Veget Hist Archaeobot (2004) 13:213–217
DOI 10.1007/s00334-004-0039-6

ORIGINAL ARTICLE

Krystyna Wasylikowa · Marijke van der Veen

An archaeobotanical contribution to the history of watermelon, *Citrullus lanatus* (Thunb.) Matsum. & Nakai (syn. *C. vulgaris* Schrad.)

Received: 9 February 2004 / Accepted: 26 April 2004 / Published online: 18 June 2004

Abstract The discovery of several 5000-year old seeds of wild watermelon, *Citrullus lanatus*, at an archaeological site Uan Muhuggiag in southwest Libya, re-opens the debate on the origin, wild distribution and domestication history of this species. The seeds were found within a plant assemblage of wild seeds and fruits, associated with pottery and bones of domestic animals belonging to Neolithic pastoralists. The presumed wild progenitor of the modern cultivar *C. lanatus* is today found exclusively in a region centring on the Kalahari Desert. This new archaeobotanical record raises the possibility that this distribution was much more extensive in the past.

Keywords *Citrullus lanatus* · Libya · Wild distribution · Domestication history

Taxonomy and origin of *Citrullus lanatus*

The taxonomy of the genus *Citrullus* is complex and no full agreement exists, though four or five species are usually distinguished: *Citrullus colocynthis, C. ecirrhosus, C. naudinianus, C. rehmii,* and *C. lanatus*. *Citrullus colocynthis* (L.) Schrad. is a perennial (rarely annual) species growing wild on sandy habitats in desert and semi-desert areas of North Africa, the Near East and south-west Asia as far as India (Fursa 1972a; Zohary 1983; Jeffrey 2001). It is also cultivated on a small scale (Jeffrey 2001). The fruits of most of the variants are intensely bitter, and were until recently collected for medicinal purposes as a purgative. The seeds contain oil and may be consumed roasted or ground into flour. Since the 1930's the colocynth was considered the progenitor of the cultivated watermelon (Zohary 1983), but see below.

Another perennial species, *C. ecirrhosus* Cogn., is known only as a wild form restricted to the deserts of the Namib area (Meeuse 1962; Fursa 1972a). *C. naudinianus* (Sond.) Hook.f. is also a perennial species growing wild in southern Africa (Fursa 1972b) and sometimes cultivated. It differs sufficiently from the other *Citrullus* species that Jeffrey (2001) included it in the genus *Acanthosicyos* (*A. naudinianus* (Sond.) C. Jeffrey). In 1990 a new annual species, *C. rehmii* de Winter, was described from Namibia (Zohary and Hopf 2000).

The most polymorphic among all *Citrullus* species is *C. lanatus* (Thunb.) Matsum. & Nakai, an annual species which has wild, cultivated and feral forms. It is divided into three subspecies. The most widely cultivated forms belong to *C. lanatus* subsp. *vulgaris* (Schrad. ex Eckl. & Zeyh.) Fursa (Jeffrey 2001). Its fruits are usually eaten raw and also serve as fodder. The seeds yield an edible oil and are consumed roasted. The second subspecies, *C. lanatus* subsp. *lanatus*, includes wild annual forms that today grow only in the Kalahari desert and are known under the local name tsamma (*C. lanatus* subsp. *lanatus* var. *caffer* (Schrad.) Mansf. according to Fursa 1972a). Many taxonomists (Jeffrey 1967, 2001; Zeven and Zhukovsky 1975) now regard this to be the ancestor of the modern cultivar. Some of these wild watermelons have relatively sweet fruits and are used by local people and animals as a source of water. This custom was observed for the first time by Livingstone who, seeing the vast areas covered with wild watermelon, noticed that people, before eating, first crushed the fruits to test if they were bitter or not (de Candolle 1886). The Citroides group of this subspecies (*C. lanatus* subsp. *lanatus* var. *citroides* (Bailey) Mansf. according to Fursa 1972a) includes primitive cultivars and weeds in watermelon fields (Jeffrey 2001). The third subspecies *C. lanatus* subsp. *mucosospermus* Fursa is known from West Africa. Fursa (1972a), who has described this subspecies, identified it as a wild or semi-cultivated (sub-spontaneous) taxon growing in West Africa (Ghana, Nigeria, Guinea and

K. Wasylikowa (✉)
W. Szafer Institute of Botany,
Polish Academy of Sciences,
Lubicz 46, 31–512 Kraków, Poland
e-mail: K.Wasylik@ib-pan.krakow.pl

M. van der Veen
School of Archaeology & Ancient History,
University of Leicester,
University Road, Leicester, LE1 7RH, UK

Senegal). Jeffrey (2001) states that it is cultivated in West Africa. Seeds are used as the source of edible oil.

Archaeobotanical records of *Citrullus lanatus*

The oldest published records of *Citrullus* remains come from Egypt, but their identification is in doubt. Leaves found in the coffin of the priest Nibsoni in Deir el Bahari, 20th Dynasty (or 21st according to Germer 1988) were identified by G. Schweinfurth as *Citrullus vulgaris* Schrad. var. *colocynthoides* Schwf. (Schweinfurth 1883, 1884). Schweinfurth considered the variety *colocynthoides* a primitive form of the extant watermelon *Citrullus vulgaris*, which was cultivated in Upper Egypt for its oily seeds. He wrote "*Citrullus vulgaris* is found wild in the greater part of central Africa, and its fruit is smaller than that of the cultivated race, and less palatable, though otherwise like it." Further on in the same publication he says: "There is association of characters in the leaves from the mummy of Nibsoni, that enable one to refer them to the varieties of the cultivated water-melon, rather than to the wild colocynth" (Schweinfurth 1883, p. 113). At present *Citrullus vulgaris* Schrad. var. *colocynthoides* Schwf. is treated as synonym of the wild colocynth *C. colocynthis* (L.) Schrad. (Jeffrey 2001), and the leaves identified by Schweinfurth may thus belong to this wild species. Under the same name *Citrullus vulgaris* Schrad. var. *colocynthoides* Schwf., Germer (1988 pp. 10, 43–44) lists three finds of fruits from graves dated to the 5th Dynasty (second half of the 3rd millennium B.C.) at Abusir, the 18th Dynasty (middle of the 2nd millennium B.C.) at Deir el-Medina, and the Greco-Roman period at Gabelên. However, the seeds from this last site, shown by her in Fig. 57, represent cultivated *C. lanatus* and not the wild colocynth. Still older seeds were recovered from the alimentary canal of a mummy discovered at the site of Naga ed-Deir, dating to the Predynastic period (first half of the 3rd millenium B.C.) and identified by F. Netolitzky (1943) as a wild form *C. vulgaris* var. *colocynthoides* Schweinf. He based this identification on the morphology of the cross section of the seed wall, which according to him was similar to *C. vulgaris,* while the small size of the seed made him think it was a wild form. However, Schweinfurth's drawings reproduced by Netolitzky (1943, p. 23) show two seeds, one of which clearly resembles *C. lanatus* and not *C. colocynthis* (Fig. 1).

The earliest reliable finds of *C. lanatus* seeds come from the tomb of Tutankhamun (ca. 1330 B.C., Hepper 1990) and Hepper suggests that the cultivated watermelon was available in Egypt at least from that time onwards. It was known in Sudan as early as about 1500 B.C. (van Zeist 1983). Early 1st millenium B.C. records of cultivated watermelon are known from Arad, Israel (Schultze-Motel 1974), from Raybun in south Arabia (Levkovskaya and Filatenko 1992) and from Samos in Greece (Kučan 1995). By the Roman period records are widespread, ranging from Libya (Romano-Libyan sites dated to the 1st-7th century A.D., van der Veen 1995) to the Netherlands (Kroll 1999) and France (Marinval 1999). Only very few records of watermelon are known from southern Africa and all belong to the younger periods, 8th to 13th century A.D. (Shaw 1976).

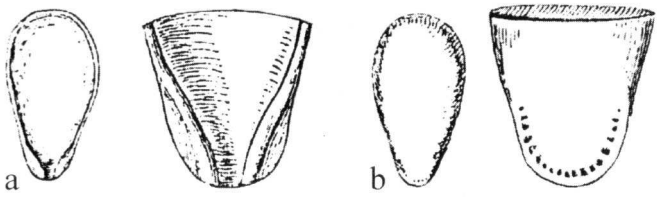

Fig. 1 Two seeds from the site Naga ed-Deir drawn by Schweinfurth and identified by Netolitzky as *C. vulgaris* var. *colocynthoides* Schweinf.; two complete specimens and their lower ends enlarged. Specimen (a) resembles seeds of cultivated *Citrullus lanatus* (redrawn from Netolitzky 1943)

A new record from Uan Muhuggiag, Libya

Seeds of *Citrullus lanatus* have been found at two archaeological sites in the Libyan Sahara: Ti-n-Torha/Two Caves located in the northern and Uan Muhuggiag in the central Acacus Mountains of south-west Libya, both rock shelters excavated by Barich (1992).

The site at Ti-n-Torha/Two Caves was inhabited several times by Epipalaeolithic tribes, living on fishing, hunting and gathering wild plants (Barich 1992; Wasylikowa 1993). Calibrated radiocarbon dates at this site range between 9115–8289 and 7594–7182 B.C. (9350±110, R-1402, and 8400±90 uncal. B.P., R-1404) for the lower layers, and 5304–5048 and 4249–3796 B.C. (6230±50, R-1403 and 5210±90 uncal. B.P., Gd-2855) for the upper ones. The plant assemblage consists entirely of wild plant species (among them one seed, of *Citrullus colocynthis*), but includes also one (uncharred, desiccated) seed morphologically identical to *C. lanatus*, found in Sector E, layer II. This layer is radiocarbon dated to 7784–7545 and 8162–7520 cal. B.C. (8620±50, R-1406 and 8650±105 B.P., R-1409). The seed itself is not dated, and stratigraphical evidence suggests that layer II was disturbed and contains younger intrusive material (Barich 1992). The date of this single watermelon seed is, therefore, uncertain.

At Uan Muhuggiag, famous for its well-preserved rock paintings illustrating hunting and pastoral scenes, the occupation deposits also consisted of two separate horizons. The older horizon, dated between 6468–6055 and 4345–3806 B.C. (7438±120 and 5290±110 uncal. B.P.), contained evidence of repeated short-term habitation by pastoral groups. Faunal remains were dominated by domestic animals (cattle, sheep and goat) but no domesticated plants were found. The younger horizon was separated from the older one by a rocky landslide, and produced calibrated ^{14}C dates ranging from 3942–3649 B.C. to 801 B.C-A.D. 230 (4980±70, Gd-2958 to 2220±220, Gd-4290, B.P.; Barich 1992; Wasylikowa 1993).

Uncharred, desiccated seeds of *Citrullus lanatus* were present in the older occupation horizon. In sector B, five complete seeds and five larger fragments were found in two samples (sample No. 4 from layer 2 and No. 6 from layer 2a). Uncharred *Balanites aegyptiaca* fruits from these same layers gave radiocarbon dates of 4450–3942 cal. B.C. (5340±120 B.P., Gd-2959) for layer 2 and 4454–3998 B.C. (5420±100 B.P., Gd-2960) for layer 2a (Wasylikowa 1993). The plant assemblage from this horizon consists entirely of wild plants (wild grasses, wild herbaceous plants and a few tree taxa; Wasylikowa 1992), even though 90% of the faunal remains belong to domestic animals, a pattern characteristic of the pastoralist sites of the central Sahara. The assemblage did not contain any indicators of plant domestication and the presence of seeds of watermelon, which does not belong to the native flora of Libya, but is thought to originate from tropical southern Africa (see above), is, therefore, of special interest. For this reason, three seeds from layer 2a were submitted for dating to test whether they represented secondary intrusions (as originally suggested by Wasylikowa 1992, 1993). The date obtained, 4361–4000 cal. B.C. (5400±80 B.P., OxA-4390), shows that the seeds are not intrusive, but date to the archaeological context from which they were recovered.

Description of *Citrullus* seeds from Uan Muhuggiag

The morphology of the *Citrullus* seeds at Uan Muhuggiag indicates that two distinct species are present. Both seed types are compressed and oval or ovate in outline. Those of *C. colocynthis* (L.) Schrad. are rounded at the top and taper gradually at the base to a narrowly rounded tip (Fig. 2). The elongated "grooves" at the narrower end do not reach the tip of the seed. The seed surface is smooth, and they are 6.3 (5.6–7.1) x 3.8 (3.1–4.4) mm in size (10 measurements). In a few samples 25 loose seeds of this species were found; in one sample a lump of cattle dung contained numerous seeds (Wasylikowa 1992).

The seeds of *C. lanatus* are also rounded at the top, but almost truncated at the base (Figs 2, 3). The elongated "grooves" are broader than in the former species, reach the base of the seed and also have the characteristic bulges on either side. The seed surface is verrucose, and they are larger than *C. colocynthis*: ca. 8.0×4.5 mm; 7.5×3.8 mm; 7.9×5.6 mm. *C. lanatus* seeds are less numerous, only 10 specimens have been found and while they occurred in the same layers as colocynth seeds, they were not found in the same samples.

In view of the date obtained for the seeds of C. *lanatus* their exact identification was of great importance and for this reason Dr. Charles Jeffrey of the Royal Botanic Gardens, Kew, was consulted. He kindly agreed to examine our specimens and two complete seeds and two seed-halves from 2 samples (UMB 6 and UMB 4) were sent to him. His opinion was as follows: "...your specimens UMB 6 and UMB 4 are absolutely identical in seed structure to our modern material from Niger (Niger, Zinde, sandy wasteland, alt. 200–500 m, 20.12.1986. Eden Foundation 4). Thus it is likely that the archaeological material represents this perennial plant, rather than the typical cultivated annual *C. lanatus* in the strict sense. The presence of the seeds cannot therefore be considered evidence for the existence of agricultural cultivation at the time of the deposit" (letter to M. van der Veen, 20 October 1994). And later: " ....The seeds of your specimens and the Niger perennial species' seeds fall within the range of variation of both *C. colocynthis* and *C. lanatus*, according to published data, so are not specifically diagnostic. The status of the perennial Niger plant is also open to question—whether the subspecies of *C. lanatus*, or product of a *lanatus* x *colocynthis* cross, or a distinct species, is impossible to say. More study is needed " (letter to M. van der Veen, 16 November 1994). Thus, the opinion of the specialist in *Citrullus* taxonomy was not conclusive but he did not rule out the possibility that our seeds represented a subspecies of *C. lanatus*.

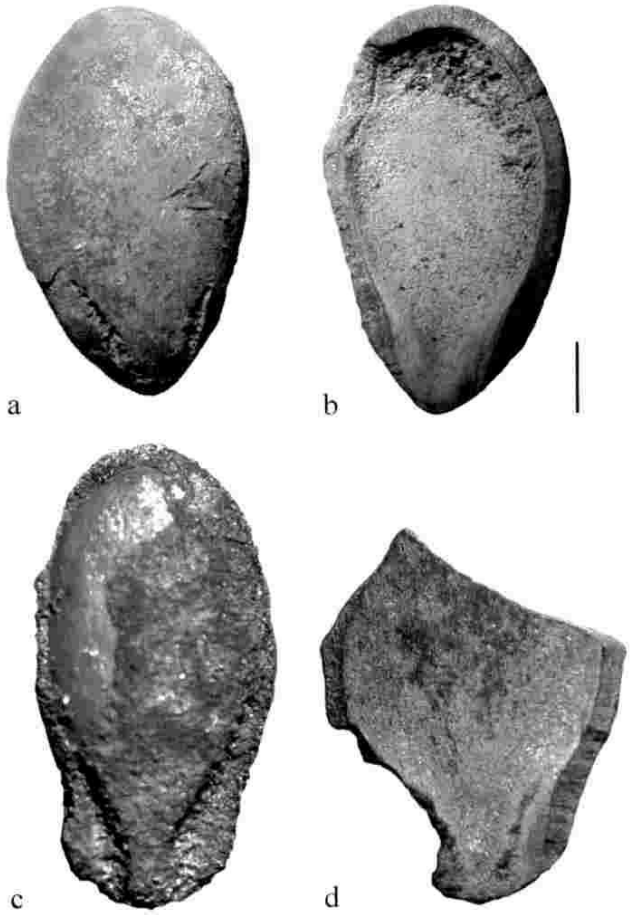

Fig. 2 *Citrullus* seeds from Uan Muhuggiag. *C. colocynthis* from sector A, layer 1, in outer view (a) and in longitudinal section (b). *C. lanatus* from sector B, layer 2a, in outer view (c) and in longitudinal section (d). Scale equals 1 mm (photos by A. Bieniek)

Archaeobotanists use seed morphology (the characteristic grooves at the base of the seed and the absence or

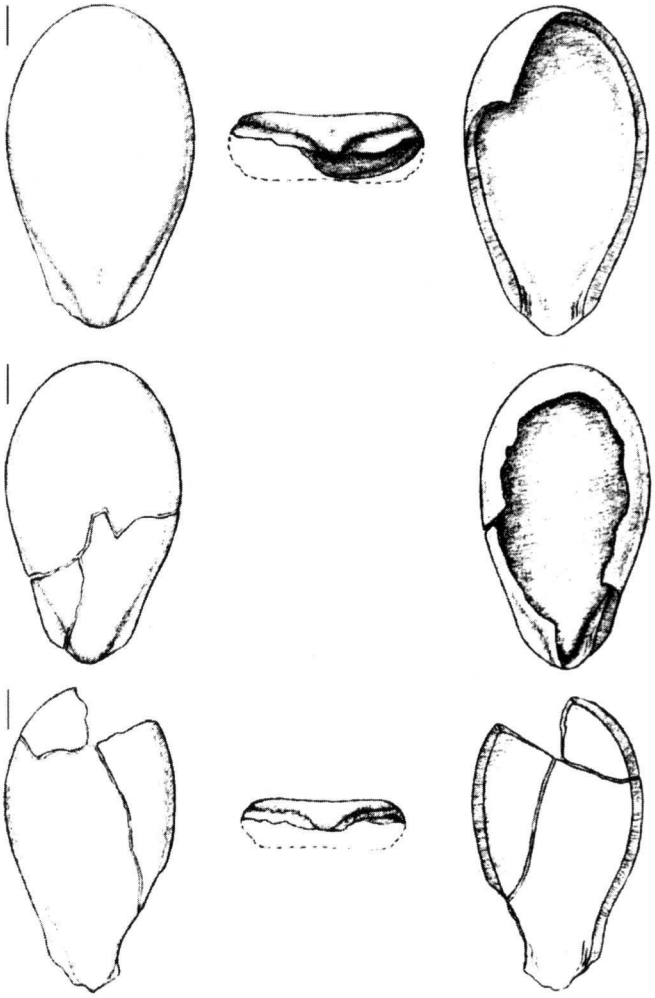

Fig. 3 Three seeds of *Citrullus lanatus* from Uan Muhuggiag, sector B, layer 2a, used for AMS dating; three specimens seen from the outer side, from the basal end and in longitudinal section. Scale equals 1 mm (drawings by S. Colledge)

presence of bulges) and seed texture (smooth versus verrucose) to distinguish between *C. colocynthis* and *C. lanatus*. Both features are clearly present on these 5000-year old specimens and on modern samples (both of us have seen a wide variety of accessions of both species and these characteristics occur in all accessions we have seen). Seed size in *C. colocynthis* is relatively constant in all populations we have seen, while in *C. lanatus* this is highly variable, probably as a result of domestication and breeding selection. We do not know what happens to seed morphology when C. *colocynthis* and *lanatus* species cross, since no information on this is published. Such research would appear necessary. With the information available to us today, we suggest that the seeds from Uan Muhuggiag represent a form of *C. lanatus* growing wild in Libya.

Environmental change and distribution patterns

At present the Acacus mountain range lies in the zone of subtropical dry desert climate, with extremely irregular precipitation and maximum rainfall in summer. Mean annual precipitation is 10 mm, mean annual temperature 25.3°C (Walter et al. 1975). Ephemeral desert vegetation develops after rain, and there is no diffuse perennial vegetation; desert savanna plant communities of *Acacia-Maerua-Panicum* and *Tamarix-Stipagrostis* type grow only in the wadis. Pollen studies from Uan Muhuggiag and Ti-n-Torha allowed Schulz (1987) to suggest that between 8000 and 5000 years ago the woodlands of *Acacia-Panicum* and *Tamarix-Stipagrostis*, which developed in wadis, were richer in composition than today and covered larger areas. Moreover, the herbaceous vegetation of annual and perennial plants was probably denser than at present. Certain sub-Saharan species, which do not grow in Libya today, were present in the area. This is also indicated by the occurrence of macrofossils of at least two species of *Brachiaria* and one of *Urochloa* at Ti-n-Torha and Uan Muhuggiag, both grass genera that have a more southern distribution today and are not found in the modern flora of Libya (Sheriff and Siddiqi 1988). Thus, both pollen and macrofossil evidence point to the fact that 8000–6000 years ago the savanna-Sahara desert boundary lay further north (Schulz 1987, 1991). If this was indeed the case, then other species, including *Citrullus lanatus*, may have grown further north than their present-day range. This matches a suggestion made as early as 1972 by Fursa, who argued that the modern range of *C. lanatus* should be regarded as a relict of a former wider distribution, which he thought might have included the area from southern Africa, through the eastern part of the continent, to Sudan and Egypt (and possibly to India) (Fursa 1972b, p. 1370). Jeffrey (2001, p. 1535) disagrees with this view: "Formerly it was hypothesized that the species was once naturally distributed in the wild as far north as Egypt and the Near East, and there domesticated, since there was no ancient agriculture in southern Africa; but there is no evidence that other than feral forms have ever occurred in the wild outside the Kalahari area, and clearly the tsamma watermelon is the ancestral form of the desert watermelon". The evidence for wild *Citrullus lanatus* seeds reported here indicates that the debate is, again, wide open.

Conclusions

The presence of 5000-year old seeds of *Citrullus lanatus* in Libya indicates that a wild form of this species was present in the Libyan Sahara at that time, though the extent of its distribution is unknown at present due to the lack of other early archaeobotanical evidence from the Sahara. This implies that the present-day wild distribution of this species is not representative of its ancient distribution, and raises the possibility that the domestication of *C. lanatus* could have occurred somewhere in northern

Africa, which would tie in with the earliest evidence for agriculture in Africa and the early records of domesticated watermelon in Egypt.

Acknowledgements We would like to thank C. Jeffrey for the examination of the Uan Muhuggiag specimens, R. Housley for his help with arranging the radiocarbon dates of the seeds, S. Colledge for the seed drawings and A. Bieniek for the seed photographs.

References

Barich, B.E. (1992). The botanical collections from Ti-n-Torha/Two Caves and Uan Muhuggiag (Tadrart Acacus, Libya) - an archaeological commentary. Origini, 16, 109–123

Candolle, de A. (1886). Origine des plantes cultivées. Félix Alcan, Paris

Fursa, T.B. (1972a). K sistematike roda *Citrullus* Schrad. [On the taxonomy of genus *Citrullus* Schrad.]. Botanicheski Zhurnal, 57, 31–41

Fursa, T.B. (1972b). K evolutzii roda *Citrullus*. Schrad. [On the evolution of the genus *Citrullus* Schrad.] Botanicheski Zhurnal, 57, 1365–1372

Germer, R. (1985). Flora des pharaonischen Aegypten. Philipp von Zabern, Mainz am Rhein

Germer, R. (1988). Katalog der altägyptischen Pflanzenreste der Berliner Museen. Ägyptologische Abhandlungen, 47, 1–72

Hepper, F.N. (1990). Pharaoh's flowers. The botanical treasures of Tutankhamun. Royal Botanic Gardens, Kew, London

Jeffrey, C. (1967). Cucurbitaceae. In: Milne-Redhead, E., Polhill, R.M. (eds) Flora of East tropical Africa. Crown Agents for Overseas Governments and Administrations, London

Jeffrey, C. (2001). Cucurbitaceae. In: Hanelt, P. (ed) Mansfeld's encyclopedia of agricultural and horticultural crops. 3. Springer-Verlag, Berlin, pp 1510–1557

Kroll, H. (1999). Literature on archaeological remains of cultivated plants (1997/1998). Vegetation History and Archaeobotany, 8, 129–163

Kučan, D. (1995). Zur Ernährung und dem Gebrauch von Pflanzen im Heraion von Samos im 7. Jahrhundert v. Chr. Jahrbuch des Deutschen Archäologischen Instituts, 110, 1–64

Levkovskaya, G.M., Filatenko, A.A. (1992). Palaeobotanical and palynological studies in South Arabia. Review of Palaeobotany and Palynology, 73, 241–257

Marinval, P. (1999). Les fruits et leurs usages au travers des restes archéologiques: en France, de la Préhistoire à l'Antiquité. Actes du colloque de La Ferté Bernard (Sarthe), 16–17 octobre 1998. AFCEV, Paris, pp 53–64

Meeuse, A.D.J. (1962). The Cucurbitaceae of Southern Africa. Bothalia, 8, 1–111

Netolitzky, F. (1943). Nachweise von Nahrungs- und Heilmitteln in den Trockenleichen von Naga-ed-dêr (Ägypten). Mitteilungen des Deutschen Instituts für Ägyptische Altertumskunde in Kairo, Erstes Ergänzungsheft, 5–33

Schulz, E. (1987). Die Holozäne Vegetation der Zentralen Sahara (N-Mali, N-Niger, SW-Libyen). In: Coetzee, J.A. (ed) Palaeoecology of Africa and the surrounding Islands. Balkema, Rotterdam, pp 143–161

Schulz, E. (1991). Holocene environments in the central Sahara. Hydrobiologia, 214, 359–365

Schulze-Motel, J. (1974). Literatur über archäologische Kulturpflanzenreste (1972/1973). Kulturpflanze, 22, 61–76

Schweinfurth, G. (1883). The flora of ancient Egypt. Nature, 28, 109–114

Schweinfurth, G. (1884). Ueber Pflanzenreste aus altaegyptischen Gräbern. Berichte der Deutschen Botanischen Gesellschaft, 2, 351–371

Shaw, T. (1976). Early crops in Africa: a review of the evidence. In: Harlan, J.R., de Wet, J.M.J., Stemler, A.B.L. (eds) Origins of African Plant Domestication. Mouton Publishers, The Hague, pp 107–153

Sheriff, A.S., Saddiqi, M.A. (1988). Poaceae. In: Jafri, S.M.A., el-Gadi, A. (eds) Flora of Libya 67, Al Faateh University, Tripoli

Veen, M. van der (1995). Ancient agriculture in Libya: a review of the evidence. Acta Palaeobotanica, 35, 85–98

Walter, H., Hernickell, E., Mueller-Dembois D. (1975). Klimadiagramm-Karten der einzelnen Kontinente und die ökologische Klimagliederung der Erde. Vegetationsmonographien der einzelnen Grossräume, 10. Stuttgart

Wasylikowa, K. (1992). Holocene flora of the Tadrart Acacus area, SW Libya, based on plant macrofossils from Uan Muhuggiag and Ti-n-Torha/Two Caves archaeological sites. Origini, 16, 125–159

Wasylikowa, K. (1993). Plant macrofossils from the archaeological sites Uan Muhuggiag and Ti-n-Torha, Southwestern Libya. In: Krzyżaniak, L., Kobusiewicz, M., Alexander, J. (eds) Environmental change and human culture in the Nile Basin and Northern Africa until second millenium B.C. Poznań Archaeological Museum, Poznań, pp 25–41

Zeist, W. van (1983). Fruits in foundation deposits of two temples. Journal of Archaeological Science, 10, 351–354

Zeven, A.C., Zhukovsky, P.M. (1975). Dictionary of cultivated plants and their centres of diversity. Centre for Agriculture Publishing and Documentation, Wageningen

Zohary, D. (1983). Wild genetic resources of crops in Israel. Israel Journal of Botany, 32, 97–127

Zohary, D., Hopf, M. (2000). Domestication of plants in the Old World. Oxford University Press, Oxford.