for Saharan research revealed extraordinary stratigraphic and technical sequences of human presence in the Acacus Mountains, notably during the Late Pleistocene Aterian phase. Research indicates that Aterian occupation at sites such as Uan Afuda and Uan Tabu dates between 90,000- and 69,000-years BP (Adaba, 2022; Garcea, 2001, 59-61). Uan Tabu stands out as the most well-preserved site, yielding diagnostic tanged tools and evidence of organized occupational structures. These findings suggest high logistical mobility and the strategic exploitation of both montane and dunefield environments (Garcea, 2001, 222-224). Furthermore, diverse lithic assemblages, primarily Aterian (Figure 6), have been identified in the surrounding regions—including Edeyen Wan Kasa, Idehan Murzuq, and Messak Settafet—spanning the transition from the Middle to the Upper Paleolithic (Foley and Lahr, 2015, 4; Cremaschi et al., 2000, 229).

By way of comparison, typological and morphological analyses offer a detailed perspective, confirming a high degree of affinity between the subsistence strategies and lithic assemblages of the Acacus and those documented in adjacent regions to the north. Data from the Tripolitanian pre-desert reveal a consistent presence of Aterian materials dating to the Late Pleistocene. Within Wadi Tabunia, Wadi al-Kharab, and Wadi Nadur, these industries consisted of a technological mosaic of Levallois methods, diverse choppers, and pointed projectile tips (Barker, 1993, 17-18). Furthermore, Levallois-Mousterian, Dabban, and Eastern Oranian lithic flakes and industries have been identified at Hagfet al-Karim, Hagfet al-Tera, Hagfet ed-Dabba, and the Cave of the Hyena (Klein and Scott, 1986, 535). During this era, human populations adapted their dietary patterns to the hunting of gazelle, zebra, and Barbary sheep (Klein and Scott, 1986, 535).

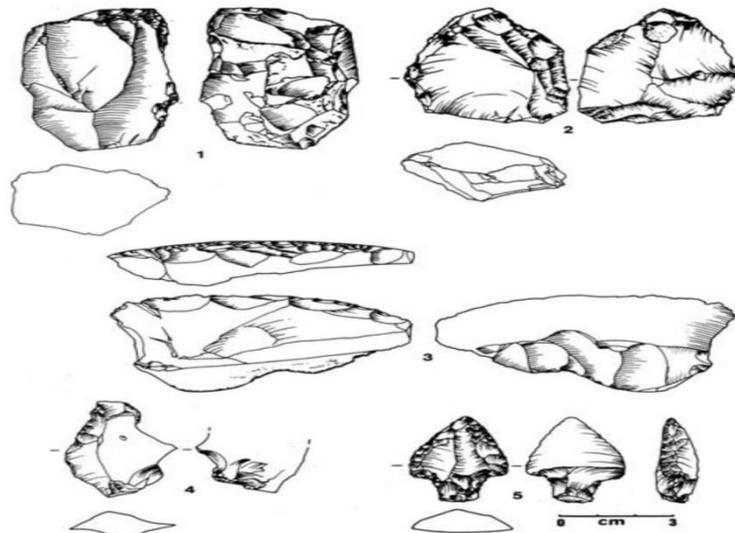
In the early 1990s, the joint Libyan-Italian Mission for prehistoric research in Jebel Gharbi successfully documented an extensive range of Upper Pleistocene lithic artifacts (Figures 7,8). The mission identified the subsistence patterns of hunter-gatherer communities utilizing Acheulean, Levallois, and Aterian technologies. These cultural phases were contextualized through an absolute chronology derived from Thermoluminescence (TL) and Optically Stimulated Luminescence (OSL) dating (Table 2). Key research areas included the Wadi Ain Zargha basin (Barich et al., 2014, 570), the site of Shakshuk—located at the mountain's base approximately 10 km from Jadu (Barich et al., 2014, 574)—Ras al-Wadi to the south of Jadu (Barich et al., 2014, 575), and Wadi Ghan to the east of Gharyan (Barich et al., 2014, 576).



**Figure (6):** Lithic material associated with the Aterian industry from Late Pleistocene layers: 1-2: pseudo-Levallois flakes, refitting; 3, 5: unretouched flakes; 4, 6: unpatterned cores. (di Lernia, 1999b, 61).



**Figure (7):** Lithic industries of the Upper Late Stone Age from site SJ-98-26, Ras el Wadi in Jebel Gharbi (After Barich, 2022, 156)



**Figure (8):** Middle Stone Age (MSA) collections. 1. Nubian Type 1 core; 2. Levallois core; 3. Transversal sidescraper; 4. Perforator; 5. Tanged. (After Barich, 2006, 576).

**Table (2):** Chronological sequence of Late Pleistocene lithic industries in Jebel Gharbi, based on dating results from the joint Libyan-Italian Prehistoric Mission.

| Late Pleistocene Industry/Culture                                       | Occupation site | Dates obtained using Thermoluminescence (TL) and Optically Stimulated Luminescence (OSL) techniques. |
|---|-----------------|--|
| Surface collections of Acheulean, Levallois, and Microlithic industries | Wadi Ain Zargha | 146,800 ± 11,000 years ago<br>114,700 ± 7,400 years ago  |
| Aterian   | Shakshuk        | 43,53 ± 21,10 years ago  |
| Aterian   | Ras el Wadi     | 30,000 ± 9,000 years ago   |
| Aterian   | Wadi Ghan       | 11,110 ± 40 years ago  |

Notably, North Africa, much like the northern Mediterranean basin, underwent a fundamental shift in lithic reduction strategies approximately 15,000 years ago. This transition was marked by the emergence of broad microlithic blade industries that persisted into the Early Holocene (c. 10,000 BP). These assemblages are conventionally classified as Epipalaeolithic, characterized by geometric microliths, backed blades, burins, and sharp bladelets (Barich et al., 2014, 576-578).

Prior to tracing the intercultural connections between Libya's Upper Pleistocene occupations and adjacent regions, a brief eco-cultural synthesis of the prevailing conditions across North Africa, the Nile Valley, the Central Saharan massifs, and the Levant is essential. This broader regional context provides a clearer framework for understanding these dynamics within their continental African and Mediterranean settings. To the west of Tripolitania, Upper Pleistocene occupation sites—predominantly associated with Mousterian and Aterian cultures—are widely distributed across the Maghreb. Key sites include Cap Blanc and Sidi Mansour (Tunisia), Bir el-Ater and Oued Djebbana (Algeria), and Dar es-Soltan, El-Khenzira, and Taforalt (Morocco) (Iovita, 2011, 1-3). These assemblages typically feature scrapers, composite tools, and various microlithic components.

East of Cyrenaica, Aterian presence in the Eastern Desert (specifically Bir Sahara and Bir Tarfawi) has been dated back to roughly 160,000 BP. The recovered material is highly diverse, comprising flakes, hand-axes, and discoidal cores, alongside Acheulean-style projectiles and knives (Wendorf and Schild, 1980). Similarly, side-scrapers, bifaces, and Levallois cores have been identified within the Gilf Kebir plateau (Le Quellec, 2013, 239-240).

Within the Central Saharan massifs of the Aïr-Ténéré (Niger)—specifically at Adrar Bous, Tagalagal, and Tama-Ya-Mellet—human occupation has been dated to approximately 100 ka BP. Comparable evidence persists in the Hoggar and Tibesti ranges, while the site of Ravins de la Mouche in Ounjougou (Mali) yields a similar Radiocarbon (C-14) chronological range (Soriano and Huysecom, 2012; Desmond, 1993, 50-51). The associated lithic assemblages are characterized by bifaces, bipoints, and foliates (leaf-shaped tools), alongside composite artifacts, side-scrapers, end-scrapers, and denticulates (Desmond, 1993, 55-57).

Extending toward the Levantine coast, notable intercultural affinities exist between the Haua Fteah sequence and various Upper Pleistocene sites in Mount Carmel (Palestine) and Ksar Akil (Lebanon). Geoarchaeological investigations in the caves of Skhul, Tabun, el-Wad, Kebara, and Qafzeh have documented lithic successions attributed to the Late Acheulean, Acheulo-Yabrudian, and Mousterian industries (Al-Ameri et al., 2011, 946-949; Bar-Yosef and Vandermeersch, 1993). Furthermore, radiometric dating of these well-preserved burials has uncovered an extraordinary series of Middle Palaeolithic hominin remains. These skeletal findings are regarded as transitional forms, bridging the evolutionary gap between Neanderthals and Modern Humans (Al-Ameri et al., 2011, 951).

It is an established fact that the material culture of Western Eurasia underwent a more profound transformation in technological and artistic innovation between 50,000 and 45,000 BP than it had in the entire preceding million years. Within this remarkably brief window of approximately five millennia, lithic toolkits diversified and evolved at an astonishing pace. The underlying drivers of this Middle-to-Upper Palaeolithic transition remain elusive, continuing to represent one of the most fundamental enigmas in palaeoanthropological research (Bar-Yosef and Vandermeersch, 1993)."

Conversely, Northern Iraq benefited from favorable palaeoclimatic and hydrological conditions that incentivized long-term human settlement. At Barda Balka, located near Chamchamal, excavations uncovered a significant lithic assemblage characterized by amygdaloid (almond-shaped) and cordiform (heart-shaped) hand-axes, pebble tools, and various scrapers. Additionally, flint flakes produced through debitage were identified alongside the faunal remains of mammals such as wild oxen, deer, and wild goats (Reynolds et al., 2018). Similarly, Hazar Merd cave yielded a comparable lithic tradition, supplemented by bone needles, borers, anthropogenic hearths, and diverse faunal remains—predominantly red deer and wild goats (Yeshurun, 2016). Furthermore, the microlithic sequences of Zarzi and the world-renowned Shanidar Cave provide critical data on regional technological evolution. Shanidar remains one of the most pivotal sites in the Near East, famous for its well-preserved Neanderthal skeletal remains and symbolic burial practices (Marín-Arroyo, 2013).

Evidence from Libyan, North African, and Eastern Mediterranean sites suggests a shared comparative framework for prehistoric occupation. Settlement systems in Libya exhibit significant parallels with those in the Maghreb, the Central Sahara, and the Nile Valley, as well as the Levant. These affinities are rooted in their adaptive strategies and interactions with the natural environment, as all these regions relied on an extractive economy based on hunting and gathering. While subtle variations in tool morphology and function exist, the fundamental commonality remains the mastery of Levallois technology. Representing a pivotal revolution in lithic production, the Levallois method involves the deliberate, pre-determined shaping of the core to control the geometry of the final flake before detachment. This sophisticated reduction process entails removing flakes through unidirectional, bidirectional, or centripetal (preferential) patterns (Shimelmitz and Kuhn, 2018, 81-91).

In a broader context, lithic toolkits from Southern Africa—specifically the Howiesons Poort complex—exhibit a level of technological advancement that appears to surpass contemporaneous industries across the Old World. This precocious sophistication is largely attributed

to the Howiesons Poort tradition of thermal engineering (heat treatment) of silcrete and other raw materials. This intentional thermal alteration significantly improved the knapping quality of the stone, facilitating unprecedented precision in achieving standardized tool forms, particularly for specialized hunting projectiles (Mourre et al., 2010, 659-660).

In light of the aforementioned data, several critical observations can be established. Most notably, pre-Aurignacian and Aterian lithic assemblages function as diagnostic proxies for the cultures that dominated the region during the Upper Pleistocene, allowing for their classification into distinct archaeological, geographical, and spatio-temporal frameworks. Furthermore, analogous to the Holocene Saharo-Sahelian technocomplex—which spanned vast territories from Mali and Niger to the Eastern Deserts of Egypt and Sudan—the Pleistocene industrial complex also maintained a widespread presence across both Mediterranean coastal and Saharan landscapes. Consequently, this complex serves as a pivotal tool for identifying regional variations and assessing inter-cultural connectivity between Libya's Upper Pleistocene occupations and their contemporaneous Saharo-Sahelian and Levantine counterparts.

Ultimately, Libya's Upper Pleistocene record should be understood as a crucial bridge within the broader cultural mosaics of Africa and the Mediterranean. The widespread adoption of Levallois reduction strategies underscores a sophisticated level of behavioral complexity among these populations. Rather than serving as simple chronological markers, these stone tools act as diagnostic signatures of inter-regional synergy. Such evidence re-positions the Saharan and coastal corridors, alongside the Levant, as vibrant epicenters of human resilience and exchange well before the Holocene Epoch.

#### **Cultural Interactions between the Coast, the Sahara, and the Levant:**

As previously established, Libya's Upper Pleistocene occupation sites hold a paramount status within the prehistoric, archaeological, and genetic discourses of North Africa and its environs. The preeminent site offering critical insights into these intercultural connections is undoubtedly Haua Fteah cave. Deep soundings at this location have revealed an intricate succession of archaeological and geological evidence, representing the most comprehensive Upper Pleistocene industrial sequence documented in North Africa and the Mediterranean basin (Douka et al., 2014).

Furthermore, the stratigraphy of Haua Fteah serves as a foundational benchmark for analyzing Middle Palaeolithic cultural processes within the Old World, exhibiting clear intercultural affinities with Late Pleistocene Levantine occupations in Palestine and Lebanon (Reynolds et al, 2018). Notably, the Libyan Pre-Aurignacian industry remains an isolated phenomenon, absent from any other known sites in North Africa or the Sahara (Scerri and Spinapolice, 2019). While analogous technologies appear in Southern Africa within the same chronological horizon, they exhibit a higher degree of technical sophistication compared to those found at Haua Fteah (Reynolds, 2018). Conversely, typological and morphological analyses confirm striking parallels between this industry and those identified at Mount Carmel. A similar high-degree of techno-cultural continuity is traceable between the Dabban industry of Haua Fteah and its Levantine counterparts at Ksar Akil. These profound resemblances support a dispersal scenario involving the migration of Modern Humans along a Southeastern Mediterranean corridor toward Europe (Bosch et al., 2019).

A second pivotal contribution of Haua Fteah cave concerns the dispersal patterns of Modern Humans within North Africa (Lahr, 2010, 30-32). It is plausible that the modern human populations inhabiting the cave migrated toward adjacent regions, particularly those along the Northern Mediterranean coast. However, this hypothesis remains tentative and subject to significant scholarly debate for two primary reasons: First, the techno-typological correlation between certain assemblages at Haua Fteah and their counterparts in Mount Carmel and Lebanon suggests a complex evolutionary dynamic. Should the Levantine sequences be conclusively dated as older than the Cyrenaican samples, it would imply a reverse migration from the Levant back into North Africa. Such a scenario would provide robust empirical support for the 'Back-to-Africa' model, suggesting a secondary re-entry of modern humans into the continent during the Late Pleistocene (Garcea, 2016, 79-89). Second, the hypothesis is constrained by the evidence that the Sahara Desert functioned as a formidable barrier to human genetic and cultural exchange. Eleanor Scerri and her team developed a palaeoclimatic model for North Africa during this period, revealing that although the Sahara was significantly 'greener' than its present state, it remained fragmented by vast, uninhabitable tracts. These arid zones acted as biogeographical barriers that impeded the continuous northward expansion and connectivity of *Homo sapiens* (Scerri et al., 2017, 210-211).

Amidst these diverse interpretations, genetic studies—specifically those analyzing mitochondrial DNA (mtDNA) and Y-chromosome lineages—suggest that the dispersal of modern humans across North Africa is far more nuanced and complex than traditional 'human cradle' models imply. The standard 'Out of Africa' (OOA) hypothesis has long maintained a singular narrative in

paleoanthropological literature: that *Homo sapiens* originated from a lone ancestral population in sub-Saharan Africa. Sustained by an extensive corpus of hominin skeletal remains from Southern and Eastern Africa, this theory posits that subsequent migratory waves led to the expansion of modern humans into North Africa, Asia, and Europe beginning approximately 200,000 years ago—and potentially much earlier (Tattersall, 1997, 60-67).

Historically, North Africa was marginalized in scientific discourses on human origins, frequently dismissed as an evolutionary 'dead-end' or a peripheral cul-de-sac. Prevailing hypotheses argued that North African population distributions were merely the byproduct of successive migrations from the East and South, driven by Late Pleistocene and Early Holocene climatic fluctuations. While these environmental shifts undeniably dictated shifts in settlement patterns and subsistence strategies, they do not preclude the possibility of genetic admixture between incoming migrants and long-standing indigenous populations.

However, the groundbreaking discovery of fossilized remains at Jebel Irhoud—including three adults, an adolescent, and an 8-year-old child—has fundamentally deconstructed this debate. Dated to approximately 300,000 years ago (300 ka) via thermoluminescence (TL) (Richter et al., 2017, 293-296), these fossils have re-established a profound evolutionary link between North Africa and the rest of the continent during the very emergence of our species. The Jebel Irhoud assemblage, featuring a partial cranium, a remarkably well-preserved face, and a complete mandible with a full dentition, has illuminated previously obscured facets of modern human ancestry, suggesting a pan-African origin rather than a localized one (Mounier and Lahr, 2019, 1-13 )."

Cranial morphology studies indicate that the Jebel Irhoud hominins possessed remarkably modern facial features—characterized by a short, flat, and retracted profile—while the braincase retained archaic, elongated proportions. These fossils provide critical clarity on the origins of our species, linking North Africa to the complex evolutionary shifts occurring across the continent. These populations were hunter-gatherers inhabiting open, verdant environments significantly more humid than today's arid landscape. They utilized Mousterian technologies, including pointed flint spears, to hunt and butcher wild game such as gazelles and zebras (McPherron, 2020, 13-14). Furthermore, recent genomic data suggests that North Africa, West Africa, and the Near East were vibrant hubs for human migration and interaction approximately 15,000 years ago. (Van de Loosdrecht, et al, 2018, 548) posits that populations across the Near East, North Africa, and Sub-Saharan Africa interacted dynamically between 23,000 and 12,000 years ago (van de Loosdrecht, et al, 2018, 549-550).

Mitochondrial DNA (mtDNA) analysis of seven 15,000-year-old individuals from Grotte des Pigeons (Taforalt, Morocco) reveals that the Iberomaurusians—renowned for their microlithic tool industries—represented a genetic mosaic. They descended from two distinct ancestral lineages: a Near Eastern group akin to the Natufian hunter-gatherers of the Levant, and a secondary, less-defined lineage with Sub-Saharan affinities. Crucially, the absence of genetic affinity between Iberomaurusians and European populations suggests a lack of trans-Mediterranean contact from the Lower through the Upper Palaeolithic.

Despite these insights, significant lacunae persist in our understanding of North African hunter-gatherers and their relationships with Sub-Saharan, Middle Eastern, or European counterparts. This scarcity of data is largely attributed to the progressive aridification of the region. During the Pleistocene, severe drought cycles and intensified erosion led to the desiccation of paleolakes and the fragmentation of flora, forcing hunter-gatherers into highly mobile lifestyles that left only ephemeral archaeological footprints. Consequently, the sparse charcoal remains and lithic scatters found at many sites offer insufficient data regarding ancestral origins or social structures. This raises a fundamental question: did this arid zone function as a restrictive 'buffer zone' or a collaborative 'roundtable' for intercultural connectivity?

Current interpretations often remain more impressionistic than empirical. For instance, the Eastern Oranian and Libyo-Capsian phases at Haua Fteah are frequently attributed to external migrations. The Eastern Oranian hunter-gatherers were likely a hybrid of indigenous groups and migrants from the Levantine coast or Northern Iraq. Conversely, the Libyo-Capsian (escargotières) groups appear to have migrated eastward toward the Jabal al-Akhdar, likely representing the direct descendants of an ancient 'Proto-Libyan' population.

Accordingly, the Pre-Aurignacian and Dabban industries at Haua Fteah exhibit pronounced Mediterranean and Levantine affinities. Thus, the remarkable stratigraphic sequences of Haua Fteah invariably evoke the Pleistocene sites of the Levant. It is increasingly evident that while the Levallois-Mousterian and Capsian industries are deeply rooted in the African continental context, they reflect a robust network of intercultural links with contemporary North African and Near Eastern populations."

In contrast, within the Saharan interior, the stratigraphic sequences, typological profiles, and chrono-cultural affiliations of numerous Palaeolithic sites reveal a complex landscape of intercultural connectivity punctuated by regional distinctiveness. This is particularly evident in the variations between the Tadrart Acacus Aterian assemblages and those from surrounding areas. For instance, the flourishing Upper Pleistocene industries of Upper Egypt and Nubia exhibited a technical sophistication that slightly surpassed contemporary developments in the Central Saharan massifs (Desmond, 1993, 65).

These regional trajectories have been elucidated through morphological and typological meta-analyses of Mousterian, Aterian, and Nubian-Mousterian lithic toolkits across 17 key North African sites. This expansive dataset includes Wadi Ghan and Haua Fteah in Libya, Bir Tarfawi and Bir Sahara in the Eastern Desert, Bir el-Ater in Tunisia, Khor Musain Nubia, and Adrar Bous in Niger (Scerri, 2017, 212). The resulting data underscores significant geographical disparities in tool morphology and manufacturing techniques; assemblages exhibited the highest degree of homogeneity when geographically proximate or linked by 'green corridors'. Conversely, populations inhabiting more isolated niches appear to have experienced prolonged periods of cultural stasis with infrequent inter-group interaction (Scerri, 2017, 215).

Despite these local variations, a cohesive cultural affinity has been identified among the Late Pleistocene complexes of the Acacus, Hoggar, and Air-Tenere massifs. These parallels—discernible through shared lithic traditions, subsistence strategies, and adaptive ecological mechanisms—allow these cultures to be integrated into a unified regional framework (Barich et al., 1984, 405-408). Within this context, the Uan Afuda cave in the Acacus serves as a definitive benchmark; its distinctive and successive evolutionary trajectories provide an ideal model for deciphering the burgeoning socio-cultural complexity of human groups across the Central Saharan Mountain ranges (di Lernia, 1999, 7).

Building upon these data, Libya's settlement patterns and cultural landscape emerge as a sophisticated, interconnected network of interactions. This framework was shaped not only by spatial parameters but also by the climatic fluctuations that governed human migration trajectories and cultural dispersal. If Haua Fteah Cave provides a window into Levantine-influenced cultures, and the Acacus Mountains serve as a lens through which to examine Saharan-African cultural depth, then the Jebel Gharbi emerges as a strategic pivot—a vital nexus between East and West. It is increasingly evident that the Jebel Gharbi was far more than a mere transit corridor; it was a zone of permanent occupation that facilitated both human habitation and the synthesis of diverse cultural traditions. Consequently, analyzing these settlement patterns through an eco-evolutionary lens is fundamental to interpreting the connectivity between the coast and the Sahara, providing critical insights into how modern humans adapted to highly volatile environments.

### **Conclusion and Results:**

This study has elucidated the significant role of Pleistocene climatic fluctuations in shaping the lifestyles of hunter-gatherers in Libya. These populations established both sedentary and ephemeral camps across diverse ecosystems, ranging from coastal plains and fertile valleys to rugged mountain ranges and arid desert regions. Given that human settlement patterns were inextricably linked to the natural environment, and specifically to the availability of critical resources like water, flora, and fauna—human activity was dictated by a series of phenological events. These events, characterized by the interplay between climatic shifts (pluvial vs. arid cycles) and plant biological rhythms, profoundly influenced human survival strategies. However, the specific mechanics of these phenological relationships remain an area ripe for further empirical investigation.

From a broader perspective, an eco-cultural framework proves to be the most robust approach for analyzing Libya's prehistoric cultural systems. This lens allows researchers to trace the reciprocal influence between human groups and their environment, providing a panoramic understanding of the inter-cultural dynamics connecting Libya to the broader Mediterranean basin and the African continent.

The lithic assemblages recovered from Upper Pleistocene sites along the Libyan coast and within the Sahara facilitate a reconstruction of cultural affinities with contemporary sites in North Africa, the Nile Valley, the Central Sahara, and the Levant. These findings strongly support the hypothesis of large-scale human dispersals involving the exchange of technological innovations, social ideas, and adaptive behaviors. Specifically, the Pre-Aurignacian and Dabban industries at Haua Fteah exhibit a clear Mediterranean affinity, sharing striking similarities with assemblages in Palestine, Lebanon, and Iraq. In contrast, the Levallois-Mousterian and Capsian industries at the same site appear more deeply rooted in the African continental tradition. In the Central Sahara, the high degree of techno-typological similarity between Upper Pleistocene industries in the Acacus, Hoggar, and Aïr-Ténéré suggests a shared geo-cultural identity. Conversely, Paleolithic industries in Upper Egypt and Nubia during this period appear slightly more technologically advanced than those found in the Central Saharan massifs.

The technical parallels between Haua Fteah and Levantine sites like Mount Carmel and Ksar Akil raise fundamental questions regarding the westward diffusion of these influences. While the Pre-Aurignacian and Dabban industries in the Jabal al-Akhdar (Green Mountain) likely represent modern human migrations via coastal routes, contemporary sites in the Jebel Gharbi may offer critical data on how these groups adapted to inland environments. Consequently, Libya emerges as a pivotal hub for studying the dispersal of *Homo sapiens*, whether through an early "Out of Africa" expansion or a "back-migration" from the Levant.

In conclusion, Libya's prehistory is a complex tapestry of migration, dispersal, adaptation, and genetic admixture. The period between 200,000 and 10,000 years ago provided ample time for the emergence and integration of modern human populations. Future research employing integrated ancient DNA (aDNA) analysis and mitochondrial DNA and studies of contemporary populations will be essential in clarifying these diverse ancestral origins. Genomic mapping can now trace global human movements and illustrate how our ancestors genetically adapted to shifts in diet, climate, and pathogen exposure.

Finally, the Haua Fteah cave remains a site of untapped potential. The discovery of human mandibles there challenges the long-standing, though now outdated, view of North Africa as an evolutionary "dead end." While fossil remains in the region are infrequent, they are tangible evidence that North Africa was a central stage in the global narrative of human evolution and dispersal.

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