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THE SMALL-SEEDED LEGUMES: AN ENIGMATIC PREHISTORIC RESOURCE

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ABSTRACT. Small legume seeds are commonly well-represented amongst the plant remains recovered from hunter-gatherer and early agrarian sites in South West Asia and North Africa. In the literature, a number of possible routes for their accumulation on site have been examined. Often the most plausible interpretation has been that they were gathered as a human food resource. This can be hard to comprehend, particularly in view of their small size and perceived difficulties in gathering and doubtful palatability. Evidence from historical, ethnographic and ecological sources illustrates how small legume seeds have been used and demonstrates that they can be a relatively concentrated and readily collected resource, which can be stored and prepared for human food.

KEY WORDS: archaeobotany, Trifolieae, nutrition, hunter-gatherer, legume, forage, ethnobotany

INTRODUCTION

The remains of small-seeded legumes are commonly found amongst the charred plant remains recovered from Old World sites in South West Asia, North Africa and Southern Europe, particularly in levels dating from the Epipalaeolithic and prepottery Neolithic periods. Characteristically, the remains consist of seeds. Fruits are very rarely found. They often comprise a high proportion of the total ancient seed material, and seem to represent more than casual intrusives from the environment. Their role has long been questioned by archaeobotanists.

THE GROSS MORPHOLOGY OF THE SMALL LEGUME SEEDS

The seeds are usually between one to two millimetres in the longest dimension; their shape may be reniform, cordate, cylindrical, or subrectangular, usually bilobate, with radicle and cotyledon lobes separated by a notch where the hilum is situated. Commonly they resemble seeds of members of the Trifolieae (clover tribe), or the Galegeae (the tribe which includes the milk vetches, *Astragalus* L.). Members of these tribes typically have bilobate seeds, which consist largely of a pair of leaflike cotyledons and a large radicle embedded in endosperm within the seedcoat or testa. Typically the ancient seed specimens are charred, and often distorted: charred endosperm tends to vacuolate and balloon through fractures in the testa. However, the original seed shape can usually be discerned. Those specimens with a rough testa may be sufficiently distinctive to be identified to the level of species. However, most commonly the seeds have a smooth testa and cannot be securely identified even to the level of genus; conventionally they have been categorised as "small legume", of "tribe Trifolieae" (Hillman et al. 1989) or as a genus type, for example "of *Trigonella* type" (van Zeist et al. 1984).

A second category of small-seeded legume is the smaller-seeded species of the Vicieae or vetch tribe. The seeds of these taxa occur sporadically and usually in small numbers amongst the charred plant remains from most periods. In contrast with the seeds of the Trifolieae, described above, they are subspherical, with a pair of starchy cotyledons, a small radicle and virtually no endosperm (eg. Helbæk 1969).

This paper mainly concerns legumes of the clover type, species of the genera *Trifolium* L., *Trigonella* L., *Medicago* L. and *Melilotus* Miller. The evidence for their role is examined from published archaeological accounts, historical and ethnographic records and personal observation. A scenario is constructed whereby the conditions for the ready collection of small legume seeds may be created, which could help our understanding of the exploitation of this category of resource.

Legume taxonomy is confused and continually changing. Where possible, the authorities used here are those also used by the International Legume Database and Information Service (ILDIS) (Lock 1989, Lock & Simpson 1991) and Zohary & Heller (1984). Following conventional practice, the authority is cited with the first reference to each taxon.

THE ROLE OF THE SMALL-SEEDED LEGUMES

The evidence for the role of the ancient small-seeded legumes is sparse, and mainly circumstantial, and it has been examined by a number of well-known archaeobotanists. Table 1 lists the potential roles for this category of plant remains compiled from some of the published discussions on the subject, which are outlined below (Helbæk 1969, Hillman et al. 1989, van Zeist & Bakker-Heeres 1982, 1984 a, b, 1985, van Zeist et al. 1984).

Table 1. The possible roles of the small-seeded legumes in Antiquity

a. accidental presence	– wild casuals from environment
b. intentionally gathered for fuel	– fresh plant tissue
	– in the form of dung
for mechanical properties	– e.g. basketry, thatch, bedding
	– floor-covering, insulation
	– pipe-stems, canes
for chemical properties	– e.g. medicinal purposes, insecticides
	– flavourings, perfumes, dyes
for agronomic properties	– ground cover (for erosion control or as mulch, green manure)
for nutritional properties	– nectar for bees, animal feed (as green fodder, or, more rarely, grain)
	human food (as vegetative organs, sprouts, roots, fruits, seeds)

Small-seeded legumes were recovered in quantity at Tell Abu Hureyra in Syria from levels dating from 10000 bc, in association with the grains of wild steppe grasses and other plant remains. It was argued that such a volume of small legume seeds and grains are unlikely to have become charred if they were casual arrivals from the surrounding environment; thus their accumulation would appear to have been the result of some deliberate activity. A derivation from forage plants incorporated in dung has been discounted: the faunal remains from that period at the site did not include those of domesticates; since wild species, such as gazelle, leave dispersed dung, this seems unlikely to have been collected for fuel; in any case, alternatives for fuel such as wood or shrubs are likely to have been plentiful. In the absence of domesticated livestock, collections of legumes for fodder are also implausible. Material used for bedding, basketry and thatching is not thought to have included legume plants. Thus food, flavourings, medicines and dyes have been their suggested roles (Hillman et al. 1989).

Van Zeist has also discussed the possible roles for these seeds. From the Late Palaeolithic site of Mureybit in Syria, the small legumes, here identified as *Astragalus*, were thought to have probably represented food, since their use as fuel was felt to be unlikely in the presence of ample fuel woods (van Zeist & Bakker-Heeres 1984 b). At Ghoraifé, Ramad and Aswad in the Damascus basin, many small legumes were found, typical of field weeds, which again included *Astragalus* but also the annual species *Medicago radiata* L., and *Trigonella astroites* (now reclassified as *Medicago astroites* (Fischer & C. Meyer) Trautv.). These sites dated from the aceramic period, with no evidence of domesticated animals, and therefore again dung is thought to have been an unlikely fuel, although the shrub, *Astragalus*, may have been collected for fuel. The legume seeds may also have been derived from field weeds. However, there were no indications as to whether they could have been crop cleaning residues or food resources. It has been suggested that they may have been a human food resource, but again there is no real evidence (van Zeist & Bakker-Heeres 1982).

At the site of Tepe Ali Kosh in Iran, Helbæk (1969) identified cultivated cereals from the earliest phases, around 7000 bc; his view that the plant remains might represent refuse from floor sweepings or meal spillage, was based on the large amount of emmer and einkorn spikelet remains. In the earliest phase over 90% by number of the plant remains consisted of the seeds from several species of small legumes; it was suggested that this showed a conscious attempt to add protein to an otherwise largely starchy diet derived from the grains of cultivated cereals and wild grasses. In the succeeding phase, there were proportionately fewer wild legume seeds, but in the final phase, in the early sixth millenium bc, during which appeared the first evidence of pottery, legumes comprised about half the seed remains. It was considered that both the small-seeded legumes and the cereal chaff were food resources, a somewhat puzzling conclusion as remarked by van Zeist (1981). At the sites of Tepe Sabz, in the immediately succeeding period, and Tepe Musiyan, in the phase dating from 4500 to 4000 bc, small-seeded legumes were less well-represented amongst the cereals, and these were interpreted as contaminants of the cereal harvest (Helbæk 1969). The associations of small-seeded legumes and cereal chaff may represent residues of cereal cleaning, and could have been intended for animal feed.

At Ganj Dareh in Iran, the presence of seeds from a number of legume species and other herbaceous taxa has been said to be indicative of a steppe vegetation, with at most an open tree cover. That the seeds were derived from dung was thought to be unlikely, since the only evidence of animal husbandry, was found within the latest phase of occupation. Van Zeist speculated that the seeds from at least some wild species may have been gathered for use as human food during the earliest period. This view was supported by the changing composition of the plant remains over time; the proportion of small legumes decreased in successive levels, as the proportion of the known food plants, which included lentils and cultivated barley, increased (van Zeist et al. 1984).

Small legume seeds are a feature of the charred plant remains recovered from the Early Neolithic levels at Nabta Playa in the Egyptian Western Desert (Wendorf et al. 1991). There is no evidence to support their derivation from animal feed: animal domestication is not clearly indicated by the bone remains (Gautier 1980), and no dung has been found (Mitka & Wasylikowa 1995). Thus the seeds are thought most likely to have been introduced as a resource for human food or other purpose, such as a fuel (Mitka & Wasylikowa 1995).

Small-seeded legumes are an important constituent of the plant remains from levels from the 3rd and 2nd millenia bc at Shortughai, Afghanistan, and *Medicago sativa* is the probable identity of the most common taxon. However, here they are associated with the grains of cultivated cereals and pulses, which would appear to remove the need for small legumes as a human dietary resource; yet their volume precludes an incidental presence. The preferred explanation is that they had been either gathered or cultivated under irrigation as a green fodder (Willcox 1991).

These accounts typify the available archaeological data and the associated arguments concerning the role of the small-seeded legumes. Data from ancient documentary sources have also been examined.

ANCIENT DOCUMENTARY ACCOUNTS OF THE USE OF SMALL-SEEDED LEGUMES

Perhaps the earliest relevant literary source is a Babylonian text of 700 BC, which refers to *Medicago sativa* L. (Klinkowski & Wing, both cited in Bolton 1962). There are brief references to *Trigonella foenum-graecum* L., fenugreek, as *sambaliltu*, and *Medicago sativa*, alfalfa, as *samisbabtu*, in Assyrian medical texts (Thompson 1949), with further records of fenugreek in Pharaonic Egypt, and in the texts of Arab writers, such as Ibn al-Baitar (cited in Townsend & Guest 1974). In Rome, termed “ox-horn” or *silicia* from the shape of the fruits, fenugreek was used to increase milk production in both women and cattle (Pliny, 8,38). The classical authors in the peri-Mediterranean areas of Greece, Italy and Spain refer to small-seeded legumes almost exclusively as fodder or forage crops. There are records of cultivation details, such as sowing seasons, crop management, and harvesting schedules, and the feeding of various taxa to particular species of livestock. The early Greek authors, Aristophanes (444–380 BC), Aristotle (384–322 BC) and Theophrastus in the 3rd century BC all mention *Medicago sativa* (cited in Bolton 1962). The Median clover referred to by Virgil (I,284), appears to be a species of *Medicago* (Townsend & Guest 1974); it was sown in Italy "when the bull ushers in the year". Columella (2:6), writing in Spain during the first century AD, considered that *Medicago*, fenugreek and vetch were the best fodder species, particularly for cattle; a single planting of medic could survive for ten years, giving four to six harvests a year; not only did it fatten livestock, it could also be used medicinally. From Italy, Pliny (8.38) reported that a single sowing of medic could provide a crop that would last for up to thirty years, not needing much water, and giving a good harvest when cut green and flowering. Varro (1:30) stated that both alfalfa, *M. sativa*, and snail clover, *M. scutellata* (L.) Mill., were beneficial for fattening sheep and for stimulating increased milk production. *M. arborea* L., the tree medic, or *cytisus*, was a feed for cattle when green, and for pigs when dried. Columella recorded it as a goat fodder, and chicken-feed and also as a nectar source for bees. It was fed to cattle to increase the milk yield and render them immune from disease, and sometimes was even given to women after boiling and dilution in water, similarly to stimulate lactation. After a spring sowing, *M. arborea* would take three years to mature (Pliny 8:47). It had a reputation for destroying nearby plants (Theophrastus 4:16), a property now known to be associated with exudates of saponin from the roots (Freeland & Janzen 1974). Varro (1:3) advised cutting clovers, *ocinum*, known to be purgative in cattle, in the green state, prior to pod formation. Cato (53, 54) advocated feeding it to the cattle before other forages, but to the plough oxen after hay.

From these documentary sources it appears that small-seeded legumes were exploited primarily for fodder, but also for their oestrogenic properties.

CHEMISTRY OF THE TRIFOLIEAE

Apart from the oestrogenic group of compounds, a number of other secondary chemical constituents, or allelochemicals occur in members of the Trifolieae. Many of these compounds are toxins; and some have useful medicinal properties. They impart properties to various legume species, which in certain instances may explain their exploitation.

The genus *Medicago*, in particular *M. sativa*, lucerne or alfalfa, tends to cause bloat in ruminants, due to the alteration of surface tension by saponins and fermentation by bacterial action of fluids in the rumen, and which is accompanied by respiratory inhibition. The concentration of saponins varies in the different plant organs. Exudations of saponins from the roots entering the soil can inhibit the germination of surrounding competing species (Freeland & Janzen 1974). Alfalfa also acts as a diuretic and antiscorbutic; it is oestrogenic, sometimes tannin rich, and allergenic. *M. polymorpha* L. also causes bloat, and photosensitisation by unknown agencies. *M. arabica* (L.) Hudson has high levels of trypsin inhibitors in the seeds.

Melilotus species contain coumarin, the compound which has been exploited under the name of warfarin, and used in treating heart disease. When fermented, the resultant coumarol derivatives interfere with the clotting mechanism and can cause haemorrhage. *Trifolium* species often contain high concentrations of tannins. Since tannins can counteract the effects of saponins, a pasture of mixed Trifolieae genera is recommended for ruminants to minimise the risk of bloat (Freeland & Janzen 1974). Some species of *Trifolium*, such as *T. subterraneum* L. and *T. pratense* L., have high levels of oestrogenic compounds, which tend to prevent conception and can cause abortion in sheep; in warm environments these clover species also produce cyanogenic glucosides, which control predation by gastropods and rodents, although sheep can adapt to gradually increasing levels of cyanogens in the diet.

Some *Trigonella* species are coumarin rich and may contain oestrogens.

Since the allelochemicals tend to be concentrated in particular organs at certain stages of plant development, the exploitation of some species for feed should be restricted to specific growing stages, a precaution of which the classical writers were obviously aware.

THE ETHNOGRAPHIC EVIDENCE

There is ethnographic evidence of a number of uses of members of the Trifolieae, which are related in large part to their chemistry.

Insect repellants

Melilotus officinalis (L.) Lam. is used as a moth repellant (Uphof 1959). *M. elegans* Ser. when mixed with butter is a hair preparation for women in Ethiopia (Uphof 1959), which might exploit an insectical property. *M. indica* (L.) All. is used by Bedouin girls in Syria to braid their hair, and has been said to have been used as a repellant for malaria mosquitoes (Townsend & Guest 1974).

Perfume

A number of species of *Melilotus* and *Trigonella*, including *M. alba* L., *M. sulcata* Desf., *T. hierosolymitana* Boiss. and *T. arabica* Del., are exploited for their perfume in Syria under the name of *handaqoq* (Crowfoot & Baldensperger 1932). *Trifolium resupinatum* L. similarly is *handagug* in Iran (Townsend & Guest 1974). Within Arab communities as a whole this perfume source is highly regarded (El-Hadidi pers. comm. 1994).

Honey plants

Clovers generally are well-known as sources of nectar. In South West Asia itinerant bee-keepers camp with their hives where clovers are plentiful. In particular *Trifolium hybridum* L. (Alsike clover) is a valuable honey plant in Iraq (Townsend & Guest 1974) as are *T. repens* L. (Uphof 1959) and *T. pratense* in Syria (Crowfoot & Baldensperger 1932). *Medicago sativa*, said to have been the first forage crop, is also extensively used for bees.

Flavouring and colouring and food preservative

The flowers and seeds of *Melilotus officinalis* are the chief ingredient in flavouring Gruyère cheese in Switzerland (Hedrick 1919). *Melilotus altissima* Thuill. (Uphof 1959) and *Trigonella caerulea* (L.) Ser. (Hedrick 1919) are also used to flavour and colour cheese in Switzerland. The dried flowers and seeds of *Trifolium repens* are used by North American Indians to flavour beechnut butter (Kavasch 1979). The leaves of *T. repens* are also used with other plant products as a preservative and flavouring for cheese in Turkey (Özçelik 1994). *T. pratense* and *Trigonella foenum-graecum* provide a yellow dye (Uphof 1959). The ground seeds of *T. foenum-graecum* are used as a spice and a butter preservative in Ethiopia (Westphal 1974).

Medicine/drugs

Medicago sativa has well-known diuretic, oestrogenic and antiscorbutic properties, and is said to be invaluable for acidosis. *M. hispida* Gaertner, burr-toothed clover, is also used in China as a diuretic and to dissolve urinary stones (Leung 1985). *Melilotus alba* has been used as a medicine of unspecified application. *M. indica* is employed as a narcotic in India. *Trifolium arvense* L. is an astringent and used for gout and rheumatism (Townsend & Guest 1974). The dried flowers of *T. pratense* can act as a sedative (Uphof 1959), as an antispasmodic, and as a topical remedy for ulcers (Townsend & Guest 1974). *Trigonella foenum-graecum* relieves stomach disorders and is used to treat rheumatism; it contains diosgenin, which can act as an oral contraceptive (Uphof 1959, Westphal 1974). The germinated sprouts are fermented as a tonic drink in Ethiopia (Westphal 1974). In the North West Provinces of India, the seeds are used as laxatives, and as a relief for colds, coughs, diarrhoea and certain diseases (Atkinson 1980). The pods of *T. hamosa* L. are imported from S.W. Asia into India as an unspecified remedy (Townsend & Guest 1974).

Human Food

The leaves of *Medicago denticulata* (now reclassified as *M. polymorpha*) are used in China as a winter vegetable (Hedrick 1919) and also in India (Townsend & Guest 1974). *M. officinalis* and *M. ruthenica* Ser. are tap-rooted perennials, which are eaten by the Kalmuks in Russia (Uphof 1959). *M. sativa*, alfalfa or lucerne, is also a tap-rooted perennial; it has upright stems and is grazing-sensitive, but drought-resistant. It is eaten widely by humans as sprouts, more rarely in the form of meal, and the young leaves are a vegetable in China and the former USSR (Ayckroyd & Doughty 1982, Blumenthal, cited in Bolton 1962, Townsend & Guest 1974). *Trifolium corniculata* L. is used as a vegetable in Bengal. *T. repens* (white clover) has perennial tap roots with creeping stolons and adventitious roots at the nodes. The pods and flowers, but seemingly neither the roots nor the seeds, were eaten during famine in Ireland and Scotland (Hedrick 1919). *T. pratense* (red clover) is another tap-rooted perennial. It is known to have been cultivated for fodder in Europe since the 4th century AD (Zohary & Heller 1984). In Ireland, the powdered flowers have been eaten between bread during times of food shortage. *Trigonella foenum-graecum* is used widely as a green vegetable, and a spice. In India the Parsees eat it, but it is more widely used as a potherb. In Egypt the seeds are eaten, and sprouted to consume with honey; in Rosetta it is roasted for coffee (Hedrick 1919). In Ethiopia an extract of the seeds boiled in water is used as a milk substitute for infants; the seeds are prepared as a vegetarian stew for fast days, and ground for use in bread (Westphal 1974).

Perhaps the closest recent parallel to the past gathering societies of temperate regions is represented by some of the indigenous peoples of North America and there are a number of references to their use of clovers as food, mainly from the West Coast, where the richest diversity of *Trifolium* species is found. The parts of the plant used are rarely specified, although sometimes deductions can be made; for example, one of the first fresh foods of the early spring have been the clovers, gathered in February and March by the people of the Central Valley Region of California (Moratto 1984), and in April and May by women of the Eastern and South Eastern Pomo tribes, which would be prior to seed maturity (McLendon & Lowy 1978). The first clover season was a time of dancing and celebration for the Ohlone (Margolin 1978) and the Wailakis (Chesnut 1974). Although there are accounts of *Trifolium pratense* being cooked on hot stones and eaten in large amounts, most commonly clovers have been consumed raw as green vegetables; for example, *Trifolium obtusiflorum* Hook., in spite of its strongly acidic taste, is a popular green food for a number of Californian tribes, as are *T. dichotomum* Hook. & Arn., *T. variegatum* Nutt., *T. virescens* Greene, *T. ciliolatum* Benth. and *T. bifidum* var. *decipiens* Greene (Chesnut 1974). *T. fucatum* Lindl. and *T. involucratum* (now known as *T. wormskioldii* Lehm.) are eaten by the Nisenan or Southern Maidu of Central California (Hedrick 1919; Heizer, cited in Wilson & Towne 1978). Older members of the Chumash tribe have recently described the tribal tradition still practised in their childhood of eating both the unprocessed leaves and seeds of several *Trifolium* species as a highly favoured food, raw "like a cow" (Blackburn & Anderson 1993).

The seeds of the Trifolieae are proteinaceous and oil-rich (Wolff & Kwolek 1971), but references to the exploitation of small legume seeds for food are rare. Usually the seeds were eaten raw and unprepared, when tender and green (Chesnut 1974), as was the case for *Medicago lupulina* L. in Southern California, *Trifolium amabile* H.B.K. in Peru and *T. ciliatum* Nutt. by the Luiseo tribe of California (Uphof 1959). However, members of the Tipai-Ipai tribe, for example, exploit two species of *Trifolium* for seeds which are collected into baskets using seed beaters; the seeds are parched by tumbling with hot coals in pots, then threshed and winnowed, before storage in covered pots (Luomala 1978). Traditionally a number of tribes gather and prepare in this way the seeds of many different taxa. Those of each taxon are always stored separately; only after grinding into meal known as pinole, are they combined in various mixtures to taste; this preparation is normally eaten raw and dry seasoned with salt or ash (Chesnut 1974).

Other uses

The seed oil of *Medicago sativa* can be used in paint manufacture (Uphof 1959). The dark-coloured and older wood from *M. arborea* has been used to make canes, sabre handles and beads (Bolton 1962). *Melilotus alba*, which can also sometimes become quite large and woody, may be used as a fuel (Post cited in Crowfoot & Baldensperger 1932), and, in Iraq, for pipe stems (Dinsmore cited in Townsend & Guest 1974).

SUMMARY OF EVIDENCE FOR THE USES AS FOOD OF MEMBERS OF THE TRIFOLIEAE

Small-seeded legumes have been used in many ways. In the Old World although the vegetative organs of members of the Trifolieae are used as food, it appears that the seeds are rarely eaten, and in some cases they seem to have been actively avoided, even under famine conditions. Fenugreek, which has the largest seeds, seems to be the only species widely used as a pulse. However, in the New World, of the few remaining semi-foraging people of temperate regions, some Californian Indian groups have recently used clover seeds as a dietary resource, both raw and when parched and ground. Their practice of pre-storage parching provides a possible opportunity for small legume seeds to become charred.

TRADITIONAL AGRONOMIES USING SMALL-SEEDED LEGUMES IN THE TEMPERATE OLD WORLD

Small-seeded legumes are a major constituent of pasture, animal feed and green manure worldwide. In semi-arid regions the long roots of *Medicago sativa* can utilise deep soil-water reserves where other small legumes fail; *M. arborea* and other shrub legumes are a useful source of leaf fodder, when herbaceous species have died down. In some temperate humid areas clovers, such as *Trifolium repens*, were first cultivated as an overwintering feed, an introduction which dramatically changed the previous livestock management practice of the autumn kill (Ellison, 1958). In North and East Africa the Trifolieae are important resources for forage and fodder; Ethiopia, a major centre of diversity for legumes, has ten endemic species of *Trifolium*, at least two thirds of which are annuals. There is a wide range of systems of legume cultivation; until recently, forage legumes were rarely cultivated, and the monocropping of forages is still uncommon. Intercropping strategies are employed, which overcome the problems of poor drainage and restricted soil aeration. As an example of intercropping, wheat or maize may be undersown with medics or clovers (Haque et al. 1993). Commonly several species of clover are either introduced into a standing grain crop, such as sorghum, or are broadcast synchronously with the main crop. The undercrops are used as fodder. The total yield is normally greater than from a single crop over the same area (Tedla & Saleem 1992). Mixed row intercropping is another practice, where for example, a number of annual *Trifolium* species may be sown in alternating rows with wheat, similar to practices in India (Kahurananga 1991). The rationale for such intercropping is usually explained by the farmers as security against the failure of single crops, with concomitant soil enrichment (Simoons 1960); in some areas it is thought to have derived from the widespread tradition amongst farmers of tolerating volunteer clovers amongst their field crops (Kahurananga 1991). The undercropping cereals and pulses with clovers and medics provides a situation whereby the main grain yield could include a mixed assemblage of small legume seeds, prior to fine sieving.

While traditional farming communities furnish many examples of agronomic systems using small-seeded legume species, they provide us with little information on whether, how or indeed why small-seeded legumes might have been exploited in the distant past by gathering communities, and during the early stages of agriculture. In order to understand how such resources might be concentrated sufficiently to make worthwhile their exploitation, some factors affecting more natural pastures can be examined.

THE EFFECTS OF PASTORALISM AND GRAZING ANIMALS

Pastoral populations commonly manage their environment by controls within their territories. The nomadic tribal groups in South West Asia have a system of reserves or "hema", where grazing is restricted during certain seasons, or permitted solely under drought conditions when pasture is poor, or totally banned, when beekeeping is a priority, or when the vegetation is being conserved as protection for hunting prey (Anonymous 1981, Batanouny 1986). The composition of the pasture is effected by these variable controls. The tendrillous or climbing legumes, such as most members of the Vicieae, can benefit from the proximity of erect taxa, which are used as a support mechanism. However, the clovers have an erect, creeping or decumbent habit (Zohary & Heller 1984), and, having relatively reduced canopies, are poor light competitors. Thus small-seeded legumes can be at a disadvantage in protected areas which favour more robust taxa of erect habit.

When grazing is freely available, the effect upon the component pasture species can be profound. Grazing ungulates, such as sheep, select the most palatable species. Heavy grazing favours the least palatable populations; however, the palatability of particular taxa tends to vary with their state of maturity. It has been shown that usually during the active vegetative stages, grasses are the preferred forage, but there is a transference to legumes as the fruits set and ripen (Stobbs, cited in Tothill 1988). Experiments with sheep in Syria have indicated that there is also a sequence of preferential grazing of particular legume species (ICARDA 1985). Following grazing, regeneration mainly tends to come from seed during drought years, but from perennial organs in benign years. The growth form which appears to regenerate most successfully after grazing is that of low and prostrate habit, and erect species respond less well. This successful habit is found in many species in the Trifolieae. In arid areas, it appears that heavy grazing would favour the small-seeded legumes, and the increased production of seed. This phenomenon is exploited by the practices developed for the cropping of fodder legumes. Clovers and medics commonly are cut up to four times a year; the second and subsequent growths later in the season tend to be less vegetative and are expected to have a higher seed set and a heavier seed yield (Tothill 1988).

From these observations, it can be inferred that in a well-grazed mixed pasture early in the season, legumes might predominate; eventually these in turn would be grazed down; in the subsequent regenerative phases, they would tend to set seed prolifically, particularly under drier conditions; this sequence of conditions would seem to most favour the production of a ready and substantial supply of legume seeds.

THE MANAGED LANDSCAPE AND GATHERING PEOPLES

Many hunting/gathering tribes employ the strategy of burning, not only to produce clearings, but also to enhance the growth of vegetation. In California, for example, the herbaceous cover periodically has been burnt off in treeless openings in the forest to encourage the new growth of grasses and clover, which attracts game animals as well as stimulating enhanced seed production for human exploitation (Lewis 1993). As one example of the evidence, the distribution in the Sierra Nevada of *Astragalus bolanderi* (Bolander's Pea), a taxon of small-seeded legumes related to the Trifolieae and recorded as an important seed food, suggests that its growth was formerly encouraged by vegetation burning (Blackburn & Anderson 1993, Timbrook et al. 1993).

PROBLEMS WITH GATHERING SMALL LEGUME SEEDS

Characteristically, papilionate legumes, such as members of the vetch tribe, the Vicieae, have highly dehiscent fruits. When ripe, the pods split explosively and disseminate the seeds over a wide area. The new plants germinate in a dispersed distribution, at a distance of several metres from the parent plant. The seeds are hard to collect in quantity both because they tend to be shed when fully ripe, and because the plants are widely separated. This also applies to some taxa in the Trifolieae, which have highly dehiscent fruits. The general perception of legumes appears to be associated with this property. Furthermore, the characteristic habit of members of the Trifolieae is low and scrambling. Some of the commonest methods of seed collection, such as by beating into baskets (Harlan 1967, 1989, Luomala 1978), on first consideration might appear to be impracticable for this plant group.

However, the fruits in some species of *Trifolium* are relatively indehiscent, and seed dispersal is either topochorous, when the seeds remain in the vicinity of the parent plants, or telechorous, when wind or animal agents provide the means of more widespread dispersal, often of units borne within persistant calyces (Zohary & Heller 1984). A number of species of *Medicago* with coiled pods tend to retain their seeds when ripe, and disseminule is the fruit (Bolton 1962). Many such taxa tend to form concentrated populations of single species. Concentrations of taxa may also arise secondarily, as a result of grazing, as described above. Consequently under natural conditions, it is possible for large numbers of single taxa, sometimes with ripe seeds remaining on the plant, to provide a resource that may be readily gathered. Further, as has been witnessed in Ethiopia by the author, individual humans can aquire the skill to collect ripe seeds by hand in considerable volume with minimal loss, from even highly dehiscent populations of ripe Trifoliaceous plants. Thus it seems that the collection of the seeds of certain small-seeded legume species may not possess the great difficulties which one might have at first supposed.

CONCLUDING REMARKS

Nearly all published references to the exploitation of members of the clover tribe refer to their function as feed resources or suppliers of soil nutrients. With the exception of the North American sources, there are comparatively few reports either from today or from the last two millenia of clovers used as human food in non famine circumstances, although some species are widely used as medicines and insect repellants. Tap roots are eaten by certain populations, the flowers and vegetative parts are certainly eaten under conditions of food stress; and the germinated sprouts are more widely consumed. Clovers are a valued vegetable resource of North American Indians on the West Coast, and the seeds are a food resource for some gathering populations. Fenugreek is the single exception in being cultivated as a pulse.

It appears that the harvesting of the seed in quantity can readily be achieved, and that seed parching prior to storage could be a means whereby the seeds might become charred. The optimal circumstances for the concentration of large populations of small-seeded legumes, and for the collection of seed in large quantities, could be associated with the heavy grazing of natural pasture in an arid environment. However, this suggestion is as yet unsupported by observation, and needs thorough investigation. One conventional explanation for the gathering of protein- or oil-rich small seeds, is the provision of dietary supplements under conditions of relative scarcity of animal protein and fat; this view hardly equates with the heavy-grazing scenario described above. While at present the role of small-seeded legumes remains largely unresolved, there are clear indications of some useful directions for future research.

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