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ANCIENT AGRICULTURE IN LIBYA: A REVIEW OF THE EVIDENCE

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ABSTRACT. A synthesis is provided of the recent archaeobotanical evidence for the beginnings and development of agriculture in Libya. Seed assemblages from three large archaeological projects are discussed: from Ti-n-Torha and Uan Muhuggiag in the Acacus Mountains in south-west Libya, from Zinchecra in the Wadi el-Agial in Fezzan, southern Libya, and from 12 settlements in the pre-desert of Tripolitania, north-western Libya. Evidence for the exploitation of wild plant resources has been recovered from early to mid-Holocene sites in the Acacus; the earliest evidence for agriculture in Libya recorded so far comes from a Garamantian settlement in Fezzan dated to the first millennium bc; while the evidence from the Tripolitanian pre-desert indicates that during the Roman period a flourishing agricultural economy was maintained through a complex system of water management. The majority of the crop plants attested at these sites are of Near Eastern or Mediterranean origin, only the date palm and the water melon are of African origin. The need for further study of the formation processes of desiccated plant remains was identified.

KEY WORDS: agriculture, archaeobotany, ancient farming, Libya, North Africa, water management, desiccated plant remains, charred plant remains

INTRODUCTION

Much of present-day Libya is either marginal or unsuitable for permanent agriculture, as 90% of the country receives less than 50 mm of rainfall per year (Allan et al. 1973). Only the coastal plain, the Gebel Nafusah and Gebel el-Akhdar receive annual amounts of precipitation of 300 mm or more, that is the amount of rainfall required for dry farming and permanent settlement (Fig. 1). As a result, most of the population is concentrated in a narrow strip along the coast and in the coastal hills; the only other permanent settlement is found in the oases of the Libyan Sahara. The present arid climatic conditions started approximately 5000 years ago; prior to that wetter conditions are known to have occurred; in fact, between c. 9000–5000 bp the Sahara did not really exist (Roberts 1989). Environmental evidence, as well as rock paintings and archaeological remains all point to much moister conditions than today. Many large game animals which presently only occur in the savanna to the south of the Sahara (e.g. elephant, giraffe, hippo, crocodile) are known to have lived in what is now desert (Roberts 1989, Muzzolini 1989, 1993, Phillipson 1993). There was sufficient water to allow small lakes to develop and fishing formed an important component in the subsistence base of the people living in the Sahara during the early Holocene, as witnessed by the fish bones and fish hooks and harpoons found at many early Holocene sites. Sutton (1977) even went as far as to identify a cultural complex, the "Aqualithic". Little is known about the use of plant foods during this period, but the presence of grindstones suggests that seeds may have been collected, ground and eaten. There is some evidence that during this wet phase a short drier spell occurred from approximately 7500–6500 bp or possibly somewhat earlier, around 8000 bp (Muzzolini 1989, 1993, Phillipson 1993). Considerable variation in short term climatic fluctuations must have occurred across the region, and detailed local work is much needed. The earliest evidence for pottery in the Sahara is dated to c. 8600 bp and the earliest definite evidence for domesticated cattle is dated to c. 6000 bp (Barich 1992, Gautier 1987, Muzzolini 1989, 1993). Despite the appearance of pottery and domesticated animals no evidence exists for the presence of crop agriculture in the central Sahara at this time. The reported presence of one "cereal-type" pollen from Meniet (c. 5350 bp)

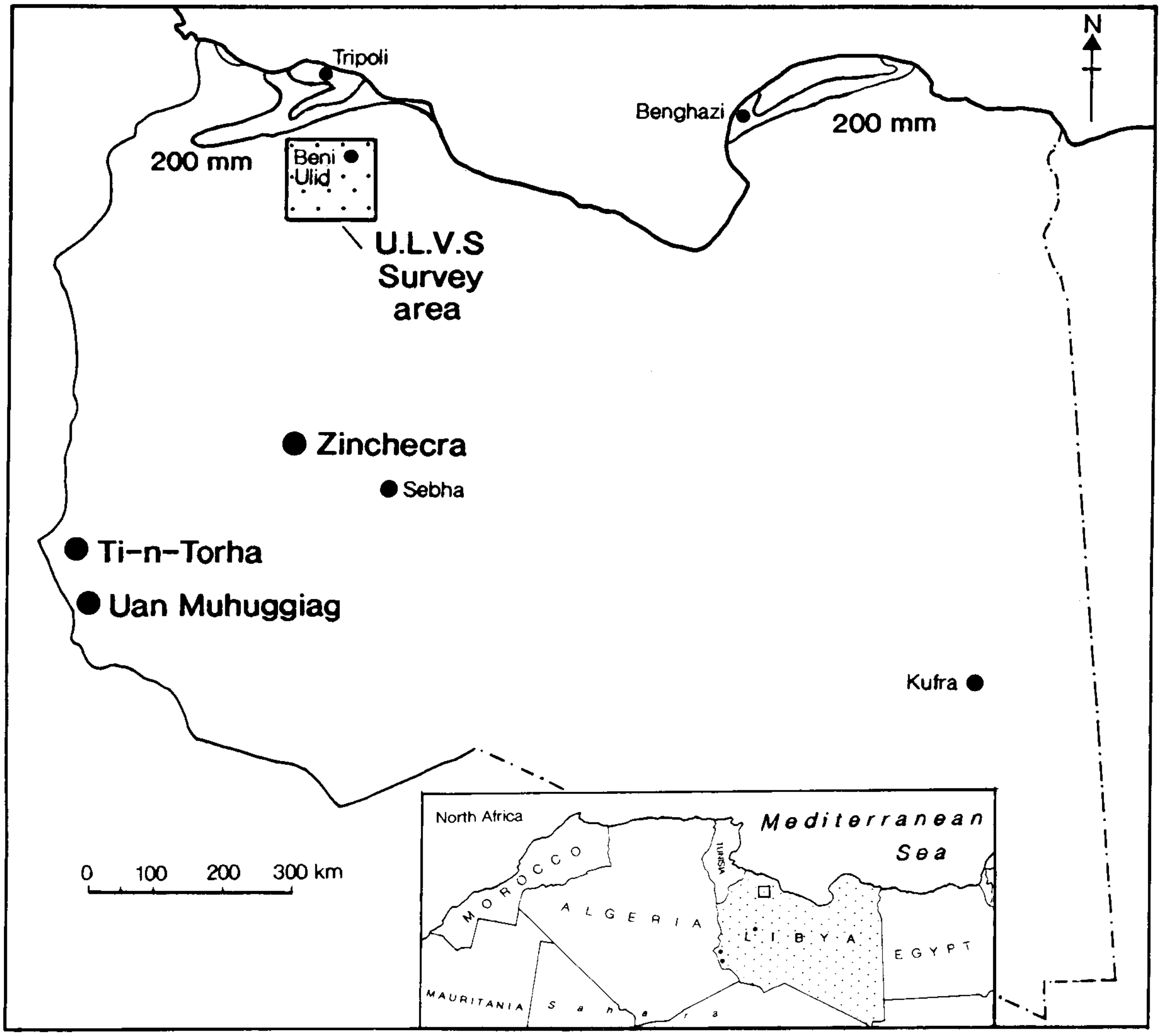

Fig. 1. Map of Libya showing the location of sites mentioned in the text

and two possible *Pennisetum* pollen from Amekni, Algeria (c. 6850 bp) are unconfirmed and thought to be unreliable (Muzzolini 1989, 1993).

During the last few years, however, several publications have appeared discussing assemblages of plant macrofossils from archaeological projects in Libya (van der Veen 1985, 1992, van der Veen & Grant in press, Wasylikowa 1992a, 1992b, 1993). For the first time it is possible to attempt a synthesis of the archaeobotanical evidence for the beginnings and development of agriculture in this country. There are, of course, still very substantial gaps in the evidence, but some general patterns are starting to emerge. This paper briefly describes the evidence that is now available, and goes on to raise some general issues for discussion and future research.

BOTANICAL EVIDENCE

Substantial archaeobotanical assemblages are now available from three areas in Libya (Fig. 1). They were recovered as part of three large archaeological projects taking place in the Acacus Mountains in south-west Libya, the Wadi el-Agial in Fezzan, and the pre-desert of Tripolitania. Samples are available from 15 different sites within these three areas and their occupation spans the whole of the Holocene (Fig. 2). The botanical assemblages are briefly described below, and the food plants and tree species found at the various sites are listed in Table 1.

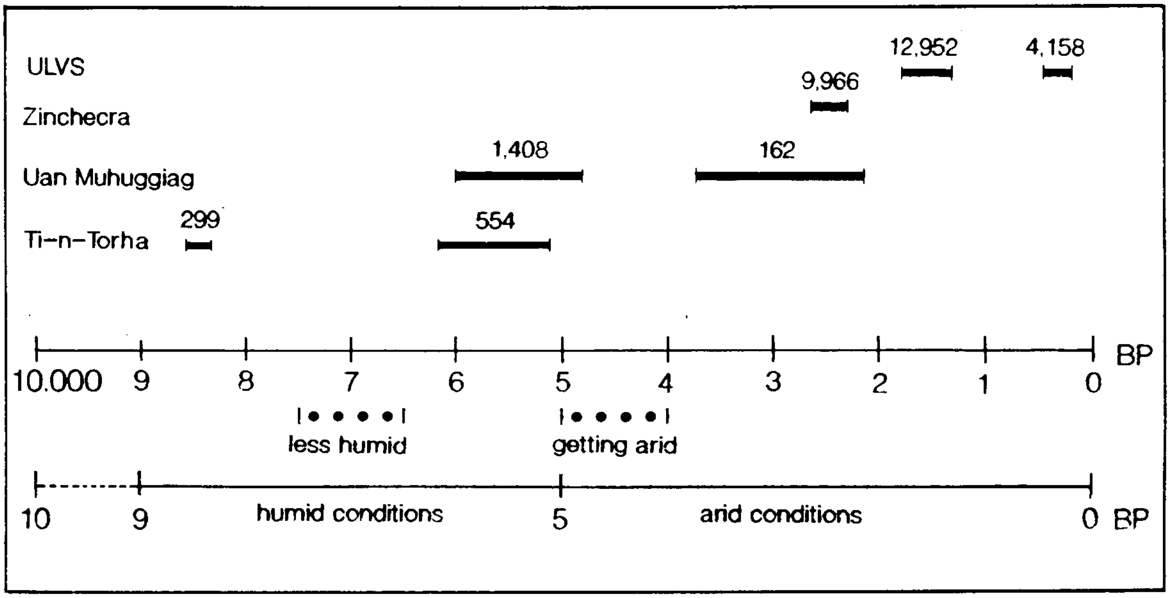

Fig. 2. Time bar, indicating the periods for which plant remains are now available. The numbers above the bars represent the number of seeds in each assemblage

TI-N-TORHA, TADRART ACACUS
(c. 6600–6400 uncal bc)

The archaeology

A long-term project, running from 1969 to 1983, was undertaken by the University of Rome in the Acacus Mountains in southwest Libya under the direction of S. M. Puglisi and, later, B. Barich (Barich 1987, 1992). Excavations were carried out at several rock shelters in two wadis, Wadi Ti-n-Torha in the northern part of the mountain range, and Wadi Teshuinat in the central part of Acacus. Plant remains are available from two of the sites: Ti-n-Torha/Two Caves in the Wadi Ti-n-Torha and Uan Muhuggiag in the Wadi Teshuinat.

The main phase of occupation at Ti-n-Torha/Two Caves dates to the 7th millennium bc (radiocarbon dates range from 8650–8400 bp; there is one earlier date, 9350 bp, probably representing the use of old wood). The top layers in the shelter represent later occupation, but they appear to be disturbed (radiocarbon dates of 8840, 6230 and 5210 bp). The shelter was partitioned into separate areas by a stone wall. The occupation deposits in the shelter contained a large number of flint tools, as well as some stone implements (including grinding stones) and bone tools. No pottery was present (other than some intrusive sherds; Barich 1987). The animal bone assemblage was poor, but the bones of Barbary sheep, gazelle, hare, birds and fish were identified (Gautier 1987).

The Botanical Assemblage

The samples were collected by B. Barich during the excavations in 1978 (Wasylikowa 1992a, 1993). There are 15 samples in total (ten from the main occupation phase and five from the later period), but they vary in nature. Some represent individual fruits or seeds picked up during the excavation or during the coarse sieving of the excavated deposits, others consist of small lumps of soil containing botanical remains; only six large soil samples were collected (Wasylikowa 1993). The plant remains were preserved in both charred and desiccated form, both occurring together. The samples were remarkably rich in plant remains and c. 25 taxa are represented (Tab. 1 and Wasylikowa 1992a, 1993). The assemblage is characterized by a large range of wild herbaceous species. The seeds of grasses (Gramineae) were the most numerous, esp. those of *Brachiaria* sp. and *Urochloa* sp., followed by those of Boraginaceae, Cyperaceae and Leguminosae (Wasylikowa 1992a, 1993). The pollen evidence suggests an open-type vegetation, with Gramineae, Cyperaceae and Compositae. Trees and shrubs are poorly represented (Schulz 1987).

Table 1. List of the food plants and trees found at the sites mentioned in the text

	TT	TT	UM	UM	ZIN	ULVS	ULVS
Approximate Date Range:	8600-8400 BP	6200-5200 BP	6000-4900 BP	3800-2200 BP	2700-2400 BP	1900-1300 BP	550-400 BP
No. of Samples:	10	5	20	8	53	180	10
No. of Seeds:	299	554	1408	162	9966	12952	4158
CEREAL CROPS							
Hordeum vulgare	.	.	.	.	*	*	*
Triticum dicoccum	.	.	.	.	*	.	.
Triticum aestivum	.	.	.	.	*	*	*
Triticum durum	.	.	.	.	.	*	*
PULSE CROPS							
Lens culinaris	.	.	.	.	.	*	*
Pisum sativum	.	.	.	.	.	*	*
Lathyrus sect. *Lathyrus*	.	.	.	.	.	*	.
FRUIT CROPS							
Phoenix dactylifera	.	.	.	*	*	*	*
Vitis vinifera	.	.	.	.	*	*	*
Ficus carica	.	.	.	.	*	*	*
Punica granatum	.	.	.	.	.	*	.
Amygdalus communis	.	.	.	.	.	*	.
Citrullus lanatus	.	.	.	.	.	*	.
Cucumis sp.	.	.	.	.	.	.	*
OIL CROPS							
Olea europea	.	.	.	.	.	*	*
Carthamus tinctorius	.	.	.	.	.	*	.
Linum usitatissimum	.	.	.	.	.	*	.
Ricinus communis	.	.	.	.	.	*	.
HERBS							
Portulaca oleracea	.	.	*	.	*	*	*
Apium graveolens	.	.	.	.	*	*	.
Anethum graveolens	.	.	.	.	*	*	.
Foeniculum vulgare	.	.	.	.	*	.	.
WILD FRUITS							
Citrullus colocynthis	.	*	*	*	*	*	*
Citrullus sp.	*	.	*	.	.	.	.
Rhus tripartita	.	.	.	.	*	*	*
Ziziphus cf. *spina-christi*	.	.	.	.	.	*	*
Pistacia atlantica	.	.	.	.	.	*	*
TREES							
Tamarix aphylla	.	*	*	*	.	.	.
Tamarix sp.	.	.	.	.	*	.	.
Acacia tortilis ssp. *raddiana*	.	.	.	*	.	.	.
Acacia spp.	.	.	*	*	.	.	.
Balanites aegyptiaca	*	.	*	*	.	.	.
WILD HERBACEOUS SPECIES							
Approximate No. of Taxa	24	28	27	16	24	25	25

The subsistence strategy

Both the archaeological and biological data from Ti-n-Torha/Two Caves indicate that the shelter had been occupied by hunting/gathering/fishing communities, similar to those found across the Sahara (Muzzolini 1989, 1993, Phillipson 1993). They exploited a wide range of wild resources, such as Barbary sheep, fish, birds, hare, gazelle and the seeds of wild plants, with Barbary sheep and wild grasses being the most numerous remains found. The later occupation of the shelter could not be interpreted reliably (the deposits are disturbed), but the nature of the occupation appears to have been similar to the earlier phase.

UAN MUHUGGIAG, TADRART ACACUS
(c. 4000–2900 bc and c. 1800–200 bc)

The archaeology

The excavations at this site are part of the same project as that described above. Most of the occupation at Uan Muhuggiag dates to the 4th millennium bc (radiocarbon dates range from c. 6000–4900 bp), but, as at Ti-n-Torha, the upper layers represent a later re-use of the shelter (radiocarbon dates of c. 3800–2200 bp; Barich 1987, 1992). The artefacts found in the occupation deposits consisted of flint and bone tools, some grinding equipment, as well as pottery. The upper layers were different, in that there was a decrease in artefact density, a reduction in tool-types, and the ceramics were different in the use of paste and decoration (Barich 1987). The faunal assemblage is characterized by the bones of domesticated animals, such as cattle, sheep and goat. Barbary sheep, gazelle, fish and other wild species are present, but numerically they are not important (Gautier 1987, Barich 1992). Through time there is a decrease in cattle and an increase in sheep and goats, and by the end of the sequence goats are more numerous than sheep. The pollen evidence points to an open vegetation (Gramineae and Compositae), with only small amounts of tree (*Maerua* and *Tamarix*) and shrub (*Artemisia*, *Cassia* and *Fagonia*) cover (Schulz 1987).

The botanical assemblage

The samples were collected by B. Barich during the excavations in 1982 (Wasylikowa 1992a, 1993). There are 28 samples in total (20 from the main phase of occupation and eight from the later period), but, as at Ti-n-Torha, they vary in nature: mostly hand-picked material, some small lumps of soil and only six large soil samples (Wasylikowa 1993). The plant remains were preserved in both charred and desiccated form, both occurring together. The samples were remarkably rich in plant remains and c. 30 taxa are represented (Tab. 1 and Wasylikowa 1992a, 1993). The assemblage is characterized by a large range of wild herbaceous species and several wild trees or shrubs. Species of the grass family (Gramineae), esp. *Urochloa* sp., *Echinochloa* sp., *Cenchrus* cf. *biflorus* and *Dactyloctenium aegyptium* were common. Tree species such as *Balanites aegyptiaca*, *Acacia* (both *A. tortilis*, ssp. *raddiana* and *A. nilotica*, Wasylikowa pers. comm.) and *Tamarix aphylla* were also numerous, followed by species of the sedge family (Cyperaceae), the Chenopodiaceae, and the seeds of the wild melon (*Citrullus colocynthis*). The assemblage differs from that of Ti-n-Torha/Two Caves in the much more abundant presence of trees and shrubs, which are extremely rare at Ti-n-Torha. This points to differences in the vegetation around the two sites, which is corroborated by the evidence from the pollen (Schulz 1987). This may be related to differences in the hydro-geological setting of the sites, or to differences in the chronology of the deposits (Barich 1992, Schulz 1987, Wasylikowa 1993). Several seeds of another *Citrullus* species were found at the site (as well as one at Ti-n-Torha). The seeds are similar to those of *Citrullus lanatus*, but appear to represent a wild form (C. Jeffrey, pers. comm.). It is not clear how they relate to *C. colocynthis* and *C. lanatus*: they are, at present, the subject of further investigations (van der Veen & Wasylikowa forthcoming a). The assemblage from the upper part of the sequence differs from that of the main part of the occupation in two ways. The samples contain fewer plant macrofossils and there are almost no grass seeds. Three date stones (*Phoenix* sp.) were found in the uppermost layer of Uan Muhuggiag. One of these gave a radiocarbon date of 2130 $\pm$ 70 bp (OxA-4389; van der Veen & Wasylikowa forthcoming b). It is extremely difficult, if not impossible, to distinguish wild from cultivated date stones, but the general size and robustness of the stones is comparable with those of *Phoenix dactylifera* (Dr. J. Dransfield, pers. comm.), the cultivated date palm.

The subsistence strategy

While the botanical assemblage of Uan Muhuggiag is broadly similar to that from Ti-n-Torha, i.e. it consists entirely of wild plants, a different subsistence strategy is inferred. Unlike at Ti-n-Torha, pottery is present at the site and the faunal assemblage is characterized by the bones of domesticated animals, such as cattle, sheep and goat (Gautier 1987). The remains point to the presence of pastoralists who, at regular intervals, returned to the shelter with their domesticated animals. For their plant food, however, they relied entirely on wild plant resources. While the archaeological evidence in the upper layers of the shelter differs from the earlier phase, there is no evidence for a marked change in the subsistence strategy. There is a greater reliance on ovicaprids, and especially on goats (probably reflecting a deterioration in the ecological conditions at the site due to increasing aridity), but the subsistence is still based on a combination of domesticated animals and wild plant resources. The presence of three date stones from the latest phase of occupation (dated to the last few centuries of the first millennium bc) suggests that the occupants of the shelter may, at that time, have been in contact with agriculturalists. We know that the date palm was cultivated in Libya from at least 2700 bp, see the evidence from Zinchecra below.

ZINCHECRA, FEZZAN
(700–400 bc or 900–400 cal BC)

The archaeology

Between 1965 and 1973 a project of large-scale survey and excavation was carried out in Fezzan, under the direction of C. M. Daniels (University of Newcastle upon Tyne, U.K). The project focussed on the Wadi el-Agial, c. 700 km south of Tripoli, and concerned a study of the Garamantes (a tribe mentioned by Herodotus) and their relationship with the Roman Empire. The archaeological evidence revealed a series of settlements, many located on the escarpment along this wadi, dating to the first millennium BC, as well as many cemeteries, some of which are dated to the Roman period (Daniels 1969, 1970a, 1970b, 1989). The archaeological remains at Germa (c. 170 km west of Sebha, the modern capital of Fezzan) were identified as representing Garama, the capital of the Garamantes, known from historical sources. The earliest remains at Garama date to the 5th century BC, but the main phase of the occupation took place during the first few centuries AD. Zinchecra is a fortified promontory site 3.5 km southwest of Germa on the southern side of the wadi; it almost certainly represents Garama's predecessor (Daniels 1989).

Survey work and excavations have identified dense occupation on the top and slopes of the hill. A large number of buildings were identified, some containing several rooms and some associated with yards. Most were built in dry-stone walling, but timber structures were also recovered. A series of eleven radiocarbon dates on seeds and charcoal from the occupation deposits range from c. 2700–2400 bp and give a calibrated date of 900–400 cal BC for the occupation (van der Veen 1992). Abundant pottery was found, largely of hand-made, local manufacture, ranging from jars to bowls and platters (Daniels 1968). Stone artefacts include scrapers, as well as rubbers, pounders and saddle querns. The occupation levels in and outside the buildings consisted of much organic debris, such as animal dung, palm wood and leaves, charcoal, ash, date stones etc. Small samples of these deposits were brought back to England and were recently analysed (van der Veen 1992). The animal bone assemblage has, unfortunately, never been studied in detail, but bones of cattle, sheep and goat were recorded (Daniels 1968).

The botanical assemblage

The samples from the occupation deposits were extremely rich in plant remains; a total of 9966, mainly desiccated, items have been identified (Tab. 1 and van der Veen 1992). The samples were dominated by chaff fragments of emmer wheat (glume bases of *Triticum dicoccum*) and barley (rachis internodes of *Hordeum vulgare*) and the fruit stones of the date palm (*Phoenix dactylifera*). Desiccated and charred grains of emmer and barley were also found, as were male and female flowers of the date palm. Bread wheat (*Triticum aestivum*) was represented by a small number of rachis internodes. Several other fruits were present apart from dates: grapes (*Vitis vinifera*) and figs (*Ficus carica*), wild melon (*Citrullus colo-*

cynthis) and sumach (*Rhus tripartita*). The seeds of some herbs or green vegetables were also found: celery (*Apium graveolens*), purslane (*Portulaca oleracea*), dill (*Anethum graveolens*) and fennel (*Foeniculum vulgare*). A range of wild herbaceous species (24 taxa) was also identified (van der Veen 1992). They included three species of Cyperaceae, *Aizoon hispanicum*, *Reseda* spp., *Chenopodium murale*, several grasses (Gramineae), and *Cornulaca monacantha*.

The subsistence strategy

The botanical assemblage from Zinchecra provides conclusive evidence for the existence of a well-developed agricultural system in Fezzan by the first millennium BC. At the present time this assemblage also represents the first recorded evidence for agriculture in the central Sahara. The crops grown were largely Near Eastern cultigens, with the exception of the date palm which is native to North Africa (although present archaeobotanical evidence suggests that the date palm might have been first domesticated in the Near East (Zohary & Hopf 1988). The samples contained the residues of the various stages of the crop processing sequence, indicating that the crops were locally produced. A range of cereals and fruits was present. The only category of plant food noted by its absence is that of the pulses. It is not clear whether this is related to the local preservation conditions or reflects a true absence.

Today all crops in Fezzan are grown under irrigation as the region receives virtually no rainfall. At Sebha, the modern capital of Fezzan, the mean annual rainfall figure is 9 mm, and the annual variation in precipitation is high (Allan et al. 1973). The arable fields or gardens of the inhabitants of Zinchecra must have been located on the wadi floor. Water is found close to the wadi surface here, there is a perennial spring near Germa, and after rare outbursts of heavy rainfall small lakes form in the wadi floor (Allen et al. 1973). At the time of the Garamantes there may well have been enough water close to the surface to grow crops without irrigation. The presence of reed and sedges in the samples (van der Veen 1992) points to the presence of standing water near the vicinity of Zinchecra. The combination of date palms, cereal crops, fruit trees and vegetables/herbs is not dissimilar to the range of crops growing in present-day oasis' gardens, where cereals, vegetables and fruits are grown under the shade of the date palms.

The survey work carried out as part of the project, has identified substantial evidence for ancient water management. Several hundred foggaras were discovered, underground water channels running from the escarpment to the wadi centre (Daniels 1970b). The purpose of these channels was undoubtedly to tap water from the aquifers in the escarpment and channel it towards the lower lying parts of the wadi, where it will have irrigated fields, gardens and/or palm groves. There is no direct dating evidence for these foggaras, but their close association with the Garamantian settlements suggests that they may have been in operation during the occupation of Zinchecra and/or Garama.

UNESCO LIBYAN VALLEYS SURVEY, TRIPOLITANIA
(1st – 7th centuries cal AD)

The archaeology

The aim of the UNESCO Libyan Valleys Survey was to investigate the long-term relationships between settlement, land-use and environment on the desert margin of north-western Libya. Between 1979 and 1989 the project (directed by Prof. G. Barker, University of Leicester, and Prof. B. Jones, University of Manchester, U.K.) carried out large-scale survey and excavation in the pre-desert of Tripolitania (Jones & Barker 1980, Barker & Jones 1981, 1982, 1984, Gilbertson et al. 1984, Gilbertson & Hunt 1990, Barker et al. 1991, Welsby 1991, Barker 1993, Gilbertson & Hunt 1993, Barker et al. in press). Today the area is sparsely populated by semi-nomadic people; permanent settlement is restricted to the oasis towns of Mizda and Beni Ulid. The project has identified extensive evidence for ancient agricultural settlements dating largely to the Roman period. Settlements were concentrated along the edges of the small tributaries of the two main wadi systems, the Sofeggin and ZemZem. Two main phases of occupation were identified: the first one is characterized by large, open courtyard farmsteads dated to the late 1st – late 4th centuries AD, the second one is characterized by the presence of large fortified farms or "gsur" dated to the late 3rd – 7th centuries AD (Barker et al. in press, Dore 1988, 1990, in press). Both the open farms and the „gsur" were associated by olive presses and the production of olive oil for the coastal markets has been postulated (Mattingly 1985 and in press, Mattingly & Zenati 1984). Across the entire survey area there is extensive evidence for water control systems. Catchment walls for cisterns, walls in and along the wadis, and sluices set in wadi walls were found at all wadis (Gilbertson et al. 1984). The animal bone assemblage was poorly preserved, but sheep, goat and gazelle bones were common. Cattle, pig and camel were present in small quantities, as was antilope. A few fish bones, of sea bream, demonstrate that the sites were in contact with the coastal settlements (van der Veen & Grant in press).

The botanical assemblage

Ten Romano-Libyan sites in the survey area were sampled for plant remains and 180 samples have been analysed resulting in 12953 identifications (Tab. 1 and van der Veen 1985, van der Veen & Grant in press). Both charred and desiccated remains were present. The samples contained a wide variety of crop plants and wild species, including cereals, pulses, fruits, oil plants, and herbs. Three cereal crops were found: barley (*Hordeum vulgare*), durum wheat (*Triticum durum*) and bread wheat (*Triticum aestivum*), as well as three pulse crops: lentil (*Lens culinaris*), pea (*Pisum sativum*) and grass pea (*Lathyrus* subsection *Lathyrus*). The oil plants are olive (*Olea europea*), linseed (*Linum usitatissimum*), safflower (*Carthamus tinctorius*) and caster oil (*Ricinus communis*). The fruit species found include both Mediterranean species: grape (*Vitis vinifera*), fig (*Ficus carica*), almond (*Amygdalus communis*) and pomegranate (*Punica granatum*), and African species: date (*Phoenix dactylifera*), water melon (*Citrullus lanatus*). Four wild fruit species are present: wild melon (*Citrullus colocynthis*), wild pistacia (*Pistacia atlantica*), the berries of the Christ-thorn (*Ziziphus spina-christi*), and sumach (*Rhus tripartita*). Finally, three herbs or green vegetables were found, purslane (*Portulaca oleracea*), dill (*Anethum graveolens*), and celery (*Apium graveolens*). The identification of the wild herbaceous plants is not yet complete, but at least 25 taxa are present, including *Raphanus raphanistrum*, *Chenopodium murale*, Polygonaceae (e.g. *Emex spinosa*), Boraginaceae (e.g. *Megastoma pusillum*), Leguminosae (e.g. *Medicago* spp.), Compositae and Gramineae.

Most samples contain both charred and desiccated plant remains, but the various species and plant parts were not found in equal proportions in the two modes of preservation. The chaff fragments and grains of the cereal crops and the cotyledons of the pulses were far better represented in charred than in desiccated form, while the seeds of the wild herbaceous plants were considerably more common in the desiccated assemblages (van der Veen & Grant in press). The fruit stones and pips were equally well represented in charred and desiccated form, while the oil plants were equally poorly represented. The residues of early processing stages of the cereal crops (i.e. rachis internodes of free-threshing cereals) were present in abundance, indicating that these crops were locally produced. The samples cover a period of c. 600 years, but no significant changes over time in the range of crops present could be detected. A more detailed account of the differences between the assemblages from the early (Romano-Libyan) and later ("Byzantine") sites is in preparation (van der Veen forthcoming a).

The subsistence strategy

The range of crop plants recovered from these sites points to the existence of a well-developed and remarkably diverse and successful agricultural economy. Most of the crops are of Near Eastern or Mediterranean origin, and, with the exception of the date palm and the wild fruit trees, which still grow in the area today, these crops are not known to be very drought resistant. The minimum amount of rainfall they require is c. 300 mm per year, though the optimal amount of rainfall for most of these crops lies considerably higher. Today the region receives less than 75 mm of annual precipitation; towards the southern part of the area this figure drops to 35 mm, and the precipitation is also extremely variable (Ahmad 1969, Allan et al. 1973). All the available evidence indicates that during the Roman period the climatic conditions were similar to those of today (Gilbertson in press). Thus, despite the area's apparent unsuitability for large-scale agriculture, the Romano-Libyan inhabitants of these sites were clearly able to sustain a successful arable economy for 600 years. Animal husbandry operated alongside crop farming, but the number of animals kept may have been small, as grazing resources were scarce (van der Veen & Grant in press).The archaeological evidence for extensive water-catchment and water control systems associated with the settlements is witness of the scale and sophistication of the agricultural system. It is likely that the farms were engaged in agricultural production (especially olive oil) for the coastal markets on the Tripolitanian coast.

UNESCO LIBYAN VALLEYS SURVEY, TRIPOLITANIA (15th - 16th centuries cal AD)

The archaeology

While the UNESCO Libyan Valleys Survey concentrated on the Romano-Libyan remains, small-scale excavations were carried out in two middens associated with two Medieval or Islamic sites (Adzam and Ben Telis) in the Wadi Merdum in the northern part of the survey area (just northwest of Beni Ulid). The deposits are dated by radiocarbon dates to c. 550 - 400 bp, or the 15th and 16th centuries cal AD (van der Veen 1985, Dore & van der Veen 1986). Very little is known about the nature of settlement in this period, but the botanical evidence is presented here for completeness. The results are preliminary as the analysis is still in an early stage and only half the samples have been analysed.

The botanical assemblage

The plant remains from the two sites differ from one another in that those from Adzam are largely charred, while at Ben Telis both charred and desiccated material was present. The crop species found consist of staple crops and fruit crops (Tab. 1 and van der Veen 1985). Three cereal crops were present: barley (*Hordeum vulgare*), durum wheat (*Triticum durum*) and bread wheat (*Triticum aestivum*), as well as two pulses: lentil (*Lens culinaris*) and pea (*Pisum sativum*). Four fruit species were found: fig (*Ficus carica*), grape (*Vitis vinifera*), date (*Phoenix dactylifera*) and olive (*Olea europea*). Three wild fruits were also present: wild pistachio (*Pistacia atlantica*) and the berries of Christ-thorn (*Ziziphus spina-christi*) and sumach (*Rhus tripartita*). A wide range of wild herbaceous species was also present in the samples.

The subsistence strategy

While the range of crop species at these sites is more restricted than that from the Romano-Libyan sites (though more species may be found once all samples have been analysed), it still represents a broad based agricultural economy. The botanical evidence clearly indicates that agriculture continued to play an important role in the region after the end of the Roman period.

DISCUSSION

THE BEGINNING OF AGRICULTURE

The plant macrofossils now available from excavations in Libya span almost the entire length of the Holocene (Fig. 2). Their evidence indicates that the origins of agriculture in Libya (and the central Sahara) were rather different from those in the Near East. There we see the domestication of crop plants well before the development of pottery and animal husbandry. The present evidence from the Sahara suggests that here pottery developed before either animal or plant husbandry, and that animals were domesticated long before crops were. The tool kit and faunal assemblage from Ti-n-Torha is similar to that of other hunter/gatherer sites of that period in the central Sahara, but the site is unique in giving us a first insight in the use of wild plant resources. The same is true of the assemblage from Uan Muhuggiag. Pottery is known from several sites in the central Sahara and domesticatted cattle has also been recorded for a number of sites, but nothing was known about the role of plant foods at pastoralist sites until the evidence from Uan Muhhuggiag became available. The Saharan pastoralists, known from their rock paintings, rock shelters and the "Steinplätze" or fire places, appear to have entirely relied for their plant food on wild resources, by harvesting wild seeds from a range of different plants. It is not clear why the domestication of animals, cattle, sheep and goat, took place exactly when it did. The dating evidence for the climatic fluctuations in the region is not, at present, precise enough to establish whether the domestication of cattle took place at the end of a short mid-Holocene dry period, but this has been suggested (Muzzolini 1989, 1993, Phillipson 1993). If this were the case, then the domestication of cattle may possibly be seen as a response to a decrease in wild animal resources. Crop husbandry, however, did not develop at this time and a number of reasons may be put forward. First, there may still have been sufficient wild plant resources, making the cultivation of plants unnecessary. Alternatively, the amount of grazing available was not sufficient for year-round occupation, forcing people into a transhumant lifestyle, which was not compatible with the cultivation of plants. The increased reliance on ovicaprids rather than cattle at Uan Muhuggiag, and later on goats rather than sheep, suggests that there was a decrease in the amount of grazing available, probably due to progressive desiccation (Gautier 1987). Finally, the amount of precipitation in the Sahara may never have been sufficient or sufficiently reliable to sustain the growth of crops outside a few well-watered areas. The evidence for pastoralists in the central Sahara decreases rapidly with the onset of the arid climatic conditions. Their fire places, "Steinplätze", are found across the Sahara, dating from 9000–3500 bp, but mostly to the period of 5800–5000 bp. They disappear around 3800 bp (Gabriel 1987) by which time conditions are as arid as those of today.

Present evidence suggests that agriculture did not develop until after progressive desiccation had set in and people had started to move out of the Sahara (south into the Sahel and Savanna zones, east into the Nile Valley, and possibly north towards the Mediterranean coast). Settlement in the Sahara became restricted to the few locations where sufficient groundwater was available to compensate for the lack of rainfall: the oases. The evidence from Zinchecra, in the well-watered Wadi el-Agial, demonstrates that by the 3rd millennium BP agriculture had successfully developed here. At approximately the same time there is evidence for agriculture on the south-western fringe of the Sahara, at Dhar Tichitt and Dhar Oualata, Mauritania (Amblard & Pernès 1989, Phillipson 1993).

Thus, the first evidence available to date for agriculture in Libya comes from Zinchecra, the Garamantian settlement in Fezzan, dated to the first half of the 3rd millennium BP, at a time when the climate was already as arid as it is today. Here a large botanical assemblage provides conclusive evidence that agriculture was practiced. The assemblage indicates that the agricultural system was fully developed; it does not represent a transition to agriculture. This does, of course, imply that the transition to farming took place earlier, but how much earlier, and exactly where, cannot be established at this stage. The evidence from the UNESCO Libyan Valleys Survey demonstrates that, despite the arid conditions, agriculture was practised in the semi-desert during most of the 1st millennium AD, and (again?) in the mid 2nd millennium AD. But by then extensive water management systems had been developed, allowing agriculture to succeed even in areas that did not have ample ground water.

THE ROLE OF AFRICAN CROPS

Crop production is often seen as the end product of a long process of increasing levels of plant exploitation. While the evidence from Ti-n-Torha and Uan Muhuggiag clearly demonstrates the presence of wild seed harvesting, this does not appear to have developed into the domestication of these species. Instead, the evidence from Zinchecra suggests that, with the exception of the date palm (*Phoenix dactylifera*) crops of African origin play no role in the agricultural regimes at Zinchecra or, later, the Libyan Valleys. All the cereal and pulse crops are of Near Eastern origin, and the majority of the fruit crops originated in the Mediterranean. Despite the arid conditions the agricultural regimes recorded so far in Libya, have more in common with those in the Near East and the Mediterranean, than with the later developments south of the Sahara. The origin of the African cereal crops, especially sorghum and *Pennisetum* or pearl/bulrush millet remains obscure, but can probably be found in the Sahel zone to the south of the Sahara. The evidence for both wild and domesticated *Pennisetum* at Dhar Tichitt and Dhar Oualata (Mauritania) dated to c. 3000 bp, appears, at present, to be the earliest evidence for these crops (Amblard & Pernès 1989, Phillipson 1993).

PRESERVATION CONDITIONS AND FORMATION PROCESSES

At all sites the plant macrofossils were present in both charred and desiccated form, often mixed together. The formation processes of desiccated plant remains are poorly understood, but the presence of both charred and desiccated material will allow detailed comparison and study in future. Already some general observations can be made. It is a well know fact that in charred assemblages from Europe certain plant species and plant parts are underrepresented (e.g. pulses and rachis internodes of free-threshing cereals) due to their reduced chance of getting in contact with fire, or their reduced chance of surviving the fire once in contact with it. However, rachis internodes of free-threshing cereals (both barley and wheat) are common in the assemblage from the Libyan Valleys, and, surprisingly, they are more often found in charred, than in desiccated form. This suggests that there may be differences in the way these by-products of the cereal harvest are treated in temperate and arid regions, and more work is planned to investigate this issue (van der Veen forthcoming b).

The preservation of whole cotyledons of pulses in desiccated assemblages is not good (van der Veen & Grant in press), but at some sites detached hila or curled-up fragments of testa have been found (van der Veen forthcoming c, U. Thanheiser pers. comm.), so that species identification may still be better in desiccated than charred assemblages.

A related issue is the possible difference in formation processes of charred versus desiccated plant remains. A simple calculation of the density of plant remains in the deposits from the Romano-Libyan sites in Tripolitania indicated that the charred plant remains were, generally, found in high densities, probably representing deliberate deposition, while the desiccated plant remains occurred in lower and more variable densities, suggesting a longer period of accumulation and different methods or mechanisms for deposition (van der Veen & Grant in press).

CHANGING WHEAT CROPS

At all agricultural sites the remains of both wheat and barley were found. While the species of barley grown during the 1st millennia BC and AD remained the same, the species of wheat changed from emmer wheat (*Triticum dicoccum*) to durum wheat (*Triticum durum*) and bread wheat (*Triticum aestivum*). This change from glume wheats to free-threshing wheats appears to have taken place during the late 1st millennium BC. A similar shift has been recorded in Egypt (late 1st millennium BC), the Mediterranean (early 1st millennium BC) and northwestern Europe (1st millennium AD; Zohary & Hopf 1988). This phenomenon has been associated with changes in the arable economy, especially with an increase in the scale of arable production. It is important to note that, even though most of North Africa is rather marginal to agriculture, the region clearly participated in supra-regional changes in agriculture.

WATER RESOURCES

One of the most striking aspects of the present evidence is the degree of sophistication with which people in the past were able to manage the limited water resources available to them. The foggaras at Zinchecra and the wadi walls, sluices and cisterns in the Libyan Valleys together with the rich botanical remains of a wide variety of crop plants are illuminating examples of people's ingenuity in coping with unfavourable circumstances. The archaeological evidence indicates that these water-management systems were often long-lived, reflecting the success of past technologies.

Modern technology claims its own success stories with mechanized water pumps, artificial fertilizers, irrigation and cultivation on a vast scale. The centre-pivot system of irrigation near the Kufra oasis in south-east Libya is a famous example. From the air each field shows up as a large circle of vegetation amidst the sand. Each circle consists of 100 ha of land, irrigated by a circulating sprinkler unit of 560 m radius (Allan 1976, Allan & Warren 1993). The very scale of the operations, however, brings its own problems. Fossil water supplies are finite, and salinization is a serious problem. While both these factors were in operation in the past, the unprecedented scale of today's operations is often their downfall (Allan 1988, Allan & Warren 1993). The problems encountered by these modern experiments are not just environmental (at Kufra the hot dry winds harmed the crops, and the fall in the water-table is affecting agriculture and population in neighbouring oases), but also social (the Libyan people preferred to live near the coast rather than in the desert) and economic (the true cost of production is often many times higher than the market cost; Allan 1976, 1988, Allan & Warren 1993). The success and longivity of the arable economy in the Roman-period Libyan Valleys provides an archaeological example of how contemporary socio-economic and political conditions play a crucial role in the success of water management schemes (Barker et al. in press).

CONCLUSION

The present archaeological evidence for agriculture in Libya has identified a complex interaction between changing environmental, cultural and socio-political climates. During the early Holocene wet phase people moved into the Sahara to take advantage of the rich wild resources that had become available (Ti-n-Torha/Two Caves). During the later part of this wet phase the environmental conditions were not favourable for permanent settlement, but the domestication of cattle, sheep and goat allowed transhumant pastoralists to utilize seasonally available grazing, while still relying on wild plant resources for the remainder of their diet (Uan Muhuggiag). When the present dry phase set in and environmental conditions deteriorated, some people appear to have moved to more favourable regions (e.g. the Sahel, the Nile Valley). Others concentrated into the few well-watered locations in the Sahara – the oases – and developed a sedentary lifestyle and oasis agriculture or garden cultivation (Zinchecra). Others still adopted a nomadic way of life with their sheep and goats (and later camels), possibly harvesting "catch-crops" in good years, and probably living in symbiosis with the oasis agriculturalists. When Libya became incorporated into the Roman Empire people rapidly took advantage of the favourable political and economic conditions, and a flourishing agricultural system was developed in the semi-desert, just south of the main ports and markets (Libyan Valleys). We know little as yet of the innovations or changes brought about by the Arab invasions and there are many other gaps in our knowledge as well, but new data is becoming available all the time (e.g. from Euesperides, Benghazi, mid first millennium BC, Mattingly forthcoming). The present botanical results have demonstrated that, when the specialism of archaeobotany is fully integrated into large-scale archaeological projects, our understanding of the subsistence strategies of past societies is enhanced immeasurably.

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