IDENTIFYING THE INTENSITY OF CROP HUSBANDRY PRACTICES ON THE BASIS OF WEED FLORAS[1]

INTRODUCTION

BACKGROUND

THE weed seeds associated with ancient grain samples offer an important avenue for the archaeobotanical investigation of past crop husbandry regimes. This is true not only for prehistory, for which archaeobotany is the only source of evidence on crop management practices, but also for the historical period, for which written accounts of farming practice are often highly selective. It has long been recognized in botanical surveys of modern vegetation that different scales of cultivation produce widely different weed floras: root or row crops and crops grown in gardens (*Hackfrüchte*, in the predominantly German literature) encourage the weed species characteristic of associations of the phytosociological class Chenopodietea (or its pseudonyms) while winter cereal crops cultivated in fields (*Halmfrüchte*) give rise to weed species characteristic of Secalinetea associations.[2] These two weed classes are therefore characteristic of different types of cultivation, the small-scale gardens generally receiving more water and/or manure and being subjected to more frequent cultivation and weeding than the field crops. Today, however, these two modes of cultivation are generally applied to different types of crops, the Secalinetea associations being exclusive to winter cereals and the Chenopodietea species characteristic of several types of crop but excluding winter cereals.

[1] Thanks are due to Diamantis Sampson for suggesting Tharounia as a suitable focus for this study; to Tony Wood for providing a house and introductions to farmers, and, together with Christina Rushe, for assistance with fieldwork; to the residents of Tharounia, Gaia, Manikia, and Partheni for their tolerance of our intrusions into their fields and gardens, and, particularly, to Vasso Kadditi, Voula Mole, 'Skantzourina' Palogou, and Kostas Kapenis of Tharounia for information on local farming; to Irini Valianatou and John Hodgson for help with identification of pressed specimens; to Carol Palmer for helpful discussions on manure; to Colin Merrony for drawing, and patiently redrawing, FIG. 1; and to Valasia Isaakidou for helping with the Greek abstract. The field study was funded by the Science and Engineering Research Council. The final stages of this research were supported by a Leverhulme Research Fellowship awarded to Dr G. Jones.

[2] e.g. J. Braun-Blanquet, *Prodome des groupements végétaux, classe de Rudereto-Secalinetales* (fascicle 3: Montpellier, 1936); R. Tüxen, 'Grundriβ einer Systematik der nitrophilen Unkrautgesellschaften in der Eurosibirischen Region Europas', *Mitteilungen der Floristisch-soziologischen Arbeitsgemeinschaft*, 2 (1950), 94–175; H. Ellenberg, R. Düll, V. Wirth, W. Werner and D. Paulissen, 'Zeigerwerte von Pflanzen in Mitteleuropa', *Scripta geobotanica*, 18 (1992) 1–258; E. Oberdorfer, *Pflanzensoziologische Exkursionsflora* (7th edn; Stuttgart, 1994); but see J. Hüppe and H. Hofmeister, 'Syntaxonomische Fassung und Übersicht über die Ackerunkrautgesellschaften der Bundesrepublik Deutschland', *Berichte der Reinhardt Tüxen-Gesellschaft*, 2 (1990), 61–81. Phytosociology classifies vegetation into associations based on the co-occurrence of species in the field; these associations are arranged in a hierarchical system of classification based on similarity in floristic composition, with associations being grouped into alliances, alliances into orders, and orders into classes. These phytosociological groupings or communities are collectively known as syntaxa and the classification of communities as syntaxonomy. Communities are mainly defined by the presence of certain 'character species,' which are restricted to a certain syntaxon. For an introduction see V. Westhoff and E. van der Maarel, 'The Braun-Blanquet approach', in R. H. Whittaker (ed), *Handbook of Vegetation Science 5: Ordination and Classification of Communities* (The Hague, 1973), 619–727.

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Several archaeobotanists have noted the greater prevalence of Chenopodietea character-species in archaeobotanical assemblages of cereal and pulse crops, from various times and places, than is usual for winter cereals in the modern phytosociological studies referred to above.[3] Various reasons have been proposed for this ancient weed flora combining character-species of both the Chenopodietea and Secalinetea: for example, spring sowing,[4] millet cultivation,[5] sparse crop growth[6] and cultivation of winter cereals and pulses on a garden scale.[7] The last suggestion, that ancient cereal and pulse crops were grown on a small scale, under intensive conditions of husbandry, has widespread implications for the productivity and stability of early farming and for the social and economic equality of early farming societies.[8]

It is difficult to establish whether the cultivation of cereals with horticultural methods would result in a mixed Secalinetea/Chenopodietea weed flora because, in the present and recent past, cereals are virtually always cultivated as field crops: it is hard to find cereals to which

[3] e.g. K.-H. Knörzer, 'Urgeschichtliche Unkräuter im Rheinland, ein Beitrag zur Entstehungsgeschichte der Segetalgesellschaften', *Vegetatio*, 23 (1971), 89–111; U. Willerding, 'Paläo-ethnobotanischen Untersuchungen über die Entwicklung von Pflanzengesellschaften', in O. Williams and R. Tüxen (eds), *Werden und Vergehen von Pflanzengesellschaften* (Braunschweig, 1979), 61–109; id., 'Ur- und frühgeschichtliche sowie mittelalterliche Unkrautfunde in Mitteleuropa', *Pflanzenkrankheiten und Pflanzenschutz*, 9 (1981), 65–74; id., 'Paläoethnobotanik und Ökologie', *Festschrift für Heinz Ellenberg: Verhandlungen der Gesellschaft für Ökologie*, 11 (1983), 489–503; K.-E. Behre and S. Jacomet, 'The ecological interpretation of archaeobotanical data', in W. van Zeist, K. Wasylikowa and K.-E. Behre (eds), *Progress in Old World Palaeoethnobotany* (Rotterdam, 1991), 81–108.

[4] e.g. W. Groenman-van Waateringe, 'The origin of crop weed communities composed of summer annuals', *Vegetatio*, 41 (1979), 57–9; I. Gluza, 'Neolithic cereals and weeds from the locality of the Lengyel Culture at Nowa Huta-Mogila near Cracow', *Acta Palaeobotanica*, 23 (1983), 123–84; K.-E. Behre, 'Kulturpflanzen und Unkräuter der vorrömischen Eisenzeit aus der Siedlung Rullstorf, Ldkr. Lüneburg', *Nachrichten aus Niedersachsens Urgeschichte*, 59 (1990), 141–65.

[5] e.g. K. Wasylikowa, 'Early and late medieval plant remains from Wawel Hill in Cracow (9/10th to 15th century A.D.)', *Berichte der Deutschen Botanischen Gesellschaft*, 91 (1978), 107–20; ead., 'Plant remains from early and late medieval time found on the Wawel Hill in Cracow', *Acta Palaeobotanica*, 19 (1978), 115–200; H. Kroll, 'Pflanzliche Großreste vom Siedlungshügel bei Kastanas', in B. Hänsel, 'Ergebnisse der Grabungen bei Kastanas in Zentralmakedonien, 1975–1978', *Jahresheft des Römisch-Germanischen Zentralmuseums Mainz*, 26 (1979), 229–39; id., *Kastanas: Ausgrabungen in einem Siedlungshügel der Bronze-und Eisenzeit Makedoniens 1975–1979: die Pflanzenfunde* (Berlin, 1983); id., 'Zur eisenzeitlichen Wintergetreide-Unkrautflora von Mitteleuropa: mit Analysenbeispielen archäologischer pflanzlicher Großreste aus Feudvar in der Vojvodina, aus Greding in Bayern und aus Dudelange in Luxembourg', *PZ* 72 (1995), 106–14.

[6] e.g. U. Willerding, 'Paläo-ethnobotanische Befunde an mittelalterlichen Pflanzenresten aus Süd-Niedersachsen, Nord-Hessen und dem östlichen Westfalen', *Berichte der Deutschen Botanischen Gesellschaft*, 91 (1978), 65–74; id. 1979 (n. 3 1983); K. Lundström-Baudais, 'Paleo-ethnobotanical investigation of plant remains from a neolithic lakeshore site in France: Clairvaux, Station III', in W. van Zeist and W. A. Casparie (eds), *Plants and Ancient Man* (Rotterdam, 1984), 293–305; S. Jacomet, C. Brombacher, and M. Dick, *Archäobotanik am Zürichsee* (Berichte der Zürcher Denkmalpflege Monog. 7; Zurich, 1989), esp. 144; id., 'Ackerbaulichen Aktivitäten und Landnutzung', in J. Schibler, H. Hüster-Plogmann, S. Jacomet, C. Brombacher, E. Gross-Klee, and A. Rast-Eicher (eds), *Ökonomie und Ökologie neolithischer und bronzezeitlicher Ufersiedlungen am Zürichsee* (Monographien der Kantonsarchäologie Zürich 20; Zurich, 1997), 254–72.

[7] K. Lundström-Baudais, 'Etude paléobotanique de la station III de Clairvaux', in P. Pétrequin (ed), *Les sites littoraux de Clairvaux-les-Lacs (Jura)* (Paris, 1986), 311–404; G. Jones, 'Agricultural practice in Greek prehistory', *BSA* 82 (1987), 115–23; ead., 'Weed phytosociology and crop husbandry: identifying a contrast between ancient and modern practice', in J. P. Pals, J. Buurman and M. van der Veen (eds), *Festschrift for Professor van Zeist: Review of Palaeobotany and Palynology*, 73 (1992), 133–43.

[8] e.g. J. Goody, *Production and Reproduction* (Cambridge, 1976); A. Sherratt, 'Plough and pastoralism: aspects of the secondary products revolution', in I. Hodder, G. Isaac and N. Hammond (eds), *Pattern of the Past: Studies in Honour of David Clarke* (Cambridge, 1981), 261–305; P. Halstead, 'Counting sheep in neolithic and bronze age Greece', in I. Hodder, G. Isaac, and N. Hammond (eds), *Pattern of the Past: Studies in Honour of David Clarke* (Cambridge, 1981), 307–39; id., 'Plough and power: the economic and social significance of cultivation with the ox-drawn ard in the Mediterranean', *Bulletin on Sumerian Agriculture*, 8 (1995), 11–22; S. Hodkinson, 'Animal husbandry in the Greek *polis*', in C. R. Whittaker (ed), *Pastoral Economies in Classical Antiquity* (Cambridge Philological Society supp. vol. 14; Cambridge, 1988), 35–74; P. E. Acheson, 'Does the "economic explanation" work? Settlement, agriculture and erosion in the territory of Halieis in the Late Classical-Early Hellenistic period', *JMA* 10 (1998), 165–90.

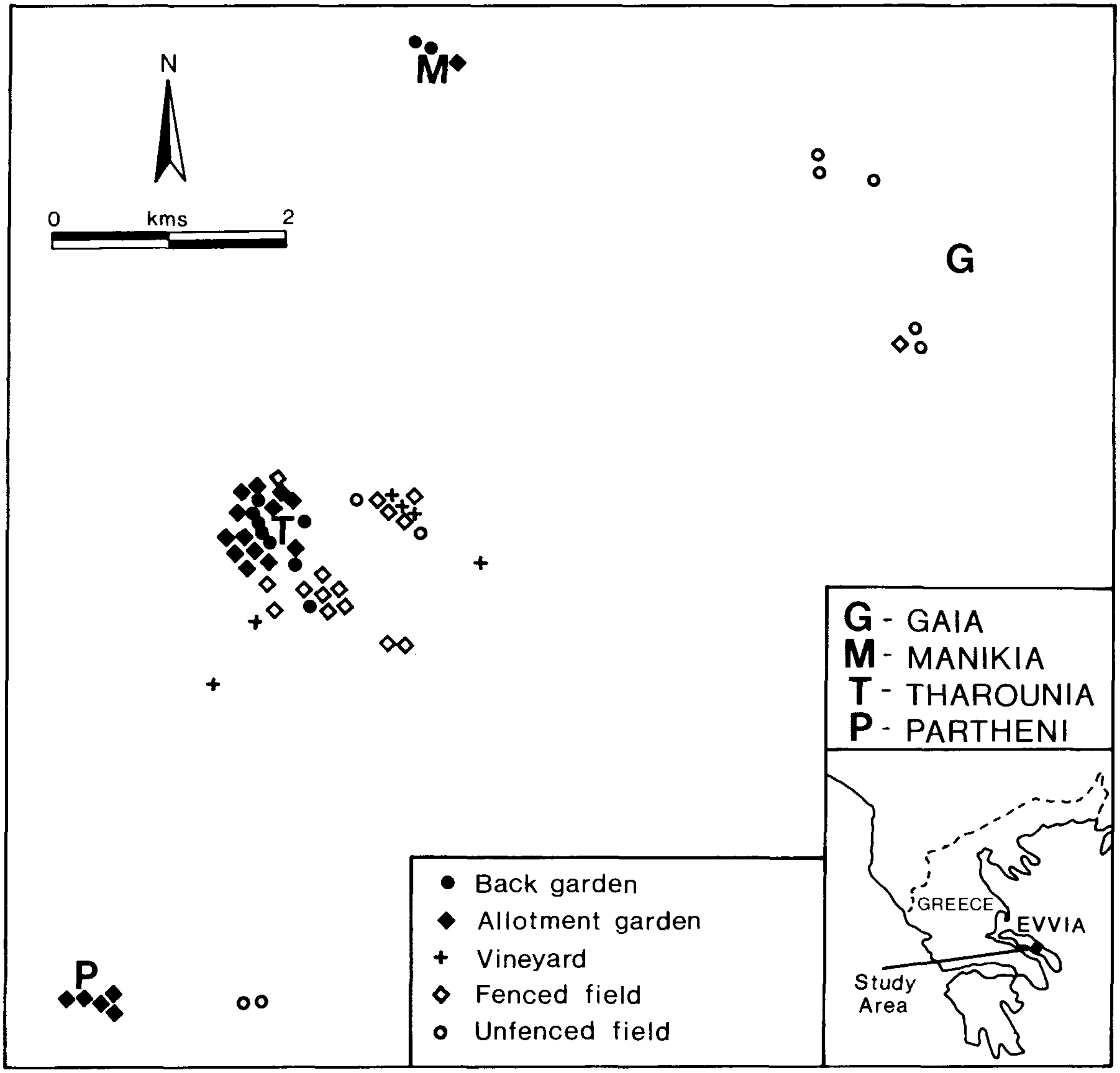

FIG. 1. Map showing location of sampled plots.

horticultural methods, such as regular hoeing or weeding, watering and manuring, have been applied. It is somewhat easier in the case of pulses, which are sometimes cultivated in gardens and also as field crops. To investigate the effects of different agricultural practices and scales of cultivation on the weeds of pulse crops, therefore, a weed survey was conducted in 1988 in central Evvia, Greece (FIG. 1).

THE STUDY AREA

The study area was selected for three reasons:

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1. Winter-sown pulse crops were cultivated both in small garden plots and, on a larger scale, in fields around the villages;
2. Both garden and field scales of cultivation (and various intermediate levels) were to be found within an area of approximately 30 km^2, thus minimizing other variation between the cultivated plots, not related to the scale or methods of cultivation;
3. Cultivation of a 'traditional' nature still prevailed, with no application of weedkillers or use of tractor-drawn ploughs, though artificial fertilizers were used as well as manure.

The field study was centred on the village of Tharounia, with more limited sampling around the nearby villages of Manikia to the north, Gaia to the north-east and Partheni to the south (FIG. 1). The sampled plots were located between *c.* 200 and *c.* 500 m altitude among the dissected south-western foothills of the mountain massif which dominates central Evvia; these foothills lie within the Quercion ilicis zone of mesomediterranean vegetation.[9] The study area comprises a mosaic of limestone, which extensively supports evergreen shrub vegetation, and a series of softer rocks including schists, phyllites, greywackes and psammites,[10] which are the primary focus of cultivation. The environment is not favourable to modern agriculture: steep slopes and rocky outcrops impede mechanization, while infertile soils and summer droughts reduce the chances of a successful harvest. As a result, the growing of cereals for human consumption has ceased over the last two to three decades, and many fields have been abandoned or devoted to fodder crops and sown pasture.[11] Pulses, however, continue to be produced for human consumption and, until the last decade, were quite widely grown in both gardens and fields.

Choice of Plots and Variables Recorded

The field study was carried out over a period of four weeks in late April–May 1988, when the pulses were almost ripe and ready to be harvested for their seed. Sixty plots were selected for study: this selection was made on the basis of the crop species cultivated, the type of plot, the plot size and the distance of the plot from the village (TABLE 1).

CROP SPECIES

The pulse crops selected for the study included broad bean (*Vicia faba* L.), winged vetchling (*Lathyrus ochrus* (L.) DC.), and pea (*Pisum sativum* L.), all of which were cultivated for their seed, which was used as food. In the 1987–8 season, these crops were sown between September and December. The vast majority of plots sampled for the study were of broad bean (TABLE 2). This is because broad beans, although they cast the densest shade of the cereals and pulses found archaeologically, were the most widely cultivated pulses in the Tharounia area.

PLOT SIZE AND DISTANCE FROM THE VILLAGE

Because the smaller and more intensive plots often contained several separate crops, plot size was measured, not as the total area defined by property boundaries, but as the actual area

[9] G. Mavrommatis, *Χάρτης βλαστήσεως τῆς Ἑλλάδος* (Athens, 1978).

[10] IGME, *Γεωλογικός χάρτης της Ελλάδος 1:50 000: φύλλον Κύμη* (Athens, 1981). This map covers only the north-east part of the study area, but adjoining sheets are, as yet, unpublished.

[11] Cf. A. Sampson, *Σκοτεινή, Θαρρούνιον: το σπήλαιο, ο οικισμός και το νεκροταφείο* (Athens, 1993), 254–62.

TABLE 1. The variables recorded for each plot

	Variable	*Categories*
general variables	crop type	broad bean (*Vicia faba* L.) winged vetchling (*Lathyrus ochrus* (L.) DC.) pea (*Pisum sativum* L.)
	plot size	sown area (m^2)
	plot location	distance from edge of village (m)
	plot type	back garden allotment garden vineyard fenced field unfenced field
husbandry variables	tillage	hoe plough
	weeding	weeded unweeded
	sowing	dibbled row-sown broadcast
	fertiliser	manure chemical none
	watering	watered unwatered
environmental variables	soil type	*koprochoma* *kokkinia* *asprouda*
	slope	flat gentle steep
	aspect	N, NE etc.
	shade	percentage
crop variables	crop height	cm
	crop cover	percentage

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TABLE 2. Characteristics of each plot

Plot no.	crop	plot size (m^2)	plot location (m)	plot type	tillage	weeding	sowing	fertiliser	organic content (%)	soil type	watering	slope	aspect	shade (%)	crop height (cm)	crop cover (%)
1	vetchling	138	300	fenced field	plough	no	broadcast	chemical	12	kokkinia	no	flat	W	0	48	90
2	bean	66	300	fenced field	plough	no	row	chemical	16	*asprouda*	no	gentle	W	5	69	40
3	bean	90	350	fenced field	plough	yes	row	chemical	17	*kokkinia*	no	gentle	W	25	49	31
4	vetchling	198	400	fenced field	plough	yes	broadcast	none	17	*kokkinia*	no	gentle	W	5	54	74
5	vetchling	77	400	fenced field	plough	no	broadcast	chemical	15	*kokkinia*	no	steep	W	25	43	66
6	bean	100	100	allot. garden	plough/hoe	yes	broadcast	manure	10	*asprouda*	no	steep	W	30	97	81
7	bean	21	2500	vineyard	hoe	no	row	none	20	other	no	flat	E	0	57	48
8	bean	120	900	fenced field	plough	no	broadcast	none	16	*asprouda*	no	gentle	W	60	94	83
9	bean	48	900	vineyard	plough/hoe	no	broadcast	manure	15	*koprochoma*	no	flat	S	0	108	93
10	bean	70	500	fenced field	plough	no	broadcast	manure	20	*kokkinia*	no	gentle	W	0	90	67
11	bean	8	village	back garden	hoe	no	dibble	none	20	*asprouda*	yes	flat	W	65	82	50
12	bean	28	50	allot. garden	plough	yes	row	chemical	12	*koprochoma*	no	flat	SW	10	106	73
13	bean	28	50	allot. garden	hoe	no	dibble	none	21	*koprochoma*	no	flat	SW	15	106	74
14	bean	6	50	allot. garden	hoe	no	broadcast	none	15	*koprochoma*	no	flat	SW	80	126	72
15	bean	60	30	allot. garden	plough	yes	broadcast	none	17	*koprochoma*	no	flat	SW	25	104	72
16	bean	28	30	allot. garden	hoe	no	broadcast	manure	19	*kokkinia*	no	flat	SW	25	76	30
17	bean	8	village	back garden	hoe	yes	row	manure	23	*koprochoma*	no	flat	SW	85	86	74

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Table 2 (*continued*)

Plot no.	*crop*	*plot size (m²)*	*plot location (m)*	*plot type*	*tillage*	*weeding*	*sowing*	*fertiliser*	*organic content (%)*	*soil type*	*watering*	*slope*	*aspect*	*shade (%)*	*crop height (cm)*	*crop cover (%)*
18	bean	30	50	back garden	plough	yes	broadcast	manure	18	*asprouda*	no	flat	SW	15	91	79
19	bean	640	500	fenced field	plough	no	row	chemical	13	*kokkinia*	no	gentle	SW	40	88	45
20	bean	28	50	allot. garden	hoe	no	broadcast	none	16	*koprochoma*	no	flat	NW	0	104	85
21	bean	96	50	fenced field	plough	no	broadcast	chemical	20	*kokkinia*	no	steep	SW	5	93	68
22	bean	60	village	allot. garden	plough	no	broadcast	manure	38	*kokkinia*	no	flat	SW	50	108	66
23	pea	10	village	allot. garden	plough	yes	broadcast	manure	31	*kokkinia*	no	flat	SW	0	45	62
24	bean	50	village	allot. garden	plough/hoe	yes	row	man/chem	23	*koprochoma*	no	gentle	W	15	81	59
25	bean	50	village	back garden	plough	yes	broadcast	chemical	14	*kokkinia*	no	flat	W	10	96	58
26	bean	18	village	allot. garden	plough	no	broadcast	none	25	*koprochoma*	no		SW	5	81	57
27	bean	10	village	back garden	hoe	yes	broadcast	manure	59	*koprochoma*	yes	flat	SW	5	97	61
28	vetchling	168	1400	fenced field	plough/hoe	no	broadcast	chemical	18	*kokkinia*	no	gentle	SE	5	26	54
29	bean	108	1400	fenced field	plough/hoe	no	broadcast	chemical	14	*kokkinia*	no	gentle	SE	5	90	42
30	vetchling	1500	1400	unfenced field	plough	no	broadcast	chemical	15	other	no	gentle	SW	5	56	70
31	vetchling	1200	1300	fenced field	plough/hoe	no	broadcast	chemical	13	*asprouda*	no	gentle	SW	15	58	70
32	bean	625	1300	fenced field	plough/hoe	no	broadcast	chemical	12	other	no	gentle	se	10	80	54
33	bean	16	village	back garden	hoe	yes	broadcast	manure	26	*ochoma*	no	flat	ne	40	76	60
34	bean	175	1200	fenced field	plough	no	broadcast	chemical	16	other	no		S	0	76	60

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Table 2 (*continued*)

Plot no.	*crop*	*plot size (m^2)*	*plot location (m)*	*plot type*	*tillage*	*weeding*	*sowing*	*fertiliser*	*organic content (%)*	*soil type*	*watering*	*slope*	*aspect*	*shade (%)*	*crop height (cm)*	*crop cover (%)*
35	bean	12	1200	vineyard	hoe	no	broadcast	manure	15	*asprouda*	no	flat	SE	15	94	61
36	bean	280	900	fenced field	plough	no	broadcast	manure	19	*asprouda*	no	gentle	NW	10	90	51
37	bean	140	1100	vineyard	plough	yes	broadcast	chemical	13	*kokkinia*	no	flat	W	5	90	54
38	bean	34	1000	vineyard	plough	yes	dibble	none	21	other	no	flat	SW	15	96	39
39	bean	192	800	unfenced field	plough	no	broadcast	chemical	12	*kokkinia*	no	flat	SE	0	78	41
40	bean	126	2000	vineyard	hoe	no	broadcast	chemical	8	*asprouda*	no	gentle	S	5	116	91
41	bean	30	200	back garden	plough/hoe	yes	row	chemical	9	*kokkinia*	no	flat	W	10	94	59
42	bean	35	100	allot. garden	plough	yes	broadcast	none	17	*koprochoma*	yes				88	84
43	bean	200	1400	unfenced field	plough	no	broadcast	chemical	10	*asprouda*	no	gentle	S	15	92	50
44	bean	600	1400	unfenced field	plough	no	broadcast	chemical	9	*asprouda*	no	gentle	S	10	78	44
45	pea	12	50	allot. garden	hoe	yes	dibble	manure	16	other	yes	flat	SW	0	136	100
46	bean	10	100	allot. garden	hoe	yes	dibble	none	18	other	yes	flat	SW	0	100	67
47	bean	30	100	allot. garden	plough	yes	row	chemical	14	other	yes	flat	SW	0	87	73
48	bean	24	village	allot. garden	plough	yes	broadcast	manure	21	other	no	flat	SW	0	80	71
49	bean	91	3500	unfenced field	plough	no	row	chemical	12	*kokkinia*	no	flat	S	10	62	31
50	bean	663	3600	unfenced field	plough/hoe	no	broadcast	chemical	18	*kokkinia*	no	steep	SW	15	67	47
51	bean	576	3900	unfenced field	plough	no	row	chemical		*kokkinia*	no	steep	SW	10	64	27

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Table 2 (*continued*)

Plot no.	*crop*	*plot size (m^2)*	*plot location (m)*	*plot type*	*tillage*	*weeding*	*sowing*	*fertiliser*	*organic content (%)*	*soil type*	*watering*	*slope*	*aspect*	*shade (%)*	*crop height (cm)*	*crop cover (%)*
52	bean	16	village	back garden	hoe	no	dibble	chemical	21	*koprochoma*	yes	flat	W	60	71	72
53	bean	12	village	allot. garden	plough/hoe	no	dibble	manure	21	*koprochoma*	yes	flat	N	20	71	94
54	bean	20	village	back garden	hoe	yes	dibble	none	20	*koprochoma*	yes		SE	20	83	65
55	bean	16	200	allot. garden	plough/hoe	yes	broadcast	none	17	*koprochoma*	no	flat	NE	5	89	70
56	bean	10	200	allot. garden	plough/hoe	no	broadcast	none	20	*koprochoma*	no	flat	NE	5	83	65
57	bean	8	village	back garden	hoe	yes	dibble	manure	21	*kokkinia*	no	flat	S	10	95	53
58	bean	375	500	unfenced field	plough	no	row	manure	11	*kokkinia*	no	flat	E	10	89	58
59	bean	625	500	unfenced field	plough/hoe	no	row	man/chem	9	*kokkinia*	no	flat	E	20	92	50
60	bean	2250	600	fenced field	plough	no	row	man/chem	19	*kokkinia*	no	gentle	S	20	85	49

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sown with the relevant crop. The size of plots so defined ranged from 6 m^2 to 2250 m^2 (TABLE 2) with small gardens within the village at one extreme and large fields, at some distance from the village, at the other. In the case of the larger plots, the area sown with pulses was normally the total area defined by property boundaries. The distance to each plot was measured not from the farmer's home, the location of which was sometimes unknown, but from the edge of the built-up area (excluding outlying houses) of the relevant village; thus any plots located within the village were recorded as such (TABLE 2). The location of plots is shown in FIG. 1.

PLOT TYPE

The various plots sampled were divided into the following five types in descending order of intensity of management: 'back gardens', 'allotment gardens', 'vineyards', 'fenced fields', and 'unfenced fields'; the plots are coded according to this classification in FIG. 1. The two types of garden were highly fertile plots, located among the village houses and/or on the alluvial margins of a nearby stream; they were watered by channels leading from the village fountains, or by an associated well, and were typically devoted to a mixture of vegetables and pulses for human consumption. Back gardens, immediately adjacent to the house, and allotment gardens, a few minutes' walk from the house, were both classified as gardens by their owners and are differentiated here because the method adopted to record location (i.e. distance from edge of village) would otherwise mask this distinction. Vineyards were plots which, though often equipped with a well, lacked the strikingly rich soil characteristic of gardens and were typically planted with a mixture of vines, vegetables, and pulses. Fenced fields were plots enclosed in recent decades for two related reasons: to allow small numbers of sheep and goats to be left to graze without a herder; and to prevent unintended grazing of the enclosed crops. These fenced fields, and particularly a few such plots temporarily used as nocturnal folds for sheep and goats, should thus have had relatively high levels of manure input and, presumably for this reason, were sometimes brought into use as more intensive allotment gardens. Unfenced fields were subject to transient grazing, while under stubble or fallow, but were not used to pen livestock. Fenced and unfenced fields were normally sown with only one crop (including, rarely, mixed or 'maslin' crops).

While the recognition of gardens and unfenced fields was straightforward, distinction between the intermediate plot types was occasionally problematic, not least because the use of plots often changed over time. In categorizing such cases, priority was given to the long-term pattern of usage (e.g. an enclosure from which long-established vines had recently been grubbed out would be a vineyard rather than a fenced field), because the very recent treatment of each plot was addressed independently in the recording of husbandry details (below). Moreover, while gardens and unfenced fields differed in intensity of both tillage and manuring, vineyards and fenced fields were intermediate for different reasons: vineyards tended to be intensively tilled (like gardens) but less heavily manured; fenced fields tended to be heavily manured (like gardens) but lightly tilled (like unfenced fields). As a result, the relative ranking of the two intermediate plot types is ambiguous. Despite such ambiguities, this typology of plots broadly matches the more objective measures of plot size and distance: gardens tended to be small and within or close to the village, while unfenced fields tended to be larger and more distant (FIG. 2).

The plots sampled in this study represent the full range of cultivation scales available in 1988. Because of the recent contraction of arable farming and the preference for planting broad beans on fertile soil, however, all the gardens and fields sampled would have fallen towards the 'infield' end of the range of plots cultivated one to two generations ago.

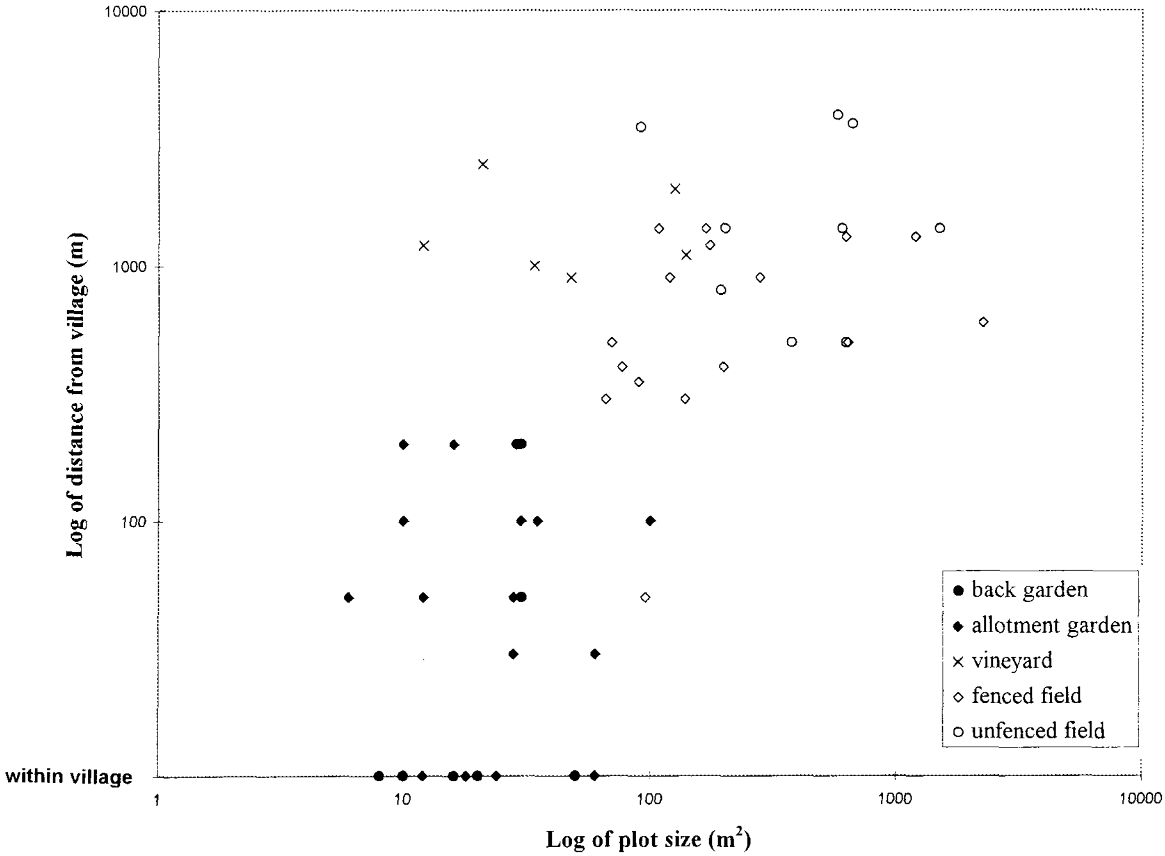

FIG. 2. Scatter diagram showing the relationship between size and location for plots of different types.

OTHER VARIABLES

As well as type of crop and type, size, and location of plot, details were recorded (TABLE 1) for each plot of relevant aspects of the husbandry regime (e.g. tillage, manuring) and potentially important environmental variables (e.g. slope, aspect of plot). A soil sample from each plot was subsequently analysed for organic content by the 'loss on ignition' method. No attempt was made to measure soil moisture as this was very dependent on whether or not the plot had recently been watered and would therefore not reflect the overall degree of watering throughout the growing season.

RELATIONSHIPS BETWEEN DIFFERENT ASPECTS OF HUSBANDRY

The relationship between scale and intensity of cultivation and particular husbandry practices is now explored in terms of the two principal ecological effects of husbandry: disturbance and productivity.

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TABLE 3. Relationship between disturbance variables

(a) Number of plots in different tillage and weeding categories

	weeded	*unweeded*
hoed	7	9
ploughed/hoed	4	9
ploughed	12	19

(b) Number of plots in different tillage and sowing categories

	dibbled	*sown in rows*	*broadcast*
hoed	7	2	7
ploughed/hoed	1	3	9
ploughed	1	9	21

(c) Number of plots in different weeding and sowing categories

	dibbled	*sown in rows*	*broadcast*
weeded	5	6	12
unweeded	4	8	25

DISTURBANCE

With regard to the timing and severity of soil disturbance, two management practices are relevant: tillage method, in preparation for sowing, and hand-weeding of the growing crop. A third variable, sowing method, is only indirectly related to disturbance. Weed floras may be influenced, to some degree, by the long-term history of disturbance of each plot, but it seems likely that the overwhelming impact of disturbance will relate to the immediately preceding growing season. Information recorded on tillage and weeding during the 1987–8 growing season, therefore, is the most appropriate for this study.

The gardens immediately adjacent to houses tended to be cultivated most intensively (TABLE 2), tilled with a hoe and thereafter regularly hand-weeded. The thoroughness of hand-weeding was variable, however, and some plots which had been carefully hoed required little or no weeding. Fields outside the village were usually ploughed with an animal-drawn ard. The larger of these fields were generally not weeded after sowing. In some cases plots (ranging from allotment gardens to unfenced fields) were ard-ploughed, with the hoe then being used to break up soil clods or to till patches too steep or stony for the plough.

The method of sowing was also variable: in gardens, the seed was often 'dibbled' into holes, whereas the larger fields tended to be sown by broadcasting. Sowing in rows was practised at all scales of cultivation. The method of sowing could potentially affect the ability to carry out later hand-weeding, with dibbled and row-sown plots allowing greater access than broadcasting, although, in the later stages of growth, the density of the crop may have reduced the impact of this difference.

The relationship between tillage and weeding is summarized in TABLE 3 *a*, which indicates that less than half of both hoed and ploughed plots were weeded. The relationship between sowing and tillage methods is summarized in TABLE 3 *b*: dibbling, the most intensive method, was largely confined to hoed plots, while broadcasting (and to a lesser extent row sowing) was usual on ploughed plots. TABLE 3 *c* shows that dibbled or row-sown plots were more likely to be weeded than broadcast plots.

TABLE 4. Relationship between productivity variables

(a) Organic content for different soil types

	mean organic content (%)	*standard deviation*	*N*
koprochoma	21.6	10.3	17
kokkinia	16.9	6.8	23
asprouda	14.9	4.0	11

(b) Organic content for different watering categories

	mean organic content (%)	*standard deviation*	*N*
watered	22.8	13.6	9
unwatered	16.8	5.7	51

PRODUCTIVITY

Small garden plots in, or very near to, the village were more likely to be watered and fertilized with animal dung while larger fields at a distance from the village were rarely watered but sometimes fertilized, often with chemical fertilizer (TABLE 2). In practice, however, because organic fertilizers break down gradually over a period of years, the application of fertilizer in the preceding growing season is arguably less relevant to weed composition than the long-term history of manuring etc.[12]

On some plots, the repeated application of manure over a number of years had resulted in the development of a rich, dark soil known locally as *koprochoma* (literally 'dung-soil') to distinguish it from the 'natural' soil types *asprouda* (white soil) and *kokkinia* (red soil); this categorization gives a better indication of long-term manuring practice than the record of fertilizer application in 1987–8. Soil organic content, another measure of long-term manuring practice, ranged from <1% to well over 20% among the plots surveyed (TABLE 2).

The very high fertility of some plots was mainly due to manuring, *koprochoma* plots tending to have a higher organic content than plots on other soil types (TABLE 4 *a*). Variability in soil moisture is to be expected since some of the plots (9 out of 60) were watered. The mean per cent organic content for watered plots was slightly higher than for unwatered plots (TABLE 4 *b*). This might suggest that manuring and watering are related, but the number of watered plots was very small and their organic content was very variable.

RELATIONSHIP BETWEEN DISTURBANCE AND PRODUCTIVITY VARIABLES

Tillage methods and hand-weeding can be combined into an ordinal disturbance scale roughly in order of decreasing severity (TABLE 5). On the basis of observations in Tharounia in 1987 and 1988, it was concluded that hoeing clearly caused more soil disturbance than ard ploughing and that weeding caused added disturbance to plant growth. It is more difficult to rank the disturbance effects of hoeing and weeding but, for the construction of this scale, it is further assumed that hoeing, which represented a single severe disturbance prior to sowing, caused greater disturbance than subsequent weeding, which varied in its thoroughness. The relationship

[12] J. F. Parr and S. B. Hornick, 'Rehabilitation of degraded agricultural soils with organic wastes', in C. E. Whitman, J. F. Parr, R. I. Papendick, and R. E. Meyer (eds), *Soil, Water, and Crop/Livestock Management Systems for Rainfed Agriculture in the Near East Region* (Washington DC, 1989), 278–87; Rothamsted Experimental Station, *Details of the Classical and Long-term Experiments up to 1967* (Harpenden, 1970), 62 table 24.

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TABLE 5. Relationship between disturbance and productivity variables

(a) Organic content for different disturbance categories

	mean organic content (%)	*standard deviation*	*N*
hoed with weeding	*26.1	*14.7	7
hoed without weeding	17.1	4.2	9
ploughed/hoed with weeding	14.7	6.5	4
ploughed with weeding	17.6	5.1	12
ploughed/hoed without weeding	15.6	3.9	9
ploughed without weeding	16.6	6.7	19

*after removal of plot no. 27, the mean is 20.6 (standard deviation 3.5)

(b) Number of plots in different watering and disturbance categories

	watered	*unwatered*
hoed with weeding	4	3
hoed without weeding	2	7
ploughed/hoed with weeding	0	4
ploughed with weeding	2	10
ploughed/hoed without weeding	1	8
ploughed without weeding	0	19

between these disturbance categories and per cent organic content is shown in TABLE 5 *a*. The most intensively disturbed plots ('hoed with weeding') had a higher mean organic content than the rest, even after the exclusion of one extreme outlying value (TABLE 2, plot no. 27; TABLE 5 *a*). The relationship between disturbance and watering is difficult to assess, as relatively few plots were watered, but watering tended to be more common at high levels of disturbance (TABLE 5 *b*).

SUMMARY

A number of interrelated practices characterize (but are not exclusively associated with) the different scales of pulse cultivation. The practices which may influence the development of the weed flora are those related to degree of disturbance (tillage, weeding, and, indirectly, sowing) and level of productivity (fertilization and watering). Both of these are, to some extent, determined by the type, size, and location of the cultivated plots, for practical reasons which have been explored elsewhere.[13]

SPECIES RECORDING AND METHODS OF ANALYSIS

The sampling and recording methods used were adapted from those developed for a similar survey of the weeds associated with different irrigation levels in northern Spain[14] and subsequently applied to a study of crop rotation and fallowing regimes in northern Jordan.[15]

[13] P. Halstead, 'Traditional and ancient rural economy in Mediterranean Europe: plus ça change?' *JHS* 107 (1987), 77–87; P. Halstead and G. Jones, 'Agrarian ecology in the Greek islands', *JHS* 109 (1989), 41–55.

[14] G. Jones, M. Charles, S. Colledge, and P. Halstead, 'Towards the archaeobotanical recognition of winter-cereal irrigation: an investigation of modern weed ecology in northern Spain', in H. Kroll and R. Pasternak (eds), *Res Archaeobotanicae—9th Symposium IWGP* (Kiel, 1995), 49–68.

[15] C. Palmer, 'An exploration of the effects of crop rotation regime on modern weed floras', *Environmental Archaeology*, 2 (1998), 39–52.

The results of this study are, therefore, directly comparable with these other weed surveys. A maximum of ten 1 m^2 quadrats were recorded in each plot: for the larger plots, these quadrats were placed along a transect from one end of the plot to the other; for small plots, quadrats were placed where they could be fitted in without overlap. A minimum of five quadrats was recorded in each plot, and plots which were too small to accommodate even 5 quadrats (i.e. < *c.* 5 m^2) were not sampled. The weed taxa present in each quadrat were recorded, and pressed specimens collected so that field identifications could be checked and refined later. The height and percentage cover of the crop were also recorded for each quadrat.

The weed data were subjected to multivariate analysis, using the ordination technique correspondence analysis.[16] This technique, like other ordination techniques, arranges sites (in this case, cultivated plots) along axes on the basis of species (in this case, weed taxa) composition. The program used for this purpose was the CANOCO package designed for the analysis of vegetation survey data.[17] The detrending methods of Hill[18] and ter Braak[19] were not used. The program used for plotting the results was CANODRAW.[20] The weed data were used in the form of number of quadrats out of ten per plot, in which each taxon occurred; for plots with less than 10 quadrats, the figures were adjusted accordingly. Only taxa present in 6 or more plots (*c.* 10% of plots) were included.[21] The correspondence analysis is presented in the form of diagrams of cultivated plots (FIGS. 3–4) and weed taxa (FIG. 5). In different versions of the former, individual plots are coded according to variables related to husbandry etc.; in the latter, individual taxa are coded according to their phytosociological classification.

THE EFFECTS OF HUSBANDRY ON THE WEED FLORA

GENERAL PLOT CLASSIFICATION (FIG. 3)

General plot characteristics, such as size, location, and type, are considered first as these are approximate corollaries of the overall intensity of management in terms of a combination of husbandry practices.

The clearest result is obtained by coding individual plots according to their size (FIG. 3 *a*). The largest category (>500 m^2) is towards the positive (right) end of the first axis, and the three smallest categories towards the negative (left) end of the same axis, with the intermediate category (100–500 m^2) spread along much of this axis. The three smallest categories are strung out along the second axis, with fields smaller than 20 m^2 situated towards the positive (top) end, the third category (50–100 m^2) towards the negative (bottom) end, and the intermediate category (20–50 m^2) between them. Thus there is a very clear trend of increasing size from top left, though bottom left, to centre right and, although there is overlap between 'adjacent' categories, there is no overlap between the smallest, the middle, and the largest categories.

[16] See M. O. Hill, 'Reciprocal averaging: an eigenvector method of ordination', *Journal of Ecology*, 61 (1973), 237–49; R. H. G. Jongman, C. J. ter Braak, and O. F. R. van Tongeren, *Data Analysis in Community and Landscape Ecology* (Wageningen, 1987); G. Jones, 'Numerical analysis in archaeobotany', in W. van Zeist, K. Wasylikowa, and K.-E. Behre (eds), *Progress in Old World Palaeoethnobotany* (Rotterdam, 1991), 63–78.

[17] C. J. F. ter Braak, *A FORTRAN Program for Canonical Community Ordination by (Partial) (Detrended) (Canonical) Correspondence Analysis and Redundancy Analysis (Version 2.1)* (Wageningen, 1988).

[18] M. O. Hill, *DECORANA — A FORTRAN Program for Detrended Correspondence Analysis and Reciprocal Averaging* (New York, 1979).

[19] Jongman *et al.* (n. 16).

[20] P. Smilauer, *CANODRAW 3.0 User's Guide* (London, 1992).

[21] Cf. Jones *et al.* (n. 14).

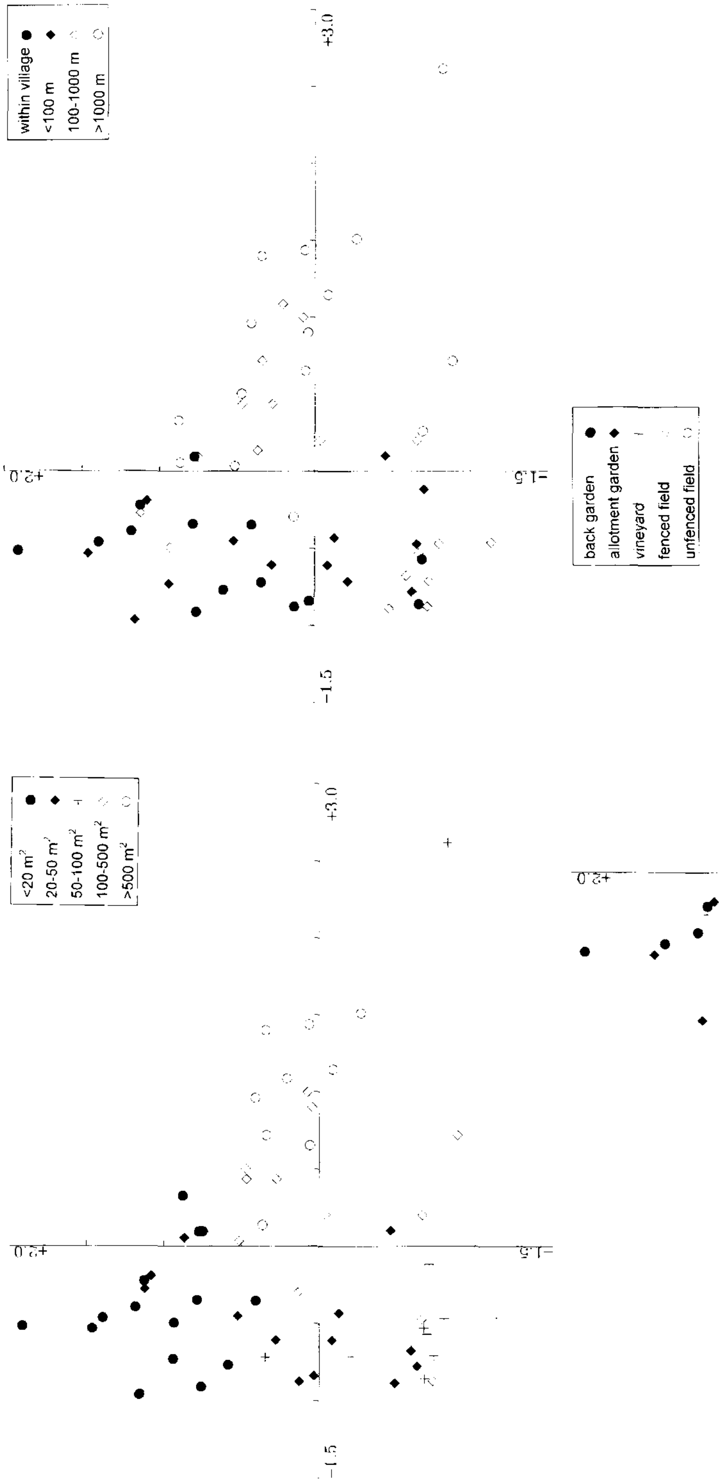

FIG. 3. Correspondence analysis diagram of plots showing general classification: (*a*) plot size; (*b*) plot location; (*c*) plot type.

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In FIG. 3 *b*, categories representing approximate distance from the village are used to code the plots. Essentially the same pattern emerges as for plot size, albeit less clearly. Plots within the village tend towards the top left of the diagram, while those within 100 m occur in both the top and bottom left quadrats; most plots between 100 and 1000 m fall in the bottom left or to the right of the diagram and those over 1000 m are to the right.

In FIG. 3 *c*, categories representing type of plot are shown, ranging from intensively cultivated, back gardens through to the least intensive category, unfenced fields. A pattern similar to those for size and location is seen. Gardens occur to the left, especially to the top left, and unfenced fields to the right of the diagram, with the intermediate categories of vineyards and fenced fields occupying intermediate positions. While fenced fields are scattered among the unfenced fields and towards the negative (bottom) end of axis 2, however, vineyards are drawn towards the positive (top) end of axis 2.

To understand these trends, it is necessary to investigate the husbandry practices associated with plots of different size, type, and location. The impact of the two main husbandry-related factors (disturbance and productivity) on the weed flora must be explored.

HUSBANDRY VARIABLES: DISTURBANCE (FIG. 4 *a*)

In FIG. 4 *a*, individual plots are coded according to the six disturbance categories described above (TABLE 5). Hoed plots, both with and without weeding, are concentrated in the top left of the diagram, at the positive end of axis 2, while ploughed plots with weeding are drawn towards the bottom left of the diagram, to the negative end of the same axis. Ploughed plots with weeding which had also been hoed are associated with both of these categories, presumably reflecting the varying intensity of the supplementary hoeing. All these plots fall towards the negative (left) end of axis 1. Ploughed plots without weeding are scattered from left to right along axis 1; on the left of the diagram, however, such plots with supplementary hoeing are drawn towards the positive (top) end of axis 2 and those without hoeing towards the negative (bottom) end.

A clear trend emerges, therefore, with the most disturbed plots in the top left of the diagram, moderately disturbed plots bottom left, and the least disturbed plots spread from left to right. This matches very closely the trend observed for size of plot etc. (FIG. 3) and suggests that disturbance was an important factor determining the differences in weed species composition between plots of different size, type and location.

HUSBANDRY VARIABLES: PRODUCTIVITY (FIG. 4 *b*–*d*)

In FIG. 4 *b*, individual plots are coded according to percent organic content. While plots with intermediate organic content (15–20%) are distributed throughout the diagram, those with extreme values are more restricted: plots with the highest organic content (>20%) are top left, extending to bottom left; here they overlap with plots of the lowest organic content (<15%), which are mostly to the right of the diagram. Again this matches the trend in size of plot etc. (FIG. 3) and suggests that soil fertility also played an important part in determining weed species composition.

The same soil fertility effect can be observed indirectly by coding plots according to soil type (FIG. 4 *c*). Plots on the two parent soil types (*asprouda* and *kokkinia*) are distributed throughout the diagram except the extreme top left. Heavily manured plots, where the parent soil types have been masked by the development of a rich dark *koprochoma*, however, are towards the negative (left) end of axis 1 and, to a lesser extent, the positive (top) end of axis 2. This agrees well with the distribution of plots with high organic content (FIG. 4 *b*).

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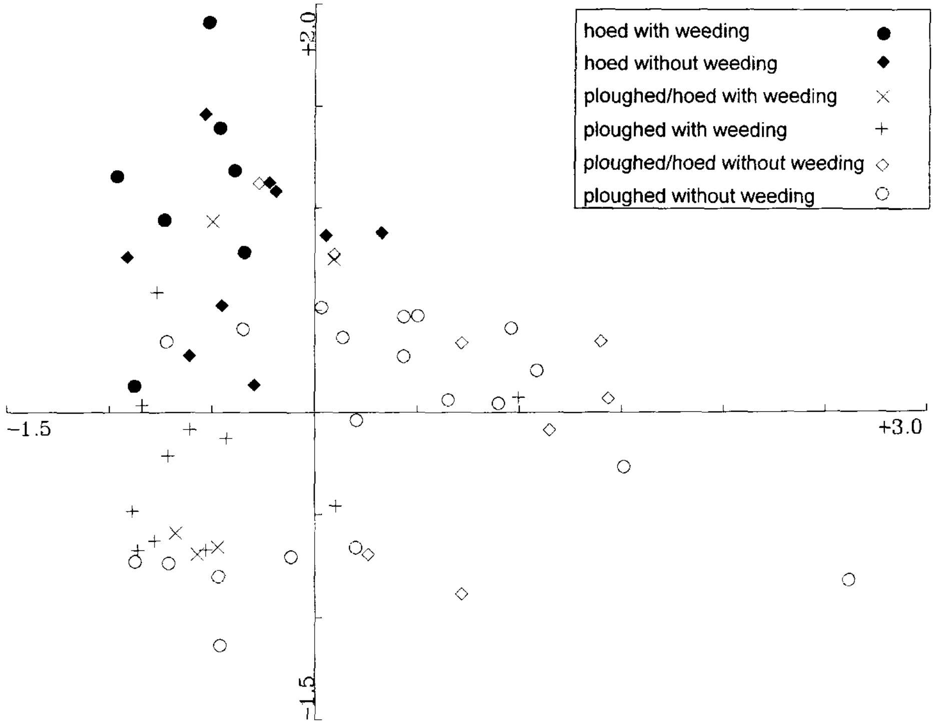

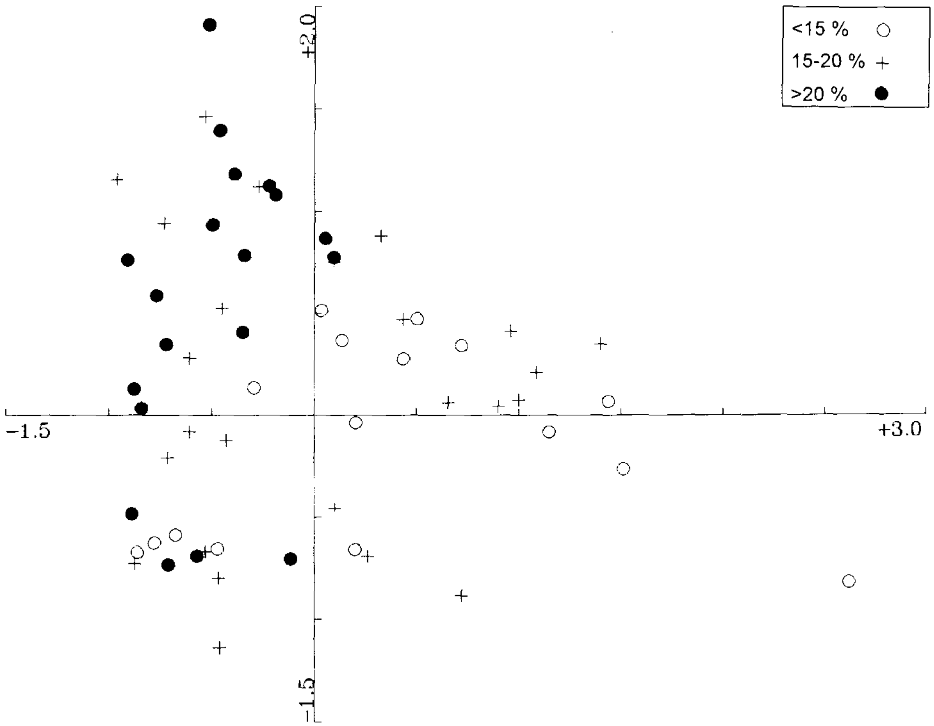

FIG. 4. Correspondence analysis diagram of plots showing husbandry variables: (*a*) disturbance categories; (*b*) organic content.

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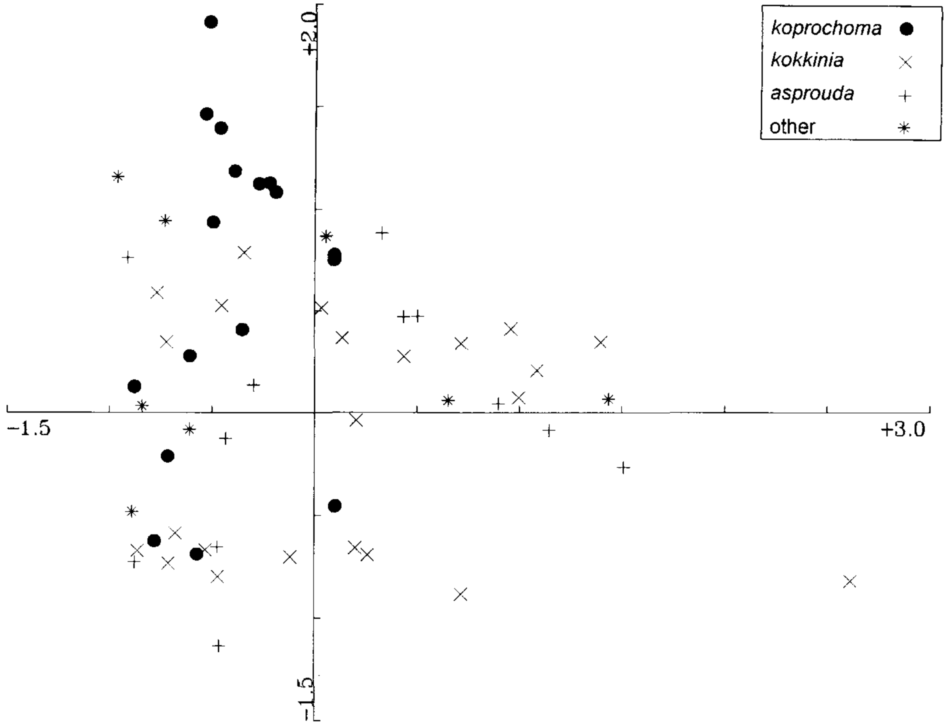

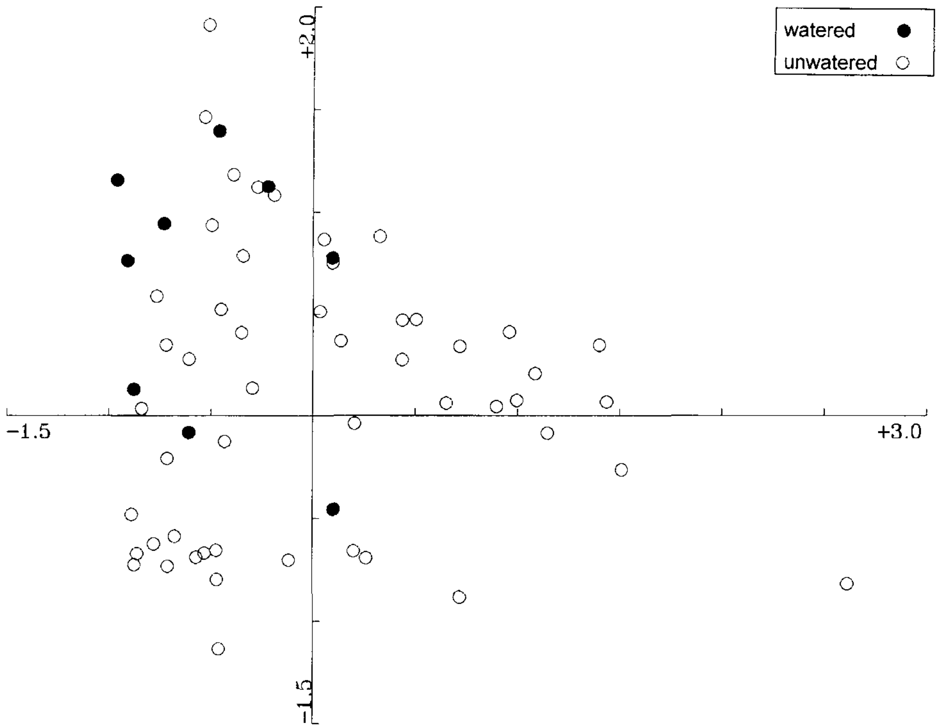

FIG. 4. continued (*c*) soil type; (*d*) watering.

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In FIG. 4 *d*, plots are coded according to whether they were watered or not. Watered plots are mostly confined to the top left, but unwatered plots are distributed throughout the diagram. Watering is thus associated with the plots receiving the greatest disturbance and with the highest organic content but matches the trend in plot size etc. only weakly.

OTHER VARIABLES (DIAGRAMS NOT SHOWN)

The plots sampled were distributed across an area of 30 km^2, encompassing a diversity of altitude and parent geology. This diversity has no apparent impact, however, on weed composition: gardens at Partheni are associated in the correspondence analysis with gardens at Tharounia and Manikia, while fields around Partheni are associated with fields around Tharounia and Gaia. Other environmental variables, such as slope and aspect of the plots, and the amount of shade cast by trees, buildings, etc., may also have an effect on weed floras, but none of these variables exhibited clear patterning in relation to species composition in the correspondence analysis. This suggests that husbandry practices relating to disturbance and productivity were the major cause of differences in weed species composition in the Evvia pulse crops.

Three further variables, which might well have a more marked shading effect than surrounding trees and structures, are crop type, crop height, and crop cover. In the case of the first variable, patterning in the correspondence analysis diagram simply reflects the distribution of each crop among different plot types: peas are restricted to gardens and winged vetchling occurs only in fields, while broad beans are ubiquitous. Crop height and crop cover exhibit only weak patterning in the correspondence analysis of weed species composition, with tall and dense crops (casting the most shade) tending towards the left or 'intensive' half of the diagram.

PHYTOSOCIOLOGICAL CLASSIFICATION OF WEED SPECIES (FIG. 5)

In FIG. 5 the weed taxa used in the correspondence analysis are plotted. Individual taxa are coded according to whether they are character species of the class Chenopodietea (or of lower syntaxa—orders, alliances, associations—within that class), character species of the Secalinetea (or its lower syntaxa), or are not character species of either. The phytosociological classification of weed taxa is based on work in Greece wherever possible,[22] but for species not included in these studies other sources were used.[23] The resulting diagram shows a very clear divergence between Chenopodietea species, which are concentrated in the top left where small garden plots are located, and Secalinetea species, to the right with the larger fields. There is an area of overlap between these two classes (bottom left and centre), where the plots of intermediate 'status' are located, but no Secalinetea species occur in the 'intensive' top left quadrant. This is exactly what is expected, given a gradient in the intensity of cultivation from small gardens to larger fields, and confirms that intensive husbandry in gardens has favoured Chenopodietea species whereas less intensive cultivation in fields has resulted in species of the Secalinetea.

[22] E. Oberdorfer, 'Über Unkrautgesellschaften der Balkanhalbinsel', *Vegetatio*, 4 (1954), 379–411; G. I. Lavrendiadis, 'Über die Unkrautgesellschaften in Feldern von Oräokastron, Reg. Bez. Saloniki', *Documents phytosociologiques*, 4 (1961), 571–84; K. Walther, 'Halmfrucht-Gesellschaften in Griechenland', *Vegetatio*, 18 (1969), 263–72.

[23] Ellenberg *et al.* (n. 2); Oberdorfer (n. 2).

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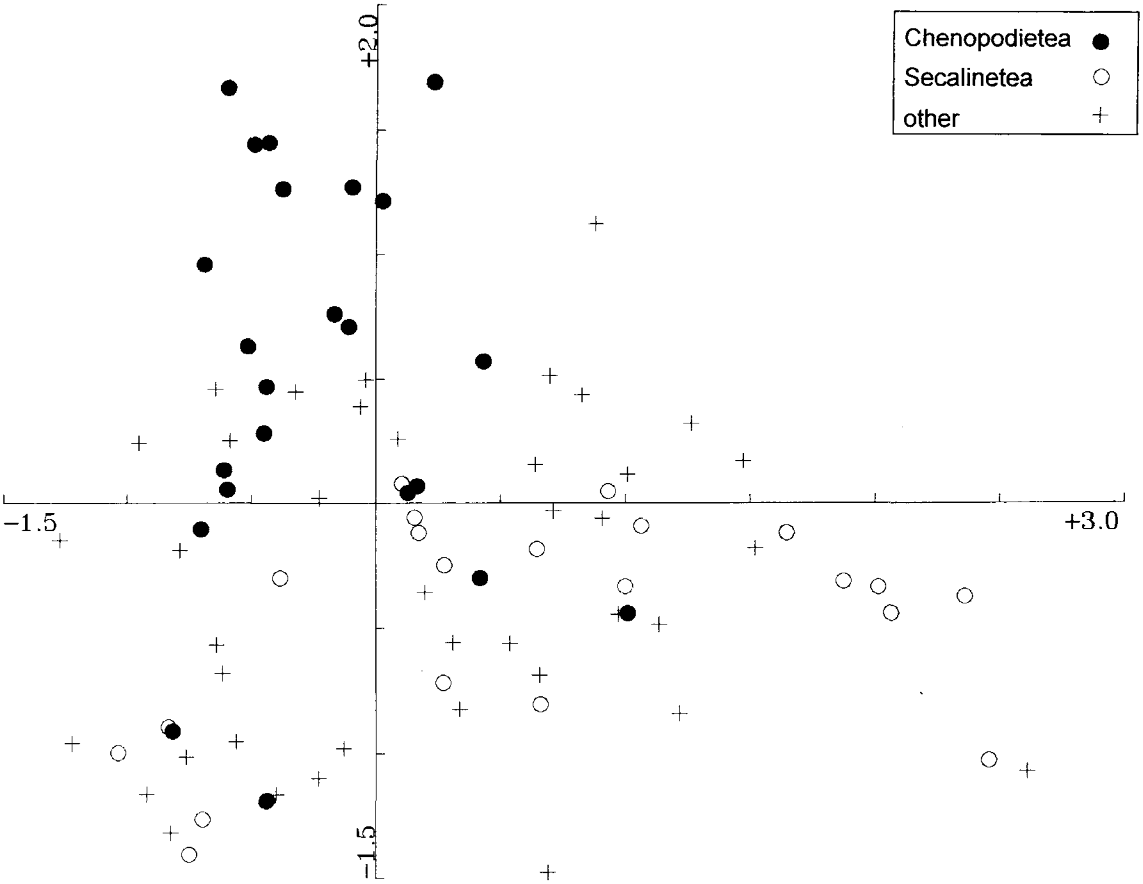

FIG. 5. Correspondence analysis diagram of weed taxa showing character species of phytosociological syntaxa

DISCUSSION

Clearly, factors relating to the scale and intensity of cultivation have had a major impact on the recent weed flora in the Tharounia area. All three 'proxy' measures of intensity—size, type, and location of plot—relate in a predictable fashion to the weed flora: a continuous trend from the smallest gardens to the largest and most distant fields is clearly matched by the differing weed composition picked up by the correspondence analysis. Moreover, Chenopodietea character species are associated with small gardens within the village and Secalinetea character species with large fields at some distance from the village, suggesting that intensive cultivation on a garden scale is indeed a possible interpretation of the distinctive weed flora of many ancient cereal and pulse crops.

The 'proxy' measures of intensity reflect a suite of husbandry practices and so, in order to understand the relationship between size, type, or location of plot and weed composition, it is necessary to consider the impact of individual husbandry practices on weed composition. The differences in weed composition brought out in the correspondence analysis clearly relate to both the degree of disturbance (measured by method of tillage and subsequent weeding) and the overall fertility of the plots (measured by organic content and the presence of *koprochoma*) as well as, to a lesser extent, the application of water. This contrasts with the environmental variables which show little, if any, relationship to weed composition. Similarly, crop height and crop cover, which exhibit only weak patterning in the correspondence analysis diagram, are likely to be consequences of plot productivity etc. rather than significant causes of weed species composition. Although both disturbance and fertility show a clear association with weed species composition, it is difficult to determine whether one or both are responsible for this result, as these two factors are themselves closely related. The fact that plot size etc., which partly reflect both factors, provide the best match with species composition is indirect evidence that a combination of husbandry practices determines which weeds grow where, but is not conclusive. The role of watering is even more difficult to evaluate, as its correspondence to weed composition is weaker than that of disturbance or fertility, and it tends to covary with both. Its partial correspondence to species composition, therefore, may be an indirect result of this relationship. A further complicating factor is that soils rich in organic matter tend to have a greater capacity for water retention[24] and intensively tilled soils a lower susceptibility to evaporation,[25] and so an apparent fertility or tillage effect may in fact be, at least partly, a response to greater soil moisture.

While disturbance and fertility are clearly associated in modern pulse plots in central Evvia, the same cannot be assumed to hold for other crops, other places, and other periods in the past. The question remains open, therefore, as to whether archaeological grain assemblages rich in Chenopodietea character species reflect high levels of disturbance, high levels of fertility and/or watering, or a combination of these factors as in the modern Evvia gardens. There are indications in the Evvia correspondence analysis that axis 1 is related to the effects of productivity (or at least fertility) on weed composition: in FIG. 4 *b*, organic content is higher on the left of the diagram than on the right; the distribution of rich *koprochoma* soils in FIG. 4 *d* points in the same direction. Conversely, axis 2 is related to disturbance (or at least tillage): on the left of FIG. 4 *a*, hoed plots are restricted to the top of the diagram and ploughed plots are drawn towards the bottom. These indications are also consistent with the distribution in the correspondence analysis of the intermediate plot types, vineyards, and fenced fields (FIG. 3 *c*). Fenced fields, which were only lightly tilled but sometimes heavily manured, are appropriately distributed from left to right along axis 1 (the 'productivity' axis), while the most fertile of them are located at the bottom ('undisturbed') end of axis 2. Vineyards, which were only lightly manured but relatively intensively tilled, tend towards the top ('disturbed') end of axis 2 and occupy a relatively neutral position on axis 1.

These patterns are not clear-cut, however: for example, plots with high organic content are concentrated at the top of axis 2, suggesting that fertility may contribute to this axis also. Moreover, these interpretations of weed composition in Evvia pulse crops are based on the circumstantial evidence of association with various plot characteristics. It is now necessary to disentangle the individual effects of husbandry practices and to establish causal relationships rather than mere associations. Such relationships can only be demonstrated through a functional ecological analysis of individual weed species.[26] By considering those functional

[24] Parr and Hornick (n. 12).

[25] H. Forbes, 'The "thrice-ploughed field": cultivation techniques in ancient and modern Greece', *Expedition*, 19 (1976), 5–11.

[26] M. Charles, G. Jones, and J. G. Hodgson, 'FIBS in archaeobotany: functional interpretation of weed floras in relation to husbandry practices', *JAS* 24 (1997), 1151–61; A. Bogaard, J. G. Hodgson, P. J. Wilson, and S. R. Band, 'An index of weed size for assessing the soil productivity of ancient crop fields', *Vegetation History and Archaeobotany*, 7 (1998), 17–22; A. Bogaard, C. Palmer, G. Jones, M. Charles, and J. G. Hodgson, 'A FIBS approach to the use of weed ecology for the archaeobotanical recognition of crop rotation regimes', *JAS* (in press).

attributes which determine a species' ability to thrive under different conditions, it should be possible to determine how far the observed differences in the weed flora between plots cultivated at different levels of intensity are a result primarily of disturbance or productivity or a combination of factors. This will be the next phase of study in Evvia and will also be the key to applying the study to archaeological weed assemblages, as the functional attributes of archaeological weed species not represented in this study may be analysed in terms of disturbance, productivity, etc. and thereby in terms of the husbandry practices applied to the crops they contaminated.

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