When and where will vetches have an impact as grain legumes?[1]

C M Francis[1], D Enneking[1], A M Abd El Moneim[2]

1 Centre for Legumes in Mediterranean Agriculture, University of Western Australia, Nedlands,W.A.6009, Australia.; 2 International Centre for Agricultural Research in Dry Areas, Aleppo, Syria.

Abstract

The diversity of the genus *Vicia* L. (vetches) provides a wealth of domesticated crop plants for Mediterranean and temperate agriculture. The levels of domestication (soft seededness, high grain yield, high harvest index, +/- reduced shattering, +/- high biomass) found in several *Vicia* spp make them attractive as grain and forage crops for dryland farming. Species such as *V. sativa L., V. narbonensis L., V. articulata* Hornem. and *V. pannonica* are candidates for further domestication towards grain legume status. Vetches have an advantage over most of the food legumes in being better suited to hay production and most are thus dual purpose crops. They will have an increasing role as animal protein becomes scarcer and more expensive. Vetches already occupy special niches in farming systems because of their wide adaptation and ability to grow where food legumes are not suited. These include extremes of winter cold and very dry conditions. They may also be considered as alternative leguminous break crops where diseases and pests may otherwise limit the production of traditional food legumes. Despite these inherent advantages, their potential role as food legumes in human diets is largely unexplored. Traditional barriers need to be overcome and breeders will have to ensure that their product is free of toxins. The current program at ICARDA is one of the few in the world aimed at enhancing the value of vetches by improving quality, harvest index and harvestability, while Australian scientists are screening *V. sativa, V. narbonensis* and *V. ervilia* collections for genotypes with higher seed production, reduced toxicity and improved palatability. The relative lack of breeding effort in itself is a barrier to domestication.

INTRODUCTION

Vetch cultivation in Mediterranean agriculture is currently going through a renaissance, which could well lead to a revolution in current farming. Vetches, being multi-purpose crops, allow for either fodder conservation or immediate cash returns through hay or grain production, while at the same time providing a green manure and grazing option. They differ currently from food legumes largely in terms of end use. This distinction however has become blurred and with adequate research, several species could assume a higher profile as alternative food legumes.

FAO (1987) reported that in 1985 there was 1.3 million hectares sown to vetches globally for a total production of 2.2 million tonnes of seed. There is no evidence that the area has decreased. The demand for meat and milk is strong and increasing and in the West Asia - North Africa region alone, the current number of small ruminants is estimated to be well over 340 million (ICARDA, 1993). A shortage of animal feed is inflicting a heavy burden on the rangelands, which are deteriorating due to the rapidly growing livestock and human population. Severe feed and food deficits have led to the replacement of the fallow barley rotation in the dry areas. New oil seeds or grain legumes permit a diversification of the cropping rotations and allows different options for weed and disease control.

Although over 20 species have been tried as a food, there is today no significant use of vetches as a food despite their widespread use as forage legumes. Of the 160 Vicia species, apart from *V. faba*, only *V. ervilia, V. sativa, V. pannonica, V. villosa* and *V. benghalensis* are widespread in the world and are sown as hay crops in mixtures with oats or barley. Several, like narbon vetch, *V. narbonensis* and *V. ervilia* have the morpho-agronomic attributes of grain crops but most have anti-dietary or toxic factors which preclude their use as food legumes. The grains with their high protein are well suited as supplements for ruminant production, although the amount which may be included in a diet and the effect of such diets on end-product quality

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require further delineation. Development of vetches as feeds for mono-gastric animals and aquaculture is still in its early stages.
The current program at ICARDA is one of the few in the world aimed at enhancing the value of vetches by improving quality, harvest index and harvestability, while Australian scientists are screening *V. sativa, V. narbonensis* and *V. ervilia* collections for genotypes with higher seed production, reduced toxicity and improved palatability.

VETCH GERMPLASM

The concept of replacing bare fallow fields with leguminous crops (Carter, 1978) has given new impetus to research on legumes, including vetches. A wealth of germplasm of species such as *V. sativa, V. villosa, V. narbonensis, V. ervilia, V. pannonica, Lathyrus sativus, L. cicera, L. ciliolatus* and *L. ochrus* has been collected by ICARDA (Robertson et al., 1996). As well as the contribution of ICARDA's collecting program, many accessions have been introduced from IPK Gatersleben and Instituto de Germplasmo Bari. ICARDA's collection of *Vicia* spp is probably the world's largest standing at nearly 5500. Since the inception of the program there have been large-scale evaluations of the species for agronomic traits and for their reaction to biotic and abiotic stresses (Saxena et al., 1993). Valuable variation has been recorded in these attributes, but many accessions show the typical wild growth habit and their domestication will depend on further enhancement and breeding. The recent collaboration between the Vavilov Institute, St. Petersburg and ICARDA provides a vital link to further enhance the genetic conservation of this agriculturally important genus.

REQUIREMENTS FOR DOMESTICATION

The requirements for domestication were summarised by Bailey (1952) when he listed the essential characteristics of a successful grain legume (Table 1). Most of these are relevant to areas with a predominantly winter rainfall and relatively short seasons. We have added requirements for soft seededness in species to be regularly cropped and for improved seed quality through low seed toxin levels.

Table 1. Desirable traits for a grain legume in Southern Australia (after Bailey 1952)

1. Ability to be harvested by conventional machinery
2. Growth period of 6 months or less
3. Tolerance to pests and diseases
4. Tolerance to adverse conditions (cold and drought)
5. Grain and fodder yields at least equal to alternatives like peas
6. Large seed size, approximately the size of a pea
7. A residual soil cover after summer grazing
8. Uniform maturity and shatter-resistant pods for mechanical harvesting
9. Soft seededness
10. Seed quality and non toxicity to monogastrics (including humans)

Progress towards domestication

Of the 10 most cultivated vetch species there is variation in their potential for success as grain legumes. Their immediate potential depends on their content of toxins, harvestability, seed yield, harvest index, pod shattering and of course environmental adaptation. The present state of progress in some of these features is summarised in table 2. The ideal grain legume would have an erect growth habit, high harvest index and a high seed yield of fairly large, toxin free seeds. High seed

protein would be desirable as well as an amino acid profile with a higher content of S containing amino acids. It is obvious from the table that most of the now cultivated species require further improvement. Narbon bean and bitter vetch (*V. ervilia*) appear well placed whilst considerable progress is being made in the development of crop types of *V. sativa.* Pod shattering, a typical wild habit characteristic, while rare for *V. ervilia,* is a major constraint in the use of many species as grain crops, but lines of *V. sativa* and more recently *V. villosa* with non-shattering pods and good agronomic characteristics have been selected (Abd El Moneim and Saxena, 1995). These improvements could lead to vetch replacing fallow in rotations, a change which would be of good economic value in North Africa and West Asia.

Table 2. Vicia spp-Summary of their grain legume characteristics

Vicia species	Adaptation rainfall, winter temp	Relative Seed yield	Seed size	Hard seed	Seed protein %	Seed Toxins	Growth habit	Reduced Shattering
articulata Hornem.	+/- 300 mm, mild	***	***	*	22 -26	low -mod	vine	available
benghalensis	>400 mm, mild	**	**	soft	28 -34	high	vine	yes
ervilia	>300 mm, cold	***	**	soft	21 -25	low -mod	erect	yes
faba	>350 mm. mild	*****	**** *	soft	21-24	low -high[1]	erect	yes
hybrida	>350 mm, cold	**	*	***	22-24	low -mod	vine	No
narbonensis	<300mm, mod cold	****	****	*	21 -30	low ?[2]	erect	yes
monantha	+/- 300 mm, mild	**	**	**	22 -26	mod - high	vine	No
pannonica	>350 mm, very cold	**	**	*	24 -26	low	vine	available
sativa	>300 mm, mod cold	****	**	**	24 -32	mod -high	vine [3]	available
villosa	>350 mm, very cold	*	*	****	28 -34	high	vine	available

1 Favism affects genetically susceptible individuals (see Enneking and Wink, this conference).

2 Erect type available (Moneim pers comm)

3 Further research needed

Soft seededness is available and selection for improved seed size is feasible in most species. Whilst the relative seed yields in the table are equivocal and are generally lower than faba bean (or pea) yields, most at least equal or exceed the yield of lentil or chick peas. Specific environmental adaptation will also give them advantages over the traditional food legumes. Hungarian vetch and Bitter vetch for example are often the legume crops of choice in very cold winter rainfall localities where traditional pulses cannot tolerate the extreme cold. On shallow limestone soils, bitter vetch is a species of choice in northern Morocco whilst on sandy acid soils, species like *V. benghalensis* and *V. articulata* will usually out perform food legumes. *V narbonensis* is the best adapted *Vicia* species on heavier alkaline soils of the drier margins of the Australian cereal belt (ca 250 mm/annum). Similar results have been obtained in the ICARDA mandate region.

Biotic stresses may also preclude the consistent production of traditional grain legumes. Where food legumes like chick pea and faba bean are ravaged by *Orobanche crenata,* resistant varieties from species like *Vicia villosa* will prove useful as would some of the *Lathyrus* spp like *Lathyrus ochrus.* Inter and intra-specific variation in *Vicia* species for resistance to major diseases is widespread and durable sources of resistance have been found to *Ascochyta* blight (*Ascochtya pisi* f.sp. *viciae*), downy mildew (*Peronospera viciae*), powdery mildew (*Erysiphi pisi* f.*sp viciae*), *Botrytis* blight (*Botrytis cinerea*), cyst nematode (*Heterodera ciceri*) and root knot nematode (*Meloidogyne artiellia*) (Abd El Moneim and Saxena, 1995).

THE PAST UTILISATION OF *VICIA* SPECIES AS GRAIN LEGUMES

The historical background to the use of *Vicia* species as grain legumes dates back to antiquity, with finds of large hoards of *V. ervilia* dating to 7000 BC, and the earliest finds of *V. faba* to 5000 BC. Since ancient times, some 20 species of *Vicia* have been utilised in agriculture, but most are no longer in cultivation. Table 3 lists *Vicia* species known to have been cultivated and their use in agriculture (Enneking, 1994, 1995; and references therein). Low seed production of locally well adapted species often

hindered their further development (Lechner, 1959). Some species are also of medicinal (*V. faba, V. ervilia*), biochemical diagnostic (*V. graminea*, anti-N-lectin) and ornamental value.

Table 3. Previously cultivated *Vicia* species and their use as grain (G) or forage (F).

Species	Synonym	Common name	Use
Vicia articulata Hornem.	V. monanthos (L.) Desf.	One-flowered vetch	G, F
V. benghalensis L.	V. atropurpurea Desf	Purple vetch	F
V. monantha Retz	V. calcarata Desf. (Dem)	Bard vetch	G
V. ciliatula Lipsky	V. ciliata Lipsky		
V. cracca L.	V. tenuifolia Gren&Godr	Tufted vetch	F
ssp.tenuifolia Gaud	V. tenuifolia Roth		F
V. ervilia Willd	Ervum ervilia L.	Bitter vetch	G, F
V. faba L.	Faba vulgaris Moench	Broad bean	G
V. fulgens Battand.		Scarlet vetch	
V. graminea Smith	V.selloi Vogel		F, G
V. hirsuta(L.) Gray		Hairy tare	F
V. johannis Taman.			G
V. narbonensis L.		Narbonne vetch	G, F
V. pannonica Crantz		Hungarian vetch	G, F
V. peregrina		Broad Pod vetch	F
V. pisiformis L.		Pale flowered vetch	G
V. sativa L. ssp. sativa		Common vetch	G, F
ssp. amphicarpa		Subterranean vetch	F
V. tetrasperma(L.) Schreb		Smooth vetch	F
V. unijuga A.Br.	Orobus lathyroides L.	Two leaved vetch	F
V. villosa Roth		Hairy Vetch	F
ssp. varia (Host) Corb	ssp. dasycarpa (Ten)Cav	Woolly pod vetch	F

Vicia species as food grains

Although the current world consumption of vetches is very small, they have been used frequently as food during famines. Unorthodox foods are often consumed in times of famine (Salih et al., 1992). This extends to biblical times and may help explain the large hoards of *V. ervilia* found in some of the early Neolithic settlements documented by Zohary and Hopf (1988). Kunkel (1984) has listed the species, occasionally used for human consumption (Table 4). Several authors have mentioned that species such as *V. sativa, V. ervilia, V. narbonensis* and *V articulata* have served as food (Enneking, 1994, 1995). The practice of soaking, leaching and fermenting seeds would probably have evolved to make them more edible. *V. ervilia* is ground, soaked and used in soups in the Rif Mountains of Morocco. Leaching of bitterness is easily monitored by taste.

V. sativa in the absence of the cyanogenic glycoside vicianine and despite the favism toxin vicine is quite palatable. Similar to beta-ODAP, beta-cyanoalanine is a glutamate analogue and can act as a flavour enhancer and phagostimulant. Combined with an attractive red cotyledon the cultivar Blanchfleur gained popularity amongst the grain trade as a lentil mimic (Tate and Enneking, 1992). [See also Enneking & Wink, this conference]. The human consumption of a white tare which was also called the Canadian lentil or Napoleon pea (*V. sativa alba*) has been reported (Wilson, 1852; Birnbaum and Werner, 1882). It had white or cream coloured seeds, with an apparently milder taste than other cultivars and was used to adulterate wheat flour by 10% in France. With its dwarf habit it produced a greater quantity of seeds than the other varieties of *V. sativa.* It was cultivated far more extensively in France and Canada than in Britain, chiefly for the sake of its seeds. Prjanischnikow (1930) reported that during the famine in 1921 the farmers in the region of Moscow include *V. sativa* flour at a rate of 25-50 % with rye flour for use as bread.

Table 4. Vicia species occasionally used for human consumption

Species	**Seedtoxins ***	**Locality**	**Parts utilised, comments**
V. articulata Hornem.	CAN	Medit. Region	Seeds used like lentils (black lentil)
V. cracca L.	GEC,CAN	Eurasia	Young shoots used as a pot-herb, leaves also used as tea, seeds used as food (Hedrick)
V. ervilia (L.) Willd	CAN	Mediterranean.	Seeds eaten in soups
V. nigricans Hook.			
ssp. gigantea (Hook)		California	Seeds edible
V. hirsuta (L.) S. F. Gray	CAN	Eurasia, N Africa	Weedy, young leaves and shoots eaten (boiled?), seeds cooked or roasted (Tanaka)
V. monantha Retz	CAN	Mediterranean.	Seeds used in soups
V. narbonensis L.	GEC	S. Europe	"A vegetable" (Tanaka), Hedrick: seeds eaten
V. noena Boiss.		Asia Minor	Seeds edible
V. bakeri Ali		Himalayan	Cultivated, as above? (Hedrick)
V. pisiformis L.		Europe, cult.	Seeds used like lentils
V. sativa L.	BCNA	Eurasia, cult.	Seeds ground into flour used in soups and bread, young shoots a pot-herb ; leaves as tea
V. sepium L.	BCNA	Eurasia	Seeds used as a food (Hedrick)
V. villosa Roth	GEC, CAN	Eurasia, cult.	" A vegetable" (Tanaka)

* CAN = canavanine, BCNA = beta cyano alanine and derivatives, GEC = gamma glutamyl - S ethenyl -cysteine

In Eastern Turkey, near Dyarbakir, *V. narbonensis* is apparently eaten as a pulse, after it has been boiled with some salt (Enneking, pers. com., Ergani village, 1991). A white-seeded variety of *V. sativa*, is used for human consumption in the province of Ratcha in the Caucasus (Hanelt, pers. comm. 1992).
Seed of *V. monantha* and/or *V. articulata* has been used for human consumption in Spain and was known as black lentil. It is however considered inferior in taste to lentils was only rarely found in markets (Fruwirth, 1921; Hegi and Gams, 1924). *V. articulata* locally known as 'lentis nigra' is still cultivated in South American countries such as Ecuador (L Robertson and R Reid, unpublished observations) where it had been introduced from Spain. Clearly, while there is ample evidence for the human consumption of *Vicia* species, other than *V. faba*, this has been limited and there is little evidence for their use as staple foods.

Vicia species as a feed grains

The vetches have a major advantage in being dual purpose crops with a value both as hay and seed. Although the use of vetch seed for human consumption has been limited, its use for animal feed is well established in some regions. *V. ervilia, V. narbonensis, V. sativa, V. articulata* and *V. pannonica* are all used for this purpose. Production is greatest in countries of the former Soviet Union, the Anatolian plateau and eastern Europe, where there is a need to conserve fodder or grain to meet shortages over the freezing winter months.

a) *V. sativa* (Common vetch)
Whilst best adapted to neutral to alkaline loamy soils, it is because of its wide adaptation that it has received most attention by breeders (Lechner, 1959). For mediterranean climates the species is the subject of plant improvement programs at ICARDA, the Aegean Agricultural Research Institute in Izmir, and in South Australia. ICARDA has produced high seed yielding, non-shattering types and more recently a type with an erect habit of growth (Abd El Moneim and Saxena, 1995). All programs are selecting for the dual purpose of forage and grain - but basically for ruminant production. Major aims are to improve harvest index and reduce pod shattering at harvest thus strengthening the crop's dual purpose. High seed yield, reduced shattering, disease and pest resistance and an erect type of growth, coupled with white seeds, as achieved within the ICARDA program, can well change common vetch from a predominantly hay species to one where the grain is the primary product. A zero tannin, white-seeded variety was recently developed in Albacete, Spain. Virtually all research has centred on *V. sativa ssp sativa* but for a grain legume the relatively large seeded *ssp macrocarpa* needs investigation (Maxted, 1995).
The possible toxic effects of the amino acid, beta-cyanoalanine, the favism toxin vicine and the cyanogenic glycoside vicianine found in *V. sativa* grain need to be kept in mind.

For ruminants there is little or no experimental evidence of any adverse effects from the feeding of *V. sativa* seeds (Pandey and Pal, 1960). In Cyprus, Koumas and Economides (1987) were able to show feed intake and conversion rates of lambs and kids were similar when soybean meal was replaced partly or completely with common vetch or faba bean and there were no detrimental effects on the health of the animals. Valentine and Bartsch (1996) compared *V. sativa* seed meal with lupins as protein sources for high quality barley/silage dairy feed and found no adverse effects at 4kg/head/day, the lupin ration resulting in higher milk yields ($p<0.001$) while vetch fed cows gained 0.2 kg more weight/day over 49 days during early lactation.

For monogastrics the situation with respect to toxicity is far less promising and levels above 20 percent of the ration should not be exceeded for fattening pigs, and 10% for piglets (Piccioni, 1970). Similarly for poultry there are numerous reports of toxicity resulting in mortality rates of as much as 90 percent with seed at 40% of the diet (Harper and Arscott, 1962) and sharp reductions in intake level and body weight gains of chickens following feeding of split red vetch (Enneking, 1994, 1995).

In Australia progress has been made with the aid of the ICARDA collection, toward selection for reduced toxin levels. Varieties with beta cyano alanine levels around 20% of the average for the species have been located amongst natural populations (J. Rathjen, M. Tate and L. Robertson, unpublished data). Further reductions can be expected by recombinant breeding.

b) *V. ervilia* (Bitter vetch)

This species has promise as a low input grain legume well adapted to shallow calcareous loamy soils. In such an environment it is very common in the Rif mountains of Morocco (Francis et al., 1994; Enneking et al., 1995) It is a domesticated species with an upright growth habit, relatively non shattering pods, soft seeds and a fairly high harvest index. Improvement in seed size, plant height and lodging resistance are desirable. Bitter vetch is a very old crop plant and probably has been selected for a lower toxicity during the last 10,000 years. Compared to other *Vicia* species the content of canavanine in *V. ervilia* seed is low (Garcia and Ferrando, 1989), however, the biochemical nature of its bitterness and its pharmacological properties remain to be investigated.

Bitter vetch seed can be fed to ruminants in large quantities and has been a favoured grain for milking cows in Spain and Morocco. Soaking of the grain prior to being fed to ruminants has the purpose of making it more palatable and digestible.

Recently (Enneking, unpublished data) has selected very low canavanine lines of bitter vetch. Some have almost round seeds and an attractive red kernel suited to splitting. The end product, like the vegetative plant, itself is a lentil mimic. It has a relatively high content of methionine for a grain legume and is certainly a species with promise both as a feed and food grain.

c) *V. narbonensis* (Narbon bean)

Narbon bean has many of the characteristics of a grain legume in terms of its upright growth habit, large seeds and reduced shattering. Its performance relative to faba beans in dry areas has led to breeding and selection programs both at ICARDA and in Australia. Resistance to major grain legume diseases, *Ascochyta* blight, *Botrytis* blight, downy and powdery mildew, and nematodes exists amongst narbon varieties.

The species contains very high levels (1-3 %) of γ-L-glutamyl - S-ethenyl -L- cysteine (GEC) which imparts a sulphurous flavour to the beans and greatly limits their palatability. No acute toxicity has been reported with the species but it may be that the unpalatability limits intake and prevents the ingestion of sufficiently high concentrations of GEC. Feeding trials have given mixed results even with wool growth when one would have considered the very high sulphur content might have been beneficial (Allden and Geytenbeek, 1980). Jacques et al. (1994) with Merino wethers noted superior animal performance for the narbon over pea supplements at low allocations of grain (1% of live weight/day). The peas offered to the sheep were eaten within half a day, whereas narbon grain was consumed more slowly over two days. The lower palatability of narbon beans compared to peas, may result in a more even consumption over time and hence their better utilisation as a grain supplement.

In the European literature, grain of *V. narbonensis* has been identified as a suitable ruminant feed, especially for cattle (Mateo Box, 1961; van der Veen, 1960). Thus the crop holds particular promise for increased beef production, while for milk production there may be some off-flavour problems. It is important to assess the flavour of meat produced from narbon fed animals.

For non ruminants Davies (1987) found that narbon grain (line RL 140001) depressed feed intake when fed as a major component (35%) of pig diets. Mateo-Box (1961) noted *V. narbonensis* to be distasteful to poultry. This was partly confirmed by Eason et al. (1990) who tested the nutritive value of *V. narbonensis* line RL 140004 in the diets of day old broiler chickens. In this study, a 10% inclusion of narbon seed in the diet reduced intake 4% and live weight 2.6% as compared to soya bean meals. However in the same trial, feeding peas at the same level resulted in a 2.7% reduction in live weight. There is thus potential for utilisation in poultry diets, if lines with low levels of anti-nutritional factors can be selected.

Breeding and selection in Victoria, Australia has produced lines with substantially lower GEC levels (Castleman and Mock, unpublished data) and reduced shattering. Best adapted to alkaline heavy soils, yields of the best lines (Siddique et al., 1997) indicate that in dry areas the species may well be a significant grain legume of the future.

d) *V. articulata* (One flowered vetch, Algarroba lentil)

V articulata Hornem. is closely related to, and often confused with *V. monantha* Retz. The illustration of *V. monantha* in Duke (1981) for example, is clearly *V. articulata. V. articulata,* is best known in Spain (Barulina, 1930; Fisher, 1938; Lopez Bellido, 1994). It is adapted to non calcareous and acid sandy soils and could be grown as an alternative to lupins. Its bushy growth habit closely resembles a lentil, but its vigour and superior plant height are advantageous in terms of its grain legume potential.

Fruwirth (1921) considered this crop to be most important as a green fodder, however besides the valuable straw, the cracked grain in quantities of up to 1/3 of the ration, was considered useful for the fattening of animals. Mixed with other feeds it has been fed to dairy cattle and horses.

An early flowering selection from the US cultivar Lafayette was released in Australia (Bailey, 1952; Herbage register 1968). In Spain, the area once sown to these species, exceeded that of lentils (Barulina, 1930). It is still commonly found in southern Spain but mostly as a contaminant in other vetch crops or as a weed in cereals. Large areas are sown in Ecuador (Reid and Robertson, unpubl.) as a multi-purpose crop, including its use as a "black lentil" for local consumption. It is favoured because of it greater vigour, relatively large seed size and seed yield as compared to lentil. Maxted and Sabanci (private communication) report the species is still cultivated in South Eastern Turkey.

Relatively large seed size and reliable seed set are good features for a grain legume. The level of pod shattering, though normally less than common vetch, and seed canavanine levels are problems which limit its potential value as a grain for monograstric consumption in the short term. Scope for selection does exist. Two *V. articulata* lines tested in Australia contained 0.1-0.2% canavanine (Enneking and Francis, unpublished data).

e) *V. pannonica* (Hungarian vetch)

Hungarian vetch is native to eastern Europe and Caucasus and is well adapted to severe winter cold. The cultivation of this species is expanding rapidly in Turkey, replacing less productive *Vicia spp.* (Sabanci pers. comm.). Adapted to heavy soils it tolerates poorly drained soils better than other vetches (Duke 1981). The species has distinct promise as a grain crop as relatively non shattering lines are available. Similar to *V. villosa* it is an outbreeding species where fertilisation and fruit set can be increased by visits of pollinators (Zhang & Mosjidis 1995). Like all vetches, its main uses have been for hay and green manure. In Moldavia, Avedeni (1989), found lines with high cold tolerance, high biomass, seed weight, seed yield and protein content. ICARDA is focussing on the selection of genotypes with higher harvest index, reduced shattering and resistance to *Ascochyta* blight. Progress has been rapid and several lines have produced seed and biological yields equal to the best *V. sativa* lines with seed yields of 1372 kg/ha recorded at Tel Hadya, Syria.

The species is extremely low in known vetch toxins (canavanine, beta cyano-alanine) in two samples examined. Bell & Tirimanna (1965) found low levels of VA3, recently identified as GEC (Enneking et al., 1998) in the seeds of this species but the seed is certainly worth testing by monogastric bioassay to assess its performance. Coupled with its resistance to extreme cold it is a potentially a very valuable feed, if not a food grain, and deserving of a greater breeding effort.

f) *V. villosa* (Winter or Hairy vetches)

Hairy and winter or woolly pod (sometimes described as *ssp dasycarpa*) vetches are second in the world in area of vetch cultivation and are prized for their herbage, hay yields, resistance to pests and diseases. *V villosa* is highly resistant to *Orobanche crenata* and many varieties also have resistance to major disease like *Ascochyta* and nematodes. The tolerance to the biotic stresses and abiotic stress, especially frost, ensure reliable dry matter production. Seed yields are however poor relative to the other *Vicia* spp mentioned here and can be improved by pollinators, as it is a species with a substantial degree of outcrossing (Zhang and Mosjidis 1995).

The seeds contain canavanine in high quantities (> 2.0 percent) and the pods shatter freely. The high content of toxins has been observed to have dramatic effects on the intake of pigs at inclusion levels as low a 4%. Enneking et al. (1993) showed that intake was reduced by 75% with 8% inclusion rates of cv. Namoi vetch seed in the diet. Likewise the toxicity to poultry of diets comprising mainly *V. villosa* seeds is well documented (Arscott and Harper 1964). Although mortality has been observed in cattle grazing green crops, the species is valued widely as a fodder for ruminants. Current knowledge suggests that the herbage becomes toxic during seed formation (Enneking, 1994, 1995).

With its vigorous and reliable dry matter production, disease and cold tolerance, and ability to grow on a wide range of soils, including sandy acid soils, it is worthy of serious attempts to select for the grain legume characteristics - reduced shattering,

larger seed and low toxicity. Such aims are likely to require long term efforts and the major place of the species will probably remain as a forage rather than a grain legume.

g) *V. benghalensis* (purple vetch)
This species has promise in temperate Mediterranean climates as a grain species as it has a low level of shattering and can easily be harvested mechanically. In the US its seed yield has been similar to common, Hungarian and monantha vetches and it has the added ability to grow in acid as well as alkaline soils (Duke 1981). In Western Australia a relatively early selection cv Barloo is in production but its seed yield have been only half that of *V sativa* cv Blanchfleur. Nevertheless, the great improvement in seed production of the early selection over the 'parent' vetch (cv. Popany) suggests further gains are achievable.
Like hairy vetch, the species has a very high content of canavanine - often > 2 %. A similar picture in terms of adverse effects on non ruminants can therefore be expected with purple vetch. This species can also be toxic to grazing animals at seed set. Particular care should be taken with earlier flowering cultivars where the toxic stage is reached earlier in the season. If selection for reduced canavanine content can be achieved, then the species has considerable potential as a feed grain.

h) Other Species
In the eastern Mediterranean region, on alkaline soils, *V. lutea* (yellow vetch) and *V. hybrida* (hybrid vetch) are occasionally dominant in farmer's fields and used as volunteer hay crops. Widespread in the regions where they occur, little effort has been made to domesticate them. Both species shatter freely and are vine types. Hybrid vetch contains both cyanoalanine acids and vicine. Yellow vetch has vicine but appears to be a relatively low toxin species, however, further screening of this species for antinutritional factors by bioassay is required before firm conclusions can be drawn.

CONCLUSION

Vetches are widely distributed ecogeographically and have been cultivated over a long period of time. Most are not well domesticated in terms of plant habit for use as a grain legume. They have considerable potential for producing high seed yields, to be relatively free from pests and diseases and some are adapted to adverse conditions such as severe winter cold. Their main role has been as dual purpose species suitable for hay and increasingly for grain production. Those species that are crop types, like bitter vetch and narbon vetch, have anti-nutritional factors which need to be corrected before the species could be widely used as feed or food grains. Hungarian vetch has almost no known vetch toxins and must have potential as a food legume in areas with cold climates.
It is likely however the main use of vetch grain will be for animal feed, especially ruminants. The rapid increase in human population in West Asia and North Africa accentuates the demand for higher protein in the diets. The grain legume resource base is currently inadequate and increased production is urgent (Moneim and Saxena 1995). Vetches are likely therefore to be of increasing value as dual purpose crops largely for animal production and a valuable legumes in areas where current food legume are not adapted or where animal industries are the most profitable. Their prospects as food legumes must be further investigated. Several species like *V. ervilia, V. sativa, V. narbonensis* and *V. pannonica* require far more breeding and research support than is currently directed to them.

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