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Southern Neolithic Cultivation Systems: A Reconstruction based on Archaeobotanical Evidence

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Introduction

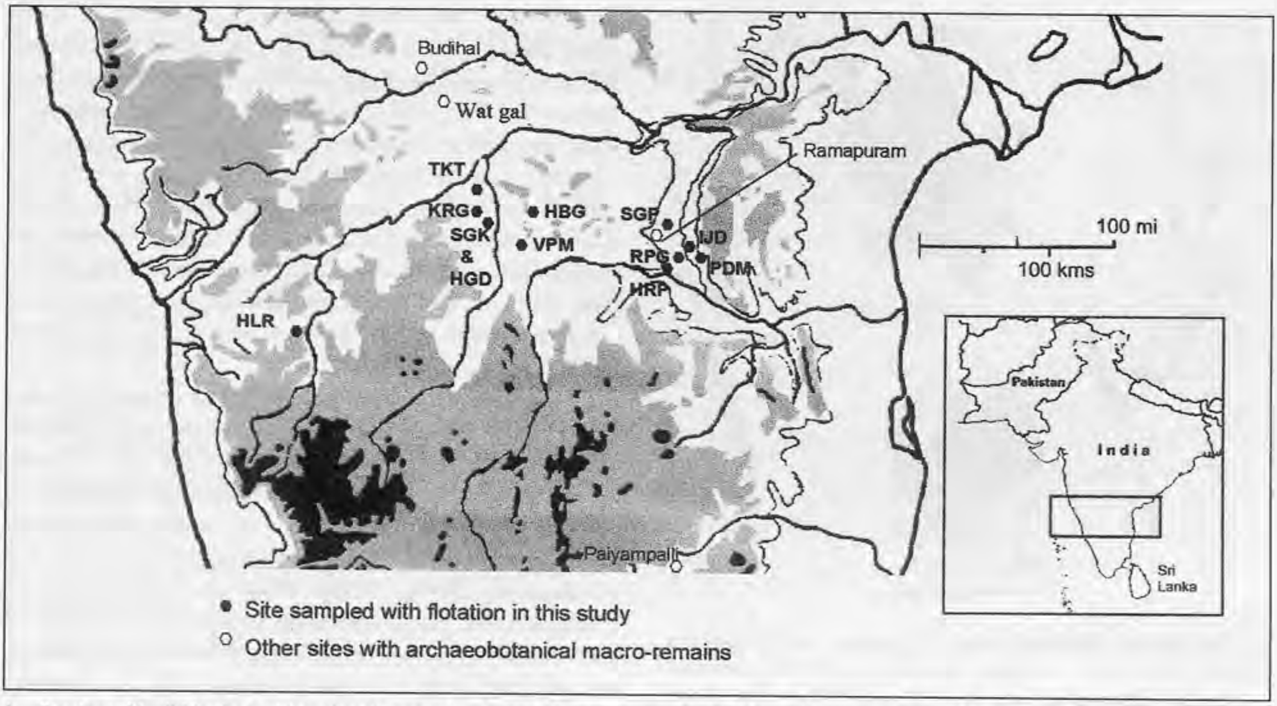
The Southern Neolithic of India has long attracted attention as an early food-producing village culture in South Asia. Thanks to its distinctive ashmound sites, and the pioneering fieldwork of Foote (1887), it was the first well-documented Neolithic culture in India. Subsequent research has clarified the basic outline of chronology, geography and material culture of this period, but large questions remain with regards to society and economy. A particular interest in the Southern Neolithic, in particular in its classic manifestation that includes the ashmound sites, is warranted due to the chronological priority of this culture over Neolithic/Chalcolithic sites in adjacent regions, such as Maharashtra (Allchin and Allchin 1982; 1997; Liversage 1991; Possehl and Rissman 1992; Korisettar *et al.* 2001). This chronological priority raises the possibility that at least of some of the Neolithic developments, such as pottery, ground stone tools, sedentism or food production, represent independent developments in South India, even if rather later than equivalent developments in the Near East or Baluchistan. In the present paper we will develop an understanding of the system of plant food resources, including cultivation, that provided the subsistence base of the Southern Neolithic, on the basis of new archaeobotanical evidence (Fuller 1999; Fuller in press a; in press b; Fuller *et al.* in press). The major plant food species discussed in this paper are summarized in Table 1, giving Latin, English and Hindi equivalents. For species in Table 1, English common names will be used throughout this article.

The role of cultivation during the Southern Neolithic has been controversial. By contrast the presence of animal herding in the economy has long been recognised, having been inferred by Foote (1916), and clarified on firmer grounds through work on animal bone remains (e.g. Allchin 1963; Paddayya 1975; Thomas and Joglekar 1994; Paddayya *et al.* 1995; Joglekar 1999a, b; Korisettar *et al* 2001) and through the demonstration that the ashmound sites derived from the burnt accumulations of cattle dung at sites of ancient pens (Zeuner 1959; Allchin 1963; Mujumdar and Rajaguru 1966; Paddayya 1992; 1998). On the other hand, clear evidence for the nature of plant food resources, and the contribution of cultivation has been more obscure. Despite a lack of archaeobotanical evidence, Allchin (1963) inferred that some sort of cultivation must have played a role in the Southern Neolithic economy (supported by Vishnu-Mittre 1989). More recently, however, Paddayya (1993a; 1993b) argued that cultivation played little or no role (also Saraswat 1992). This minimal cultivation view developed from the contrast between abundant evidence for domesticated animals and the lack of much archaeobotanical evidence from excavations at Budihal despite systematic sampling.

It can now be definitively stated that pulses and millets, almost certainly cultivated, were widespread in the Southern Neolithic region and must have contributed a major part of the diet (see below). Since the 1960s there have been sporadic reports of plant remains, which had been recovered in small quantities haphazardly (Nagaraja Rao and Malhotra 1965; Rao 1968; Vishnu-Mittre 1971; Kajale 1974; 1989). In more recent years some material has been recovered through flotation from several sites (Kajale 1996a; Venkatasubbaiah and Kajale 1991; Paddayya 1993a; Devaraj *et al.* 1995; Kajale and Eksambekar 1997), and the present authors have undertaken a fairly extensive program of flotation from scraped sections and fresh test-pits (Fuller 1999;in press a; Korisettar *et al* 2001; Fuller *et al. in press*). The limited evidence collected in earlier years from a number of sites indicated the presence of horsegram, hyacinth bean, wheat, jujube, *Vigna* sp. (mung or urid), and finger millet (Vishnu-Mittre 1971; Vishnu-Mittre and Savithri 1979; Kajale 1974; 1991). More recently, barley as well as Indian cherry and emblic myrobolan have been reported from Budihal (Kajale 1996a; Kajale and Eksambekar 1997, p. 221). In Andhra Pradesh, barley, hyacinth bean, *Vigna* sp., *Setaria* sp., pigeon pea, and wild okra (*Abelmoschus* sp.) were reported (Venkatasubbaiah and Kajale 1991; Kajale 1991). The reported finds of finger millet, however, have been repeatedly questioned on the grounds of identification (see Vishnu-Mittre 1977, p. 575,

Latin name and botanical authority	English name	Hindi name
Cereals and millets: These are starchy staples, which can be ground into flour to make bread, cooked into gruel, or boiled and served like rice		
Triticum diococcum Schubl.	emmer wheat, a glume wheat, requires extra threshing	gehu
Triticum durum/aestivum	free-threshing wheat (including either durum or bread wheat, in their broadest senses)	gehu
Hordeum vulgare L.	barley	jau
Oryza sativa L.	rice	chauval, dhan
Sorghum bicolor (L.) Moench.	sorghum, 'great millet'	jowar
Pennisetum glaucum (L.) R. Br.	pearl millet	bajra
Eleusine coracana (L.) Gaertn.	finger millet	mandal, ragi
Brachiaria ramosa (L.) Stapf.	browntop millet	N/A
Setaria verticillata (L.) P. Beauv.	bristley foxtail	laptuna
Paspalum scrobiculatum L.	kodo millet	kodon, kodu
Panicum sumatrense Roth ex Romer et Schultes	little millet	sawa, kutki
Echinochloa colona (L.) Link	sawa millet	sawank
Pulses or grain legumes: These are secondary staples providing protein, which may be boiled and fried as dhal, ground into flour for batters and some breads (e.g. papads), or they may be eaten fresh when still green (like pod peas).		
Vigna radiata (L.) Wilczek	green gram, mungbean	mung
Vigna mungo (L.) Hepper	black gram	urid
Macrotyloma uniflorum (Lam.) Verdc.	horsegram	kulthi
Cajanus cajan (L.) Millsp.	pigeonpea	arhar, tuvar
Lablab purpureus (L.) Sweet	hyacinth bean	sem
Lathyrus sativus L.	grasspea	khesari
Fruits: These are important vitamin sources which may be eaten fresh or preserved as pickles		
Ziziphus mauritania Lam.	jujube	ber
Phyllanthus emblica L.	emblic myrobalan	amla, aonla
Buchnania lanzan Sprengel	Cuddapah almond	chironji
Cordia dichotoma Forst. f.	sebesten, Indian cherry	chokargond, lasoora
Syzigium cumini (L.) Skeels.	jamoblana, java plum	jamun, jambu
Ficus spp.	figs, including wild species	bar, domoor, gular, kathum-bar, timla, etc.
Tubers: These are starchy rootlike organs; some require boiling to detoxify		
Dioscorea spp.	yams, including numerous wild species	chuprialu, kanta-alu, ratalu, susnialu, etc.

Table 1. Important food plants discussed in this paper, indicating scientific names, English and Hindi common names, and general category of use.



1. Southern Neolithic sites with archaeobotanical evidence. Floatation samples in this study were collected from sites indicated by three letter abbreviations. Other important Southern Neolithic sites with published archaeobotanical evidence are indicated by open symbols and full names. Abbreviations as follows: Hallur (HLR), Tekkalakota (TKT), Kurugodu (KRG), Sanganakallu (SGK), Hiregudda (HRG), Hattibelagallu (HBG), Velpumadugu (VPM), Singanapalle (SGP), Injedu (IJD), Rupangudi (RPG), Peddamudiyam (PDM), Hanumantaraopeta (HRP). Elevations indicated: 300 m. contour, 600 m. contour (grey), 900 m. contour (black).

n.1; Hilu *et al.* 1979; Kajale 1996a; 1996b) and must be disregarded due to problematic identification criteria (Fuller 2001; in press c). The additional data we have collected confirms and expands the list of other taxa utilised and provides some quantitative grounds from which to assess dietary significance. In this paper, we briefly review the evidence for Southern Neolithic staples as well as several minor crops and crops that were adopted during the course of the Neolithic. Working from these finds we infer the likely seasonal scheduling of Southern Neolithic subsistence, as well as some general observations of agricultural intensity and the organisation of food production within the broader Neolithic settlement landscape.

We outline aspects of the cultivation system of the Southern Neolithic, especially in its core region, that of the ashmound tradition. Based on the crop species present and their frequency and ubiquity, we propose a model of the seasonal scheduling of agricultural production as well as that of probable wild plant food gathering. We then discuss probable spatial and temporal patterning in the processing and preparation of the staple crops, in particular as they relate to the distribution of grinding/pounding equipment. This in turn suggests a spatial and temporal differentiation of the hilltop sites, such as Sanganakallu, and ashmound sites, reflecting a specialised non-agricultural function for the habitation at ashmound sites. This in turn has implications for the integration of pastoral and crop production during the Southern Neolithic.

Neolithic staples and secondary crops

A picture of staple and likely secondary crops of the Southern Neolithic has been generated by archaeobotanical evidence from a pilot study of several sites across the region. Twelve Neolithic sites across a roughly east-west transect of northern Karnataka and western Andhra Pradesh were sampled stratigraphically (Fig. 1). Sampling loci were chosen to include sites across different geographical-environmental zones, as well as those from different sub-cultures within the Southern Neolithic. These sediment samples were processed by means of water flotation to extract charred plant remains, which were then sorted and the seeds identified (Fuller in press A; Fuller *et al.* in press). The material came from archaeological levels that can be referred to Phases II and III in the Southern Neolithic chronology of Allchin and Allchin (1982), equivalent to 2300-1800 cal. BC and 1800-1200 cal. BC respectively. The antiquity of these remains is yet to be confirmed by direct AMS dating of individual seeds. The bulk of seed/fruit

2. The Southern Neolithic native crop package, shown clockwise from left, *Setaria verticillata, Macrotyloma uniflorum, Brachiaria ramosa, Vigna radiata*. Not to scale. Sources of illustrations: Coldstream 1889, Church 1886, Blatter and McCann 1935, Church 1886.

material was found to consist of pulses and millet grasses (Table 2; Fig. 2). The millet grasses have been identified as being primarily from two species, which comparative study suggests can be referred to species known to be utilised on only a small or localised scale today: browntop millet and bristley foxtail millet-grass. Although rare, these species are both still cultivated locally in some areas of southern India (De Wet 1995; Grubben and Partohardjono 1996; Maheshwari and Singh 1965; Pandey and Chanda 1996; Kimata *et al* 2000), while bristley foxtail is known to be harvested from wild stands (Gammie 1911). The consistently recovered pulses are two species native to the region, mungbean and horsegram present from the earliest levels, while other pulses appear only in later levels (Table 2). The wild progenitor of mungbean is known to occur in the wet and dry deciduous forests on the eastern edge of the Western Ghats (Saldanha 1984; Fuller 2001), while horsegram is native to *Acacia* thickets on the peninsula (Jansen 1989; Fuller 2001).

Several non-native cereal taxa are also present on Southern Neolithic sites. They almost always occur together, and include emmer wheat, free-threshing wheat and barley (including both some hulled and naked forms and some twisted grains of four/six-row forms). At the site of Hallur small quantities of rice were found. Although these taxa occur in early levels at two sites, Sanganakallu and Hallur, and therefore could have been present from the beginning of the Neolithic (we do not have yet any earlier samples with which to check this), the frequency of these taxa increases through time at these sites suggesting that they may initially have been adopted on a small scale and increased in importance later on, rather than having been established from the beginning of the Neolithic. In addition, there were two pulses that are later additions: Pigeonpea originating in Orissa, eastern India (van der Maeson 1995) and hyacinth bean from east Africa (Verdcourt 1970). Also, a few finds of pearl millet and one grain of finger millet were noted at Hallur, both of African origin (Harlan 1995).

Additional food plants and crops utilised included wild fruits, as well as probable oilseeds and a probable fibre crop. Widespread evidence for the use of jujube fruits came from charred seeds and seed fragments at several of the sites studied here, as well as figs of some sort, and possible Jambolan from Hallur and the Cuddapah district. *Rubia cordifolia*, identified from Sanganakallu, may have been gathered as a source of red pigment. *Cucumis* sp. (comparable to C. *prophetarum*, or perhaps C. *trigonus*) was found at Hallur in Karnatara and Hanumantaraopeta in Andhra Pradesh. This is a wild squash-like vegetable which has edible, bitter fruits; and it is also possible that its seeds could have been processed for an edible oil (Sturtevant 1979; cf. Roxburgh 1932, pp. 722-724; Watt 1889-1896). Also recovered at Hallur were a few fragmentary seeds of *Luffa* sp. (Cucurbitaceae) the fruits of which when young are eaten as vegetables (Sturtevant 1979). Although cotton has been cultivated since pre-Harappan periods in Pakistan, and may have been a major non-subsistence crop of the Harappan civilisation (Costantini 1983; Fuller 2001), the history of its cultivation in the Deccan is obscure. Finds of a few fragmentary cotton seeds from a single context of the Neolithic at Hallur (perhaps ca. 1200-1000 BC), suggest that cultivation of this crop had at least begun in the peninsular region during the final Neolithic phase (later second millennium BC), although the scale and significance of this remains obscure.

Also present in the archaeobotanical samples were charred fragments of parenchyma tissue, suggesting the use of tuberous foods. Although the parenchyma has not yet been identified, the methodology of Hather (1994) should make this possible, the consistent presence of these fragments argues for some use of tubers, whether from wild-gathered or cultivated plants. Ethnographic evidence indicates that there is a wide range of edible wild roots available, especially in the wetter forests of the hills (e.g. Singh and Arora 1978; Vishnu-Mittre 1985; Chatterjee 1991). Particularly prominent amongst the species that the parenchyma could represent are wild yams. It is also possible that some species were cultivated in drier regions such as the Bellary district. In general it appears that parenchyma fragments were

Neolithic sub-phase	Phase II					Phase III						
Site	SGK	HGD	VPM	HBG	HLR	SGK	HGD	KRG	HLR	HRP	RPG	PDM
pulses												
Macrotyloma uniflorum	X	X		X	X	X	X	X	X	X		X
Vigna radiata	X	X		X	X	X	X		X	X	X	X
Vigna cf. mungo					o				o	o		o
Vigna trilobata					o				o	o		
Lablab purpureus					+	+			+			
Cajanus cajan						+						*
millets (and related grasses)												
Brachiaria ramosa	X	X	X	X	X	X	X	X	X	X	X?	X?
Setaria verticillata	X	X	X	X	X	X	X	X	X	X	X	X
Echinochloa cf. colona							o		o	o		
Setaria pumila	o					o						
Panicum sumatrense					o			o	o			
Paspalum scrobiculatum									o			
Pennisetum glaucum					+							
Eleusine coracana									+			
large cereals												
Hordeum vulgare	+	+		+		+		+				
Triticum sp.	+	+				+		+				
Triticum diococcum		+				+						
Triticum durum/aesitvum	+	+				+						
Oryza sp.					o/+				o/+			
misc. food/crop plants												
Ziziphus sp.	o	o			o	o		o				
Ficus sp.								o	o	o		
cf. Syzigium cumini					o					o		
Cucumis cf. prophetarum					o				o	o		
cf. Luffa cylindrica									+			
Linum usitatissimum									+			
Gossypium sp.									X/+			
Abelmoschus sp.					o				o	o	o	*
parenchyma fragments	X/o	X/o	X/o	X/o	X/o	X/o	X/o	X/o	X/o	X/o	X/o	X/o

X = Presence of inferred crop, possibly derived from domestication in Southern India
+ = Present as crop, introduced from another region
o = Present in limited quantity, possibly gathered from wild
* = presence reported by Venkatasubbaiah and Kajale 1991

Table 2. Presence of crops and other food plants identified from Southern neolithic sites in the present study. For site abbreviations and locations, see Figure 1.

more frequent in the lower levels of sites than the upper levels, suggesting that the use of tubers gave way increasingly to that of cereals and pulses during the course of the Southern Neolithic.

Seasonality and Scheduling

Seasonality is an important aspect of cultural organisation, particularly prominent in agriculture and food consumption. With the exception of modern, industrialised supermarket economies, seasonal patterns in food consumption are universal (De Garine 1994). Agriculture represents a scheduling decision in which labour time is devoted to cultivation of a few plant species, leaving less time available for foraging and hunting. The seasonal labour demand for agriculture provides important insights into ethnographic studies of agricultural organisation (Stone *et al.* 1990), and therefore we might ask when during the year work was put into cultivation and what was done during other seasons. While seasonality in terms of crop sowing, ripening and harvesting may be easily inferred, estimating the amount of labour-investment in terms of the proportion of the population involved in cultivation during the seasons of cultivation is more difficult. In addition no direct correlation can be assumed between the seasonality of a plant, in terms of when its fruits or seeds are produced, and the seasonality of human occupation on a site where such seeds are recovered, due to the important intervening role of storage. What is attempted here is a general model that can establish the broad parameters of seasonality and intensity and predict how they may have changed.

In India there are two traditional periods of cropping. On the one hand there is summer cropping during the monsoon season (*kharif*), while on the other there is 'winter' (cool and dry) cropping (*rabi*). The important contrast between the winter seasonality of crops of Southwest Asian origin and the summer/monsoon seasonality of many other crops in India has been widely discussed (e.g. Allchin and Allchin 1968; Fairservis 1971; Hutchinson 1976; Possehl 1980; 1986; Kajale 1988; Weber 1991; Saraswat *et al.* 1994, p. 321; Reddy 1994; Meadow 1996). To some extent these seasons are determined by growth and fruiting mechanisms in the plants, i.e. whether flowering is triggered by lengthening or shortening day length (Willcox 1992), although for most crops there exist varieties in the modern context which are photoperiod neutral. Although it is not always clear whether experimental studies have established the inherent seasonality of many of the crops, it will be assumed here that traditional cultivation reflects the optimal or inherent seasonality of a plant.

The importance of *kharif* (summer) cultivation for the establishment of permanent settlements in monsoonal India (i.e. east of the Indus region) has emerged as an issue of particular interest. Possehl (1980, pp. 8-9, 54; 1986; 1997) attributed the proliferation of sites in Gujarat in the Late Harappan period at the end of the third millennium BC to the availability of summer cultivated (*kharif*) millets, especially those originating in Africa. The importance of *kharif* millet crops in this region has been confirmed by subsequent systematic archaeobotany (Vishnu-Mittre 1990; Weber 1991; Reddy 1994; 1997; Dhavalikar 1995; Fuller and Madella 2001), although most of these are not African in origin and Weber (1998) has suggested that these African millets were readily accepted only because there was an established tradition of millet cultivation.

Seasons of Southern Neolithic Crops

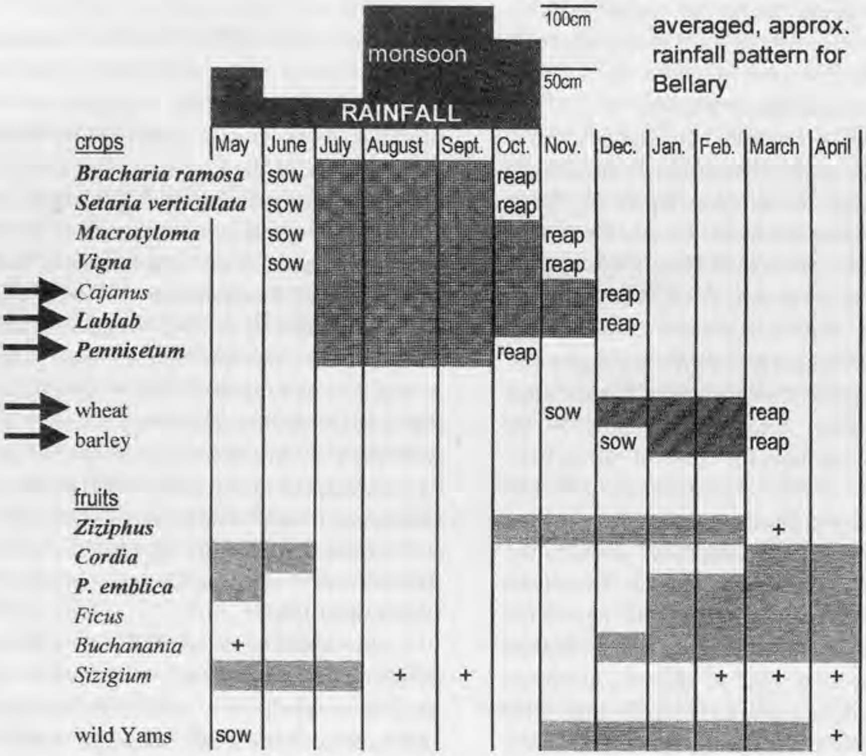
The basic package of indigenous species had a monsoonal (*kharif*) seasonality. *Vigna radiata* has been shown to be a short-day crop, i.e. flowering after summer, and also having a short growing season, maturing usually in three (two to four) months after sowing in late June or July (Watt 1889-1896; Kachroo and Arif 1970; Duke 1981; Siemonsma and Lampang 1989; Kajale 1988b). Horsegram is simiarly short-day flowering, but matures fully somewhat more slowly (4-6 months) (Watt 1889-1896; Purseglove 1968; Kachroo and Arif 1970; Jansen 1989; Duke 1981). Photoperiod sensitivity and length of growth period of the Neolithic millet-grasses is not detailed in the literature, although they share rainy season growth with the pulses and post-monsoon seed set (e.g. Cooke 1908; Singh 1988; Venkata Raju and Pullaiah 1995), and generally mature in about three months (the growth season is clear from the taxa in that they are reported to be grown together in modern contexts, see e.g. De Wet *et al.* 1983a; 1983c). *Setaria pumila* (yellow foxtail) when cultivated is reported to be sown in June-July and reaped October-November (Gammie 1911, p. 4). Other native small millets are similar, including kodo millet and little millet and the latter is noted for its sometimes very rapid maturation in two-and-a-half months (Rachie 1975; Grubben and Partohardjono 1996; De Wet *et al.* 1983a; 1983b); the wild little millet (*P. sumatrense* ssp. *psilopodium*) is reported to germinate after the first rains (late June) and to set seed at the end of October in the Varanasi area of north India (Sant 1964). It is likely that when cultivated, harvest would have occurred prior to natural seed set in order to reduce loss of shattering spikelets, i.e. during September/October. In Tamil Nadu where the Northeast (winter) Monsoon is the most important source of rainfall, germination is delayed until the first rains of this weather system in October/November with seed set three months later (Whyte 1964, p. 130). It should also be noted that wild millet-grasses, and presumably early cultivars, may have been prone to asynchronous ripening, and thus have required several harvests over a period of several weeks (see, for example, Lu's (1998) harvesting experiments with *Setaria viridis*).

The African millets possess the same natural seasonality as the native millets. Pearl millet and finger millet are both short day plants (Bourlag *et al.* 1996), normally sown at the start of the monsoon and harvested three or four months later (Watt 1889-1896; Kajale 1988). Thus these species (and sorghum) could readily have been substituted for the indigenous small-millet package. The evidence for small quantities of pearl millet only at Hallur, and a single grain of finger millet at a later period, suggest that these cereals were slow to be adopted in south India, perhaps for cultural rather than ecological reasons.

Additional crops from South Asia and from Africa share the same basic summer/monsoon seasonality, although some have longer growing seasons. This is the case with pigeon pea, which is a short-day perennial. Many forms of it have a five to six month growing season and some take as long as a year to mature, although some modern types mature as quickly as 95 days after sowing (Van der Maeson 1989; Kachroo and Arif 1970; Duke 1981). The short-maturing varieties, known colloquially as *Tuvar* (var. *flavus* DC) are more common in Peninsular India, although it is unclear how early they evolved (Van der Maeson 1995). Primitive cultivars are likely to have had longer periods of maturation, to have ripened unevenly, and may have retained dehiscent pods, as some do today (Van der Maeson 1995). Hyacinth bean is similar in showing a wide range in terms of maturation, from two to ten months, but it is normally sown at the start of the monsoon, often together with a millet or other pulse (Purseglove 1968; Shivashankar and Kulkarni 1989; Duke 1981), and five to six months is probably a good median estimate of maturation period. Rice also has basically monsoon seasonality, and it is the *indica* cultivars that are most tied to day length as short-day plants, generally with long growing seasons of at least four months (Shastry and Sharma 1974). Taxa that could have been either gathered or grown on a small scale in garden plots, including cucurbits (*Cucumis, Luffa*), are likely to have shared the same seasonality as the millets and pulses with harvesting during the post-monsoon period, October to December (cf. Watt 1889-1896; Paddayya 1982). Cotton (*Gossypium arboreum*) was probably grown as a bushy perennial and harvested after the monsoon at the start of the dry season, like long-duration *kharif* crops (Santhanam and Hutchinson 1974; Watt 1889-1896).

The Southwest Asian winter cereals differ in their seasonality which is significant in South India because of water requirements. These *rabi* crops are normally sown after the *kharif* crops are harvested, i.e. in November-December, and harvested in February or March (Watt 1889-1896; Kajale 1988). Given the seasonality of rainfall, the cultivation of these crops is challenged with the problems of supplying adequate water. On highly retentive, clay-rich soils, such as the black cotton soils of Maharashtra, or the Kunderu river valley of this study, it is possible that residual moisture after a particularly wet year might be adequate to produce a crop. Given that there may have been slightly more monsoon rainfall during the third millennium BC (see Fuller and Madella 2001; Korisettar *et al.* 2001; Enzel *et al.* 1999) this might have been somewhat more feasible during the earlier Neolithic, but evidence for these crops increases towards the later Neolithic, and they were at this time being cultivated on an extensive scale in Maharashtra judging by their high ubiquity and their dominance of samples at Inamgaon (Kajale 1988). In general, and for the sandy soils of the drier Bellary district in particular, it is likely that some form of irrigation would have been necessary (also Kajale 1988).

In addition to periods of agricultural activity, planting and harvesting, it is necessary to consider periods of availability of fruits that would have been gathered from the wild. Although there is likely to have been some localized variation in the timing of fruitset (cf. Adams and Bohrer 1998), it should nevertheless be possible to assign general seasons of availability. The seasonality reported here is based on floras (Talbot 1909; Singh 1988; Venkata Raju and Pullaiah 1995) and previous ethnoarchaeological investigations, for the Pune district, Maharshtra (Kajale 1988), the Hungsi valley, Shorapur District, Karnataka (Paddayya 1982), and southeastern Cuddapah district, Andhra Pradesh (David Raju 1988, Chap. 5). From these sources the widest possible availability is estimated, although it should be recognised that in reality only a portion of this range is likely to have been important at any local area or period. For the ubiquitous find of *Ziziphus* sp. (presumably jujube), October to February covers the reported fruiting periods of jujube. For Indian cherry and emblic myrobalan., both reported from Budihal (Kajale and Eksambekar 1997), we can assign March to June and January to May respectively. Most wild figs are available year-round in the wet evergreen forests of the Western Ghats (Saldanha 1984) but are more seasonal in the drier regions of the Deccan plateau often fruiting for only a couple of months (Singh 1988; Venkata Raju and Pullaiah 1995). In the Hungsi valley they are reported to be gathered from January to April (Paddayya 1982). The as yet archaeologically unreported Cuddapah almond fruits December to April (Singh 1988; Saldanha 1996), with April to May reported by Talbot (1909). For jamoblana there is a wide window of potential flowering and fruiting. Talbot (1909) indicates fruits from May to



3. Inferred basic seasonality of Southern Neolithic cultivation and foraging, based on the predominant modern seasonality of the dominant indigenous crops, present from at least the start of Phase II. Diversification during Phase II and III by the adoption of non-indigenous crops is indicated by arrows. Yams are included to account for the high ubiquity of charred parenchyma tissue (although no definitive identification of this material is yet available).

August, while May to July is reported for the Kurnool District (Venkata Raju and Pullaiah 1995). Theses periods are bracketed by the reports of February to September flowering and fruiting reported for Karnataka (Singh 1988; Saldahna 1996). Nevertheless most of the fruits can be generalised to dry season availability, as is also the case with several other gathered fruits of the Deccan for which there is as yet no archaeobotanical evidence.

Incorporating the presence of tubers (indicated by the so far unidentified parenchyma fragments) into a model of Southern Neolithic seasonality is more problematic. First, without specific identification it is easy to make mistakes in choosing analogues. In addition, detailed seasonality information on native, wild tubers has been difficult to find. Although ethnobotanical compilations list edible tubers, they do not provide information on seasonality (e.g. Maheshwari and Singh 1965; Singh and Arora 1978; Vishnu-Mittre 1981; 1985). Ethnographic information often lacks specific identifications of tuber crops (e.g. Grigson 1938, p. 152; Paddayya 1982; David Raju 1988). In general one would expect tubers to be least attractive during the active growing season as starch may be used to fuel plant growth or has not been fully converted to tuberous storage (Alexander and Coursey 1969). This would suggest that use of tubers during the dry season would optimise the available starch stores. Indeed traditional Indian cultivation of yams involves planting prior to the monsoons (April to June) with harvesting in December (Watt 1889-1896), although it is likely that harvesting could take place anytime between October and May. Nevertheless, some tuberous food sources remain available during the monsoons, as it is reported ethnographically that forest roots and tubers are gathered during the rainy season among the Yanadis of Cuddapah district (David Raju 1988) and the Gonds of Bastar (Grigson 1938, p. 152). Although it is not yet clear that yams were part of Southern Neolithic subsistence, they may well prove to be the source of the parenchyma, and will be hypothetically added to the seasonality model as a resource that was available during the dry season, although it is perhaps most likely that tubers were utilised throughout much of the year on a small scale or whenever supplies of other foods ran short.

Site type, Archaeological characters	Examples	Botanical preservation	Social/economic Interpretation
Settlements, Deep, stratified deposits, evidence for structures, usually on hilltops	Sanganakallu, Tekkalakota, Velpumadugu, HattiBelagallu, Kurugodu,	consistent recovery of seed assemblages	Permanent settlement Above agricultural plains (occasional sites near base of hills such as Kurugodu, Bellary Face Hill, Watgal)
Ashmounds, with no stratified deposits around them	Kudatini, Godekal Utnur, Chopadamagudda	no sediments to float	Seasonal, short-stay(?) encampments of single pastoral groups
Ashmounds, with some habitation deposits around them	Kupgal, Palavoy, also Budihal (Paddayya 1993a, b; 1998)	very poor recovery of seeds	Seasonal, long-stay encampments of pastoral groups, in dry season. Often multiple ashmounds (perhaps from several pastoral social groups). Often near sources of lithic raw materials

Table 3. Tabular summary of the three main site types of the Ashmound Tradition of the Bellary region, including notes on the extent of preservation of archaeobotanical material.

Crop Adoption and Changing Seasonality

Working from the above information on crop seasonailty it is possible to derive the basic scheduling framework for different Southern Neolithic sites and regions. Given that the core staples are consistent, it is possible to postulate a seasonal calendar of plant-food availability (Fig. 3) which was focused around the monsoon cultivation of small millets and pulses which can be seen as balanced by the dry-season availability of a range of fruits as well as wild yams (and presumably other tubers). It should be noted that despite the common sowing period for the crops, there are likely to have been two harvest periods, one for the millets and one for horsegram, while mungbean pods would have been picked intermittently as they matured. This basic scheduling would have been shared across the entire Southern Neolithic region and can be inferred in the lowest levels of sites studied here, such as Sanganakallu, Tekkalakota, Hanumantaraopeta and Hallur (Fig. 1). This simple biseasonality was probably the original cultivation regime of the Southern Neolithic. This cultivation system could represent an indigenous development of cultivation from an earlier seasonal gathering schedule based around the same resources, post-monsoon grains and pulses and dry season fruits and tubers. These different resources, however, are likely to have been gathered in different vegetational zones, the dry desciduous woodlands and grassland on the one hand and the (semi-)evergreen or wet deciduous forests on the other.

At particular sites (and regions) this basic scheduling was augmented by the adoption of additional crops, made available from other regions. The first and most widespread crops to be adopted in the Bellary region were winter cereals, wheat and barley, which added a new cropping season to the calendar (Fig. 3). As noted above, these crops are not well-suited to the rainfall regime of monsoonal India and are likely to have required some form of irrigation. At sites such as Tekkalakota, Kurugodu, Hattibelagallu and Sanganakallu there were no local rivers that could have served as sources of water during the winter, and it is unlikely that water from the natural seepages, or cisterns in the granite hills, would have been easily harnessed. Thus it seems likely that the South Indian tradition of tank irrigation or bunding of water near the bases of local hills may have begun, although the start of this tradition is usually attributed to later periods, especially the Early Historic Period or perhaps the Iron Age (Wheeler 1959, p. 163; Gurukkal 1989; Champakalakshmi 1996, pp. 36, 82-83). This then represents the first form of agricultural intensification through irrigation and through adding additional seasons of tilling, sowing and harvesting. The relatively low frequency and ubiquity of wheat/barley and the likelihood that they could fail without sufficient irrigation argues *against* these crops being adopted for reasons of buffering risks or greatly augmenting food supply—which would have been more reliably served by intensifying and expanding the tried-and-true monsoonal crops. We might expect winter pulses also to have been cultivated if augmenting food supply were the primary reason for the adoption of winter cultivation, since some of the winter pulse varieties are highly drought resistant, notably grasspea (although this may have been grown on a small scale at Tekkalakota, cf. Vishnu-Mittre and Savithri 1979). The evidence of native pulses implies a pulse-heavy diet and it would be surprising if additional pulses had not played a role in shortage-buffering efforts - especially some of the drought resistant winter pulse varieties. Thus it can be inferred that the adoption of wheat/barley was due at least in part to cultural/social concerns rather than strictly economic/adaptive motives.

Some sites have evidence for the adoption of additional crops indicating the selective and local nature of adoption. In the Bellary region, evidence for additional adoptions comes from Sanganakallu, where two additional pulses were added, pigeonpea and hyacinth bean (see Fig 4). These species, although having similar seasonality to the pulses already cultivated, differed in the length of growing season, meaning that they would have been harvested at yet another period. Thus although they fit into the pre-existing cultivation regime in terms of planting times and being watered by monsoon rains, they would have required a reorganisation of labour during the post-monsoon harvest period. That these crops were pulses, and in the case of hyacinth bean came to make such a significant contribution to archaeological assemblages, suggests that these taxa, or hyacinth bean at least, did play an important dietary role. These adoptions therefore might be suggested to relate to increasing food supply or to provide some risk-buffering since spreading the harvest period might also spread certain risks associated with crop loss. Social or cultural values assigned to these foods cannot, however, be ruled out.

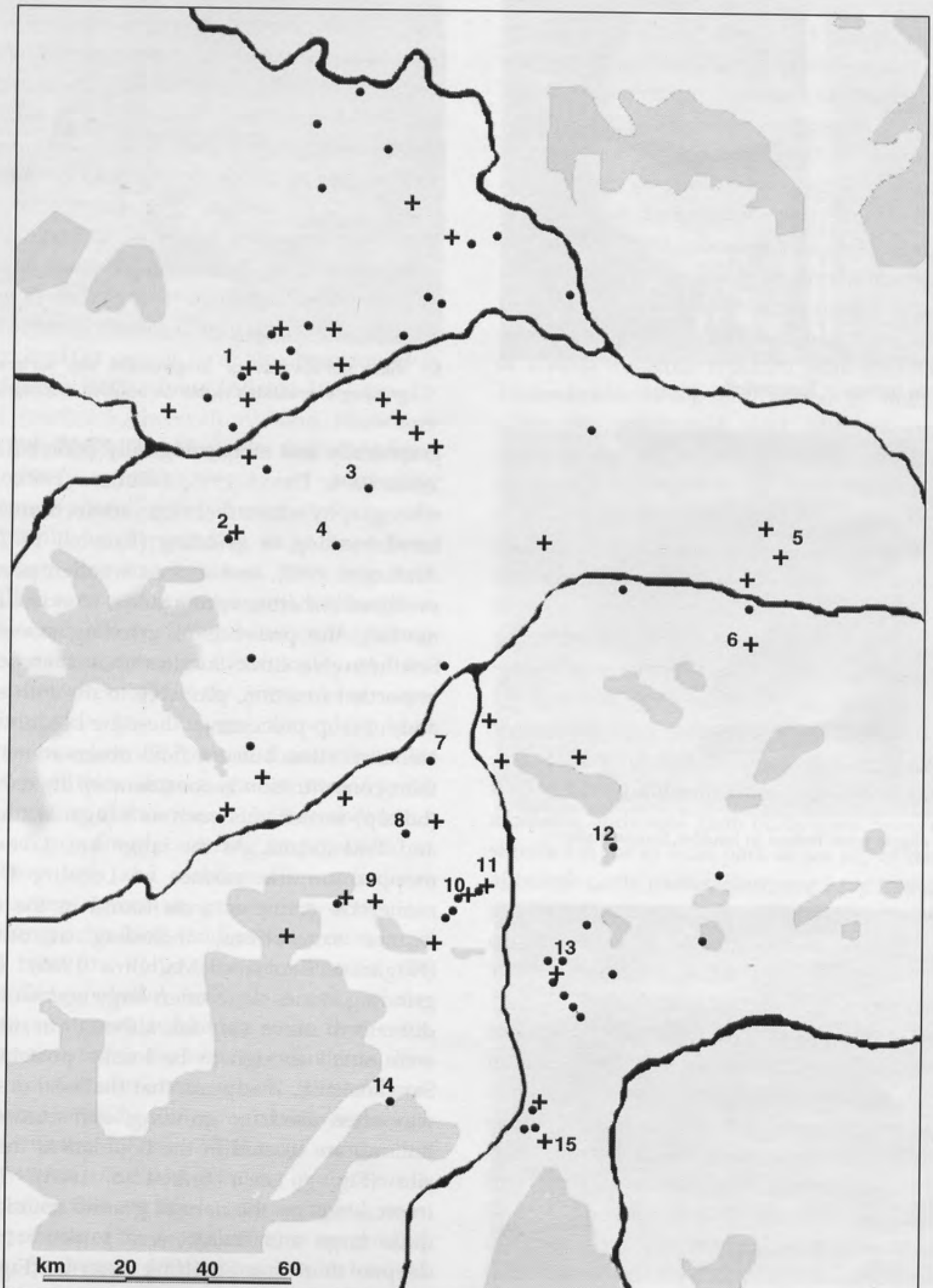
At Hallur there is evidence for a greater diversity of minor crops including numerous adopted species, including those of Southwest Asian origin, possible north Indian origins (e.g. rice) and from Africa. In addition, although they may have merely been weeds, several additional native small millets were present which could have offered additional opportunities for cultivation or wild harvesting. Although the basic Neolithic staples remained prominent throughout the sampled sequence, the additional crops served to diversify subsistence by spreading harvest periods.

Such strategies of diversification may have helped to spread agricultural labour and help to overcome labour bottlenecks (in the sense discussed by Stone *et al.* 1990). Thus evidence for diversification occurs alongside the possibility of some forms of technological intensification, especially in the form of irrigation, that was necessary for the cultivation of winter cereals.

Crop processing in its regional setting: a working hypothesis.

The seasonal patterns of crop production can be placed into a settlement system model by considering the likely role played by different categories of sites. Our fieldwork in the Southern Neolithic area, in particular that of the Ashmound Tradition in the Bellary district suggests that sites can be grouped into three categories (Table 3). First there are well-stratified settlement sites that have yielded abundant evidence for crops. Although beyond the scope of this paper, our general understanding of the formation processes of charred seed assemblages suggests that they derive primarily from the incidental waste of crop processing, which we would expect to have been more extensive and more routine on permanent sites near which cultivation was carried out and on which crops were stored (Fuller 1999; 2001; in press B). In opposition to these sites are ashmound sites where very little evidence of archaeobotanical remains has been recovered, with the exception of very limited finds from Budihal (see Paddayya 1993a; 1993b; Kajale 1996a; Kajale and Eksambekar 1997). Ashmound sites can be divided into two main groups, those with evidence for extremely limited habitational refuse, such as Kudatini, Gudekal or Utnur, that can probably be considered short-stay encampments, and those with some limited stratigraphy of habitational refuse that may have been longer-stay encampments, such as Budihal, Palavoy or the ashmounds of Kupgal (Korisettar *et al.* 2001; see also Allchin 1963). The role of ashmound sites in pastoralism is clear from evidence for penning, dung accumulation and animal bones (Allchin 1963; Paddayya 1998), but this does not mean that people at these sites did not consume plant foods or agricultural produce, but rather that they carried out less processing, probably only the final food preparation stages, and on a more restricted scale. When considered on a general regional scale it can be seen that groups of permanent village sites and ashmound encampments form geographical clusters that might represent networks of agricultural villages with associated hinterlands of pastoral transhumance (Fig. 4). In the region of Hallur, insufficient survey data are available to suggest similar site-type divisions. In the Cuddapah district further analysis is necessary but provisionally at least two broad divisions can be drawn, perhaps equivalent to permanent agricultural sites and seasonal, pastoral encampments, albeit without any evidence for ashmound formation.

The functional distinction between hilltop settlement sites and the ashmounds may also be reflected in artefactual evidence for seed-food processing, namely in grinding stones. Although grinding stones have numerous potential uses, their use for the dehusking or grinding of seed foods is well documented ethno-

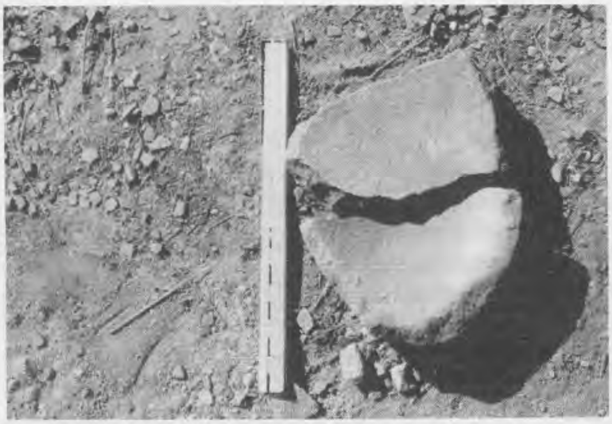


4. Distribution of Southern Neolithic sites in the core region of the Ashmound Tradition. Ashmounds indicated by crosses, while other sites (presumed to be villages) indicated by black circles.

Selected sites labelled:

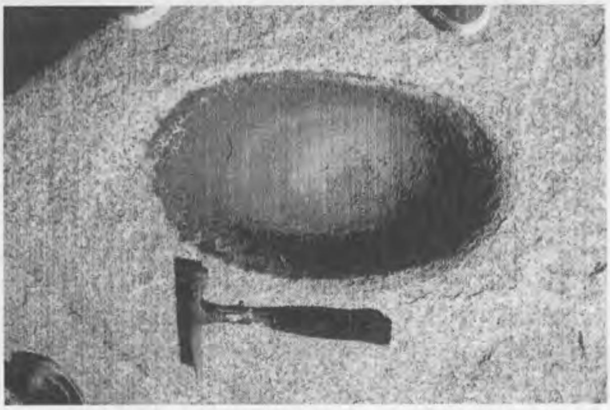
1. Budihal
2. Piklihal
3. Watgal
4. Maski
5. Utnur
6. Gudekal
7. Tekkalakota
8. Kurugodu
9. Kudatini
10. Sanganakallu and Chaudammagudda ashmound
11. Hiregudda and Kupgal ashmounds
12. Hattibelagallu
13. Velpumadugu
14. Brahmagiri
15. Palavoy.

Grey shading indicates elevation over 600 meters.



5. Quernstone on surface at Sanganakallu

6. View northwards of Sanganakallu site surface with artificial grinding impressions visible on boulder in foreground.



7. Close-up of elliptic grind hollow in boulder, Sanganakallu

8. Large artificial grinding hollow in boulder, Sanganakallu

graphically and archaeologically (Kraybill 1977; Wright 1991; 1994; David 1998; Fujimoto 1993; 1996). While ethnography warns that stone artefacts are not necessary for dehusking or grinding (Kraybill 1977; Cane 1989; Anderson 1992), and indeed wooden pestles are often preferred (whether with a stone, wooden, or earthen pit mortar), the presence of grinding stones during the Southern Neolithic implies that these did serve an important function, probably to do with seed grinding and/or crop-processing. These are ubiquitous finds at all Neolithic sites, but our field observations indicate that their concentration is considerably higher at permanent (hilltop) settlements such as Sanganakallu , Kurugodu and Tekkalakota. At the latter site, 17 examples were mapped on the surface of Locality I. In addition numerous examples were found in the course of the former excavations, including at other localities (Nagaraja Rao and Malhotra 1965). Free-standing grinding stones were often large and would have been difficult to move very far, although in other cases they were small enough to be locally portable (Fig. 5). At Sanganakallu, it appears that the local granite hill itself was often used for grinding, and numerous grinding hollows are located in the boulders at the edges of the site (Fig. 6; also Subbarao 1948). The grinding impressions on the natural granite boulders were often quite large and many were somewhat rounder and deeper than free-standing querns (Fig. 7, 8). This morphology might have been produced by pounding, as in preparing cracked grain, or perhaps de-husking, and not merely grinding. The querns and grinding impressions indicate that much of the grinding of grains was done outside rather than inside dwellings, and also suggests that pounding/dehusking may have been carried out on the hillsides immediately around the site, at least at Sanganakallu. Similar possible artificial round grinding/pounding impressions were located on Chaudamma Hill, although there were fewer of them, and at Kupgal Hill and at Kurugodu, where some examples were found immediately around the sites, as well as a short distance from it in areas where there was no other archaeological record, such as part way up the hillside south of the site area.

No examples of pounding/grinding impressions in the natural rock were noted at solitary ashmound sites, such as Godekal or Palavoy, although ashmound sites do have querns. Quernstones are likely to have been used to make flour. Some of the ashmound sites, which have been identified as long stay encampments, have produced quite large numbers of quernstones, e.g. thirteen on the surface at Palavoy (Rami Reddy 1978, p. 26), as well as some at Budihal (Paddayya 1993a; 1993b). A few grinders and/or querns have also been found at Kudatini (Paddayya 1992), Utnur (Allchin 1963, pp. 42-43), Gudekal (authors' observation), and elsewhere (Allchin 1963, pp. 77-78). This suggests that some food processing, namely grinding, was not seasonally restricted, although pounding may have been.

Much grinding and pounding must have been done at the same sites and locations, including both permanent hilltop sites and encampments, although an important distinction can be drawn between the hilltop settlements and encampments in their vicinity and the solitary ashmound sites. While the presence of some querns at ashmound sites indicates that plant seed processing was also carried out at these sites, the quantity and size of these argues against intense grain processing or grinding at these sites. On the other hand the presence of grinding/pounding impressions at permanent hilltop sites and associated encampments suggests that more intensive processing activities, probably including dehusking (and perhaps on a large scale judging from the large size of some of the impressions at Sanganakallu) took place only in the vicinity of the permanent habitation sites that were presumably associated with the areas of cultivation. The encampments near these sites, which it has been suggested were seasonal dwellings for mobile segments of society (Korisettar *et al.* 2001), fits with the ethnographic generalisation that grinding equipment is often cached at sites that are repeatedly occupied, near the actual living stands of the food stuffs that are ground (Harris 1984, p. 65; Wright 1994). This would tend to suggest that these were temporary dwelling places that were reused at the time of year when pounding was carried and food grinding (of cereals or pulses) was most intensive.

Conclusions

The Southern Neolithic stands out from preceding Mesolithic cultures of the region by its more archaeologically visible sites, a condition that is likely to have resulted from food production and increased sedentism. While the visibility of the ashmounds was due to specific practices that led to the burning of accumulated dung, the visibility of non-ashmound sites is due to their deep stratigraphy, in addition to their frequent hilltop locales. The archaeological accumulations at the latter sites suggest either intensive or prolonged occupation, and we have argued that they are likely to have sustained at least some year-round occupation. Our field observations and archaeobotanical sampling at a several ashmounds and non-ashmound sites, indicates that millets and pulses, in all likelihood cultivated, played a prominent role in subsistence, at least at non-ashmound settlement sites. At ashmound sites, with the exception of limited evidence reported from Budihal (Kajale and Eksambekar 1997), cultivation is not in evidence, although artefactual and chronological evidence indicates that these two types of sites were inhabited during the same prehistoric periods. We have suggested that this is probably a product of the formation processes of charred archaeobotanical assemblages, and that at ashmounds, although agricultural produce may have been consumed, it is unlikely to have been produced and processed in bulk. This reconstruction differs from the suggestions of Paddayya (1992; 1993a; 1993b; also Deveraj *et al* 1995), who has suggested that ashmounds were typical habitation sites of the Southern Neolithic and that pastoralism was of paramount economic importance while cultivation was not. The evidence now available indicates that cultivation was economically significant for at least part, if not all, of the population, although cattle pastoralism may have had a pronounced symbolic importance, as suggested by the probable ritual connections of the ashmounds (Allchin 1963; Murty 1989; Korisettar *et al.* 2001).

The cultivation of the Southern Neolithic focused on *kharif* (monsoon) cultivation of pulses and millets, although *rabi* (winter) cultivation also played some role at some sites during some periods. The basic staple crops (mungbean, horsegram, browntop millet, bristly foxtail millet-grass) could all have been brought into cultivation from wild populations in the Southern Deccan, and may thus represent an instance of primary domestication. The cultivation of these is likely to have been based on dry-cropping from naturally available monsoon rainfall, and may have used an extensive system, perhaps even shifting fields, although there is not yet direct evidence for this. Nevertheless, through time with the adoption of additional crops, agricultural diversification, in terms of crops and cropping seasons, and intensification, probably including at least irrigation, seems to have been undertaken by at least some communities. This hints at drives towards increased agricultural production, although whether for socially-motivated surpluses or to counteract growing populations or crop failures remains unclear. The fact that ashmound formation may have declined during the Southern Neolithic, especially in later Phase II to Phase III (cf Allchin 1963; Allchin and Allchin 1982; Korisettar *et al.* 2001) suggests symbolic changes in ritual practices but also might hint at the increasing valuation of dung for agricultural purposes. Thus manuring may have also played a role in intensification and facilitated repeated cropping on the same land. Whether or not cattle-traction tillage played a role in cultivation is unclear. The trends towards increasingly diverse cropping systems and some intensification could have facilitated increased populations and/or increased social complexity, and should perhaps be considered as crucial background for understanding later historical developments of more hierarchical societies in South India.

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