Archaeobotanical Taphonomy, Crop-Processing Patterns and the interpretation of archaeobotanical seed & chaff assemblages.
植物考古埋藏学、作物加工模式和对植物种籽糠壳组合的解释

Dorian Q Fuller & Qin Ling 2008.4.17

This hand-out includes selected diagrams on crop processing 大纲包括以下各家的模式

- •Minnis' taphonomic diagram, the 'catch-all' model
- •Dennell's general processing assemblage formation model
- •Hillman's activities and assemblages relationship diagram
- •cereal disarticulation (for wheats and barley).
- •G. Jones summary of processing affects of weed seed types, and statistical summary of separation of products and by-products
- •C. Stevens pictorial summary of key stages in crop-processing (glume wheats) [based on Hillman 1984 and G. Jones 1987]
- •Rice processing model from Harvey and Fuller (2005) based on Thompson (1996)
- •Hulled milled processing model from Harvey and Fuller (2005) based on Reddy (1997)
- •Pulse processing model from Fuller and Harvey (2006)
- •Diagram of potential variables affecting pre-depositional, depositional, post-depositional stages of charred assemblages
- •A synopsis of some of the key publications in the development of thinking on archaeobotanical formation processes
- •bibliography is included at the end. 参考文献附后

English-Chinese glossary of some basic crop-processing terms

harvest/ harvesting 收割

thresh/ threshing 脱粒. This separates components by weight
usually together with raking
threshing may be down by hand by beating with sticks 用手敲打
of by trampling (often with domestic animals like cattle or donkeys) 利用家畜践踏
or be threshing sledges (especially in the Near East), usually pulled by animals. 用机械
*Note: Threshing may not be necessary for wild species which are gathered by beating or basket-swinging. Threshing is always necessary for domesticated species which have loss natural shattering mechanisms. *对于野生的收集，脱粒不一定是必须的；但驯化作物丧失了自动落粒性，所以脱粒是必须的加工步骤“

Winnow 扬谷： first winnowing
various winnowing methods including pouring from a weight 利用重量进行扬场这种筛选
shaking
fanning
throwing

first sieving 筛选：coarse sieving, in which the threshed crop (grains in husks) fall through the sieve
Sieving separates components by size. 利用尺寸进行筛选

 # dehusking (by pounding) 脱壳: this breaks down husks to free grains, often uses deep mortar & pestle; also a flat grinding stone and roller may be used.用较深的臼，或平的磨盘

 # winnow 扬谷：second winnowing:
#Note: dehusking and second winnowing are not necessary for "free-threshing" crops.*脱壳和二次扬场对于“无壳”作物不是必须的。

second sieving 筛选：fine sieving, in which crop grains are retained in the sieve

hand-picking 手工拣选

Note: all stages are imperfect and include some loss of grain, and some failure to remove chaff or weeds. Differences between stages are nevertheless very clear statistically in the ratios of components.
所有的加工步骤都会丢失一部分谷物，或者仍旧保留一部分糠壳和野草。不过不同部分的比值间的差别在不同步骤间仍是相当明显的。

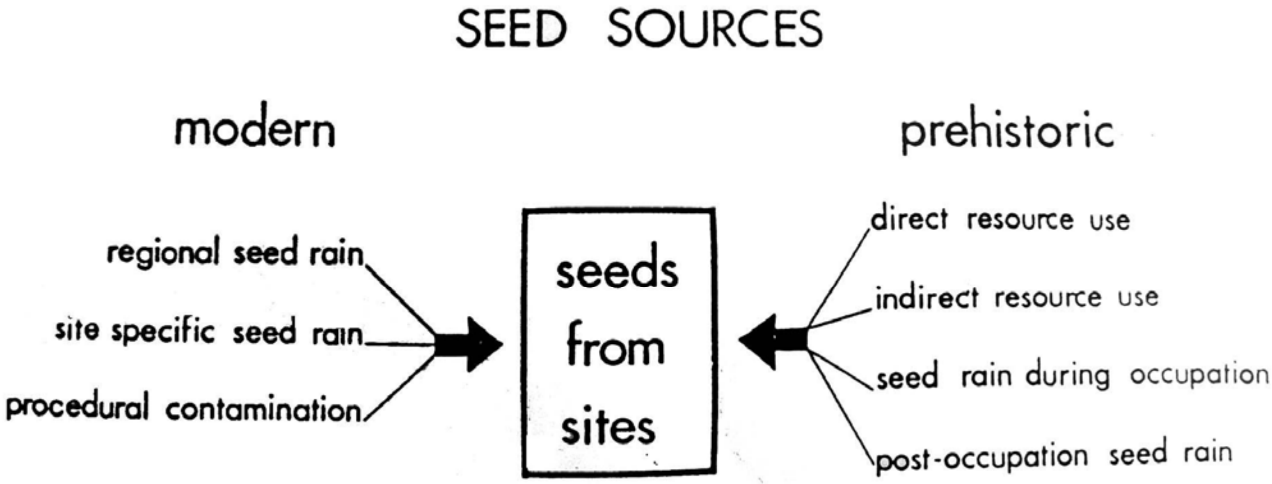


Figure 1. Sources of seeds recovered from archaeological sites.

Minnis (1981) the catch-all model of potential seed sources. Important distinction between intrusive modern and ancient material. 1981 年 Minnis 的模式，重要的是对现代扰乱和古代遗存进行的区分

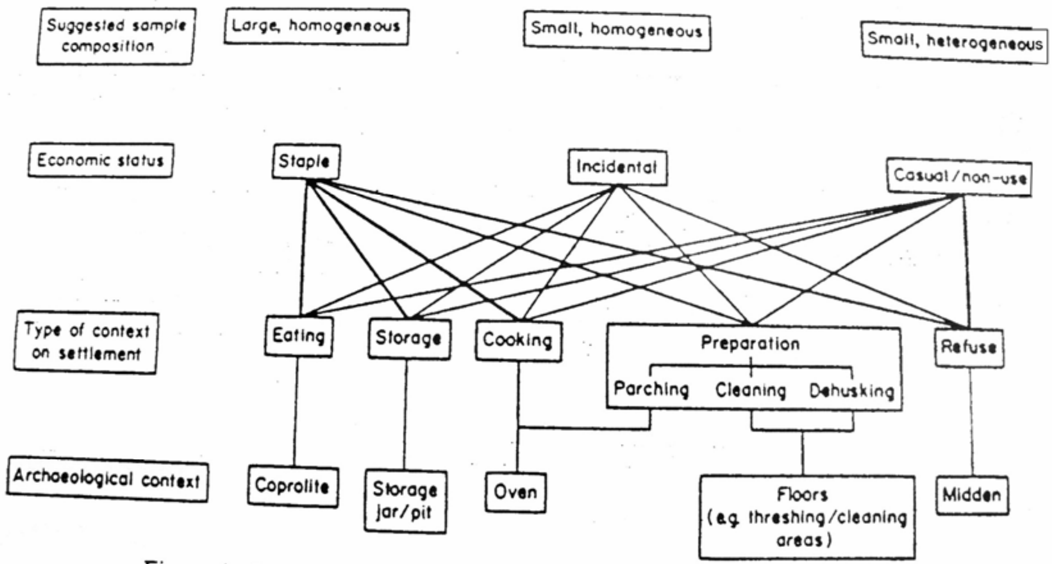


Figure 1. Suggested relationship between economic status of a plant, its archaeological context and sample composition. Width of line indicates degree of association between economic status and context.

Dennel (1976): common sense model of use type and archaeological context in relation to sample size and heterogeneity. This is important for emphasizing the need to consider the composition of individual samples from individual contexts: a leve a data analysis which is still sometimes overlooked. Note the suggested relationship between larger samples and staples. Note: Hillman criticized this for not being based on rigorous ethnographic data. Also, this model fails to explain charring, how seeds and crop-processing waste become carbonized, thus allowing preservation. 1976 年 Dennel 的模式，重要的是强调了单个样品所反映的单个遗迹单位的特性。*Hillman 曾批评这一模式不是建立在严格的民族学资料上的。而且，这个模式没有解释炭化过程。

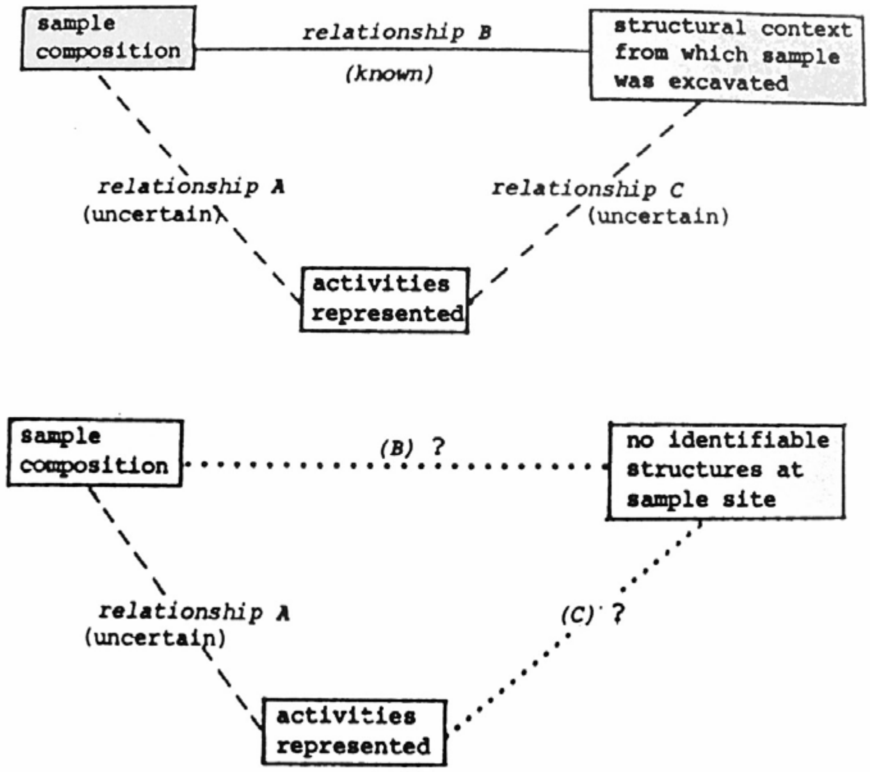


Figure 2. Two sets of relationships encountered on archaeological sites (from Hillman 1973)

Hillman's (1973) diagram of the relationships between source 来源, context 单位 and assemblage composition 组合.

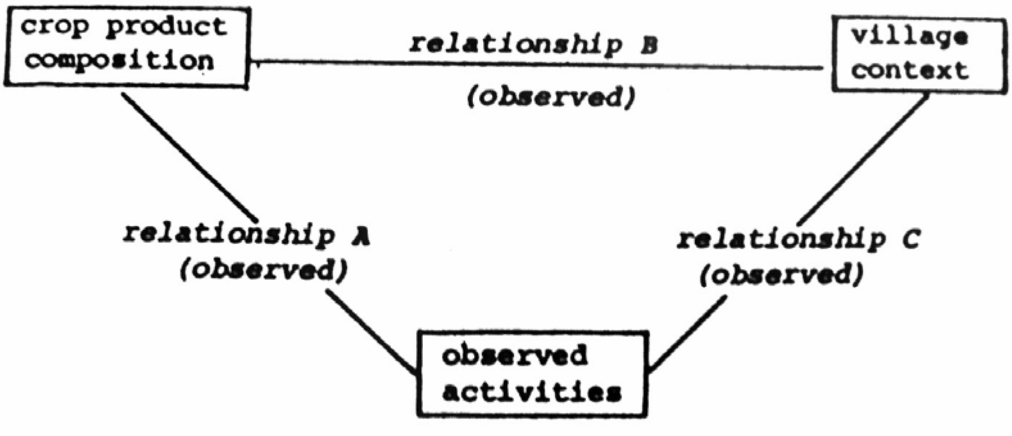
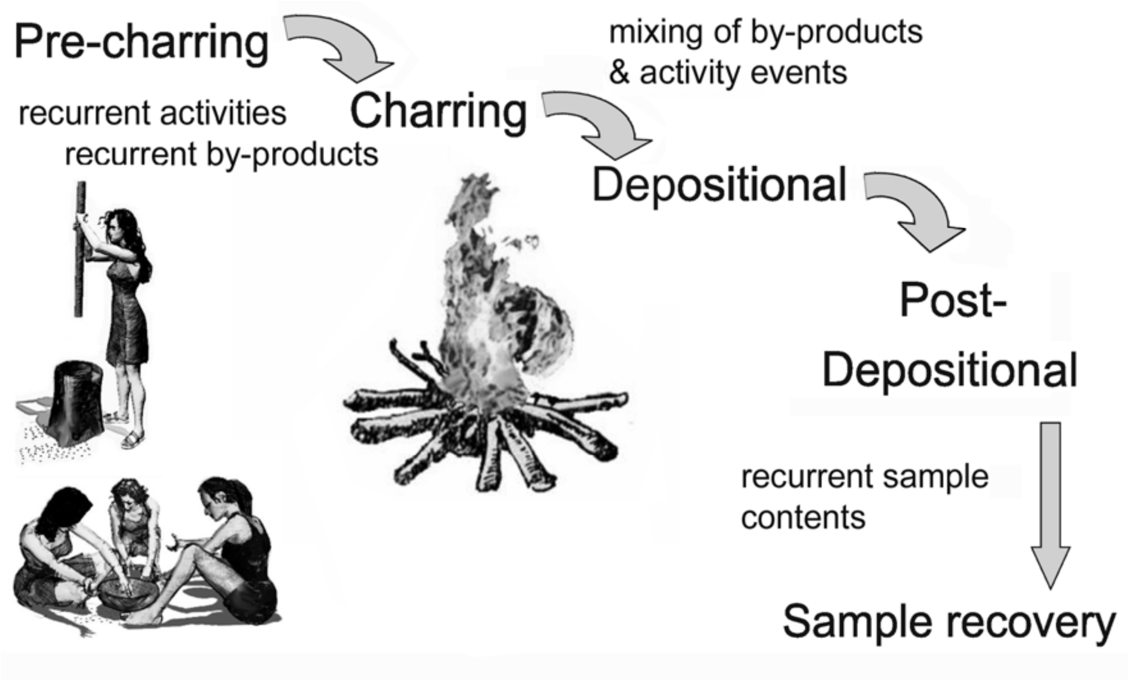


***Figure* 3. The same relationships on present-day settlements: all are observable and measurable.**

Hillman's (1973) diagram of observable relationships in ethnographic contexts.民族学观察的模式 This indicates the role of ethno-archaeology for archaeobotany, by observing patterns in the relationship between the components of grains, chaff and weeds in products (or by-products) of particular activities. This relationships, which can be quantitified then provide a basis for interpreting the presence of such activities in the past from archaeological assemblages.说明民族考古学对植物考古的重要性，通过观察民族资料中谷物、糠壳和杂草的比值变化，理解考古遗存的组合。



The formation of an archaeobotanical (carbonized) sample in terms of patterning composition. The importance of considering routine activities and regular inputs to fire for preservation. (From Fuller, Stevens and McClatchie, in press/ available for download from:
http://www.homepages.ucl.ac.uk/~tcrndfu/downloads.htm#archaeobotany).
植物遗存（炭化）的形成过程。重要的是考察了日常生活行为和日常用火对遗物保存的影响

Harvest 收割

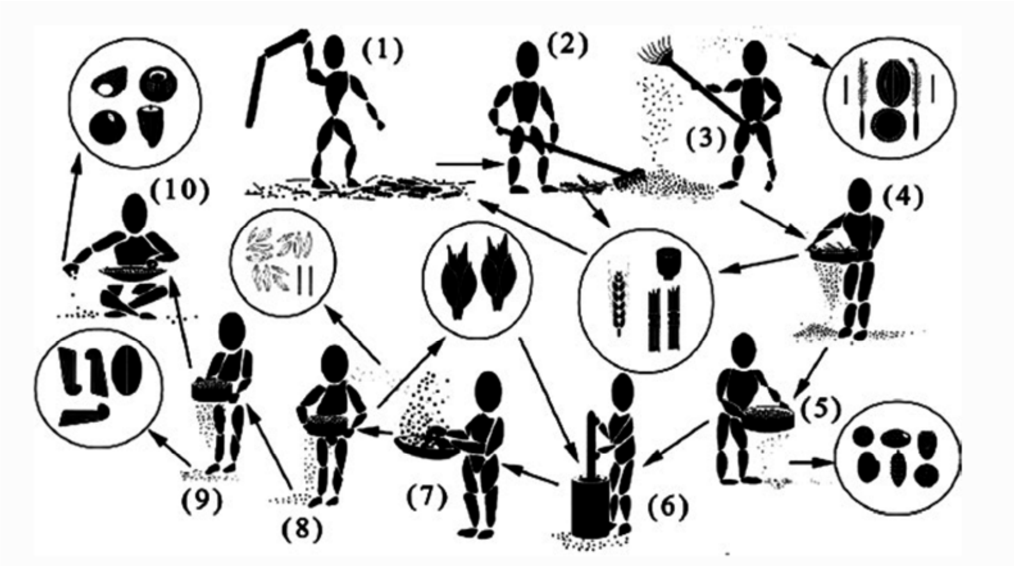
Winnowing 扬场 → Small Free Light

Coarse Sieving 粗筛 → Small Headed Light; Small Headed Heavy; Big Headed Heavy

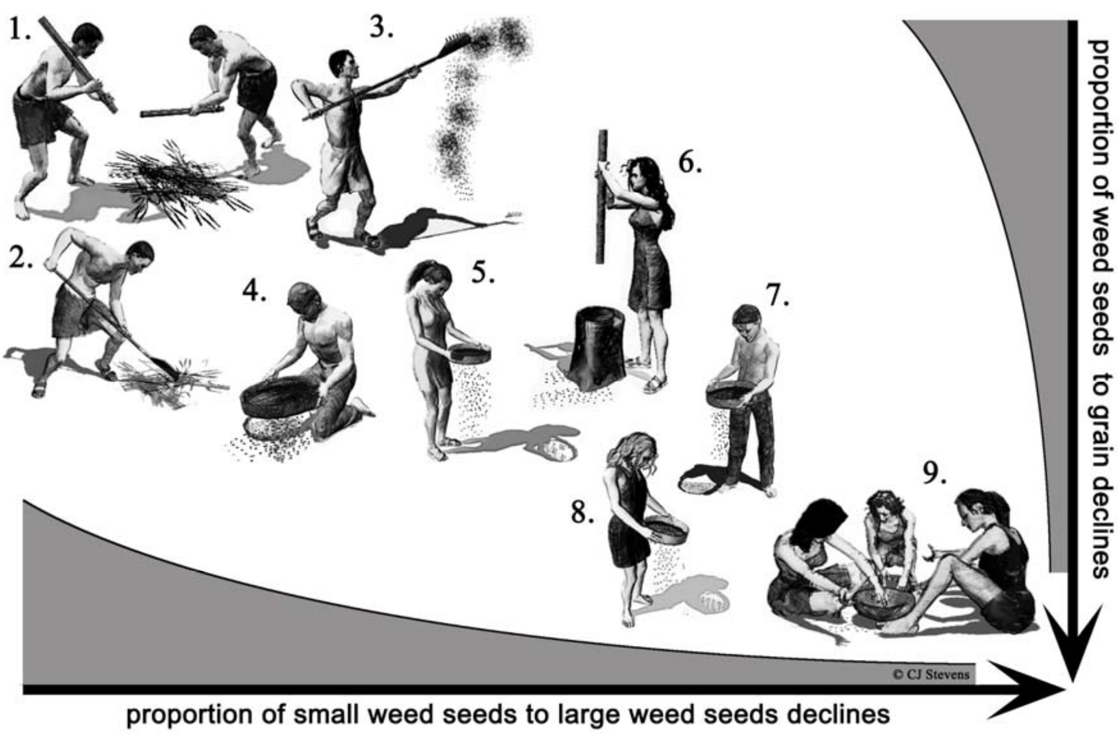
Fine Sieving 细筛 → Small Free Heavy

Big Free Heavy [hand-picking]

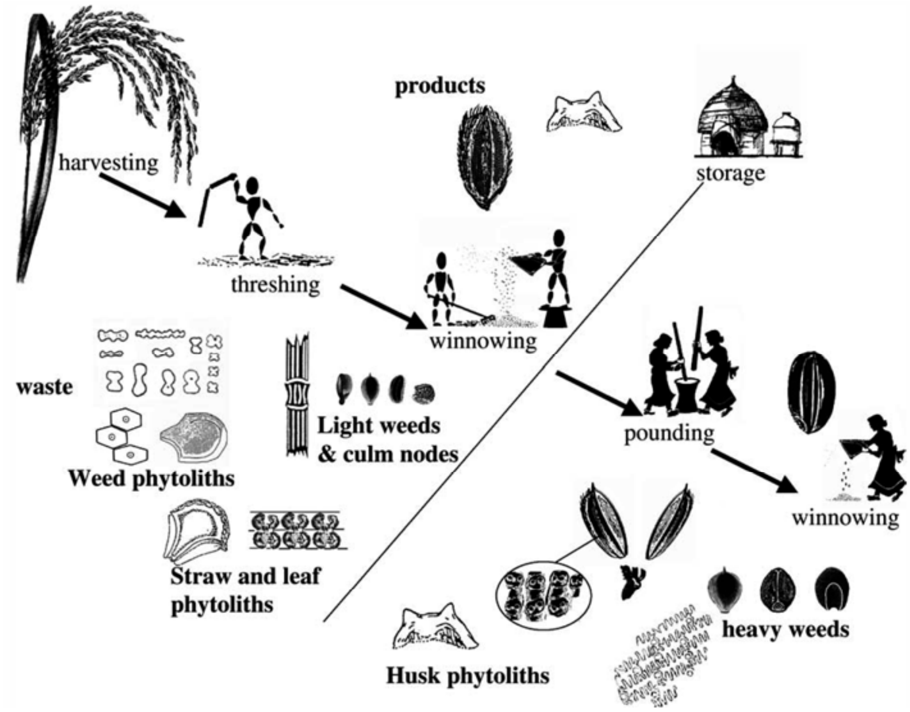
Diagram of main categories of weed seeds expected in by-products of main processing stages (after G. Jones 1984; 1987).杂草作为伴生物在遗存组合中出现的模式



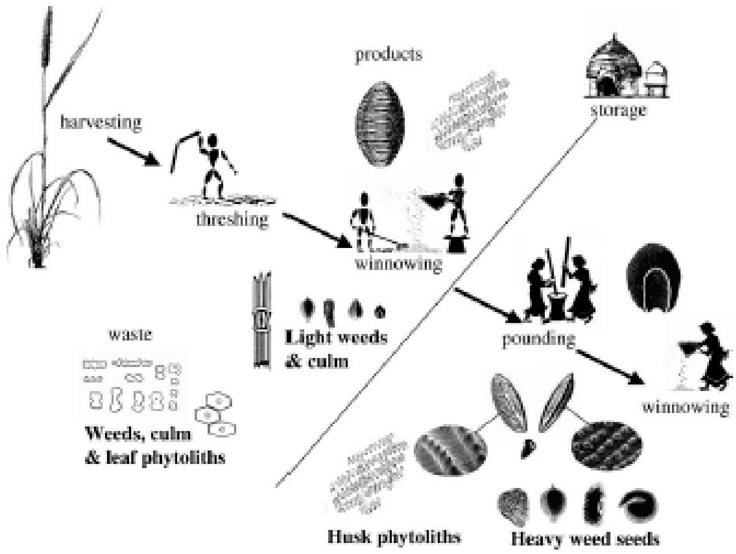
Cartoon of the main crop-processing stages for glume wheats (from Stevens 2003): 1. Threshing 打谷（脱粒）. 2. Raking 粗筛. 3. Winnowing 扬谷. 4. Coarse sieving [note return of some by-products to threshing]粗筛. 5. Fine-sieving.细筛 6. Pounding (de-husking).脱壳 7. Winnowing.扬谷 8. Coarse sieving (to return undehuksed spikelet to previous step).粗筛 9. Fine sieving.细筛 10. Hand-picking 挑选.有壳小麦的主要加工步骤。



Schematic representation of main quantitative patterns through the course of crop-processing (from Fuller Stevens and McClatchie, in press).加工过程中组合变化趋势的图式。Y 轴：杂草/谷物的比值逐步下降；X 轴：小型杂草比大型杂草的比值逐步下降。



Simplified schema of rice processing (from Harvey and Fuller 2005) indicating products (top) and by-products (bottom). Potential macro-remains shown black, potential phytolith outputs shown in outline. Also summarized on the next page.稻米加工步骤图式。上半部分为每个步骤留下的产品；下半为每步骤遗留的伴生物。黑色为大植物、白色为植硅石。 Fuller & Harvey can be downloaded from
ttp://www.homepages.ucl.ac.uk/~tcrndfu/downloads.htm#archaeobotany



Millet processing (also from Harvey and Fuller 2005). Also summarized in text on the next page. Millet processing presents additional archaeobotanical complications because rachilla components (from dehusking) do not usually preserve. Use of presence of husk fragments adhering to millet grains and immature grains can be used instead, as introduced in Fuller and Zhang (2007).小米的加工。小米加工呈现不同的植物考古遗存的复杂性，因为穗轴部分很难保存。用带壳碎片和不成熟谷物等指标进行分析，见相关文献。

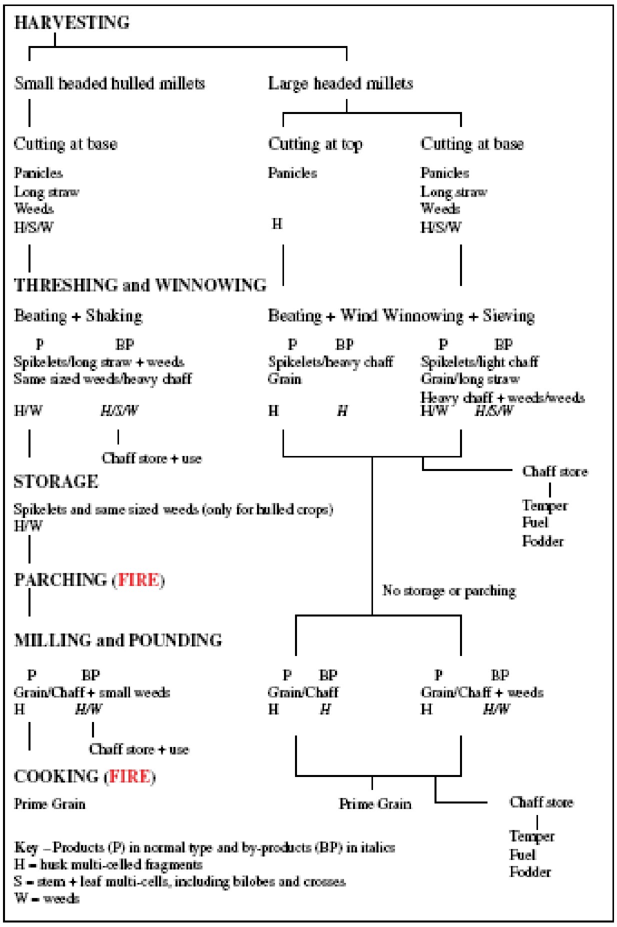


Fig. 4. Simplified outline of millet crop processing (based on Reddy, unpublished PhD dissertation,

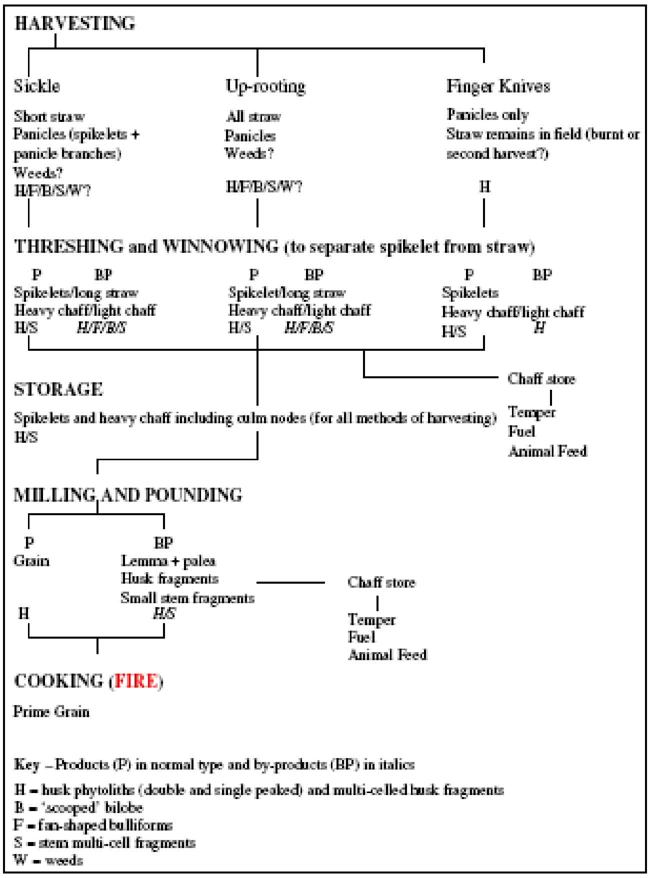


Fig. 2. Simplified outline of rice crop processing (based on Thompson [69]).

Table of hulled vs. free-threshing cereals [after Fuller and Weber 2005] 带壳和不带壳谷物

Crop groups	**Hulled cereals requiring threshing** 需要脱壳的谷物	**Free-threshing cereals (no dehusking)** 不需要脱壳的谷物
Wheat (*Triticum*)	Einkorn wheat (*Triticum monococcum*), emmer wheat (*T. diococcum*) 一粒小麦、二粒小麦	Common (bread) wheat (*Triticum aestivum*), durum wheat (*T. durum*) 普通小麦、硬粒小麦
Barley	Hulled barley (*Hordeum vulgare* var. *vulgare*) 大麦	Naked barley (*Hordeum vulgare* var. *nudum*) 裸麦 （青稞）
Rice	*Oryza sativa* – all varieties	
Sorghum	*Sorghum bicolor* race *bicolor* [primitive] (includes traditional Gaoliang sorghums) also race *kafir* [South Africa]	*Sorghum bicolor* races caudatum (Africa, mainly Western, and Inddia), guinea (mainly East & South Africa), durra (Northeast Africa & India) 硬杆高粱
		Finger millet (*Eleusine coracana*) most varieties 禾参
		Eragrostis tef [Ethiopia and Yemen]
	Pearl millet (*Pennisetum glaucum*) some small-grained primitive varieties 珍珠粟，一些小粒形的原始变种	Pearl millet (*Pennisetum glaucum*) most varieties 珍珠粟
	Panicum miliaceum *黍* *Panicum sumatrense* *印度小型黍*	
	Setaria italic *粟* (other *Setaria* spp.)	
	Paspalum scrobiculatum 鸭乸草	
	Brachiaria ramose 多枝臂形草	
	Echinochloa frumentacea, 湖南稗子 *Echinochloa utilis* 紫穗稗	
		Oat (*Avena sativa*) 燕麦
		Rye (*Secale cereale*) 黑麦
	Digitaria spp.马唐	

Tabular summary of pulse (legume) processing variables (from Fuller and Harvey 2006)
豆类加工模式

Table 5 A general model for pulse crop-processing

Modelprocess	variant	pulse taxa	effects	remarks
Havesting	uprooting	*Macrotyloma* (Watts 1908, 506); *Vigna radiata* (Watts 1908, 200)	incorporates weeds, especially climbers	
	cutting near base	*Lablab* (Watts 1908: 510); *Cajanus* (Westphal 1974; Van der Maeson 1989); *V. aconitifolia* (Vcan Oerrs 1989a); *Macrotyloma* (Jansen 1989)	incorporates weeds, especially climbers	
	plucking pods	*Lablab* (Shrvashankar & Kulkarni 1989; Duke 1991); *Vigna radiata* (Watts 1908, 200; Weber 1991, 98)	selects against weeds	more likely in Neolithic due to uneven ripening. skip down to coarse sieving or pounding and rewinnowing
Threshing	free-threshing	*Lablab, Vigna*	frees pulses from pods and plants	some pods will not shatter, threshing of the by-product can be repeated one or more times to increase seed recovery
	pod-threshing	*Macrotyloma, Cajanus,*	separates pods from plant	in Cajanus leaves are stripped or separated by simple shaking
Winnowing and Raking	free-threshing types	*Lablab, Vigna*	separates light material including pod fragments: product includes pulse seeds, large and small weeds, pod pedicils(?)	skip pounding and rewinnowing (pod-threshing) step. By product may be used as fodder. If some pods are insuffieciently broken, threshing may be repeated.
	pod-threshing types	*Macrotyloma, Cajanus,*	separates light material; product includes pods, large heavy weeds, headed weeds, stem pieces. Pulse seeds from broken pods may enter by-product	By-product may be used as fodder. Mature seeds may enter dung. Possible stored as pods after this step. Possibly stored as pods after this step
Coarse sieving	free-threshing types	*Lablab, Vigna*	removes plants stalk parts, weed heads. Will lose some pulse seeds, especially unshattered pods.	By-product may be used as fodder. Mature seeds may enter dung.
	pod-threshing types	*Macrotyloma, Cajanus,* some *Lablab*(?)	removes small and large weed seeds, pulse pods and weed heads remain (could be hand-picked)	
Fine Sieving	free-threshing types	*Lablab, Vigna*	removes remaining small weeds, chaff fragments Only weeds very similar in size and weight to pulse remain, possibly some pod pedicels (especially in *Vigna*). Will lose some small/immature pulse seeds.	store after this step as cleaned pulses: sieved again or hand-picked to remove remaining large weeds before cooking. Possible route to archaeological preservation.
	pod-threshing types	*Macrotyloma, Cajanus*		this step probably skipped
Pounding and rewinnowing	free-threshing types	this step unneccessary		
	pod-threshing types only	*Macrotyloma, Cajanus,* some *Lablab*(?)	removes pods, only some weed seeds or heads that are very close in size and wieght to pulse remain	possibly a daily routine processing: most likely route to archaeological preservation
Parching		parching or dry-rosting reported for *Vigna* spp., *M. uniflorum* (Watts 1908). *Lablab* reported to be 'dried' before storage (Shivashankar & Kulkarni 1989)	could lead to accidental charring and archaeological preservation	parched before grinding, or dry-roasting for consumption. Archaeological preservation route

Major publications in the development of archaeobotanical formation processes (for charred assemblages, especially from agricultural periods). 植物考古形成过程研究的主要文献（主要关于农业阶段炭化组合）

Körber-Grohne (1967, in German; 1981 in English [synoptic article]) discusses spatial distribution of archaeobotanical remains in relation structural features and potential processing and consumption activities.

Knörzer (1971, in German) observes that most charred assemblages includes cereals and herbaceous plant many of which are known field weeds. Thus most assemblages derive from arable ecosystems and weed species present can be used to infer aspects of agriculture. Also draws on Körber-Grohne's approach.

Dennell (1972) observes differences in composition of archaeobotanical assemblages between contexts, including the size of cereal grains. Carries out sieving experiments to confirm that past sieving of crops, as part of processing, may have contribute to the formation of distinct product/by-product assemblages. Subsequently, Dennell (1974; 1976) develops a general predictive model for comparison and interpretation of assemblages related to assumptions about the affecting of major crop processing stages on their composition. Hubbard (1976) disputes the statistical validity and assumptions of Dennell's model.

Hillman (1973) outlines need for ethnographic observation to produce generalisations that can be used to interpret archaeobotanical evidence

Hillman (1981; 1984) published crop-processing model on ethnographic work and turkey. Discusses its implication for interpreting archaeobotanical remains in terms of crop husbandry and producer/consumer sites.

G. Jones (1984; 1987) published similar processing sequence observed independently in Greece and discusses the potential of statistical analysis of weed seed types for distinguishing processing stages.

M. Jones (1985) applied elements of crop processing reasoning to question of distinguishing produce vs. consumer sites (but via method opposite Hillman 1981. See review in Van der Veen 1992). Also, a brief history of archaeobotanical interpretation in Europe.

Mikcesek (1987) general review article. Broad perspective but with less interest in crop processing, and a somewhat mistaken summary of early Dennell and Hillman work. Hastorf (1988) reviews importance of crop processing and highlights need for similar studies of New World crop species.

Boardman and Jones (1990) experimental charring demonstrating the much greater likelihood of chaff elements to be destroyed by charring, while grain are preserved, thus majorly biasing pre-charring ratios of chaff to grain.

Experimental work on processing, and charring maize reported by Goette, Williams, Johannessen and Hastorf (1994)

Reddy (1991; 1997; 2003) applies Hillman-Jones approach to Indian millets, with ethnographic and archaeological study.

Thompson (1996) applied Hillman-Jones approach to rice processing in Thailand

D'Andrea et al. (1999); Butler et al. (1999) preliminary report of ethnoarchaeological study of crop processing in Ethiopia, including tef and pulses.

Stevens (2003) develops the importance of routine processing (as the main source of waste) and considers how this allows contrasts to be interpreted in terms of labour mobilization. While recently Van Der Veen and Jones (2006) have critiqued this, they seem to have misunderstood Stevens and arrive at very nearly the same conclusion! Van der Veen (2007) now also promotes a routine activity view of most archaeobotanical remains.

Application to phytolith analysis (for rice and millets) by Harvey and Fuller (2006)

A model of the variables in pulse processing, distinguishing pod-threshing and free-threshing pulse types (Fuller and Harvey 2006)

Modifications to the counting of millet-dominated assemblages to better examine crop-processing wre introduced in Fuller and Zhang (2007), this includes separation of millets with husk-fragments adhering and immature millets, and combining those in ratio that can be compared to the millet to weed ratio. Initial **publication is in English and Chinese**.

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