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THE COLONISATION OF SOUTH ASIA BY *HOMO SAPIENS*

Assessing Alternative Hypotheses through Cladistic Analyses of Lithic Assemblages

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Introduction

Some of the most important questions about the colonisation of South Asia by modern humans remain unanswered. For example, we are uncertain about which route or routes were used, nor the economy and technology in place at the time. The situation is made more difficult by a dearth of sites, and a total absence of fossils dated to the relevant time period, which is 100–40 ka before present (BP). The humid tropical environment of South Asia is not conducive to the preservation of organic materials like human bone and items of material culture that may be indicative of modern human artisanship. At present, a huge temporal gap exists between the archaic Hathnora skullcap (dated at around 400 ka) and the oldest known modern human remains from Fa Hien Lena Cave in Sri Lanka dated to around 35–46 ka (Wedage et al. 2019a, 2019b; Kennedy 2000). The genetic record from modern populations and more limited ancient DNA also indicates a disjunct between estimates for Out of Africa of c.50–72 ka (Malaspinas et al. 2016; Mallick et al. 2016), vestiges of an earlier Out of Africa dispersal preserved in Neanderthal and modern genomes (Kuhlwilm et al. 2016; Pagani et al. 2016; Posth et al. 2017), and the burgeoning modern human fossil record pointing to one or more exits from Africa between 200 and 100 ka (Schwarcz et al. 1988; Stringer et al. 1989; Grün et al. 2005; Demeter et al. 2012; Liu et al. 2015; Westaway et al. 2017; Groucutt et al. 2018; Hershkovitz et al. 2018; Shackelford et al. 2018; Harvati et al. 2019). Solving the problem of modern human arrival in South Asia has therefore fallen largely on archaeology, and comparative investigations of stone technology in particular. Work at numerous sites in India has centred on finding and dating sites in this crucial 100–40 ka temporal window and documenting the stone technologies present in those sites with a view to determining the identity of their hominin creators. However, stone tool technology is notoriously unreliable for determining hominin species (Foley and Lahr 2003). This is especially so given that there is much overlap in the technology and behavioural capabilities of Neanderthals and contemporaneous sub-Saharan modern humans, and that there are clear signs of convergence in stone technology throughout later human evolution (Clarkson et al. 2018). South Asia also offered a unique environment compared to what the colonists

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would have been familiar with farther west and hence adaptation likely transformed toolkits. All of these factors may confound a technological signal for a given hominin species. However, as Clarkson (2014) has argued, such a signal may nevertheless exist and is worth the search. It is still early days in the quest for definitive answers to the question of 'when, how and with what did *Homo sapiens* arrive in South Asia?'

In the present paper we review hypotheses about the colonisation of South Asia by modern humans, discuss key sites across the subcontinent that fall into the 100–40 ka temporal window for the possible arrival of modern humans, and examine the associated stone artefact industries. From this review, we attempt to draw some preliminary conclusions about when modern humans may first have arrived in South Asia, presenting finds from key sites and an analysis in which we used a suite of methods from evolutionary biology called cladistics to test between three key hypotheses: (1) that modern humans arrived after 60 ka with a Howeisons' Poort-like microlithic technology; (2) that modern humans arrived at least 100–200 ka with a Middle Stone Age (MSA) (also known as Middle Palaeolithic outside of Africa) toolkit featuring Levallois and handaxe technology; and (3) that modern humans arrived between 100 and 50 ka with an essentially sub-Saharan African MSA technology that included recurrent Levallois and point technology.

Out of Africa and Entry into South Asia: Hypotheses

In the last few years, archaeologists have put forward three competing models of the process by which *H. sapiens* colonised the Middle East, Europe, Asia, and Australasia. Mellars (2006) and Mellars et al. (2013) have argued that *H. sapiens* left Africa sometime after 60 ka with a distinctive, Howeisons' Poort-like microlithic technology, arriving in South Asia by around 50 ka. Other cultural components, he suggests, included engraved cross-hatched designs, bone or antler projectile technology, and the manufacture of perforated disc-shaped beads. Mellars (2006) and Mellars et al. (2013) contend that this package was lost *en route* to Southeast Asia and Australia due to successive founder effect and changes in raw material availability, resulting in a much-simplified technology arriving in Australia without microlithic artefacts. For the purposes of this paper, we will call this the *Late out of Africa with microlithic technology* model.

Another possibility is that modern human lineages populated Eurasia, including India, at least 100–200 ka, consistent with the early modern human fossil evidence from Greece, China, and Israel (Schwarcz et al. 1988; Valladas et al. 1988; Stringer et al. 1989; Grün et al. 2005; Liu et al. 2015; Hershkovitz et al. 2018; Harvati et al. 2019). These studies point to one or more periods, perhaps climatically driven, in which *H. sapiens* moved out of Africa and either became extinct or interbred with later populations of anatomically modern humans. In Africa, assemblages of this age contain Levallois and handaxe technology (Garrod 1937; Groucutt 2018 Sahle et al. 2019). In India, contemporaneous assemblages include distinctive Late Acheulian assemblages that feature Levallois and/or handaxe technology, as seen at sites such as Patpara, Sihawal, and Bamburi 1, dated to c.140–104 ka in the Middle Son Valley of northern India (Haslam et al. 2011; Shipton et al. 2013). We term this the *Early out of Africa with hybrid MSA technology* model.

Lastly, several studies have proposed that the *H. sapiens* dispersal into South Asia took place significantly earlier than posited by Mellars (2006) and Mellars et al. (2013), but not as early as the fossil evidence from Greece, Israel, and China might suggest (Petraglia et al. 2007, 2010; Armitage et al. 2011; Rose et al. 2011; Blinkhorn et al. 2013; Clarkson 2014; Clarkson et al. 2020). Instead, according to this model, recent evidence from Southeast Asia and Australia implies that modern humans made their way across Arabia and into South Asia sometime before 65 ka (Demeter et al. 2012; Clarkson et al. 2017; Westaway et al. 2017; Groucutt et al. 2018). Petraglia et al. (2009) have argued that a reduced Thar Desert may have allowed *H. sapiens* to move into India prior to the Toba eruption at 75 ka. Recently, Blinkhorn et al. (2013) and Clarkson et al. (2020) have drawn attention to the similarity of certain elements of Indian lithic assemblages to MSA tools from East Africa, including discoidal, recurrent, and preferential Levallois and Nubian point core technology alongside point and scraper products. They suggest that this may indicate *H. sapiens'* colonisation of South Asia with Levallois technologies well before 50 ka, but probably not before 100 ka. Here we term this the *Late out of Africa with MSA technology* model.

The *Late out of Africa with microlithic technology* model is consistent with genetic estimates of 50–72 ka for the timing of modern human expansion across Eurasia and Australasia. However, microlithic industries do not appear in South Asia or Europe until after 45 ka (Clarkson et al. 2009; Perera et al. 2011; Mishra et al. 2013), between 5000 and 20,000 years after *H. sapiens* had likely colonised Australia (Clarkson et al. 2017). Furthermore, most lithic industries along the Indian Ocean Rim dating to the relevant timeframe exhibit centripetal and single/multiplatform core reduction strategies with or without bipolar technology and lack any evidence of microlithic production (Clarkson 2014).

We further examine these three hypotheses below, but first we review key sites in South Asia from which the evidence is derived.

Key Sites in South Asia Dating 100–40 ka

Many sites in South Asia have seen detailed excavation and analysis, but few have undergone comprehensive and high-precision dating using modern techniques such as Accelerator Mass Spectrometry (AMS) radiocarbon and luminescence dating. Furthermore, it has long been noted that there is an absence of sites along the west coast as well as in the Tamil Nadu plains. The northern foothills of the Nilgiris to the rest of the rocky triangle between the Narmada River to the north is rich in sites, and there is much potential in that region for identifying more sites. Despite more than a 100 years of surveys, no Pleistocene sites are known along the western seaboard and south of the Kaveri in the southern peninsula (Korisettar 2007). This remains an ongoing bias in the archaeological record and makes testing the hypothesis of a coastal dispersal more difficult. Here we review 11 sites from widespread regions of South Asia and draw some conclusions about their technologies and place in the dispersal debates (Figure 2.1).

Late Acheulian Sites

Attirampakkam

The earliest Levallois technology in South Asia occurs in an industry with Acheulean handaxes and cleavers at Attirampakkam in Tamil Nadu, which dates to over 300 ka (Akhilesh et al.

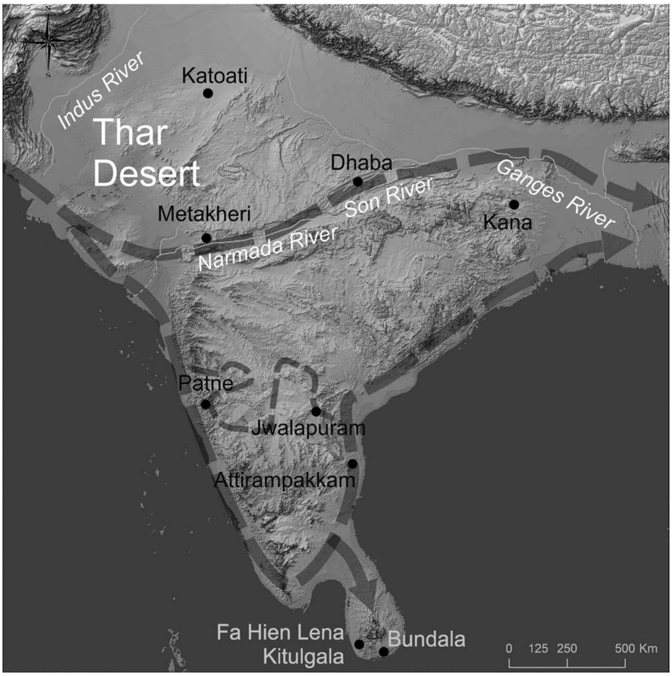

FIGURE 2.1 Map showing key sites mentioned in the text and modelled routes of colonisation across South Asia after Field et al. (2007). Topographic and bathymetric data was obtained from GEBCO 2014 Grid, version 20150318, http://www.gebco.net.

2018). However, in this early manifestation the Levallois technology does not appear to be recurrent, in the same way as the overlying layers. Levallois products were typically point forms. Bifaces continue in association with Levallois technology although at decreasing frequency until ~172 ka, after which there is a hiatus until 74 ka when bifaces are no longer present.

Middle Son River Valley: Patpara, Sihawal, and Bamburi 1

These three sites represent a transitional Acheulian to Middle Palaeolithic industry with handaxes and cleavers alongside Levallois technology dating to ~140–104 ka. Recurrent centripetal flaking dominates the Levallois core technology (Shipton et al. 2013).

Middle Palaeolithic Sites

Katoati, Thar Desert, Rajasthan

Katoati is the earliest known definitive Middle Palaeolithic occupation, with Levallois technology and an absence of bifaces from ~96 ka (Blinkhorn et al. 2013). Levallois products are typically points and the use of distal preparation is reminiscent of the Nubian technology documented in the Nile Valley and Arabia. Middle Palaeolithic occupation at Katoati is still evident at 77 ka and later.

Dhaba, Middle Son River Valley

This site presents a long sequence of Middle Palaeolithic occupation stretching from 78 ka, through the Toba ash, to the transition to a microlithic industry ~48 ka (Clarkson et al. 2020). Recurrent centripetal is the dominant mode of Levallois flaking with a variety of products including Levallois flakes, blades, and points.

Jwalapuram 3 and 22, Jwalapuram River Valley

Jwalapuram 22 is a locality underlying the Toba ash while nearby Jwalapuram 3 has occupation below and above the ash (Haslam et al. 2010, 2012; Clarkson et al. 2012). From below the ash there are a variety of Levallois products with the cores and dorsal scar patterns on flakes indicating both recurrent centripetal and recurrent unidirectional preparation. These modes of Levallois technology continue above the ash but there are no points among the products.

Patne, Maharashtra

Patne was excavated some time ago and represents a composite of many sections from a large area (Sali 1985). As such, its dating may be problematic. However, the site is important in documenting a gradual transition from late Middle Palaeolithic to Microlithic assemblages. The site contains engraved ostrich eggshell from the microlith layers that are at least 25 ka and abundant backed microliths and blade technology.

Site 70, Bundala, Sri Lanka

This site has a long sequence of technological change in a red earth close to the ocean on the southern tip of Sri Lanka (Deraniyagala 1989). The sequence shows discoidal core and scraper technology with backed artefacts later in the sequence, spanning at least the last 70 ka according to Infrared Stimulated Luminescence dating from the 1980s. The assemblage is made almost entirely on quartz, and this may limit the technical finesse of artefacts to some degree.

Microlithic Sites

Mehtakheri, Narmada River Valley

From 45 ka microblade technology is known from this site in central India (Mishra et al. 2013), approximately coeval with its appearance at Dhaba. Backed microliths occur among the retouched tools at both sites.

Jwalapuram 9

A microblade technology begins >35 ka here, again featuring backed microliths (Clarkson et al. 2009).

Kana, Bengal

In eastern India, microblade technology and backed artefacts are documented from 42 ka at Kana (Basak and Srivastava 2017).

Kitulgala Beli-lena and Fa Hien Lena Caves, Sri Lanka

Microliths including backed artefacts are also known from Sri Lanka from 45 ka, but unlike mainland India there is no microblade technology here, with blanks produced largely using bipolar flaking (Wedage et al. 2019a, 2019b, 2020).

Cladistic Analysis

Cladistics is a method of reconstructing evolutionary or 'phylogenetic' relationships. Within the cladistic framework, if two taxa exhibit a derived similarity that is not exhibited in a third taxon, this provides evidence that they are descended from a common ancestor of more recent origin than the last common ancestor shared with the third taxon, and therefore are more closely related to each other than either is to the third taxon. Ideally, the distribution of similarities among a group of taxa will be such that the characters support relationships that are congruent with one another. Normally, however, a number of characters will suggest relationships that are incompatible. This problem is overcome by finding the tree diagram or 'cladogram' that requires the least number of evolutionary changes to account for the distribution of character states among the taxa. This approach is based on the principle of parsimony, the methodological injunction that states that explanations should never be made more complicated than is necessary (Sober 1988). Similarities that are consistent with the most parsimonious cladogram are assumed to be the consequence of shared ancestry and are referred to as "homologies", while similarities that conflict with the most parsimonious cladogram are labelled "homoplasies". Homoplasies can arise through several processes, including convergence and horizontal transmission (Sanderson and Hufford 1996).

Cladistics was originally developed to reconstruct the phylogenetic relationships among species (Hennig 1966), and is still widely used for this purpose (e.g. Christiansen 2008; Smith and Grine 2008; Dohrmann et al. 2009; Rindal and Brower 2011; Goloboff et al. 2018), but in recent years it has been increasingly used to tackle problems in the social sciences and humanities as well (e.g. Robinson and O'Hara 1996; Holden 2002; Tehrani and Collard 2002, 2009; Jordan and Shennan 2003; Rexová et al. 2003; Ben Hamed et al. 2005; Eagleton and Spencer 2006; Larsen 2011; Lycett 2017). This cross-disciplinary borrowing of cladistics is premised on the idea that the transmission of language and culture share key features in common with the transmission of genes (e.g. Boyd et al. 1997; Collard and Shennan 2000). Crucially for present purposes, among the uses to which social scientists and humanists have put cladistics is the reconstruction of prehistoric colonisation events from linguistic and archaeological data (e.g. Gray and Jordan 2001; Holden 2002; Buchanan and Collard 2007; Jennings and Waters 2014; O'Brien et al. 2014; Smallwood et al. 2019). Languages and artefacts have long been used to reconstruct colonisation events in prehistory, but most of the relevant studies are narrative in nature, and therefore it is difficult to assess the merits of contradictory findings. Cladistics is advantageous in this regard because it allows competing hypotheses to be compared statistically (Gray and Jordan 2001; Buchanan and Collard 2007).

We analysed stone tool assemblages from sites dated >42 ka along the hypothesised eastward arc of dispersal from Africa to Australia (Lahr and Foley 1994; Field et al. 2007; Oppenheimer 2009; Clarkson 2014). We recorded assemblage composition from 57 sites in Sub-Saharan Africa, Arabia, the Levant, Europe, India, Southeast Asia, New Guinea/Melanesia, and Australia. We clustered the assemblages into 11 taxa (Figure 2.2). The taxa are defined

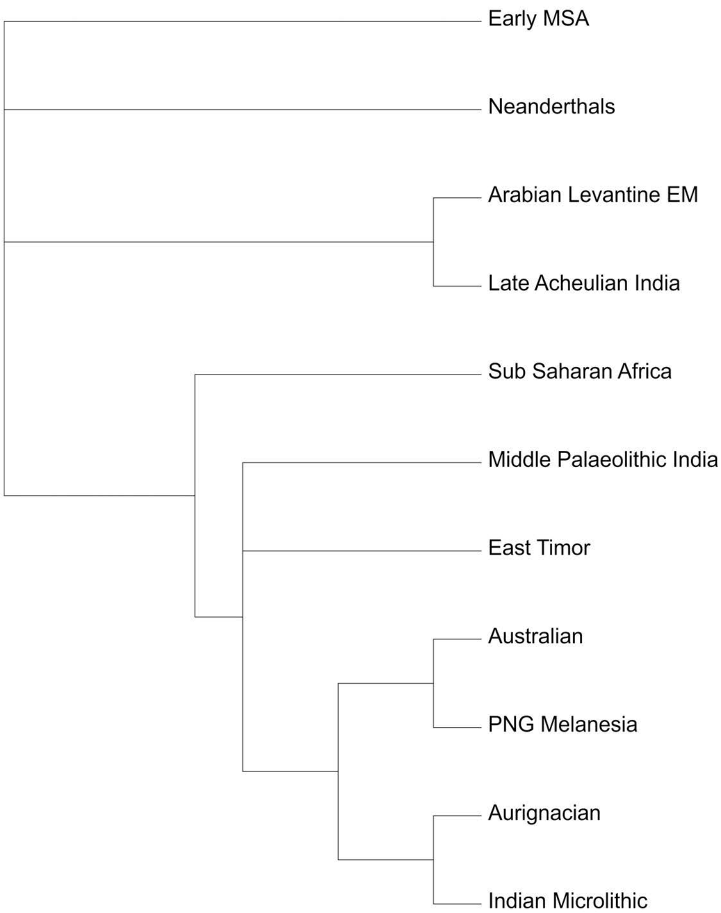

FIGURE 2.2 Hypothetical cladograms representing modern human dispersal of out of Africa.

according to time, space, and putative species affiliation. The characters we examined are 19 commonly recognised artefact types and core reduction strategies (Table 2.1). We coded the presence of a particular artefact type or reduction strategy as 1 and its absence as a 0. Sites were coded for the 19 characters based on the archaeological literature and, in some cases, the analysis of the assemblages themselves (Table 2.1).

The character state data matrix was subjected to maximum parsimony analysis in PAUP* 4.0 (Swofford 1998) using the branch-and-bound search routine, which is guaranteed to find the shortest length cladogram. The characters were treated in such a way that a change from 0 to 1 cost the same in terms of number of steps as a change from 1 to 0. Because the analysis yielded multiple equally parsimonious cladograms, we generated a consensus cladogram, which showed the relationships among taxa that all the equally parsimonious cladograms have in common. We created a majority-rule consensus cladogram. A clade must appear in 50% of the cladograms in order to be retained in a consensus cladogram.

The goodness of fit between the dataset and the most parsimonious cladograms was assessed with the Retention Index (RI). The RI measures the number of similarities in a dataset that are

TABLE 2.1 List of technological traits used in the cladistics analysis by region and period.

Site Clusters	*Bifacial Radial Cores*	*Hierarchical Surfaces*	*Prepared Recurrent Removals*	*Preferential Removals*	*Shaping of Upper Surface*	*Bidirectional*	*Unifacial Radial*	*Formally Retouched Artefacts*	*Levallois Points (Including Nubian)*	*Handaxes*	*Blades >4 cm (>10%)*	*Tanging*	*Points*	*Bipolar*	*Unidirectional Cores*	*Backed Microliths*	*Microblades <4cm (>10%)*	*Axes*	*Edge Ground Axes*
Early MSA (Outgroup)	1	1	1	1	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0
Neanderthals	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0
Arabian/Levantine Early Moderns	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	0	0	0	0
Late Acheulian India (>100 ka)	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0
Sub-Saharan Africa	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	0	0	0
Middle Palaeolithic (<100 ka) India	1	1	1	1	1	1	0	0	0	0	0	0	1	1	1	0	0	0	0
East Timor	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Australian	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	1
PNG/Melanesia	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0
Aurignacian	0	0	0	0	0	1	0	1	0	0	1	0	1	0	1	1	1	0	0
Indian Microlithic	1	1	1	0	0	1	0	1	0	0	0	0	0	1	1	1	1	0	0

inferred to be homologies in relation to a given cladogram. The RI is insensitive to the presence of derived character states that are present in only a single taxon, or 'autapomorphies'. The RI is also insensitive to the number of characters and taxa employed, which means that RIs can be compared among studies (Sanderson and Donoghue 1989). RIs for the most parsimonious cladograms were calculated and compared to RIs for 21 biological and 21 cultural datasets reported by Collard et al. (2006).

Next, following Jordan and Shennan (2003) and Buchanan and Collard (2007), we used the Kishino-Hasegawa (K-H) test (Kishino and Hasegawa 1989) to evaluate the goodness-of-fit between the hypothetical dispersal models and the consensus of the most parsimonious cladograms. In the K-H test, cladogram length, the standard deviation of length values, and the t statistic are used to measure the significance of the difference in cladogram-to-dataset fit between the most parsimonious cladogram(s) and one or more hypothetical cladograms and, where relevant, the difference of fit among the hypothetical cladograms. If the difference in length between any two cladograms is more than 1.96 times the standard deviation, then they are deemed to be significantly different at $p < 0.05$.

We created hypothetical cladograms based on the three Out of Africa dispersal models. These are illustrated in Figure 2.3 and can be summarised as follows:

1 *Late out of Africa with microlithic technology*. This model is consistent with Mellars' (2006) and specifies a late African exit with backed microblade technology, entering India and Europe sometime after 60 ka. According to this model, SE Asian, New Guinean/Melanesian, and Australian technologies are descended from Arabian/Levantine technology but lack microliths because they were lost en route due to founder effect.
2 *Early out of Africa with hybrid MSA technology*. This model posits an early dispersal from Africa, at least 100–200 ka, and possession of an MSA toolkit that featured Levallois and handaxe technology. The Aurignacian is considered a separate offshoot to the Levallois technology that dispersed eastwards and arrived in India prior to the Toba eruption. SE Asian, New Guinean/Melanesian, and Australian technologies are hypothesised to be descended from late Acheulian Indian technologies, while the Indian Microlithic is posited to be indigenous to the subcontinent (Petraglia et al. 2009).
3 *Late out of Africa with MSA technology*. This model takes into account recent genetic evidence for an African exodus after the Toba eruption at 75 ka, and posits that the migrants had a late Levallois toolkit that lacked both handaxes and microliths. SE Asian, New Guinean/Melanesian, and Australian toolkits are seen as descended from Indian post-Toba technologies. The Aurignacian and Indian Microlithic share a common ancestor with Levallois post-Toba assemblages but it is implied that Australia was already colonised by the time this split took place.

The parsimony analysis returned 26 equally parsimonious cladograms with tree lengths of 34. The RIs for these cladograms (0.66) are comparable to those obtained from datasets used to reconstruct the relationships of species and higher-level biological taxa (Collard et al. 2006). This suggests that the dataset contains a reasonably strong signal of branching, which supports the idea of using it to track the dispersal of early *H. sapiens* from Africa to Eurasia and Australia.

Figure 2.3 presents the 50% majority-rule consensus of the most parsimonious cladograms. The topology of the consensus cladogram suggests that the 75–50 ka Sub-Saharan African technological tradition is ancestral to those found in South Asia, Southeast Asia, New Guinea/

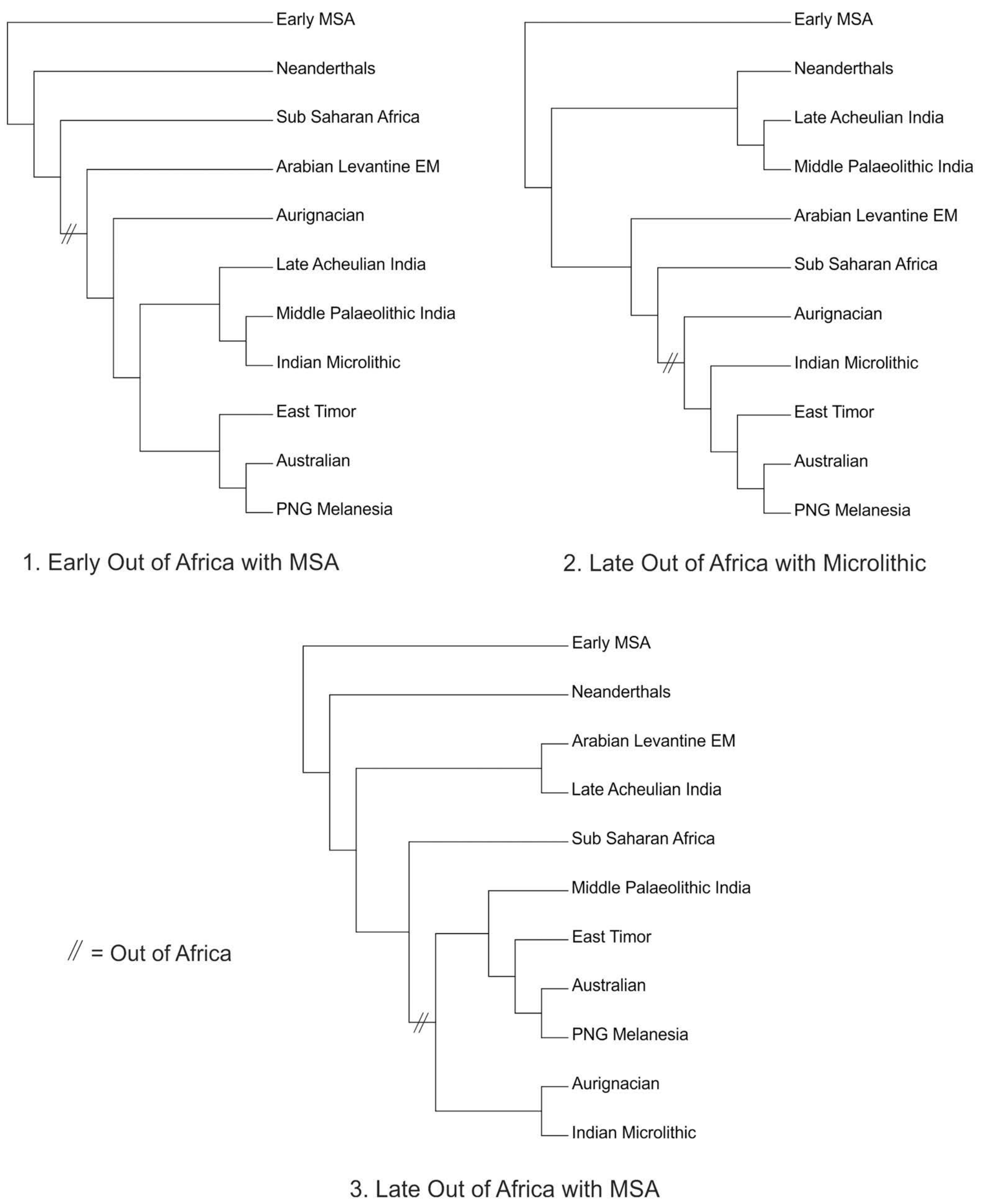

FIGURE 2.3 The 50% majority-rule consensus of the most parsimonious cladograms ($n = 26$).

Melanesia, and Australasia after the Toba eruption. Lithic assemblages found prior to the Toba eruption in Arabia and India appear similar to each other and likely pre-date the expansion of *H. sapiens* out of Africa that resulted in the colonisation of Australia, or represent an earlier expansion of *H. sapiens*. They are therefore likely to be associated either with archaic hominin species such as *Homo heidelbergensis* or an earlier dispersal of *H. sapiens* that has not contributed to extant populations. Lastly, the consensus cladogram suggests that the European

TABLE 2.2 Results of the Kishino-Hasegawa test comparing the observed cladogram with the three hypothetical cladograms.

Model	*Length*	*diff*	*SD*	*t*	*P**
Observed cladogram	34	(best)			
1. Early out of Africa with MSA	44	10	3.67	2.73	0.0138*
2. Late out of Africa with microlithic	40	6	2.92	2.05	0.0551
3. Late out of Africa with MSA	34	0	2.05	0	1.000

Aurignacian, Indian microlithic, New Guinea/Melanesian, and Australian technological traditions are offshoots of a technological tradition that developed subsequent to the post-Toba dispersal of *H. sapien*s into South Asia and Southeast Asia.

The K-H test in which we compared the consensus cladogram to the three hypothetical cladograms revealed that the *Late out of Africa with MSA technology* (Model 3) and *Late out of Africa with microlithic technology* (Model 2) models were not significantly different from the 50% majority-rule consensus cladogram (Table 2.2). Of these two models, the *Late out of Africa with MSA technology* is a better fit to the observed cladogram having the same tree length and structure, whereas the *Late out of Africa with microlithic technology* model was six steps longer than the observed cladogram. The *Early out of Africa with hybrid MSA technology* (Model 1) model was significantly different than the observed cladogram. Thus, the K-H test indicates that the late out of Africa scenario involving *H. sapiens* with an MSA technology lacking backed microliths is the model that best fits the currently available technological data.

Conclusion

Phylogenetic methods offer a powerful means of testing models of human dispersal using cultural datasets. Using data from 57 Palaeolithic stone tool assemblages and a suite of phylogenetic methods called cladistics, we tested between the three main hypotheses concerning the colonisation of South Asia. The hypothesis that was best supported by the data was the one in which modern humans left Africa relatively late—but most likely before the Toba eruption at 75 ka—and did so with a late Levallois technological assemblage, which lacked both handaxes and microliths. Improved dating, larger sample sizes and better descriptions of lithic assemblages from many sites, as well as the discovery of new sites, would be beneficial for refining analyses like these, but current models must be tested against the available evidence. In this case, our phylogenetic analyses offer strong support for a non-microlithic technology accompanying *H. sapiens* eastward out of Africa. We suggest the possibility of a later spread of microlithic technology from the Middle East into the Indian Sub-continent after 45 ka, although the mechanisms and archaeological signature for such a demographic event await future investigation.

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