THE EARLY DOMESTICATION OF PLANTS IN SOUTH AND SOUTHEAST ASIA — A CRITICAL REVIEW*

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ABSTRACT

The paper reviews both the palynological and palaeobotanical evidences that have been put forward to suggest early domestication of plants in the Indian sub-continent, Thailand, Taiwan and China.

It appears that the distinction between cereal and non-cereal pollen grains has been based upon insufficient data, and stages of the earliest occupation phase have not been judiciously inferred from the pollen diagrams.

A careful sifting of all the evidences from India suggests that the domestication of plants commenced around 3,000 B.C.

The alleged earliest records of domestication described from the Spirit Cave in Thailand and radio-carbon dated to 11,500 B.P., on scrutiny suggest a more advanced and discriminating stage in food-gathering, rather than domestication.

This paper suggests a more detailed botanical identification of the plant remains and a careful evaluation of ethnographic information towards the inference of early domestication.

INTRODUCTION

THE paper discusses from botanical and agricultural viewpoints the qualitative significance of some recently reported interesting and tantalising evidences, based upon archaeobotanical materials or pollen analyses of archaeological sediments or of natural lakes, and supported by radio-carbon dates, concerning early domestication and cultivation of plant species dated from about 10,000 years B.P. from south and southeast Asia (Chang, 1970; Solheim, 1971; Singh, 1971).

Certain distinct characters distinguish cultivars from their wild progenitors such as the retension of seed in the head (spikelet), the curved glume keels in emmer, the articulated internodes and toughening of the spike axis in barley and toughening of the rachis in rice, large-sized fruits and pollen grains and lastly the dependence of the cultivars upon the tiller. How far early man has been responsible for introducing these changes in the wild species is not clear yet. Man's role in introducing a wild plant from its wild habitat into the new environment created by him through preparation of a field and provision of care and natural amenities cannot be underestimated. Did natural mutations occur in such an environment? Alternatively did the early man select a natural mutant which stood prominently amidst a wild population and commence its cultivation? The discovery of seeds of *Hordeum spontaneum* and *Triticum boeticum*, the wild progenitors of cultivated barley and wheat, from the earliest Neolithic strata in western Asia and dated to about 10,000 B.P. (van Zeist & Casparie, 1968), would suggest that early man began with the wild progenitors rather than with a mutant. Have we positive evidence that these progenitors were cultivated during the early Neolithic? Their seeds could as well have been gathered.

Some evidence in this regard may be provided by Pollen Analysis through evidence of clearance of forest followed by farming as indicated by pollen grains of Cerealia and of weeds of cultivation. Difficulties have been, however, experienced in Western Asia in distinguishing cereal pollen from that of wild grasses. The recognition of Cerealia type pollen unaccompanied by disturbance of forest and pollen of weeds may be unsound evidence for early agriculture as in Western Iran (van Zeist, 1966). On the other hand the part of the interglacial pollen diagram from Hoxne, Suffolk, England corresponded with a horizon from which late middle-Acheulian hand-axes have been found (West, 1956), provides a sound evidence for disturbance of forest

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by man or by natural causes. It has however, been interpreted as an evidence of Palaeolithic man's interference with natural vegetation, though the positive evidence in this regard is lacking.

The criteria (modified after Iversen, 1941) for a sound pollen -evidence in a forested region ought to include:

a) An evidence of deforestation or clearance of vegetation followed by spread of weeds associated with cultivation and appearance of cereal pollen.
b) An evidence of spread of plant species colonising the abandoned fields to suggest an event of abandonement of the site by man.
c) Recovery of the forest.
d) An evidence of the presence of man initiating the above changes in vegetation.

Cereal pollen grains although larger in size than those of wild grasses (pollen grains of some millets are smaller) are produced in small numbers due to autogamy and usually not disseminated over long distance (exception being rye, *Secale cereale*). Their percentage in pollen analyses is usually very small (under 1-2%) even in very high counts of pollen grains.

Pollen diagrams constructed from an undisturbed forested region may not exhibit all the criteria outlined above. In the event of clearance and farming activities occurring farther away in the vicinity, pollen of cereals or weeds may sometimes be discovered at appropriate depth of a pollen profile. The West Iranian diagram referred to above lacks any evidence of deforestation but Cerealia type pollen is encountered at a depth dated to about 10,000 B.P. More or less at this time the earliest archaeobotanical evidence has been found along the western borders of Iran. The pollen evidence is indeed insufficient for the inference that farming was practised in the vicinity of the site pollen analysed.

There would obviously be no involvement of deforestation prior to cultivation in a forest-less area. The clearance or disturbance of ground vegetation would be the criterion here instead. But, the event of farming in a pollen diagram from a forest-less area which ought to be reflected by a sudden decline of the wild herbaceous elements and appearance of weed and cereal pollen grains if the latter can be recognized, may often be offset by the high pollen production of grasses and other herbs.

The former evidence of cultivation of fruit trees and vegetables is beset with far more difficulties than of cereal cultivation for the pollen of most of them is insect-pollinated and is less easily distinguishable. The remains of edible fruits of the wind pollinated wild species would provide the necessary information than the pollen grains. At the large village site of 'Pan-p'o' in Shensi, China, a pot was found filled with edible seeds of hazel, pine and chest nut. The pollen recovered at this site suggested a wide grassy plain around the village with a scatter of elm, persimon and other deciduous trees providing animal fodder but not human food (Watson, 1969). The seeds had obviously been gathered at a distance for their pollen was not found.

The gaps and limitations in our knowledge are apparent from the examples cited above. These indeed serve us a note of caution in our interpretations of early domestication and cultivation as contrasted from food gathering in the wake of insufficiency of positive data without any allowance for presumptions, conjectures and imagination. The early West Asian evidence referred to above could be considered domestication if it could be proven that both wild barley and wheat were cultivated otherwise it would remain a case of gathering. Populations of wild barley and wheat must have grown as they do today in the vicinity of the site.

EARLY DOMESTICATION OF PLANTS IN THE INDIAN SUB-CONTINENT

The Neolithic in India has so far been dated from about 2500 B.C. (Burzahom in NW India; Kodekal in dist. Gulbhaga; Utnoor in South India) though in some parts of the country it is dated from 1800 B.C. or even later. The seeds of weeds of *Lithospermum arvense*, *Medicago denticulata*, *Lotus corniculatus* and *Ipomoea* sp. from the Neolithic of Burzahom dated to 2300 B.C. in the Kashmir Valley would suggest gathering of these seeds rather than cultivation (Vishnu-Mittre, 1968, 1974). The species today occur as weeds in the cultivated fields of wheat, barley or even millets as well as in the open on immature and nitrophilous soils. Likewise *Dolichos bi-*

florus from the Neolithic of Tekkalkota dated to 1800 B.C. and *Eleusine coracana* from Hallur, Mysore dated to 1800 B.C. are suggestive of gathering rather than cultivation until more positive information regarding their cultivation becomes available.

No site in India has so far been struck with the direct evidence of cultivation suggesting early stages of domestication except the Harappan site Kalibangan in Rajasthan where Lal (1970-71) has discovered a furrowed field. The crop cutting implement at the Neolithic site Burzahom is not only post-Neolithic but also too insufficient an evidence for the purpose.

Pollen evidence for the earliest clearance phase based upon pollen of *Plantago lanceolata*, a weed of cultivation, together with evidence for deforestation and the recovery of forest was first demonstrated in the Kashmir Valley (Vishnu-Mittre & Sharma, 1966). This evidence still remains undated by radiocarbon. In the subsequent clearance phase cereal pollen was also identified. The possibility can not be overlooked for want of more evidence that these so-called clearance phases might have been caused by factors other than man. In the light of recent work on the pollen morphology of cereals, their progenitors and some selected wild grasses distributed in the Indian sub-continent, it would appear that the identification of cereal pollen in the Kashmir pollen diagram can not be beyond doubt (Vishnu-Mittre, 1973). The large sized grass pollen may best be referred to Cereal pollen type, and accompanied as it is by evidence of deforestation and by weed pollen, an inference of the episode of farming here would not be incorrect it supported of its Neolithic context by radiocarbon. The 58% cereal pollen from the terrestrial sediments at the Harappan site, Kalibangan, in Rajasthan (Singh, 1971), and large quantity of large-sized grass pollen of a cultivated variety in Bengal peat (Chanda & Mukherjee, 1969) however, cannot belong to cereals. Owing to autogamy prevalent among Cereals except in *Secale cereale*, it is not possible to recover such a high percentage of cereal pollen in soil and lake sediments (Iversen, 1941; Faegri & Iverson, 1964). Wild grasses producing large-sized pollen are obviously indicated here.

The decline of Chirpine woods, evidence of fire, rise of oak woods, appearance of weeds and of cereal pollen type in the postglacial pollen diagram from Naukutchiya Tal could be the result of natural fires or those caused by early man (Vishnu-Mittre *et al.*, 1967). There is considerable evidence of natural fires in the Chirpine forests in the Himalaya. Weeds of cultivation also occur in natural habitats apart from in the cultivated fields and their spread after deforestation would be a natural consequence of plant succession. A similar disturbance in vegetation simulating a clearance phase has been observed in pollen diagram from Kakathope, Ootacamund, Madras, dated to 23000 years ago (Vishnu-Mittre & Gupta, 1971; Gupta, 1973). Here it seems that some other factors of local significance perhaps edaphic or intraspecific were responsible for the shifts in pollen curves, or else the disturbance in vegetation was caused deliberately by the Palaeolithic man (positive evidence lacking) as a consequence the weed element appeared from its natural habitat to participate in natural succession. No case can be made of an attempt towards early farming here.

Based upon single grain of cereal pollen type of the size range of 40-50 μ which is unaccompanied by recognizable fluctuations in vegetation, a case has been made for the earliest farming dated to 6000 B.C. from pollen diagrams constructed from Rajasthan (Singh, 1971). The arboreal vegetation is extremely poorly and sporadically reflected several species being insectpollinated but grasses, *Artemisia* and Cyperaceae form prominent curves. Together with the cereal pollen type, Singh (1971) presents the supporting evidence of deforestation through charcoal fragments. The pollen evidence is indeed too far fetched and clearance if any (not observed in the pollen diagrams) through fire could as well have been by natural phenomena rather than by man. Even if the evidence was accepted at its face value, both farming and disturbance of vegetation would be attributed to Mesolithic Man as in India the Neolithic does not commence prior to at the most 3000 B.C.

Intensive burning and cultivation episodes dated to 2700 B.C. and corresponded with the Harappan civilization have been interpreted from the pollen diagram from the Sambhar lake, Rajasthan by Singh *et al.*,

1974. At the corresponding depth the pollen diagram exhibits maximum values attained by the pollen curve for *Artemisia*, a member of ground vegetation; the curve for Gramineae is consistently high except for a minor decline corresponding with rise in *Artemisia*; and against maximum burning indicated by charcoal fragments, the curves for trees also attain higher values. It is amazing that the vegetation had remained unaffected by the episodes of clearance by fire and cultivation (Singh *et al.*, 1974, 498). In the light of the above fact the inference of cultivation and slash and burn practice in the entire pollen diagram becomes suspect. As no clearance is indicated at this depth in the diagram, the charcoal fragments are certainly not derived from it. Are the changes in shrub pollen curves observed at depths prior to it the result of selective grazing by sheep, goat, camel and the other animals (Vishnu-Mittre, 1974) some of which are known to feed upon the foliage of trees and shrubs. What did they burn after all and where and how? Is the charcoal derived from the hearth or hearths of early man in the vicinity of the lakes?

The find of a single grain of *Spergula rubra*, a weed of fallow fields together with cerealia type pollen at a depth dated to 8300 years B.P. and that too only in the Sambhar lake pollen diagram (Singh *et al.*, 1974) renders its genuine occurrence and identification suspect. With the increase in farming as inferred towards the top of the diagrams, its value would have increased but it has been found singularly absent in all the diagrams except at lower depth cited above.

EARLY DOMESTICATION OF PLANTS IN SOUTHEAST ASIA

The imprints of rice on potsherds from Non Nok Tha, Thailand and dated by radiocarbon to 3500 B.C. have been referred to *Oryza sativa* but it has not been possible to determine whether they belong to the wild or cultivated variety (Solheim, 1971: personal communication; the result of subsequent examination of Non Nok Tha potsherds by me and Miss R. Savithri).

The remains comprising legumes, root and fruit crops dated to 11,500 years and known from the Spirit Cave in the north of the provincial centre of Mae Hougson in the extreme northwest of Thailand include nuts of *Madhuca, Canarium, Terminalia, Aleurites* (Candle nut), betel nuts, pepper, bottlegourd, *Phaseolus, Vicia*, peas, cucumber, almond, and *Trapa*. The identifications are restricted to the generic level only (Gorman, 1969). The large size of some of these has led the excavator to suggest their domestication (Gorman, *op. cit.*). In view of their tentative identifications the evidence cannot be stretched so far as to press domestication here. The large size may be due to natural mutations. On the other hand the plant remains suggest most probably a forest environment comprising trees of *Madhuca, Canarium, Terminalia, Aleurites*, betel nut and *Piper*. The species of *Cucumis, Phaseolus* and *Vicia* might have occurred in the open areas and in grasslands and around ponds in the vicinity. The most plausible inference would be that the early Thais were still at the food-gatherer-hunter stage and had gathered these fruits and seeds primarily for eating. There is hardly any suggestion toward domestication or cultivation of these as practised today by the modern Thais.

Commenting upon the above data Harlan and de Wet (1973) draw attention to the questionable authenticity of botanical identifications, to the extraordinary assemblage of tropical Southeast Asian and Mediterranean plants among the identifications and remark that in quality the evidence falls too short of demonstrating early agriculture in Thailand.

The pollen evidence dated to 12,000 B.P. from Taiwan reveals a gradual growth of secondary forest accompanied by charred woody fragments (Tsukada, 1967). However, more pronounced changes are discernible around 4200 B.P. corresponded with the farming activity of Lungshanoid peoples. This pollen evidence does, however, suggest disturbance of natural vegetation whether by man or natural fires, but the decisive indication is lacking.

The evidence of pollen of *Oryza* dated to about 3200 B.C. identified in the Chikoaka remains in Kanazawa city, Central Japan (Fugi, 1973), is based upon insufficient criterion that in its shape and size it is distinguishable from the pollen of wild grasses which in fact is not true. Its shape and size are shared by pollen of quite a few wild grasses in Japan Flora (Ikuse, 1956).

Further variability in size and shape in the pollen of taxa of grasses a usual phenomenon is apparent from the dimensions of pollen of two specimens of *Oryza sativa* cited by Ikuse (*op. cit.*, 41). Personal discussions of the senior author with Dr. Fugi in 1971 at Novosibirsk, U.S.S.R. revealed that Dr. Fugi had not considered the possibility of overlap between the pollen of wild and cultivated grasses. Rice as the first cereal arrived in Japan in second cent. B.C. in spite of the fact that the pottery using Jomon culture in Japan had subsisted for some six millenia (Watson, 1969, 397).

In China closely connected with the ancient plant economy of South and Southeast Asia, there is hardly any absolute or even developed chronology for the Neolithic period. The archaeobotanical evidence available from China not only lacks in undoubted context but also in primitive strains (Watson, 1969). The rice husks are usually referred to 'resembling rice' whether of cultivated or wild is not determined. However, rice remains in baked clay at sites on the Chiang Han Plain, Hupai dated to the late Neolithic period are referred to *Oryza sativa* ssp. *spontanea* Roschev. Wheat identified from the Neolithic context at Tiao Yu Tai in northern Anhui (Ying, 1959; Yuch-Chien, 1957) remains to be determined taxonomically.

DISCUSSION

A critical examination of the archaeobotanical and pollen records in south and south east Asia reveals that definite evidence exists of highly evolved cultivars dating from about 5000 B.P. The records predating this are not carefully documented qualitatively. The evidence of the shifting cultivation from pollen record is not based upon sufficient and convincing criteria and the involvement of certain other local factors has been overlooked. The cerealia pollen or cerealia-type pollen alone can not be used to infer former cultivation in view of the overlap of its characters with those of large-sized pollen of wild grasses unless accompanied by shifts in pollen curves in a well determined Neolithic context (Vishnu-Mittre, 1973, 1974). The earliest evidence from Southeast Asia suggests a food-gatherer-hunter stage rather than domestication. The earliest evidence from Rajasthan in India dating from 6000 B.C. and based upon pollen record can not be upheld owing to difficulties of identification of cereal pollen and lack of shifts in pollen curves.

Continued efforts and cautious approach are highly essential to bring out unquestionable evidences of domestication in South and Southeast Asia — a recognised centre for the origin of rice and root crops.

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